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Middle Stone Age bone tools from the Howiesons Poort layers, Sibudu Cave, South Africa

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Abstract

Recently discovered bone implements from Middle Stone Age (MSA) deposits at Sibudu Cave, South Africa, confirm the existence of a bone tool industry for the Howiesons Poort (HP) technocomplex. Previously, an isolated bone point from Klasies River provided inconclusive evidence. This paper describes three bone tools: two points and the end of a polished spatula-shaped piece, from unequivocal HP layers at Sibudu Cave (with ages greater than ~61 ka). Comparative microscopic and morphometric analysis of the Sibudu specimens together with bone tools from southern African Middle and Later Stone Age (LSA) deposits, an Iron Age occupation, nineteenth century Bushman hunter-gatherer toolkits, and bone tools used experimentally in a variety of tasks, reveals that the Sibudu polished piece has use-wear reminiscent of that on bones experimentally used to work animal hides. A slender point is consistent with a pin or needle-like implement, while a larger point, reminiscent of the single specimen from Peers Cave, parallels large un-poisoned bone arrow points from LSA, Iron Age and historical Bushman sites. Additional support for the Sibudu point having served as an arrow tip comes from backed lithics in the HP compatible with this use, and the recovery of older, larger bone and lithic points from Blombos Cave, interpreted as spear heads. If the bone point from the HP layers at Sibudu Cave is substantiated by future discoveries, this will push back the origin of bow and bone arrow technology by at least 20,000 years, and corroborate arguments in favour of the hypothesis that crucial technological innovations took place during the MSA in Africa.

Keywords: Howiesons Poort; Hunting technology; Bone tools; Behavioural modernity

1. Introduction

The early appearance in the African Middle Stone Age (MSA) of innovations such as the systematic use of pigments, personal ornaments and complex bone and lithic technologies, has been used to support a scenario (McBrearty and Brooks, 2000) in which these innovations are interpreted as the behavioural corollary of the emergence of anatomically modern humans on the continent. After a long-term process of continuous accretion and increasing complexity, the key advances favoured the expansion of modern humans out of Africa, and the replacement of biologically and behaviourally archaic human populations in Eurasia. Evidence for complex bone tool manufacture in the African MSA has not, however, been conclusively supportive of this model. The bone tools from the M2 phase of Blombos Cave (Henshilwood et al., 2001), with an age of ~78 ka (Jacobs et al., 2006a), have until recently represented the only well-dated early instance of the systematic production of bone tools comparable to those found at Upper Palaeolithic sites in Europe after 40 ka. A recent analysis of worked bone pieces from southern African MSA sites was able to refute the uniqueness of the Blombos bone industry (d'Errico and Henshilwood, 2007) but even so, the sample of MSA sites yielding convincing evidence of

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deliberately shaped bone remains small. These authors pointed out that the HP, which follows the Still Bay, contains no conclusive evidence for bone tool manufacture. Such an absence may be perceived as contradicting the out of Africa scenario for the origin of modernity. The view underlying this model is that the emergence of each innovation marked a threshold in the history of humankind; thus, the accumulation of innovations contributed, like genetic mutations, to the creation of human societies increasingly different from those of their non-modern counterparts. The identification of a discontinuous pattern, with innovations appearing and disappearing, or being associated in a way that does not match the expected trend, supports the view that some of these innovations, such as complex lithic and bone technology, do not necessarily represent reliable hallmarks of modernity, and cannot be attributed an unequivocal evolutionary significance (Wadley, 2001; Backwell and d'Errico, 2005; Villa et al., 2005a). Alternatively, it may suggest that the observed pattern is not determined, or not determined only by the alleged emergence of our biological species in Africa, and that we have to evoke social, demographic and climatic factors to explain the emergence, disappearance, and re-emergence of such innovations among both African and Eurasian early Upper Pleistocene populations (d'Errico, 2003; d'Errico et al., 2003; Hovers and Belfer-Cohen, 2006). In order to test these hypotheses it is crucial to document and date occurrences of such innovations in and outside of Africa, and to use the resulting chronicle to identify trends that can be compared and possibly contrasted with those offered by other disciplines. There is a cogent need for this in southern Africa, given that a relatively small number of post-100 ka sites have been excavated or dated using modern standards. This deficiency makes it difficult to establish whether the apparent disappearance of cultural innovations, particularly when these are embodied in small, fragile items, is due to sampling, excavation methods, taphonomic processes, variability in subsistence strategies, or a loss of previously acquired cultural traits.

In this paper, we present our analysis of two bone points and a polished spatula-shaped piece recently found in the HP layers of Sibudu Cave, South Africa, dated by Optically Stimulated Luminescence (OSL) to >61 ka (Wadley and Jacobs, 2006). Microscopic and morphometric analysis of one of these pieces, a well-preserved bone point, interpreted as a projectile point, reveals technological continuity with bone spear points from Blombos Cave, and morphological affinities with the bone point from Peers Cave, and to a lesser extent the Klasies River specimen, as well as bone points from Later Stone Age (LSA) and historical Bushman sites. The Sibudu evidence is consistent with a process of reduction in size of bone projectile points that may suggest the use of a bow and arrow hunting technology by HP communities. Importantly, Sibudu has no LSA deposits so the bone tools belong unequivocally to the MSA.

1.1. Research background

Recent research has shown that the use and manufacture of pointed bone tools is not the preserve of MSA or Upper Palaeolithic cultures. The earliest use of pointed bone tools comes from the Plio cave deposits at Sterkfontein, Swartkrans and Drimolen in South Africa (Robinson, 1959; Brain and Shipman, 1993, 2004; Keyser et al., 2000; Backwell and d'Errico, 2001, 2004a, 2005; d'Errico et al., 2001, 2003; d'Errico and Backwell, 2003). The wear pattern on the tips of these implements has been interpreted as the result of digging, either for extracting tubers from the ground (Brain and Shipman, 1993, 2004) or termites from their nests (Backwell and d'Errico, 2001, 2004a, 2005; d'Errico et al., 2001, 2003 d'Errico and Backwell, 2003). Evidence of shaping by means of grinding on some of the more robust horncores suggests that early hominins had the cognitive ability to modify bone intentionally for optimal efficiency as part of a non-modern behavioural repertoire, albeit for expedient use (d'Errico and Backwell, 2003; Backwell and d'Errico, 2004b, 2005). Bone objects from Broken Hill (Kabwe), Zambia, attributed to the early MSA and thought to be associated with *Homo heidelbergensis* (elsewhere named *Homo rhodesiensis*), are interpreted by Barham et al. (2002) as two gouges and a point. A point from Mumbwa Cave (Pinto Llona et al., 2000) is considered doubtful (d'Errico, 2003). Other evidence for bone working in the MSA is provided by barbed and unbarbed bone points from the Katanda sites in the Semliki Valley, Democratic Republic of the Congo (formerly Zaire), dated ~90 ka (Yellen et al., 1995; Brooks et al., 1995; McBrearty and Brooks, 2000; Feathers and Migliorini, 2001). A point tip, a mesial fragment, an almost complete spear point, a tanged bone point and twenty-six awls are reported from M1 and M2 MSA layers at Blombos Cave, with ages ~84–72 ka (Henshilwood and Sealy, 1997; Henshilwood et al., 2001; d'Errico and Henshilwood, 2007; Jacobs et al., 2006a,b). A single massive point, different from those found in the MSA and LSA layers at Blombos Cave, was recovered in the dune sand layer, with an age of ~70 ka (Jacobs et al., 2003, 2006a) sealing the MSA sequence. An awl and a possible flaked shaft fragment come from the Blombos M3 phase, with an age of 98.9 ± 4.5 ka (Jacobs et al., 2006a). A bone point from Peers (Skildergatkop) Cave was retrieved from either the HP or Still Bay layers at the site (Peers, 1929). A recent study of carbon-nitrogen ratios in the Peers point, and a sample of LSA and MSA faunal remains from this site, demonstrates that the point originates from MSA layers (d'Errico and Henshilwood, 2007). A single bone point (SAM-42160) was discovered at Klasies River in layer 19 of Shelter 1a at the base of the HP (Singer and Wymer, 1982). A date of approximately 80–60 ka, centred on 70 ka, was suggested for the HP at Klasies River (Deacon, 1989; Thackeray, 1989; Wurz, 2002; Deacon and Wurz, 2005). Uranium–Thorium (U-Th) analysis of limestone at the site produced an age range of 70–60 ka (Vogel, 2001), while Thermoluminescence (TL) and OSL ages of sediments suggest an age of 60–55 ka (Feathers, 2002). Thermoluminescence dating of burnt lithics provided a weighted mean age of 56 ± 3 ka for the HP at the site (Tribolo et al., 2005). The only other pointed bone implement known from the MSA is a polished bone pin (Cain, 2004) from layer Co, with an age of ~35 ka attributed to the late MSA at Sibudu

Cave (Wadley and Jacobs, 2006). Bone points similar to those known ethnographically occur at many LSA sites, including Oakhurst (Sampson, 1974; Deacon and Deacon, 1999), Rose Cottage (Sampson, 1974; Wadley, 1993, 2000) and Nelson Bay Cave (Inskeep, 1987; Deacon, 1982, 1984), and Jubilee (Wadley, 1989, 1993), Bushman Rock (Plug, 1982) and Giant's Castle Rock Shelters (Sampson, 1974). Bone points are associated with the Border Cave Early LSA assemblage, with an age of ~36 ka (Beaumont et al., 1978; Grün and Beaumont, 2001). Bone points used as awls, arrow points and linkshafts occur with regularity in Iron Age occupations, for example at Mapungubwe, Robberg Cave and the Vredefort Dome site. Bone points serving as arrow heads, linkshafts, barbs and hooks were in common use among Bushman hunter-gatherers in the nineteenth century, and even though metal is used nowadays for most armatures, the properties of bone for arrow point production are still favoured by some hunter-gatherers in southern Africa.

1.2. Background to Sibudu Cave

The bone implements described here come from the HP layers at Sibudu Cave, situated on the KwaZulu-Natal north coast of South Africa (Fig. 1). The site has revealed a long sequence of MSA occupations, with stone tool assemblages attributed, from the bottom to the top, to a pre-Still Bay phase, the Still Bay technocomplex, the Howiesons Poort technocomplex, a post-Howiesons Poort phase, and late and final MSA phases directly overlain by Iron Age occupation (Wadley and Jacobs, 2004, 2006; Villa et al., 2005a; Wadley, 2005a, 2007; Lombard, 2008). A combination of single aliquot and single grain Optically Stimulated Luminescence (OSL) ages for post-Howiesons Poort assemblages at Sibudu Cave provide a weighted mean age of 57.5 ± 1.4 ka (Jacobs et al., in press). Ages for the older HP industries fit within Oxygen Isotope Stage (OIS) 4, i.e. earlier than ~61 ka (Wadley and Jacobs, 2006). The HP has been excavated from a 2 m^2 trial trench, and is found in layers PGS, GS2, GS, DRG2, DRG, WA, GR2 and GR (Table 1, Fig. 2). The polished spatula-shaped bone implement derives from near the top of the HP sequence in layer GR2. The refitted bone point comes from the underlying layer GS, and the slender incomplete point from layer PGS at the bottom of the sequence (Table 1).

The lithic assemblage in these HP layers is dominated by segments and other backed tools manufactured mostly from dolerite and hornfels (Delagnes et al., 2006). There is a relatively high proportion of blades and large sandstone flakes (Wadley, 2006). The extensive use of ochre at the site is evident in the high number of modified ochre nodules recovered (Wadley, 2005a) and lithics that have deeply ingrained ochre on their backed edges or bases. The evidence suggests that in addition to serving a potentially symbolic role, ochre was used as a loading agent in mastic recipes (Lombard, 2005a, 2006, 2008; Wadley, 2005b,c). Environmental data indicate a humid climate for the area during the HP, with surrounding evergreen forests (Allott, 2006; Glenny, 2006; Schiegl and

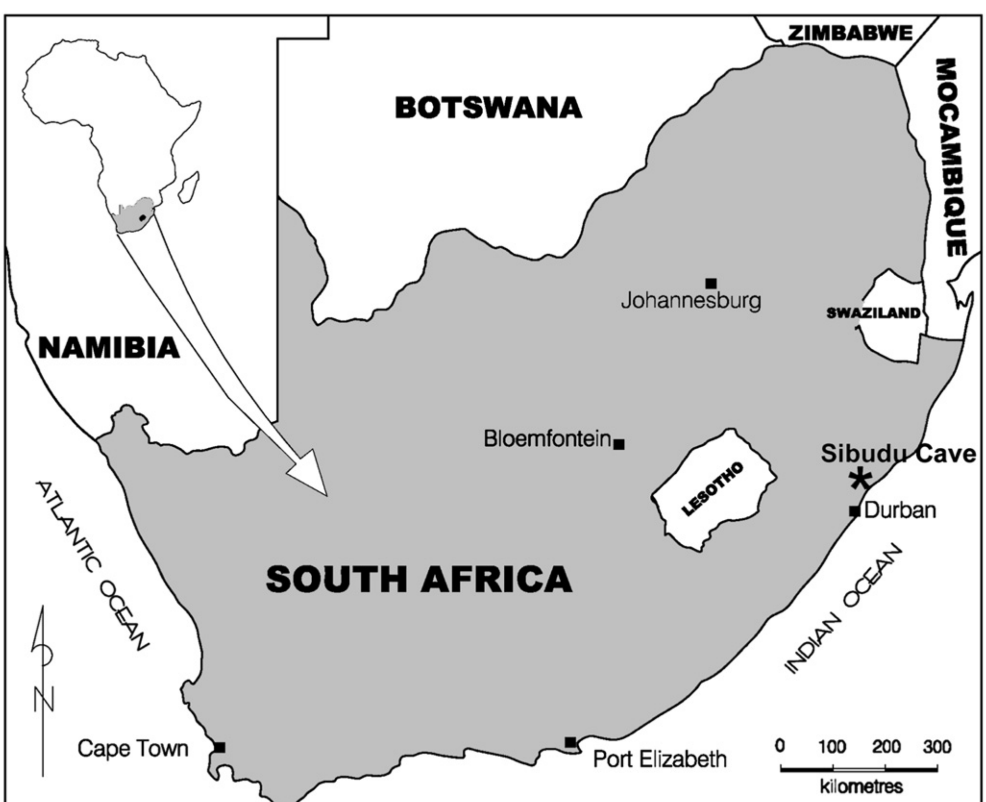

Fig. 1. Map of South Africa showing location of Sibudu Cave.

Table 1
Sibudu MSA stratigraphy, OSL ages, lithic designation and location of worked bone (Cain, 2004; Wadley and Jacobs, 2006; Wadley, 2007; Jacobs et al., in press)

Layer	OSL age in ka	Lithic designation	Worked bone
Co	34.7 ± 1.7	Final MSA (informal)	Bone pin
Bu	35.6 ± 2.0		
LBMOD	48.9 ± 2.8		
MC (hearth)			
Es			
Mou, DMou			
PB		Late MSA (informal)	
Ore, Ore2			
RD	49.0 ± 2.0		
Cad, Pu			
MOD	48.3 ± 2.0		
OMOD	48.3 ± 1.8		
OMODBL	47.0 ± 1.8		
OMOD2			
OMOD2BL			
GMOD, BMOD			
RSp	46.6 ± 1.9		
YSp			
BSp	58.0 ± 2.1	Post-Howiesons Poort (informal)	
BSp2			
SPCA			
BL, Or			
Mi			
SS	53.6 ± 2.0		
Che, Eb			
Ma, MY			
BO			
P	59.1 ± 2.2		
OP			
BP			
Iv			
BM			
Ch			
Su, Su2			
P1			
G1			
Ch2	58.6 ± 1.9		
Y1	58.2 ± 2.5		
B/Gmix, B/Gmix2	57.8 ± 2.3		
BL2, BL3			
BOr, Ymix			
YA1			
YA2			
Br under YA2			
DRG		Howiesons Poort (formal)	
GR			
GR2			Spatula-shaped bone tool
GS			Bone point
GS2			
PGS			Slender bone point
RGS	>70 ka	Still Bay (formal)	
RGS2			
LBG			
LBG2, LGB3			
LGB4		Pre-Still Bay (informal)	
BS			
BEDROCK?			

Conard, 2006; Sievers, 2006; Renaut and Bamford, 2006; Wadley, 2006). Preliminary faunal analysis shows a wide range of mammal species represented, with blue duiker (*Philantomba monticola*) predominating (Wadley, 2006; Clark and Plug, in press; Lombard, 2008).

1.3. Howiesons Poort technocomplex and its makers

The Howiesons Poort is a MSA technocomplex characterised by the production of backed tools. Blades, backed segments and trapeze-shaped tools, of varying lengths, predominate. This archaeological entity is recorded at a number of well-dated sites in southern Africa, with long stratigraphic sequences that pre- and post-date the HP industry, including Klasies River, Border Cave, Rose Cottage, Peers Cave, Apollo 11, Diepkloof and Sibudu Cave. The recent discovery at the last two sites of Still Bay assemblages below the HP layers (Rigaud et al., 2006; Wadley, 2007) has finally settled the debate over the stratigraphic succession of these two MSA facies. Based on OSL ages of overlying layers, the HP at Sibudu Cave predates ~61 ka and falls within the estimated age range for the HP, radiometrically dated at six sites to between ~76 and 45 ka. Klasies River spans ~66–45 ka (Vogel, 2001; Feathers, 2002; Tribolo et al., 2005). Rose Cottage Cave has single aliquot OSL ages of between 67.7 and 54.4 ka (Pienaar, 2006). An age of 62.4 ± 2.0 ka was obtained for Boomplaas based on the Uranium–Thorium method (Vogel, 2001). Electron Spin Resonance (ESR) ages of 76 ± 4 and 58 ± 2 ka (Grün and Beaumont, 2001; Grün et al., 2003) are reported for the HP at Border Cave, and Diepkloof has TL ages of between 65 and 55 ka (Rigaud et al., 2006). At Sibudu Cave, as at many other South African sites, the HP is replaced by about 60 ka (Villa et al., 2005b; Cochrane, 2006; Wadley and Jacobs, 2006; Jacobs et al., in press) with a flake technology characterised by a low standardisation of the end-products, many of which are retouched to obtain regular edges.

It is generally accepted that, by the time of the HP, and probably well before, people in southern Africa were anatomically modern (McBrearty and Brooks, 2000; Grün and Beaumont, 2001; Deacon and Wurz, 2005; Marean and Assefa, 2005; Brooks et al., 2006; Wadley, 2006; Lombard, 2008). This idea is based mostly on human remains from Klasies River (Rightmire, 1984; Rightmire and Deacon, 1991; Bräuer et al., 1992) and Border Cave (Beaumont et al., 1978; Rightmire, 1979, 1984; Beaumont, 1980) and to a lesser

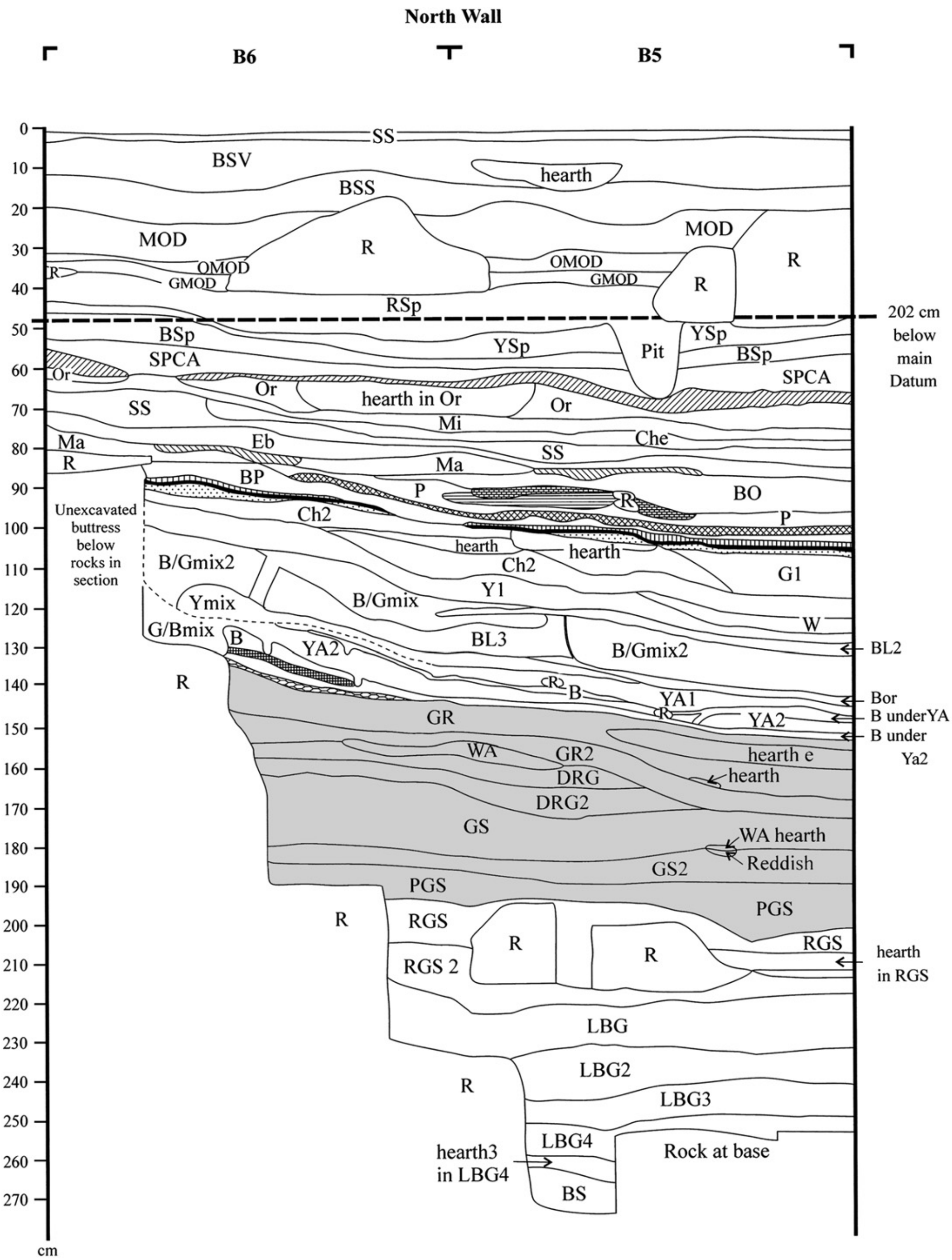

Fig. 2. Stratigraphic section of Sibudu Cave North wall (modified after Wadley and Jacobs, 2006) showing HP layers in grey (PGS, GS2, GS, DRG2, DRG, WA, GR2 and GR) buttressed by rock on the left (R).

extent on the identification of modern features in human remains from Ethiopia, such as Herto (White et al., 2003) and Omo Kibish I (McDougall et al., 2005).

2. Materials and method

2.1. Archaeological material

Apart from the newly discovered bone points from Sibudu Cave, our MSA sample (Table 2) is restricted to three pieces from Blombos Cave interpreted as spear points, and one specimen each from Peers Cave and Klasies River (according to Singer and Wymer (1982), but d'Errico and Henshilwood (2007) question an MSA attribution for the Klasies piece). The LSA material selected for comparison includes 13 points from three sites, and the Iron Age sample comprises 25 points from one site. Bone arrow points studied here were distinguished from link-shafts and other pointed bone tools (awls, fish-hooks, punches, needles, pegs) by their distinct similarity to Bushman arrow points of slender cone shape, following the

Table 2
Contextual information on the bone points analysed in this study

Site	Cultural attribution	Age	*n*	Museum/Institution	Reference
Blombos Cave	MSA (SB)	~84–72 ka	3	Iziko	Henshilwood et al., 2001; Jacobs et al., 2006a; d'Errico and Henshilwood, 2007
Klasies River Mouth	MSA (HP)	66–45 ka	1	Iziko	Singer and Wymer, 1982; Deacon and Wurz, 1996; Wurz, 1999; Villa and d'Errico, 2001; d'Errico and Henshilwood, 2007
Sibudu Cave	MSA (HP)	>61 ka	1	Witwatersrand University	Wadley, 1987, 2006; Wadley and Jacobs, 2004, 2006
Peers Cave	MSA (SB/HP)	75–50 ka	1	Iziko	d'Errico and Henshilwood, 2007
Nelson Bay Cave	Later Stone Age	9000–5300 BP	5	Iziko	Inskeep, 1987; Deacon, 1982,1984
Jubilee Shelter	Later Stone Age	8500–5200 BP	7	Witwatersrand University	Wadley, 1989, 1993
Rose Cottage Cave	Later Stone Age (IW)	4000–2000 BP	1	Witwatersrand University	Sampson, 1974; Wadley, 1993, 2000
Mapungubwe	Iron Age	AD 200–present	25	Witwatersrand University	Voigt, 1983
Namibia (Kalahari)	Modern San hunter-gatherers	Historical times	117	Museum Africa	Wanless, 2007

SB, Still Bay; HP, Howiesons Poort; CW, Coastal Wilton; IW, Interior Wilton.

definition of Goodwin (1945) and Cooke and Robinson (1954).

2.2. Ethnographic material

The Bushman bone arrow points and fore-shafts that we have analysed (Table 2) are part of the Fourie collection, accumulated between 1916 and 1928 by Dr Louis Fourie, a Medical Officer for the former Protectorate of South West Africa (Namibia). The collection includes three-and-a-half thousand artefacts, three hundred photographs, and documents from numerous Khoisan groups living in the region (Wanless, 2007). Most of these are housed in the ethnology stores at Museum Africa, while some are in the Art Galleries at the University of the Witwatersrand. The collection includes hundreds of bone artefacts in an excellent state of preservation. Notes by Fourie and numerous benchmark features identify the functions of the tools. Most composite tools are complete, enabling ready distinction between arrow heads, linkshafts, needles and awls. The bone arrow heads studied here were collected from thirteen different Bushman groups from twenty-seven localities in the eastern part of the country. Bone arrow heads are standardised between groups and are of Kalahari variety (Wanless, 2007).

Clark (1977) identified four traditional Bushman arrow types used in southern Africa during the late eighteenth and early nineteenth centuries. Type 1 arrows are those with stone segments or microliths mounted with mastic on a fore-shaft of bone or wood. Type 2 arrows are wooden-tipped with thick cylindrical heads (with or without a triangular tip), and were used to hunt birds. Type 3 and 4 arrows are bone-tipped, and both are represented in the Fourie collection. Type 3 is described by Goodwin (1945) as the better-known bone-tipped arrow with reversible fore-shaft (Fig. 3a,b), and it appears to have been the arrow universally used in southern Africa by Bushmen (see Schapera, 1927, 1963; Rudner and Rudner, 1957; Deacon, 1992). Type 3 fore-shafts comprise long and slender arrow points with cone-shaped tips that are always bound to link-shafts (Fig. 3a, i–iii). The slender bone arrow head is completely encrusted with poison, so when not in use, it is reversed in the reed (Fig. 3b). In this position, the torpedo- or lens-shaped link-shaft takes on the appearance of a robust Type 4 bone arrow point (Fig. 3c). Goodwin describes these as poisoned bodkin-type points that are bound directly to reed shafts, and have short feather quill barbs. This description is consistent with the type reported by Schapera (1927) from the Kalahari. Type 4 arrow heads studied in the Fourie collection are only marginally larger than Type 3 link-shafts, and in complete tools, are distinguished from link-shafts by having a more straight-sided appearance. This is because fixed bone arrow heads are inserted deeper in the reed at the broadest part of the piece, where they are tightly secured by a single sinew collar. Another feature distinguishing an inverted link-shaft from a fixed arrow head is the presence of two adjacent sinew collars where the link-shaft enters the reed, showing that they are not bound together. This is, however, not always the case, because some slender link-shafts insert deep into the reed, thereby hiding one of the sinew collars. Some fixed arrow heads are not particularly symmetrical, and may be quite oval in section. In addition, while clearly pointed, they are not always very sharp. Contrary to Clark's description, Type 4 arrow heads studied in the Fourie collection did not have barbs or poison, elements that were apparently confined to Cape Bushmen, considering that Goodwin (1945) regards unfeathered shafts as typical of Kalahari Bushman arrows.

The two bone arrow types used by the Bushmen represent different hunting techniques: long slender points with associated link-shafts (Type 3) administer a poison injection before detaching from the reed. Detachment of the shaft is intended to prevent wounded animals from removing the arrow, thereby relying on the efficacy of poison in causing death (Clark, 1977). Type 4 arrow heads are robust and firmly bound to the shaft, so are not designed to detach upon impact. Dunn (1879-1880) reports that arrows used by Bushman for big game were poisoned, but that those used on small game were not.

Fig. 3. Ethnographic examples of Bushman Type 3 (a, b) and Type 4 (c) bone arrow heads. Type 3 fore-shafts comprise slender poison-encrusted bone points (i) bound with reed collars (ii) to torpedo- or lens-shaped bone link-shafts (iii) that insert into reed shafts. The sinew collar on the reed shaft is to prevent the reed fibres from splitting upon impact. Component parts of a Type 3 fore-shaft are shown ready for use (a) and with bone points in the reversed position when not in use (b). Type 4 fixed bone arrow heads (c) comprise robust bone points that insert directly into reed shafts, and are secured with a single sinew collar. Note the similarity between Type 3 link-shafts (b) and robust Type 4 bone points (c). Scale bar = 10 mm.

2.3. Actualistic and experimental data

Identification of anthropogenic modification was based on comparison with a reference collection of bones modified by human and nonhuman agents, including hyena, dog, leopard, cheetah, porcupine, river gravel, spring water, flood plain, wind and trampling (Backwell and d'Errico, 2004b) and taphonomic literature (see for example Maguire et al., 1980; Brain, 1981; Shipman, 1981; Cook, 1986; Olsen and Shipman, 1988; White, 1992; Fisher, 1995). Identification of shaping techniques and use-wear was based on data from microscopic analysis of experimentally worked, used, manipulated and transported bone artefacts. These included bone tools that were used to treat skin and hide with or without the addition of sand, remove bark from trees, process fruit and dig in various sedimentary environments (Shipman et al., 1984; Shipman and Rose, 1988; Shipman, 1989; Backwell and d'Errico, 2004b). Other pieces were intentionally shaped using different techniques (LeMoine, 1997; d'Errico and Backwell, 2003) and submitted to treatments mimicking long-term transport in leather bags (d'Errico, 1993).

2.4. Analytical procedures

The Sibudu worked bones were examined with a Leica Z6APO stereomicroscope fitted with a Nikon Coolpix 990 digital camera. Resin replicas of the tips and modified areas were moulded using Coltène® President light body high resolution dental impression material, and cast in M resin (Plastomax, South Africa). The transparent replicas were analysed and photographed under transmitted light using the same microscope. Smoothing on the spatula-like piece was recorded using a Stil Micromeasure optical profilometer (Stil, France), and the resulting high resolution microtopography was analysed with Mountain Map software. Morphometric data were collected with digital callipers and these included, whenever possible, the maximum width and thickness as well as these same measurements at 5, 10 and 30 mm from the tips of all the specimens studied.

3. Results

3.1. Sibudu specimens

Specimen A (Fig. 4) is a refitted bone point from unit B5d, layer GS. The body of the piece was found in hearth C, in grey rocky sediments, while the tip came from a white ash layer below the hearth. The piece represents an indeterminate small mammal limb bone with an ancient break on the proximal end. It measures 49.34 mm in length, and has a maximum width and thickness of 5.51 mm and 5.61 mm, respectively. Manganese dioxide coats much of the piece, though exposed areas show ochre-brown discolouration of the type caused by heat. Traces of manufacture consist of clear longitudinal facets covered in places by thin, parallel striations. These facets were produced by the vigorous scraping of a burin edge or a robust unretouched flake edge.

Specimen B (Fig. 5) is an incomplete slender point from unit B5c, layer PGS, a pinkish-grey sand. The piece is a small mammal ulna fragment with ancient breaks on the proximal and distal ends. It measures 15.79 mm in length, with a maximum width and thickness of 2.91 and 3.20 mm respectively. Stone tool-generated marks in the form of longitudinal striations cover all aspects of the bone. Scraping was applied to produce four flat faces, resulting in a pin, rectangular in section. Scraping was more intensively applied on one of these faces where it removed the entire depth of the compact bone, thus opening a longitudinal fracture. The piece is blackened by heat, and charring of internal bone is noted on the distal broken end, and on damaged parts of the surface. Traces of

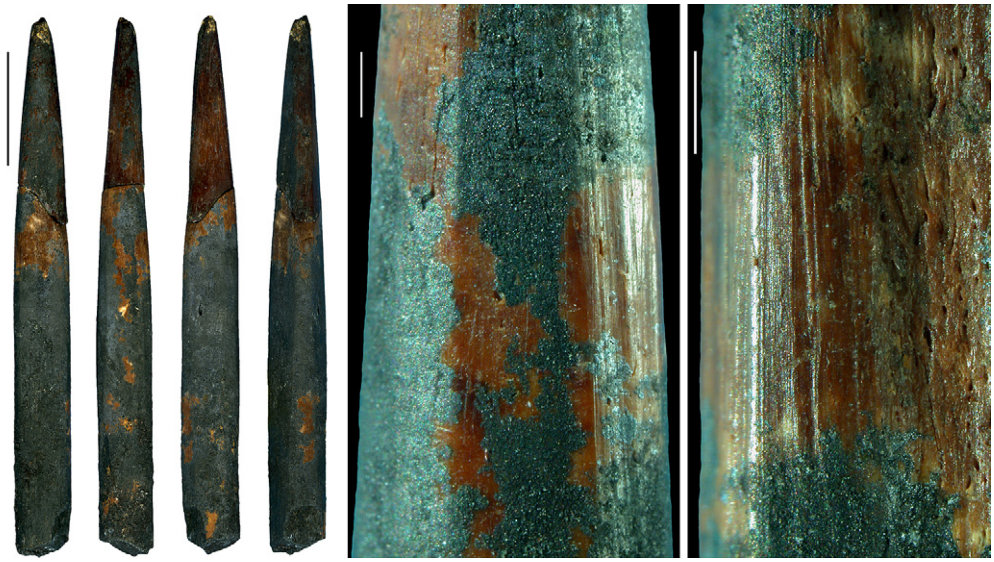

Fig. 4. Left: refitted bone point from the HP layers at Sibudu Cave. Right: close-up view of two aspects showing the facets covered by fine longitudinal striations produced by scraping with a burin or unretouched stone edge. Notice the dark appearance of the surface, most likely produced by heat, and black manganese dioxide coating much of the piece. Scale bars = 10 mm.

manufacture are overlain by ancient microscopic impacts and randomly oriented striations of various section and depth. Some individual striations, deep and perpendicular to the main axis, may be due to the use of the tool in a piercing motion, while others are syndepositional and were probably caused by trampling.

Specimen C (Fig. 6) was found in unit B5d, hearth B, in layer GR2 (grey rocky sediments) and is the distal end of a slender spatula-shaped tool. Visible structure of the Haversian canals indicates that the blank comes from a relatively robust shaft fragment. Ancient breaks are recorded on the sides and proximal end. The piece measures 18.58 mm in length, with a maximum width and thickness of 7.52 mm and 4.59 mm, respectively. Undamaged areas of the tip are highly polished and show at microscopic scale occasional pits and curved striations originating from the edge or sub-parallel to it. There is no evidence of intentional shaping, suggesting that the rounding and polishing resulted from use. A single elongated and flat-troughed striation evidences post-discard gnawing by a small rodent. The piece is brown in colour, and does not appear burnt.

3.2. Morphometric analysis

When compared with bone points from MSA, LSA, Iron Age and ethnographic contexts (Figs. 7 and 8), the Specimen A bone point from Sibudu appears significantly more robust than Type 3 reversible arrow heads made by the Bushmen and points found at LSA sites, as well as more fragile than Bushman Type 4 fixed arrow heads and link-shafts. The Sibudu specimen shares this feature with a single LSA point from Rose Cottage. As far as the MSA sites are concerned, the morphology of the Sibudu specimen falls very close to the Peers specimen and the thinnest of the Blombos Cave

Fig. 5. Top left: incomplete bone point from the HP layers at Sibudu Cave. Bottom left and right: Close-up views indicating multiple parallel striations, interpreted as stone tool-generated scrape marks, overlain in places by use-wear and trample marks. The piece is blackened by heat, and charring of internal bone is noted on the distal broken end, and on damaged parts of the surface. Scale bars = 10 mm.

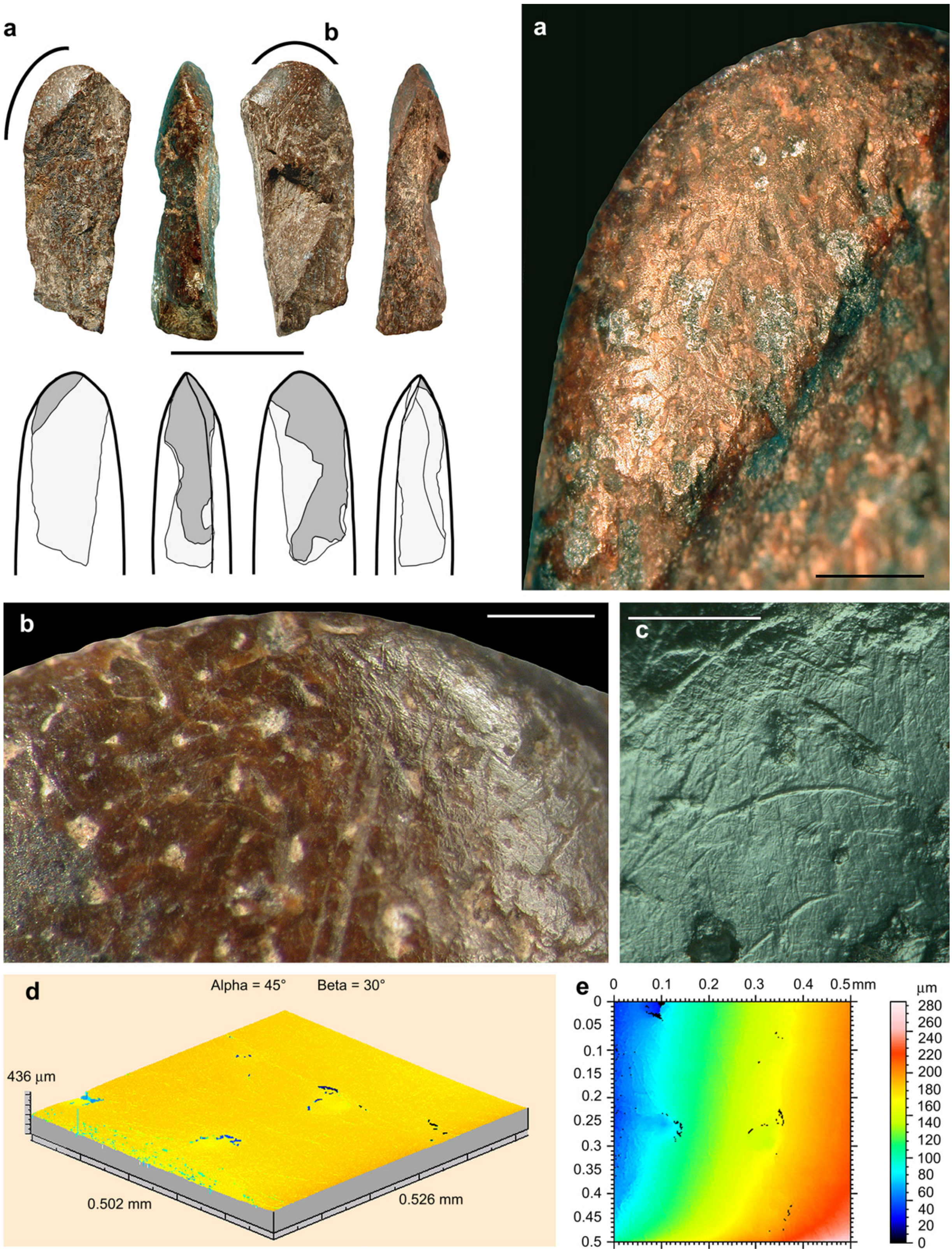

Fig. 6. Top left: distal fragment of a bone tool with a highly polished rounded tip from the HP layers at Sibudu Cave; a and b indicate areas enlarged on the right and below. Ancient breaks represented in pale grey in the sketch are recorded on the sides and proximal end. The original surface of the tool, shown in dark grey, extends over the anterior and posterior aspects of the tip. Fine curved striations perpendicular to the tool edge are observed on a resin replica under transmitted light (c). These are overlain by coarser striae and pits. A single flat-troughed striation (b) and curved v-shaped striae (c) evidence possible post-discard gnawing by a small rodent. Three-dimensional rendering of the tip with a profilometer shows in microns extreme smoothing and pitting (d) associated with fine multiple striations (e). Scale bars in a–c = 10 mm.

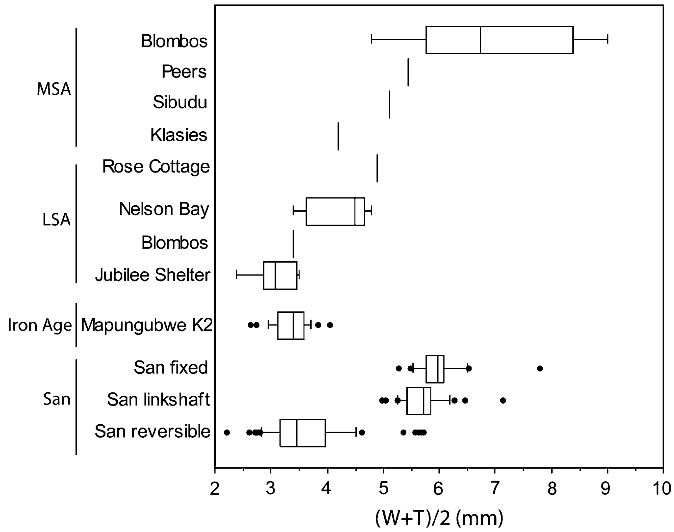

Fig. 7. Variation in size at 30 mm from the tips of bone points from MSA, LSA and Iron Age sites, and ethnographic San/Bushman hunting kits. Note the difference in standardisation between the specimens from Blombos Cave, interpreted as spear heads, and those from later contexts.

points, while it is stouter than the Klasies River specimen, which falls within the LSA variability. Two observations result from this comparison. First, there appears to be a difference in size between the Still Bay and the HP points and a further reduction between the HP and some LSA specimens. Secondly, there is a remarkable difference between the specimens from Blombos Cave and those from later contexts, including the Sibudu specimen.

4. Discussion

Three fragmentary formal bone tools have been recovered from the HP layers at Sibudu Cave: the end of a thin spatula-shaped piece with polish reminiscent of bones experimentally used to work animal hides, a shaped pin that may have been used in delicate piercing tasks, and the tip of what most certainly is the head of a deliberately worked projectile point. While confirming the existence of a bone tool technology in the HP, their identification also raises questions about the role that bone tools played in HP subsistence strategies,

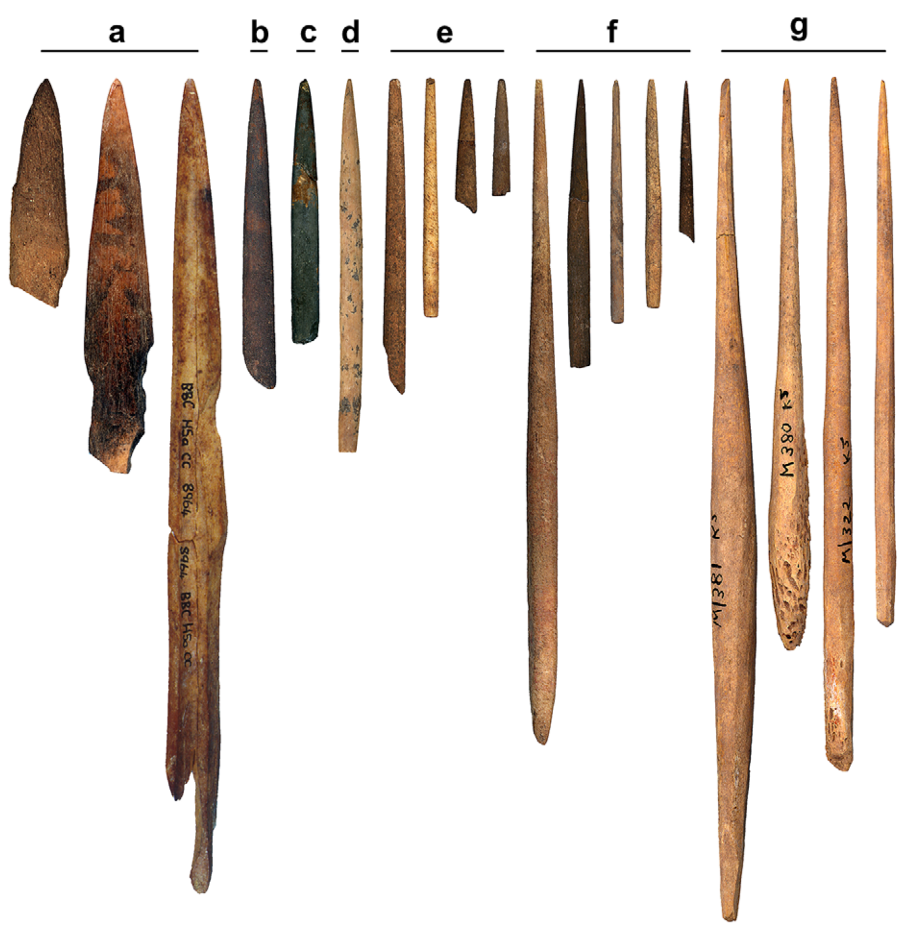

Fig. 8. Bone points from MSA deposits at Blombos Cave (a), Peers Cave (b), Sibudu Cave (c) and Klasies River (d); Later Stone Age layers at Rose Cottage Cave (e) and Jubilee Shelter (f), and an Iron Age occupation at Mapungubwe (g). Note the robustness of the Blombos points compared to those from later contexts, and reduction in size between the Still Bay and the HP, and between the HP and the LSA. Apart from a large flat point from Still Bay layers at Blombos Cave, burin-like scraping is typical on MSA points, while later points evidence shaping through scraping and grinding. Scale bar = 10 mm.

and their significance for the origin of modern behaviour debate. The discovery of a consistent bone tool collection at Blombos Cave indicates that MSA people had, from at least 75 ka and probably ~78 ka, the cognitive capacities to develop complex bone tool technologies, including the production of a variety of formal bone tools. There is no reason to believe that Sibudu HP inhabitants could not have produced more bone tools if they wanted to. Why then have so few bone tools been discovered at Sibudu and at other HP sites? At Sibudu the low frequency of these items may be attributed to the relatively small area of HP occupations excavated so far, some loss of bone through burning in hearths (Cain, 2005; Hanson and Cain, 2007) or the site function, which may not have required intensive use of bone tools or weapons. At other HP sites, excavated some time ago, the absence or rarity of bone tools in HP layers can be partially attributed to their fragility and small size, which may have prevented preservation, identification and recovery (particularly if a large mesh-size was used for screening excavated deposits). However, these explanations seem somewhat inadequate considering that at least twenty-four HP sites have been excavated to date (Lombard, 2005b), six of which (Klasies, Rose Cottage Cave, Boomplaas, Border Cave, Diepkloof, Sibudu Cave) by modern excavation standards, and with the exception of Rose Cottage Cave, all have good preservation of osseous material.

If the similarity in arrow breadth is taken as evidence for chronological proximity and common cultural affiliation, the point from Peers Cave would be attributed to the HP rather than the Still Bay. By the same token, the specimen from Klasies River should be attributed to the LSA rather than to the MSA (d'Errico and Henshilwood, 2007). Even if we accept Singer and Wymer's hypothesis that the specimen from Klasies River belongs to the HP and that it illustrates a large, as yet unknown, dimensional variability in HP points, a sample size of three sites remains very small and there is a considerable distance in kilometres between the two Cape sites and Sibudu in KwaZulu-Natal.

The second aspect that makes this evidence perplexing is the episodic appearance of worked bone technology in the archaeological record. Attested at a single Still Bay and possibly three HP sites, bone tools are absent at Sibudu in the Still Bay below the HP, and in the post-Howiesons Poort at ~58 ka and late and final MSA, ~48 and ~35 ka, save a notched rib at ~58 ka and a bone pin at ~35 ka (Table 1). This rarity of bone tools at Sibudu ~58–~35 ka is particularly striking because 21 m^2 of deposit have been excavated in these upper layers of the site (Wadley, 2006; Wadley and Jacobs, 2006). The period ~60–~40 ka is characterised at a number of other sites by a complete absence of bone tools. The next oldest examples of bone points that could be arrow heads are from transitional MSA/LSA layers at White Paintings Shelter, Botswana (Robbins et al., 1994) and the Early LSA layers at Border Cave (Beaumont et al., 1978), and both of these occurrences are at least 20 ka younger than the Sibudu HP bone point and the other two worked bone artefacts. Even if they may be seen, at first glance, as filling a gap between the Still Bay and the LSA, Sibudu bone tools represent another isolated occurrence that can hardly be used to support the "classic" out of Africa scenario for the emergence of these behaviours. The classic scenario predicts increasing complexity and an accretion of innovations during the MSA, determined by biological, including neurological, change.

If the discontinuity in bone-working is confirmed by future research at Sibudu and at other sites, this would imply that innovations were partially or totally lost and possibly were reinvented a number of times. If the latter situation was the case, each reinvention may have taken a different form and economic role in MSA societies. At Sibudu, for example, bone tools may have been of minor importance compared to their use at Blombos, which chronicles previously unrecorded tool types such as a bone end-scraper, and a reduction in size of projectile points. This last observation deserves closer examination because it may reflect changes in hunting technology occurring between the Still Bay and the HP.

The morphological variability in the bone points from Blombos Cave, and the size and weight of the one complete specimen, suggests they are more likely spear points than arrow points. Large powerful bows are known ethnographically that can project very large arrows (Holmberg, 1985), however, it is reasonable to expect that the development of a bow and bone arrow technology should be preceded by the invention of hafted bone spear points. The Blombos points are the first known bone points of this type, thus, the more parsimonious explanation is that they represent the first step in a process that may have led to the invention of more advanced propulsion technology, such as the use of the spear thrower or the bow. The interpretation of the Blombos bone artefacts as spear points is consistent with ethnographic and recent archaeological stone point dimensions, which show spear tips to be five times larger than arrow heads (Shea, 2006; Villa and Lenoir, 2006). It is also consistent with the remainder of the Still Bay tool kit found at Blombos Cave, which includes bifacial points made of silcrete and quartz, many of which are of a size and weight incompatible with their use as arrow points. The Sibudu bone point, like those from Peers Cave and Klasies River, lacks the weight and robustness of spear heads, and falls within the morphological and morphometric variability of fixed bone arrow points (Type 4) used by Bushmen, i.e. relatively large arrow points used without poison on small game, and designed not to detach from the reed shaft upon impact. Points of this size cannot mortally wound a large animal without poison and such points were used by Bushmen for hunting birds or small mammals. The high frequencies of the tiny blue duiker, *Philantomba monticola,* in the Sibudu HP (Clark and Plug, in press) support the suggestion of similar HP hunting strategies for small animals.

The difference at Sibudu between the prey of the HP and the prey of the post-HP, and attendant differences in vegetation, may help to explain why there is technological variability between the two industries. The predominant prey (comprising 33.6% of identified prey species) in the HP is the blue duiker, which seldom weighs more than 5 kg (Clark and Plug, in press). In total, 91.4% of the HP assemblage comprises species that prefer closed or semi-closed environments (Clark and Plug, in press). The Gambian giant rat (*Cricetomys gambianus*) that occurs in the HP at Sibudu (Glenny, 2006) seems to be a useful environmental indicator because today it lives only in evergreen forest and woodland where rainfall is greater than 800 mm annually (Skinner and Chimimba, 2005: p. 193). The predominant woody genus in the HP charcoal assemblage is the evergreen *Podocarpus* (Yellowwood), which suggests a forest signature (Allott, 2006). The presence of calcite (and absence of gypsum) in the HP deposits (Schiegl and Conard, 2006) further supports the idea of humidity in the shelter because calcite is less soluble than gypsum. Gypsum is abundant in the post-HP ~60 ka deposits (Schiegl and Conard, 2006), which are thought to coincide with a drier environment (Wadley, 2006). In contrast to the HP, the post-HP ~60 ka fauna, which includes large grazers such as the blue wildebeest, hartebeest, and zebra, is principally representative of open conditions, comprising grassland and open savannah (Plug, 2004; Cain, 2006; Clark and Plug, in press). Spear-hunting seems especially useful for obtaining medium and large animals (Villa and Lenoir, 2006) in open country, but it is less suitable for hunting of small, shy, territorial animals that live in forest. Technological studies of stone tools (Villa et al., 2005a; Cochrane, 2006; Villa and Lenoir, 2006), together with residue and macrofracture analyses of retouched points (Lombard, 2004, 2005a), suggest that hunting with stone-tipped weapons, such as spears, was practiced at Sibudu in the post-HP. Different tools are representative of the HP: retouched stone tools comprise mostly backed tools and the industry is distinctive in the sequence. Thus, the bone point that accompanies the backed tools in the HP of Sibudu may signify part of a hunting adaptation to small prey in a closed forest environment.

The Sibudu evidence fits the hypothesis that the origin of bow and arrow technology occurred in the HP and that the application of poison, rather than the invention of the bow, was the crucial LSA innovation in this field. The fact that slender LSA points fall within the same dimensional variability of modern Bushman reversible arrow points is consistent with this hypothesis. Of course, the sample size is too small to draw definite conclusions and new discoveries are needed to test this hypothesis. It is worth noting that the size of the bone points is not the only support for the use of the bow in the HP. Experimental work has shown that the backed stone tools of the HP may have served as arrow heads or barbs for arrows. Hafting arrangements that used geometrically-shaped backed tools as barbs, and microlithic backed points as tips, were effective projectiles for penetrating carcasses (Crombé et al., 2001). Another experiment, using replicated Howiesons Poort-type segments, showed that these function well as projectile tips and are effective when hafted in a variety of positions (Pargeter, in press). Many backed tools from the HP at Sibudu Cave have macrofractures that can be considered diagnostic of impact/hunting use and these, in combination with animal micro-residues on the sharp edges of the tools, and use-wear evidence, suggest that HP segments were inserted into composite hunting tools as tips, barbs or cutting inserts (Lombard, 2008). Lombard's research cannot yet disclose whether the backed tools were parts of spears or arrows, but the research by Crombé et al. (2001) and Pargeter (in press) implies that arrows may have been intended on some occasions. Thus the HP may have contained both early bone and stone arrow heads. However, stone arrow heads could have been an innovation predating the HP. Technological studies of small stone points suggest that some of these may have served as stone-tipped arrows long before the creation of bone arrow heads. The Aduma 4 site in Ethiopia, estimated to be older than 70 ka, has small points of a size that places them within the spear-thrower or arrow range, based on ethnographic specimens (Brooks et al., 2006). If the ~70 ka lithic points from Aduma are indeed darts or arrows, they are the first of their kind, because prior studies of MSA and Middle Palaeolithic stone points conducted by Shea (2006) and Villa and Lenoir (2006) found support for the view that the use of lithic projectile technology, in the form of spear-thrower dart tips and arrow heads, occurred only from *c.* 50,000–40,000 years ago. The bone point from the HP at Sibudu could be the earliest example of the use of *bone* arrow heads.

If an effective innovation, like the bow and the lithic and bone arrow heads associated with it, was lost at the end of the HP and only re-emerged in the early LSA, this can be seen, at the present stage of our knowledge, as supplementary evidence to support the absence of progressive and interdependent steps that led to the emergence of behavioural modernity in the MSA. Population extinction, or migration as a consequence of abrupt environmental changes, are likely explanations for such dramatic losses of cultural traits, which do not seem to reflect, contrary to the requirements of the out of Africa hypothesis, changes or increasing complexity in the cognitive abilities of the populations involved.

5. Conclusion

The finding of three task-specific bone tools in unequivocal HP layers at Sibudu Cave confirms the existence of a bone tool industry in the HP. Comparative analysis of bone points shows a reduction in size between the Still Bay and the HP, and between the HP and the LSA. We tentatively interpret this, together with the extreme symmetry recorded in the tip of the Sibudu Cave point, as a shift from the use of hand-delivered bone spear heads in the Still Bay to bow and bone arrow technology in the HP. If this is confirmed by future discoveries, the bone point from the HP layers at Sibudu Cave would push back the origin of bow and bone arrow technology by at least 20 000 years, substantiating arguments in favour of the hypothesis that crucial innovations took place during the MSA in Africa. Such innovations, however, can hardly be used to support the "classic" out of Africa scenario, which predicts increasing complexity and accretion of innovations during the MSA, determined by biological change. Instead, they appear, disappear and re-appear in a way that best fits a scenario in which historical contingencies and environmental rather than cognitive changes are seen as main drivers.

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