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Pointed bone tool technology in southern Africa: results of use-trace analyses

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ABSTRACT

Bone tools represent an important but often understudied aspect of past material culture. Apart from some notable exceptions, bone tool studies are still dominated by typological descriptions. This paper reviews the history and current state of bone tool functional studies in southern Africa. I present the results of use-trace analyses of 378 bone points from 12 archaeological sites spanning the last 18 000 years. The results suggest that manufacturing techniques remain unchanged for most of the time span considered. Damage on the distal ends indicates that not all bone arrow points were pointed, but that some arrows may have included a metal or stone tip. On certain specimens, use-wear and residue remains suggest that at least some bone points (morphologically identical to San bone arrow components) may have been used to process plant material. Whether they were used solely for this purpose or as multi-functional tools is uncertain. The most variability in use-trace indicators on bone points occurs during the Wilton, particularly after 4000 BP. Such changes in bone point form and function do not correlate neatly with lithic technological oscillations. It is not certain to what extent this pattern is a reflection of taphonomic conditions.

KEY WORDS: bone points, hunting, macro-fractures, micro-residues, South African and Lesotho Stone Age sequence, use-wear.

Organic tools, like their stone equivalents, are present in the archaeological record of almost every ancient society and time period; yet, for various reasons, they seldom have been afforded the same attention. In this paper I begin to explore some of the functions that pointed bone artefacts may have served in southern Africa during the Terminal Pleistocene and Holocene from approximately 18 000 years ago until the last few hundred years when the Stone Age hunter-gatherer cultures came under the influence of immigrant Iron Age agriculturalists and colonial settlers. The artefact category commonly referred to as bone points, and presumed to be arrow points, is considered from twelve archaeological sites spanning the last 18 000 years, and from four historic collections from the last few hundred years. Evidence from a large-scale use-trace study (Bradfield 2014) is discussed in relation to our current understanding of the South African and Lesotho Stone Age cultural sequence (see Lombard et al. 2012). In this paper I question whether all archaeological bone points can be correctly classified as hunting-weapon components based solely on their morphological characteristics.

I have drawn upon a number of techniques to investigate the past function of bone points, all of which can be subsumed under the general heading of use-traces (Bradfield 2015). Simply put, use-traces are the combination of micro- and macroscopic features that develop on objects that have come into contact with one another, either during use or manufacture. As with other functional studies, the aim of use-trace analyses is to reconstruct, as completely as possible, the primary economic activities of prehistoric groups (Keeley 1974; Rots 2010).

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Use-trace analyses have the potential to transcend traditional typological studies, which hold that the shape of a tool dictates its function.

In southern Africa, and indeed in the rest of the world, Stone Age societies are largely understood in terms of their technology. The way in which we frame our research and understanding of these past societies is based almost exclusively on stone tools and ceramics; yet, these materials represent only a portion of traditional hunter-gatherer paraphernalia and do not necessarily reflect the complexity of cultural adaptation and technological achievement (Hayden 1979; Binford 1981; O'Connor et al. 2014). Studying components of past technological systems in isolation risks creating a distorted image of the past (Hayden 1979; Van Gijn 2007).

One reason for the apparent bias in research agendas is that bone points are neither incredibly abundant nor particularly rare, and therefore seem less attractive to archaeologists when compared with ceramics and stone tools (Olsen 2007; St-Pierre & Walker 2007). This situation, by no means unique to southern Africa, has led Becker (2001: 130) to describe bone tools as the "unloved children" of our discipline. Perhaps the most patent reason for this bias is the comparatively low survival rate of organic materials (LeMoine 1994; Olsen 2007). The degree of organic preservation at archaeological sites is highly variable and is dependent on a host of factors that all contribute to the destruction of organic remains, such as the acidity of the soil (Choyke & Daróczi-Szabó 2010), rate of deposition, soil compaction and bioturbation (Shipman 1981; Olsen 2007).

Bone tools nevertheless played an important role in southern African hunter-gatherer culture. Whereas stone arrow tips were eventually replaced with metal by the 1870s, bone points continued to be used to tip hunting arrows until the 1970s (Smith et al. 2000; Bosc-Zanardo et al. 2008). Furthermore, the discard rate of still-usable stone tools compared with those of bone was much higher (Stow 1905; Marshall-Thomas 2006), signalling that a higher value was attached to bone tools (*sensu* Knecht 1997). Bone has numerous advantages over stone as a weapon. For example, it is more durable and easily mended, thereby increasing its use-life (Arndt & Newcomer 1986; Knecht 1997; Rots & Williamson 2004; Rots 2010). It is possible, however, that bone was not favoured purely for its functional advantages. Material choice, although dependent on task suitability, may, in some cases, have been driven by ancient cultural traditions, now lost to time (McGhee 1977; Hodder 1991; Russell 2001; Luik 2011). A comprehensive study of organic tools, such as those made from bone, has the potential to provide information about past societies that is simply not available from stone tools or ceramics.

SITES DISCUSSED

The twelve sites referred to in this paper (Fig. 1) were chosen because of their geographical and chronological distribution (Table 1) and the presence of high numbers of pointed bone artefacts. The sites cover the Early and Middle Iron Ages and most Later Stone Age technocomplexes (see Lombard et al. 2012 for the latter). The four historic collections examined come from the Dunn, Burchell, Jameson and De Lisle collections, currently housed at the Pitt Rivers Museum, Oxford. Only bone points that showed clear proximal and/or distal ends were examined. The total number of bone points discussed here comes to 378.

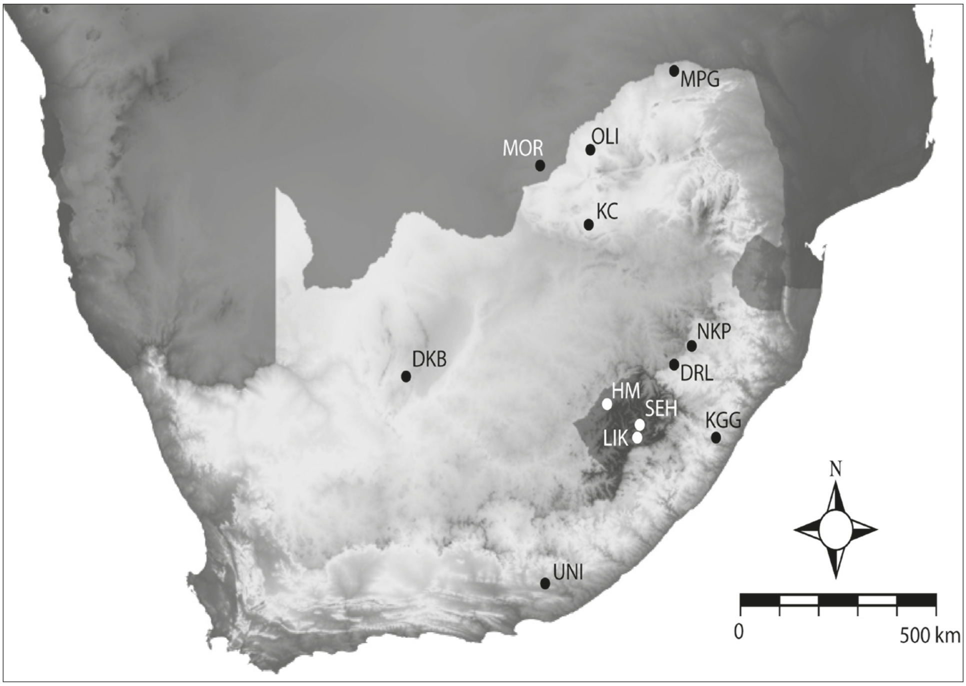

Fig. 1. The spatial relationship of the 12 archaeological sites. DKB: Dikbosch; DRL: Driel; HM: Ha Makotoko; KC: Kruger Cave; KGG: KwaGandaganda; LIK: Likoaeng; MOR: Moritsane; MPG: Mapungubwe; NKP: Nkupe Shelter; OLI: Oliboomspoort; SEH: Sehonghong; UNI: Uniondale.

TABLE 1

Pointed bone tools analysed from each site. FLSA=final Later Stone Age; CFLSA=ceramic final Later Stone Age

Sites examined	Technocomplex	Number of tools analysed
Dikbosch	FLSA, Robberg	19
Driel	CFLSA	19
Ha Makotoko	Oakhurst	3
Kruger Cave	CFLSA, Oakhurst	33
KwaGandaganda	Early Iron Age	27
Likoaeng	FLSA	24
Mapungubwe	Middle Iron Age	83
Moritsane	Middle Iron Age	9
Nkupe	FLSA	28
Olieboomspoort	FLSA	19
Pitt Rivers Museum collections	CFLSA	33
Sehonghong	Wilton, Oakhurst, Robberg	61
Uniondale	Wilton	20

BACKGROUND

A brief history of bone tool use-wear studies

The functional study of bone tool technological systems first came to prominence with the publication of the English translation of Sergi Semenov's seminal work on use-wear analysis (Semenov 1964). Prior to Semenov, however, Tyzzer (1936) had recognised that certain breakage formations on bone tools were far more important as evidence of the nature of usage than simple morphology and perceived suitability of shape. In his analysis of bone points from Harbour Island, Nova Scotia, he found shattering and chipping indicative of terminal impact, and other micro-wear traces that suggested repeated use (Tyzzer 1936). This study remained in relative obscurity, and it was only after Semenov's work was introduced to the English-speaking community that attention began to be focused on functional aspects of bone tools that went beyond morphological description and analogy.

In the late 1960s and 1970s, investigations began into the identification of hominin bone 'pseudo-tools', which, in the previous decade, had been popularised by Raymond Dart's (1957) osteodontokeratic culture. Dart's theory stated that certain bone fragments were used as tools, perhaps as weapons. While Dart's interpretation of these tools was speculative, others began using experimentation to distinguish naturally from anthropically modified bone (e.g. Brain 1967). These studies suggested that, while Dart may have exaggerated aspects of his osteodontokeratic culture, organic materials, including bone tools, certainly played a prominent role among prehistoric peoples subject to the limitations of a Stone Age technology (Sadek-Kooros 1972; Backwell & d'Errico 2001). Later, during the 1980s, a suite of experimental replication studies suggested that cut marks could be linked both to hunting and to scavenging behaviours, and prompted the development of new experimental protocols, including the use of high-powered microscopy, such as scanning electron microscopy, to distinguish between these behaviours (e.g. Bunn & Kroll 1986; Domínguez-Rodrigo 2002).

Despite the seeming progress in the study of bone tools during this period, ideas continued to develop in relative isolation. Language barriers hampered the dissemination of ideas and research (Choyke & Bartosiewicz 2001; Griffitts 2006). Perhaps these 'unloved children' were deemed unfit for publication in international scientific journals and were thus marginalised in local, language-specific journals and museum annals. This state of affairs began to change after 1997, when Ian Riddler founded the Worked Bone Research Group under the auspices of the International Council of Archaeozoologists. This research group continues to bring together researchers from all over the world to share their findings and ideas with colleagues. The results of this collaboration are published every few years (e.g. Choyke & Bartosiewicz 2001; St-Pierre & Walker 2007; Legrand-Pineau et al. 2010).

Notwithstanding the progress that has been made over the past two decades, bone tool studies continue to be hampered by problems of preservation, which result in far fewer specimens surviving intact compared with ceramics and stone tools (LeMoine 2001). Bone usually only preserves in alkaline soils (Berner 1971), which means that the archaeological record of bone tool use will inevitably be incomplete and skewed towards those few sites and regions that are favourable to organic preservation. In addition, the convergence or overlap in dimensions of bone tools hinders the establishment of any informative typological classification comparable with those of stone tools and ceramics (Newcomer 1974). Modern interpretations of ancient bone tool functions rely on microscopic analyses, experimentation and ethnographic analogy (Olsen 2007). Bone surface modification constitutes a crucial line of evidence for investigating issues as diverse as site formation, taphonomic processes and ritual behaviours (Cook 1986; Runnings et al. 1989; Fisher 1995; Russell 2001; Choyke & Daróczi-Szabó 2010). Such interpretations, however, must be augmented with, and borne out by, experimentation and other lines of evidence (Chomko 1975; MacGregor 1975). Guthrie (1983) and Arndt and Newcomer (1986) demonstrated that, on a macro scale, bone behaves much like other brittle solids, making it suitable for macrofracture analysis (see Bradfield 2011; Bradfield & Lombard 2011), thereby opening up a new avenue of functional exploration of bone tools.

Bone tools have been used as temporal and cultural markers for many years, yet their associated technology has been largely ignored (McBrearty & Brooks 2000; LeMoine 2001; Scheinsohn 2010). Recent studies have applied use-trace analyses to the study of bone tool technology. Use-trace analyses can shed light on past activities for which no direct evidence remains; for example, hide working, basketry and weaving (Griffitts 2001; LeMoine 2001; Olsen 2007; St-Pierre & Walker 2007; Van Gijn 2007; Stone 2010). In North America, where bone 'awls' constitute an ambiguous catch-all morpho-functional category, St-Pierre (2007) has used use-wear analysis to determine the precise function of individual bone points. Bone tools with similar morphologies, which may otherwise have been classified as the same tool under a morpho-typological approach, have been found, using use-trace analyses, to have been used for diverse and sometimes multiple functions (e.g. Buc & Loponte 2007; Buc 2010, 2011).

One should bear in mind that while functional demands can drive stylistic change, such functions need not be utilitarian. Technology can include symbolic aspects (Schiffer 1992). This is evident when bone-tipped arrows persist after the introduction of metal (Griffitts 2006). Metal is in all ways superior to bone, and if functional efficacy were the only criterion then bone would be discontinued in favour of metal among those groups where metal was easily accessible. Radley (1997) reminds us that certain objects, especially personal objects, may be closely tied to memory and could be used to establish links with the past, thereby reinforcing and sustaining group identity. The deliberate burial of objects, identifiable by use-trace indicators, may signal such personalisation (Choyke & Daróczi-Szabó 2010). The preference of certain skeletal elements or certain donor animals over others may signal that a special significance was attached to this animal or body part by the tool makers (McGhee 1977; Birtalan 2003).

In recent years increasing attention has been focused on the worked bone technology from Châtelperronian sites in Europe associated with the remains of *Homo neanderthalensis*. Previously, the presence of worked bone in these levels was attributed to acculturation with incoming groups of *Homo sapiens* (Bar-Yosef et al. 2006; Golovanova et al. 2010). However, new evidence is emerging that Neanderthals may, in fact, have developed an independent bone tool technology (d'Errico 2003; d'Errico et al. 2003, 2011; d'Errico & Stringer 2011). Such then has been the progression of bone tool studies in other parts of the world.

In southern Africa, Brain's (1967) functional investigation of early hominin bone tools stimulated a new set of studies using use-trace analysis and actualistic experiments to investigate the past functions of purported hominin bone tools from sites in the

Cradle of Humankind. These studies showed that certain tools were probably used for digging for termites (Backwell & d'Errico 2001, 2003, 2005, 2008, 2009). Through use-wear analyses, the authors were able to show that the hominin makers had a clear understanding of bone properties and could anticipate the end product (Backwell & d'Errico 2005). Furthermore, the tools were shown to have been deliberately shaped prior to use (d'Errico & Backwell 2003)—a finding with far-reaching consequences for our understanding of early hominin behaviour.

Although southern Africa still lags behind the rest of the world when it comes to functional studies of bone tools, much headway has been made, especially with respect to the rare Early and Middle Stone Age bone tools, which are now regularly described in terms of past function, empirically derived from use-trace studies (e.g. d'Errico & Henshilwood 2007; Backwell et al. 2008; d'Errico, Backwell & Wadley 2012; d'Errico, Backwell, Villa et al. 2012). One of the questions at the forefront of archaeology today is how to understand how we became human. Symbiotic technologies, such as the bow and arrow, are taken as evidence for complex cognition (Lombard & Haidle 2012). How far back in time such technologies may extend is a topic of debate (cf. d'Errico, Backwell & Wadley 2012; Mitchell 2012). The most reliable means of determining the past function/s of tools is through use-trace analyses. If we can better understand the functional and stylistic variation of more recent bone artefacts, then we might be able to gain greater confidence regarding our interpretation of the role of bone points in Middle Stone Age societies. This, in turn, will reduce our reliance on ethnographic analogy. For example, being able to identify artefacts that were hafted and/or functioned as arrow tips might provide insight into levels of past technological, behavioural and cognitive complexity (e.g. Lombard in press), feeding into the question of where and when *Homo sapiens* started to think and behave like us. The application of use-trace studies is being carried over to Later Stone Age bone tools (e.g. Bradfield 2011, 2012a,b; d'Errico, Backwell, Villa et al. 2012; Robbins et al. 2012; Bradfield 2013; Bradfield & Brand 2015), previously confined to morpho-functional typologies.

Some problems with analogy

There is always a risk involved when applying ethnographic analogues to interpret archaeological finds. Often the tendency is to miss the analogy and treat it as a homology, thereby occasioning the treatment of prehistory as linear and unchanging. Ethnographic observations should inform rather than dictate interpretation. Nineteenth- and twentieth-century hunter-gatherer societies were not isolated populations, independent of the rest of the world (cf. Lee & DeVore 1976; Marshall 1976; Lee 1979; Marshall-Thomas 2006). Rather, what we see today is the product of generations of social interaction, first with immigrant Bantu-speaking agriculturalists and later with European colonial settlers, which shaped the socio-economic structures of hunter-gatherer societies (see Denbow & Wilmsen 1986; Wilmsen 1989). The exact effect that these interactions had on the material culture of various hunter-gatherer groups is a complex issue that may have taken many and diverse forms in the past (e.g. Eastwood & Fish 1996; Sadr 1997, 2002; Smith et al. 2000; van Doornum 2007; Bradfield et al. 2009; Mitchell 2010; Forssman 2013; Hall et al. 2013). Archaeological evidence suggests that by at least 1850, Bushman groups had successfully integrated herding and raiding into their hunter-gatherer way of life (Mitchell 2010). This observation can easily be applied to material culture. Given the depictions of recurved bows in rock art (*sensu* Manhire et al. 1985) and evidence of heavier and fletched arrows (Schapera 1927; Logie 1935), the possibility exists that technology not seen by ethnographers and early travellers may indeed have existed in the past.

What is clear is that it is not necessarily appropriate that the cultural analogues of these hunter-gatherer societies be uncritically superimposed onto much older Stone Age societies. The interpretation that bone points found in archaeological deposits represent hunting arrows and by implication transfer of goods akin to the *hxaro* system of 1950s to 1970s Ju|'hoansi groups (e.g. Wadley 1987; *sensu* Wiessner 1983) should not be uncritically imposed, as it risks allowing historical observations to traverse thousands of years of human history (see Parkington 1998; Mitchell 2003). For this reason, studies of Middle Stone Age bone tools have focused on independent use-wear studies that aim to understand the function of these early bone tools (Backwell & d'Errico 2009; Bradfield & Lombard 2011; d'Errico, Backwell & Wadley 2012). Bone tools from the more recent Later Stone Age contexts, as well as contexts where hunter-gatherers were in contact with immigrant Bantu-speaking farming communities, are, however, still largely interpreted through morphological analogues.

An inherent problem with how we refer to bone tools is the morpho-functional categories into which we lump them. Bone points have an air of uniformity all over the world (LeMoine 2001) and, though only a limited amount of variability is possible while still allowing for optimal functionality (Knecht 1997), such variation is as likely to reflect social choices as issues of function (Guthrie 1983; LeMoine 2001). Viewed through the eyes of use-trace analyses we see that 'bone points', usually assumed to be components of arrows, can encompass a large variety of quite different implements and comprise a broad variety of shapes (Becker 2001). A similar conclusion has been reached for 'awls', one of the most ambiguous categories among archaeological bone tools (Legrand & Sidera 2007; Olsen 2007). Chomko's (1975) study revealed that awls within a single morphological type occasionally displayed evidence of divergent uses, while awls of different morphological types displayed evidence of similar uses. Equating form with function can be misleading, as it denies the possibility of multiple or alternative uses and ignores the morphological variability within a particular tool class (St-Pierre 2007).

Exacerbated by the small number and fragmented nature of most archaeological bone assemblages (Newcomer 1974), worked bone research has suffered from divergent and oftentimes nebulous typologies (Choyke & Bartosiewicz 2001; Buc & Loponte 2007), the result of which, together with the relative scarcity of organic remains, has seen stone and ceramic remains favoured over worked bone when it comes to interpretations of archaeological material culture. Through use-trace studies, the Worked Bone Research Group (http://www.wbrg.net) is helping to produce a clear and accepted terminology for working with archaeological bone tools, although the methodological techniques used by the various researchers still differ.

METHODS

Use-wear

All manufacturing and use-related traces were recorded using a Celestron handheld digital microscope (model #44302-A). This is a portable USB microscope with magnification ranges of 10×–50× and 100×–150×. The microscope uses six mounted LED lights for illumination and has a built-in camera—ideal for in-field analysis. In two cases, Olieboomspoort and Kruger Cave, the specimens were analysed using an Olympus binocular light microscope (model #SZX16) with magnifications of between 10× and 110×. Low-power magnification such as this is eminently suitable for use-wear analysis (see Semenov 1964; Legrand & Sidéra 2007; Evora 2015) as it does not lose the context of the micro-traces as does high-power magnification. Use-wear, particularly on tools where manufacturing traces are still visible, must be interpreted in relation to the whole tool.

In each case, striations were recorded and described and, where possible, a distinction was made between use-related striations and manufacturing-related striations. Following the rule of superimposition, striations overlying polish or other striations were interpreted as use-related. The direction, orientation and shape of striations may all yield information about the probable function of a particular pointed bone tool.

Polish was recorded and described in terms of its lustre, extent, orientation and placement in relation to other traces. I distinguish between dull, smooth, high or bright (I use the word bright to avoid confusion with topographic location) and intense polish. In most instances (but not all), polish develops along a linear spectrum—the more intense the polish, the longer the duration of use, and vice versa. The degree of light reflection and the extent of manufacturing-trace obliteration corresponds with the intensity of the polish. Not all worked materials, however, leave identical polishes, and not all worked materials cause polish. For this reason, details of the extent and placement of the polish were recorded, as well as other associated indications of wear, such as rounding. Polish is most easily observed by light-source manipulation, and occasionally, if the polish is particularly pervasive, use-wear striations may be observed in the polish.

Macrofractures were recorded following the criteria and methods previously described (e.g. Bradfield 2011; Bradfield & Lombard 2011). A very small percentage of tools examined displayed macrofractures. This may be due to the state of the bone at the time of breakage. Wet or fresh bone tends to fracture in a spiral manner, whereas dry bone displays the fracturing properties of brittle solids on which the macrofracture method is based. While step-terminating fractures do occur as a result of impact (Bradfield & Lombard 2011), I have chosen to omit them from the list of diagnostic impact fractures following recent studies that have shown them to also result from non-hunting-related activities with bone points, such as hide piercing, dropping and trampling (Pargeter & Bradfield 2012; Bradfield & Brand 2015).

Micro-residues

Ancient micro-residues as well as modern contaminants were identified in the first instance using the Celestron microscope. The residues were photographed and their placement and orientation on the tools were recorded. Where it was felt that the residue/substance required further investigation, the residue was lifted using a cellulose-based adhesive peel and analysed under laboratory conditions using an Olympus BX51M light microscope with polarising and cross-polarising capabilities, and using Bright- and Dark-Field illumination. Magnifications ranged from 50× to 500×, although, typically, 200× proved sufficient for most residue interpretations. Residues were interpreted based on their morphological traits (see Fullagar & Jones 2004; Cooper & Nugent 2006; Lombard & Wadley 2007; Wadley & Lombard 2007; Lombard 2008; Högberg et al. 2009; Bradfield 2014).

Archaeological residues that may be thousands of years old are not expected to look identical to their modern counterparts. Decay and contamination both play their part in obscuring identifiable features and are considered when conducting any analysis of this nature. Contaminants can adhere to a tool surface through handling, but also through soil deposition. In some cases it was possible to distinguish between these two causes based on superimposition of residues. Residues lying directly on the tool surface or in the manufacturing striations are more likely to result from use, whereas those lying above the surface, either on top of other residues or on sandy encrustations, are more likely to have resulted from contamination.

RESULTS

Manufacturing techniques

The primary manufacturing technique noted on bone points is grinding against an abrasive surface and scraping parallel to the long axis of the bone tool. The absence of chattermarks (diagnostic of scraping) on all but the Pitt Rivers collections is interesting. Bone is more easily worked by grinding than scraping (Semenov 1964; Newcomer 1974; Guthrie 1983; Bradfield 2011), yet evidence for scraping with a sharp lithic edge extends as far back as the Middle Stone Age in South Africa (see d'Errico & Henshilwood 2007). My own experiments have shown that chattermarks are more likely to develop when a metal edge is used to do the scraping rather than a lithic edge, although lithic edges can sometimes also produce chattermarks (Semenov 1964; Newcomer 1974). Interpretations of scraping are based on the orientation and appearance of the striations, which accord well with experimental examples. If my interpretations are correct, then it appears that the primary difference in manufacturing between the archaeological bone points and those in the Pitt Rivers collections is in the type of tool used to manufacture them.

The incidence of diagonal grinding striations, which nearly always overlay the longitudinal striations, is ubiquitous, but does not occur on every specimen. On examples where they do occur, they are commonly orientated from the top left to the bottom right. This orientation is indicative of dextrality. The opposite orientation, present on single specimens from KwaGandaganda, Mapungubwe, Sehonghong, Nkupe and the Jameson collection, may indicate that the individuals who manufactured these specimens were left-handed. It is possible, though, that reversing the orientation of the tool in the hand with the point facing towards the palm will produce contrary striations. However, it is difficult to avoid injuring oneself using this method, and I propose that bone points would have been fashioned with the pointed end facing away from the palm. If I am correct, this detail has interesting implications for the issue of agency, because we can say that at least two individuals were involved in the manufacture of bone points at, for example, Mapungubwe (although it is probable that several individuals made bone points). Diagonal striations are present in all the technocomplexes and at all the sites, except Moritsane. Figure 2 presents the incidence of diagonal manufacturing striations over time. In every case, the diagonal striations appear to be the result of secondary shaping.

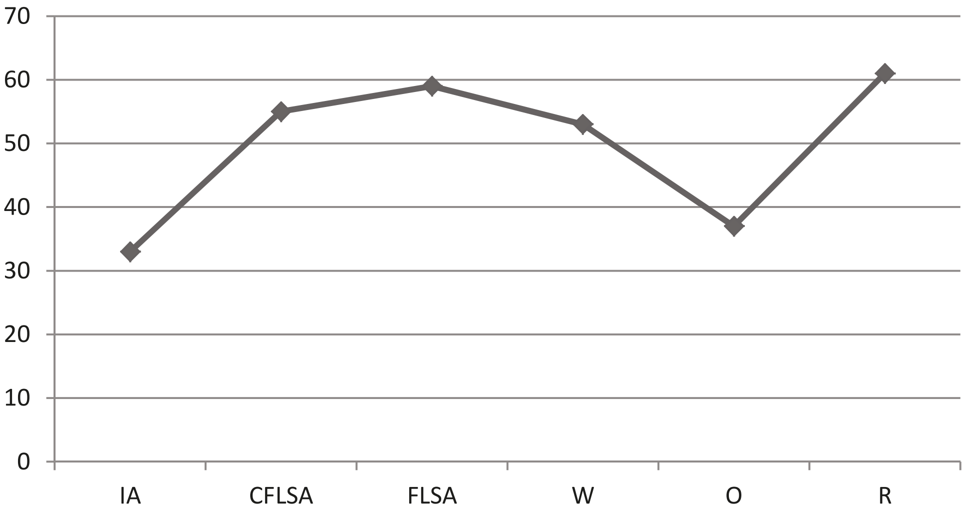

Fig. 2. Incidence of diagonal striations over time. IA=Iron Age; CFLSA=ceramic final Later Stone Age; FLSA=final Later Stone Age; W=Wilton; O=Oakhurst; R=Robberg.

Apical modification

Forty-five bone points have one or both apical ends deliberately snapped and occasionally ground smooth. Deliberately snapped bone points were identified by the evidence of working along the circumference of the snapped edge and on the facet of the snapped end. The occurence of deliberately snapped bone points does not seem to correlate neatly with temporal or geographical factors. Table 2 shows that the incidence of deliberate snapping occurs predominantly at the proximal end. In the Pitt Rivers collections, the proximal end was the only end on which I observed deliberate snapping, although I did not remove the metal components of those specimens with metal heads. There are many examples, however, such as those from Mapungubwe, where the distal ends of the bone points are deliberately snapped. The primary technique for snapping the ends is the ring-snap technique. The ring-snap technique involves chipping or sawing along the circumference of the bone shaft in order to narrow the shaft and make it easier to control the break. This is either left as is, or modified by smoothing the facet through grinding against an abrasive surface (Table 3).

On several examples, notably from Nkupe, Kruger, KwaGandaganda and Likoaeng, there is evidence that suggests that bone points were reused after they fractured. This is borne out by the presence of use-wear along the fracture edges (Fig. 3). This implies a certain degree of technological investment and curation. Once again, there does not seem to be any geographical or chronological pattern in the distribution of these specimens.

Another apparent chronological use-trace variable is the incidence of circumferential chipping present on the edges of deliberately ground ends (Fig. 4). Circumferential chipping is only present during the last thousand years on pieces from the final Later Stone Age through to the Iron Age—being almost entirely absent in older assemblages. This chipping appears consistent with a repetitive impact against a harder material.

TABLE 2

Location of deliberate snapping.

Base	Tip
Dikbosch (n=8)	KwaGandaganda (n=4)
Driel (n=3)	Moritsane (n=3)
Kruger (n=3)	Olieboomspoort (n=11)
KwaGandaganda (n=7)	Nkupe (n=8)
Moritsane (n=2)	Mapungubwe (n=24)
Nkupe (n=2)	
Olieboomspoort (n=3)	
Sehonghong (n=7)	
Uniondale (n=4)	

TABLE3

Type of finish on snapped ends.

Ring snapped	Squared and ground
Kruger (n=1)	Kruger (n=3)
Nkupe (n=1)	Nkupe (n=10)
Driel (n=3)	Driel (n=4)
Dikbosch (n=3)	Dikbosch (n=5)
Sehonghong (n=3)	Sehonghong (n=4)
Moritsane (n=4)	KwaGandaganda (n=9)
	Likoaeng (n=4)
	Olieboomspoort (n=8)
	Mapungubwe (n=24)
	Uniondale (n=5)

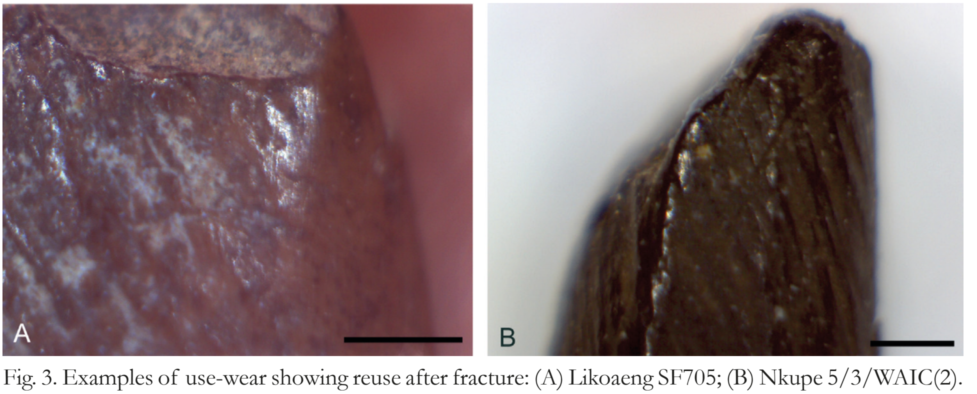

Fig. 3. Examples of use-wear showing reuse after fracture: (A) Likoaeng SF705; (B) Nkupe 5/3/WAIC(2). Scale bars are 1 mm.

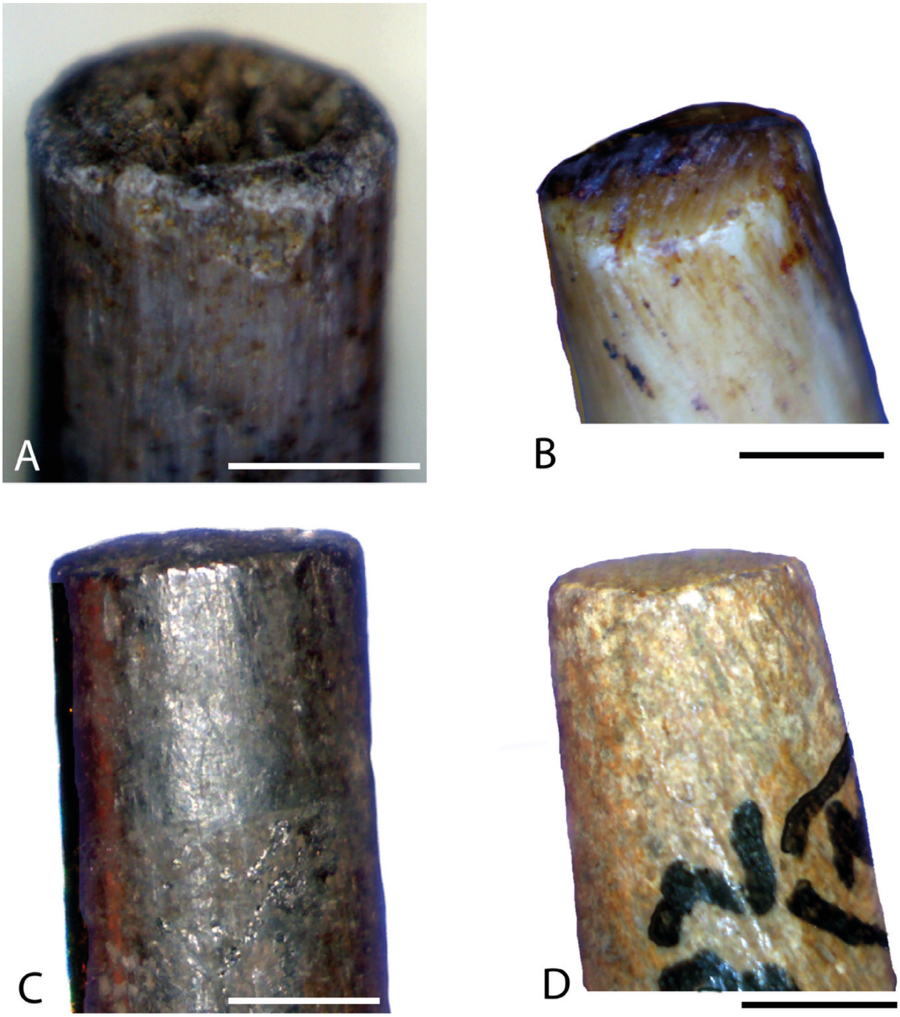

Fig. 4. Examples of circumferential chipping: (A) Moritsane M/4/100; (B) KwaGandaganda 25 C7; (C) Nkupe S10 MBS1; (D) Driel D3(4). Scale bars are 2 mm.

While it is possible that this chipping occurred while in the reed collar, for example at Olieboomspoort where, in most cases it occurs at the proximal end, it is more likely that it resulted from contact with metal or a hard mastic at the distal end. Such traces could provide indirect evidence for the attachment of a metal head or the insertion of stone segments into a mastic haft. Unfortunately, I was not able to confirm this assertion on the Pitt Rivers collections as the act of removal of the metal heads from the bone is considered destructive. The temporal placement of these features within the last thousand years, however, supports my interpretation of a metal component. This has interesting implications for relative dating and arrow typology, as the occurence of these features may mean that a metal component of the arrow is missing (see Bradfield in press).

Use-wear

Use-wear consists primarily of polish and occasional striations. On the vast majority of specimens I examined, use-wear features are fairly uninformative—meaning that they are insufficient to isolate a specific activity. This is nevertheless consistent with hunting. Use-wear only becomes diagnostic after prolonged, fricative contact—unlikely to be occasioned through hunting. However, a few bone points from six of the sites do display signs of use-wear that are diagnostic of hide working and wood working (Table 4). Contrary to expectation, more bone points show signs of wood working than hide working (Fig. 5). These activities are inferred based on the presence of multiple instances of characteristic use-wear (see Bradfield 2014). Single use-wear indicators,

TABLE 4

Archaeological sites with incidence of wood-working and hide-working use-wear features

Wood working	Hide working
Kruger (n=1)	Nkupe (n=3)
KwaGandaganda (n=3)	?Olieboomspoort (n=1)
Likoaeng (n=3)	
Mapungubwe (n=3)	
?Olieboomspoort (n=1)	

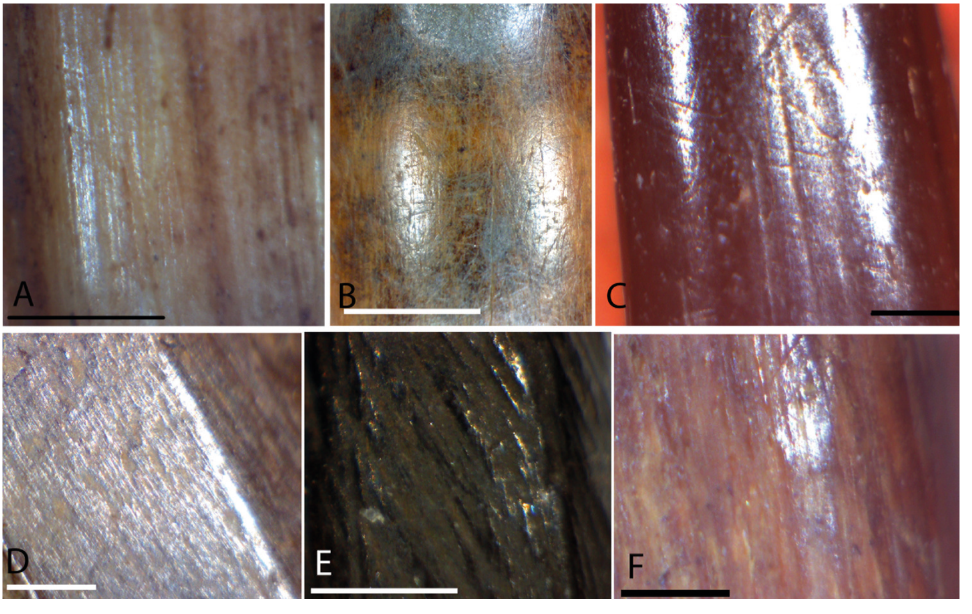

Fig. 5. Examples of typical wood-working and hide-working use-wear. (A) hide-working polish on Likoaeng SF105; (B) hide-working polish on Kruger Cave KC2688; (C) hide-working polish on Ha Mokotoko HM233; (D) wood-working polish on Kruger Cave KC313; (E) wood-working polish on Nkupe 5/3/WAIC(2); (F) wood-working polish on Sehonghong SF598SA. Scale bars are 1 mm.

such as bright polish, when considered in isolation, are particularly problematic as they may have several causes (Choyke & Doróczi-Szabó 2010). Other features, such as striations, pitting and general surface topography, must also be considered. Among the tools examined, only one specimen, from Olieboomspoort, is of ambiguous function. With the exception of the Kruger Cave specimen, which is associated with the Oakhurst, the tools that evince wood-working traces are associated with the Iron Age and final Later Stone Age, hinting at a greater functional diversity during the last 2000 years.

The final use-trace indicators that I looked for were macrofractures. Table 5 provides the percentage of diagnostic impact fractures in each technocomplex. The recent realisation that step-terminating bending fractures can no longer be considered diagnostic of longitudinal impact (Pargeter & Bradfield 2012; Bradfield & Brand 2015) has led me to drop this category. The result is that only spin-off fractures (>6 mm) are considered. Diagnostic impact fractures seldom approach 10 % of the total bone tool assemblage per technocomplex, and only marginally exceed this percentage in the ceramic final Later Stone Age. When individual sites are considered, however, the percentage of diagnostic impact fractures ranges from 7 % at Mapungubwe to 27 % at Dikbosch. This is within the range present at other archaeological sites (Bradfield 2012a) and on experimental hunting samples (Bradfield 2011; Bradfield & Lombard 2011), once step-terminating fractures have been excluded from the calculation.

TABLE 5

Percentage of diagnostic impact fractures (DIFs) in each technocomplex

Technocomplex	**Percentage of DIFs**
Iron Age	6 %
ceramic final Later Stone Age	12 %
final Later Stone Age	5 %
Wilton	7 %
Oakhurst	4 %
Robberg	–

Micro-residues

Contaminants are the most common residue on the archaeological tools. The antiquity of the residues was determined based on their placement on the tool relative to other residues (see Bradfield 2014). Residues are rarely preserved on bone points from deposits older than the Wilton (ca 4000–8000 years ago). Table 6 presents a conservative estimate of the ancient residues present on the bone points. The only evidence for ancient plant material comes from Dikbosch and was found concentrated at the base of the tool (Fig. 6). This strongly suggests a hafting residue. Dried blood remains are present at Dikbosch, Kruger Cave and Sehonghong (Fig. 6). Mostly, these residues are concentrated at or near the tip, suggestive of hunting; but the Kruger Cave specimens show signs of blood all over the bone points. As all these tools are well polished and have a reddish-brown tinge, I suggest that blood may have been used to polish them and give them an added lustre, rather than coming from hunting necessarily.

TABLE 6
Conservative estimate of micro-residues present on artefacts from sites included in this study.

Residue	Sites and collections
Plant	Dikbosch
Blood	Dikbosch, Kruger, Sehonghong
Animal	Pitt Rivers Museum collections, Driel, Likoaeng, Sehonghong
Mastic	Pitt Rivers Museum collections, Driel
Poison	Pitt Rivers Museum collections, Driel, Kruger, KwaGandaganda

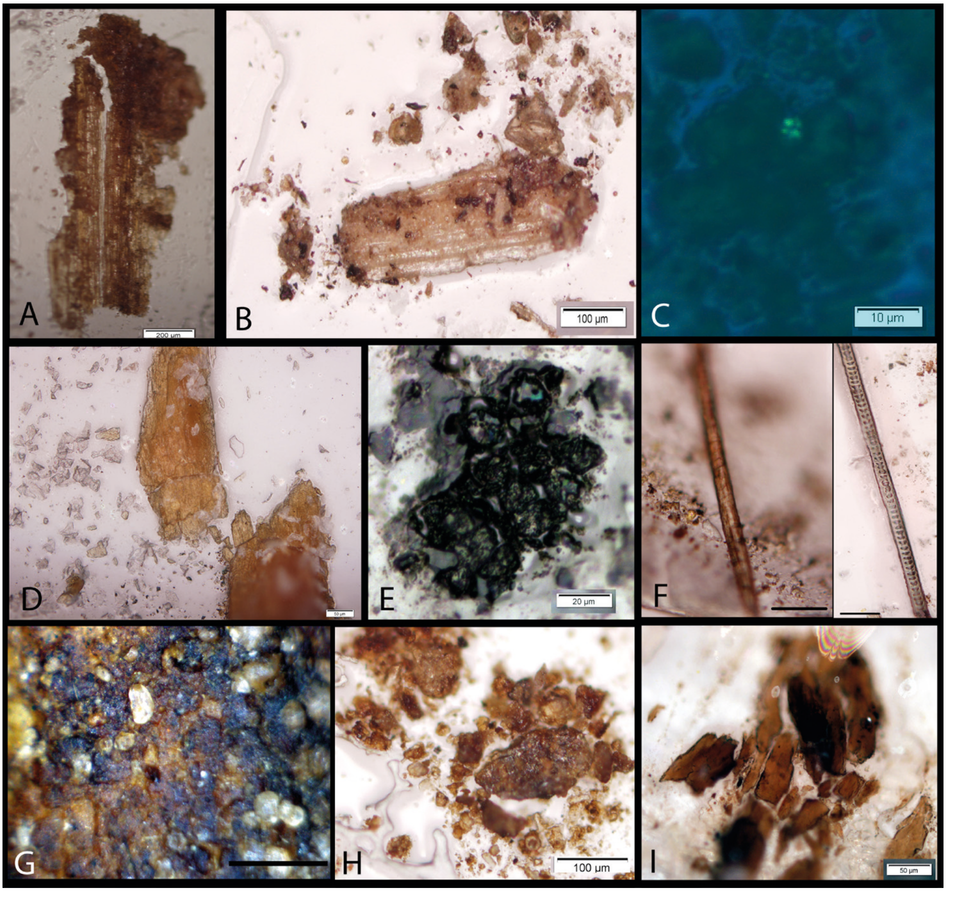

Fig. 6. Examples of micro-residues recovered from archaeological bone tools. (A) plant material recovered from Dikbosch 6480IID1; (B) cellulose plant structure recovered from Sehonghong SF095 DC; (C) starch grain viewed under cross-polarised light recovered from Sehonghong SF915f DC; (D) secondary context bone flakes recovered from Sehonghong SF024 DC; (E) blood cells recovered from Sehonghong SF055 GWA; (F) proximal and distal sections of a hair strand recovered from Likoaeng 2829DB34 (scale bars are 1 mm); (G) poison coating from 1900.69.1.3 among the Pitt Rivers collections (scale bar is 2 mm); (H) poison residue recovered from Driel E3(3); (I) mastic traces recovered from the proximal portion of Sehonghong SF598 SA.

Traces of what is probably mastic were found at the base of specimens from Driel and the Pitt Rivers collections (Fig. 6). The presence of these traces on the specimens from the Pitt Rivers collections where the bone point attaches to the reed shaft and then to the link-shaft, suggests that bone arrow points from Driel may have been similarly configured. Mastic is often difficult to differentiate from poison. In my experience, poison has a very gritty consistency, with different ingredients being discernible (Fig. 6); whereas mastic, which primarily contains tree gum, usually has a more homogenous consistency. Traces of possible poison were recovered from Driel, Kruger Cave, KwaGandaganda and Sehonghong, although no chemical tests have been conducted as yet to confirm this identification. The presence of poisoned points at an Iron Age site is interesting and could point to an early association with Bushman hunters in KwaZulu-Natal (*sensu* Morton & Hitchcock in press).

Animal residues comprise mainly bone flakes and hair shafts (Fig. 6). Analysis of the medulla characteristics of these hair shafts suggests that they belong to the order *Rodentia*, which includes hares and hyraxes, as well as rats and mice (Sapp n.d.). Although only two specimens from Likoaeng and the Pitt Rivers Museum collections contained these hair shafts, it is noteworthy that both residues are from the same order of animal. Despite the prevalence of large-game hunting with bow and arrow among the Kalahari San, the bow and arrow is better suited to hunting small fauna in mesic environments (Churchill 1993). At Boomplaas Cave in the Cango Valley, for instance, the Holocene deposits are dominated by rodent remains (Deacon 1995). Small, fast-moving animals are effectively caught using a bow and arrow. Livingstone (1857: 54) describes rodents as being a favoured prey item among the Bushmen of what is now Botswana, although he does not mention how they were caught. The versatility of the bow and arrow, or at least the bone point, is attested to at Likoaeng, where the faunal evidence suggests bone points were also employed to catch fish, although whether as part of an arrow or a spear is still uncertain (Plug et al. 2010). It would be a stretch at this stage to say that the same tools were being used to hunt small animals and to catch fish at Likoaeng, but the possibility exists that the bone-pointed arrow was used for both tasks.

DISCUSSION

So, how do the results obtained from the different methodological avenues relate to one another? Of the specimens that had both micro-residues and use-wear indicators present, 55 % (n=12) provided complementary information. In other words, in 55 % of cases tools that displayed use-wear suggestive of wood working, for instance, also contained plant residues supporting this functional interpretation. In only four instances (18 %) were conflicting results obtained. This is possibly due to certain tools experiencing multiple uses, although a margin of human error in identification and interpretation should always be allowed for. Because use-wear is only diagnostic after prolonged fricative contact, it is unlikely that the plant residues and wood-working traces arose through incidental contact during hunting. In the remaining 26 %, the use-wear indicators were inadequate to either support or contest the residue results. Use-wear and residue indicators supported diagnostic impact fracture results in 80 % of cases. However, in only one case (7 %) did a diagnostic impact fracture occur in association with woody residues and plant-working use-wear. While plant-working and hide-working activities are indicated among the pointed bone tools examined in this study, the majority of specimens have poorly developed use-wear traces, nonetheless consistent with hunting-related activities.

Two types of manufacturing techniques were identified, namely scraping longitudinal to the long axis and abrasive grinding diagonal to the long axis. At most sites, however, both techniques appear to have been used. At sites with multiple period deposits, there is a slight tendency for older bone points to favour longitudinal scraping rather than coarse, abrasive diagonal grinding. This is, however, not true of sites such as Dikbosch, Moritsane and Uniondale, where the pattern is reversed. I therefore do not think there is a meaningful difference in manufacturing techniques through time, but rather that both were used, with diagonal abrasive grinding either being to aid in poison adhesion or to resharpen/rework the bone point. In all cases where diagonal grinding occurred, it was the most recent manufacturing trace preserved on the surface of the tool.

Figure 7 attempts to situate the main results of this study into the broader framework of the southern African archaeological sequence. Much of the Later Stone Age tends to oscillate between macro- and microlithic stone implements and between blade- and scraper-based technologies, although this is not as simple as it appears from the graph, as there are many sites with contrary variants (see Lombard et al. 2012 for information on all the dated Stone Age sites). At most sites where stone scrapers dominate, there are few backed tools and the stone assemblage tends to be macrolithic. Bone points tend to be more common in these assemblages, but again, there are many exceptions. After ca 64 000 years ago, bone points are rare in the archaeological record until the beginning of the Oakhurst, some 12 000 years ago (Deacon 1978, 1984; Mitchell 2000, 2002). At about the same time people started to focus more on smaller animals, due to the changing climatic conditions during the Holocene (Mitchell 2002).

Several sites in the Eastern and Western Cape provinces, as well as KwaZulu-Natal and Lesotho, show a replacement of large gregarious grazers with small non-gregarious species from the Robberg to the Wilton, and especially after 4000 years ago (H. Deacon 1976; J. Deacon 1978; Mazel 1989; Mitchell 2000, 2002; Plug & Mitchell 2008). At about the same time, much of the sub-continent was changing from open grassland habitats to more mesic or bushy environs (Deacon 1978). This shift was paralleled by a concomitant focus on more predictable resources, such as geophytes, shellfish and tortoises, as well as a decrease in backed microliths and an increase in stone scraper frequency (Deacon 1976; Mazel 1989; Mitchell 2002). Whether for taphonomic or subsistence reasons, this period is also marked by the increased visibility of bone points in the archaeological record (Mitchell 2000, 2002). As far afield as North America, a similar pattern emerges where the shift to predominately smaller ungulates is accompanied by increased reliance on osseous technology (Guthrie 1983). The decrease in microliths associated with increased frequencies of bone points hints at a reliance on simple bone point technology, without the addition of stone inserts.

Table 7 presents a list of sites showing faunal samples dominated by large and small animals respectively. I include all wild mammal species, not just bovids. The data used for this table are derived from the MNI counts provided in the original site reports. The three exceptions are Olieboomspoort and Likoaeng, where only NISP counts are provided, and Kruger Cave, where no species counts are given. In the latter case I have extrapolated from the text of the faunal report. It should be noted that while

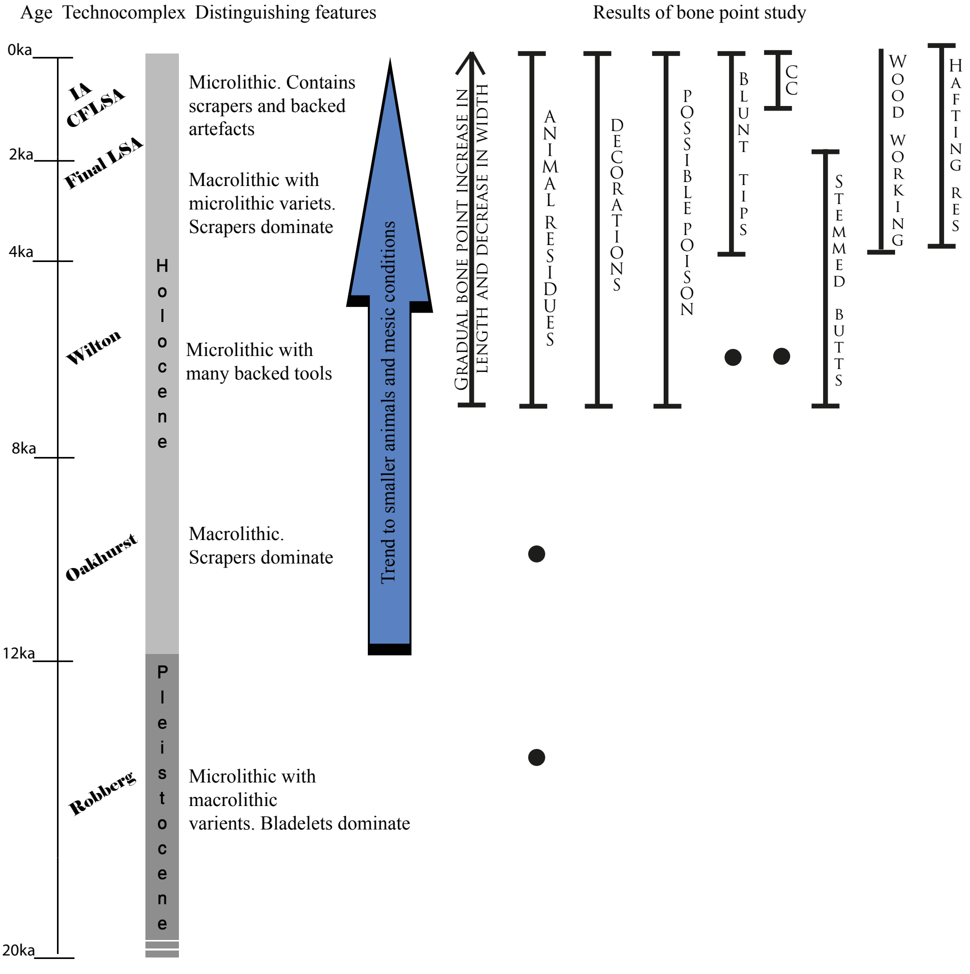

Fig. 7. Technocomplexes and chronology in relation to main findings of Bradfield 2014. CC stands for circumferential chipping. Single dots represent isolated, possibly anomalous occurrences.

large animals contain more meat per animal, it has been estimated that the bulk of the dietary meat component at most hunter-gather dispersal sites came from small animals (see Vinnicombe 1976; Wadley 1987). I have limited my study to the wild animal component. As can be seen from the table, small animals (< 20 kg) dominate at most sites, and are also the dominant size class at other early to mid-Holocene sites such as Melkhoutboom (Deacon 1976). While raptors and other carnivores cannot be ruled out as possible accumulators of small animal remains (*sensu* Plug & Mitchell 2008), there is sufficient evidence that Bushmen preyed on hares and rodents too (e.g. Livingstone 1857). With the exception of Uniondale, the sites that had a predominance of large-animal remains dated to within the last 2000 years.

As is evident from Figure 7, bone points only start displaying variability during the last 6000 years. While manufacturing techniques remain fairly constant for the 20 000

TABLE 7

Comparative list of sites showing large- and small-animal dominance in the faunal record.

Large animals (>20 kg)	**Small animals (<20 kg)**
Driel	Nkupe
Mapungubwe	Ha Makotoko
Kruger	Olieboomspoort
Uniondale	Sehonghong
Moritsane	Dikbosch
	KwaGandaganda
	Likoaeng

years represented in the figure, a gradual thickening and shortening is only noticeable from the mid-Wilton onwards. The bone points from the Wilton are significantly different from other periods (Bradfield 2014). While this may be due to the presence of the peculiar stemmed bone points from Uniondale in the Wilton, it is perhaps not coincidental that this period also marks the appearance of a variety of ancient residues and decorations (Fig. 7; also see Bradfield in press). Animal residues, such as blood, bone and fat cells, are rare in the Robberg and Oakhurst, and are only prevalent on bone tools during the last 6000 years. Possible poison residues were present on tools from the mid- to late-Wilton (ca 6500–4000 years ago) onwards. It is still uncertain to what extent this pattern is a reflection of taphonomic conditions. The concomitant increase in tool width, however, unaffected by taphonomy, would seem to argue in favour of their integrity.

Possible hafting residues, on the other hand, in the form of gum, resin and woody parenchyma cells, were only found on bone tools younger than 4000 years. Use-wear evidence suggestive of wood working is present during the same period, as are deliberately blunted tips. Circumferential chipping along the distal breaks occurs during the last thousand years, supporting my interpretation that a metal component was responsible. Figure 7 shows a concomitant increase in functional variability between ca 6000–4000 years ago. While changes in bone point form and function do not correlate neatly with lithic changes associated with technocomplexes, and do not show the same fluctuations, it is possible they reflect larger-scale changes, related perhaps to the Holocene Climatic Optimum (ca 9000–5000 years ago), during which time average temperatures and precipitation experienced a marginal increase (see Deacon & Lancaster 1988; Deacon 1995; Deacon & Deacon 1999).

According to Bousman's (2005) risk management model, wetter conditions in the interior of South Africa produced lower risk conditions and elicited a shift towards more reliable technologies, among which bone points rank. Granted that I have considered only a small sample of bone points, there does not appear to be a marked 'innovative technological production' or clear linear evolution in bone point design and manufacture in response to apparent environmental or demographic fluctuations or concomitant with changing lithic technocomplexes (*sensu* Bousman 2005). The most noticeable changes occur during the Wilton and after the widespread adoption of metal as a component of the arrows during the ceramic final Later Stone Age (also see Deacon 1992). In other words, changes in bone points seem to occur during rather than at the boundaries of lithic technocomplexes. Based on the sites considered here, the increase in length and decrease in width of bone points seems to parallel a shift to exploiting comparatively larger game in the last 2000 years (cf. Table 7). Longer, thinner points have a greater chance of penetrating vital organs and injecting poison into the bloodstream of large animals with thick hides. Our current understanding of Later Stone Age exploitation strategies, based on faunal evidence, shows a more focused exploitation of smaller game from the mid-Holocene until about 2000 years ago (see Deacon 1976; Mazel 1989; Mitchell 2002). It seems that this focus reversed after the introduction of herders and farmers onto the landscape, and that this is reflected in the size of the bone points. Seasonality and mobility strategies may also play a role in whether people exploit predominantly large or small animals, with larger game being more abundant in winter, during which time groups may have come together to participate in communal hunting activities (*sensu* Wadley 1987; also see Mackay et al. 2014). Of the sites considered here, where seasonality has been established, all support Wadley's observation.

It has been said with reference to bone technology in southern Africa that the similarity of bone points through time could signal the antiquity of certain behaviours or practices (Plug 2012). Indeed, bone technology present at Border Cave at roughly 40 000 years ago has been taken as signalling the early emergence of quintessential Bushman culture (d'Errico, Backwell, Villa et al. 2012). In fact, the uniformity of bone tools, both in finished form and manufacturing technique, is not unique to southern Africa. Bone is optimally shaped using the groove-and-splinter technique, followed by grinding against an abrasive surface—and the same technique is used almost universally (e.g. Clark & Thompson 1953; Semenov 1964; Newcomer 1974; Morrison 1986; Smith & Pogenpoel 1988; Knecht 1997; Choyke & Bartosiewicz 2001; St-Pierre 2007; Legrand-Pineau et al. 2010; Rabett & Piper 2012a, b). While cortical bone can be flaked similarly to stone, it is ill-suited to produce a sharp edge (Johnson 1985; Fisher 1995), and so a pointed shape is the most logical outcome for a bone-tipped hunting weapon. In other words, there is a limited amount of variability in bone tool shape if function is to be maintained (Knecht 1997).

Archaeologists too often assume that people will always act in a way that maximises fitness. Changing tool design or persistence of a design is seen as an adaptive response to varying environmental or demographic stress factors (e.g. Fitzhugh 2001; Bousman 2005). While shifting cultural fitness trajectories (*sensu* Lombard 2012, in press; also see d'Errico & Banks 2013) might in some ways explain the differential preservation of bone points through time, it does not explain why bone continued to be used in arrows long after the introduction of metal. In this respect the beliefs and rituals held by most human societies should also be taken into account (Lewis-Williams & Pearce 2006). Such beliefs may manifest in stylistic detail.

CONCLUSION

The results of use-wear and residue analyses presented here reveal a wider range of functions for pointed bone artefacts morphologically akin to arrow points. Evidence of wood or plant working is evident on some specimens, albeit the vast minority, that would otherwise have been interpreted as hunting weapons if only morphology had been considered. Unsurprisingly, the majority of specimens conform with hunting-related use-wear/residues, although most of the use-wear features are from manufacture. No use-trace features contra-indicating hunting were found on the Oakhurst and Robberg samples, whereas several specimens from the later time periods showed demonstrable evidence of wood working. Thus it appears that bone points were more versatile during the last 2000 years than previously thought. Evidence that small animals were hunted using bone points (probably with bow-and-arrow technology) during the last 4000 years, comes from hair strands left on two specimens from Likoaeng and the Jameson collection. It is worth noting that Oosthuizen (1977) reported seeing short hairs embedded in the poison on the arrows from a KwaZulu-Natal hunting kit. The increased length and narrowing width of bone points during the last 2000 years suggest a focus on larger animals, concomitant with the introduction into South Africa of herders and farmers, although the hair-strand evidence from the Jameson collection indicates that bone-tipped arrows were still used to hunt small game until very recently.

It is generally recognised that organic technology played a major role in most hunter-gatherer societies from early on (see Hayden 1979; Binford 1981; St-Pierre & Walker 2007; d'Errico, Backwell & Wadley 2012). Bone and other organic artefacts, however, will always remain under-represented in the archaeological record and our understanding of the diversity of bone tools will remain meagre until such time as they receive the same attention as stone tools. This will require the concerted effort of more than just a handful of researchers. Use-wear and residue studies have enormous potential for understanding the diversity of past functions of bone artefacts, but are seldom included in analyses. Similar to the lithic component of archaeological sites, bone tools deserve closer scrutiny.

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