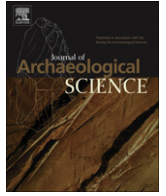


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Journal of Archaeological Science

journal homepage: <http://www.elsevier.com/locate/jas>

Identifying regional variability in Middle Stone Age bone technology: The case of Sibudu Cave

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ARTICLE INFO

Article history:

Received 14 December 2011

Received in revised form

27 January 2012

Accepted 29 January 2012

Keywords:

Still Bay

Howiesons Poort

Microscopy

Bone tools

Pièces esquillées

Wedges

Pressure flaking

ABSTRACT

A few pieces of worked bone were previously reported from Sibudu, a site from KwaZulu-Natal in South Africa featuring a stratigraphic sequence with pre-Still Bay, Still Bay, Howiesons Poort, post-Howiesons Poort, late and final MSA cultural horizons. Here we describe an expanded collection of worked bones, including twenty-three pieces. Technological and use-wear analysis of these objects, and their comparison with experimental and ethnographic data, reveals that a number of specialised bone tool types (wedges, *pièces esquillées*, pressure flakers, smoothers, sequentially notched pieces), previously known only from the Upper Palaeolithic and more recent periods, were manufactured and used at least 30,000 years earlier at Sibudu Cave. These tools appear to be part of a local tradition because they are absent at contemporaneous or more recent southern African sites. Variability in Middle Stone Age material culture supports a scenario in which, beyond broad similarities in lithic technology, significant differences between regions, and trends of continuity at a local scale emerge in other aspects of the technical system, and in the symbolic domain. The archaeological record is revealing a complexity that prevents evaluation of the modern character of Middle Stone Age cultures in antinomic terms. We argue here that it is the detailed analysis of cultural variation that will inform us of the non-linear processes at work during this period, and contribute in the long run to explaining how and when crucial cultural innovations became established in human history.

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1. Introduction

For much of the 20th century formal bone tools, defined as functional artefacts shaped with techniques specifically conceived for bone, such as scraping, grinding, grooving and polishing (Mellars, 1973; Klein, 1999), were seen as a technological innovation directly stemming from the spread of anatomically modern humans across Europe at the beginning of the Upper Palaeolithic and strictly associated with a panoply of critical inventions that followed this peopling event (cave and mobiliary art, personal ornaments, blade technology, complex funerary practices, musical instruments, etc.). Upper Palaeolithic bone industries were used, in this framework, to support the scenario of a cognitive revolution

occurring in Europe at ca. 40 ka. The discovery of bone awls and projectile points at a number of Still Bay (SB) (Henshilwood et al., 2001; d'Errico and Henshilwood, 2007) and Howiesons Poort (HP) sites in South Africa, securely dated to between 75 ka and 60 ka, as well as at other sub-Saharan Middle Stone Age (MSA) sites (see Backwell et al., 2008 for a review) has challenged this view, and the production of formal bone tools during the MSA is now an established fact. The early appearance of bone tools in the African MSA has become, together with that of pigments (Watts, 2009), engravings (Henshilwood et al., 2009; Texier et al., 2010), personal ornaments (d'Errico et al., 2009a), and other "modern" behaviours (Brown et al., 2009; Wadley et al., 2009) one of the reasons to support the so called Out of Africa scenario (McBrearty and Brooks, 2000), which postulates a causal connection between the origin of our species in Africa around 200 ka and a gradual emergence of modern cultures on that continent. This model predicts a gradual, continuous accretion of cultural innovations in Africa, culminating in the spread of our species out of that continent and the replacement of archaic hominin forms. In this context, the

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discovery of formal bone tools in the MSA has been interpreted as a significant behavioural corollary of the emergence of anatomically modern humans in Africa. If the Out of Africa scenario were correct, however, we should not find behaviours considered specific to our species associated with archaic populations outside of Africa. This is contradicted by the fact that Neanderthals exhibited many of these behaviours (pigment use, formal bone tool manufacture, funerary practices, complex hafting techniques, personal ornamentation) before or at the very moment of contact with moderns (d'Errico, 2003; d'Errico et al., 2003, in press; Pettitt, 2002; Soressi and d'Errico, 2007; Zilhão et al., 2009; Koller et al., 2001; Mazza et al., 2006; Caron et al., 2011; but see Bar-Yosef and Bordes, 2010). Also, a growing body of discoveries in Africa shows no evidence for exponential growth in innovations, but rather a discontinuous pattern, with innovations appearing, disappearing and reappearing again in different forms, indicating discontinuity in cultural transmission (Villa et al., 2005; Jacobs et al., 2008a; d'Errico and Vanhaeren, 2009; d'Errico et al., 2009b; d'Errico and Stringer, 2011; Lombard and Parsons, 2011) that contradicts the Out of Africa scenario. Climatic change (Lahr and Foley, 1998; Henshilwood, 2008; Ambrose, 1998a; d'Errico et al., 2009a), demography (Henrich, 2004; Shennan, 2001; Powell et al., 2009), and changes in the mechanisms of cultural transmission (Hovers and Belfer-Cohen, 2006) are proposed as explanations to account for such a discontinuous pattern. However, it is still unclear how much each of these factors potentially contributed to the process, and if so, to what degree they were inter-related. Global climatic change, for instance, may have differently impacted human populations in different regions, resulting in variable population dynamics. It has been recently argued, for instance, that global climate data for the African sub-continent during Marine Isotope Stage (MIS) 4 (ca. 74–59 ka) are unable to predict regional responses and, as a consequence, to model the impact of climate change on human populations (Chase, 2010). On the archaeological side too, emergence and disappearance of innovations in southern Africa is still insufficiently documented and understood. Researchers tend to assign the occurrence of innovations discovered at single or a few sites with the associated MSA archaeological culture, defined on the basis of diagnostic stone tools, but have no clear explanation for why these innovations are absent at other sites of the same technocomplex. Blombos is the only site that contains engraved ochre in association with unequivocal shell beads, numerous pieces of pigment, and a large bone tool collection. Diepkloof is the only HP site with engraved ostrich eggshells. Is this due to the relatively low number of sites excavated using modern standards, to the different function of the sites that have yielded those special finds, or to hitherto unidentified regional variation in MSA technocomplexes? If the last is the case, are those regional variations only at work during the period of a particular technocomplex, or do they represent the expression of local traditions that span changes in diagnostic lithic tool types? Regional traditions may signal continuities in population, mechanisms of cultural transmission, availability of local resources, and environmental setting. In other words, documenting the tempo and mode of the emergence of innovations in each region of southern Africa is a means to test current models on the emergence of behavioural complexity. In this paper we address the above questions by analysing an expanded collection of bone tools from the MSA layers of Sibudu Cave. The oldest formal bone tools in Africa yet discovered are the Katanda harpoons, thought to have an age of ca. 90 ka (Yellen et al., 1995). So far the oldest formal bone tools from southern Africa are found in the SB layers of Blombos Cave (M2 phase) and dated to between ca. 84 and 76 ka ago (d'Errico and Henshilwood, 2007; Henshilwood et al., 2009). These and younger bone tools from Peers, Klasies, Sibudu, and Border Cave are almost

exclusively restricted to pointed types such as awls and projectile points (see Backwell et al., 2008). The only exceptions are a bone percussor from the SB layers of Blombos (Henshilwood et al., 2001), a few incised pieces from Apollo 11 (Vogelsang et al., 2010), Blombos, and Klasies, some from the latter site interpreted as tools (d'Errico and Henshilwood, 2007), and two “gouges” of uncertain age from the MSA deposits at Broken Hill (Barham et al., 2002). Here we identify a formal bone tool in pre-SB layers (>72 ka) at Sibudu Cave, making it the second unequivocally oldest known formal bone tool occurrence in southern Africa. We also expand the Sibudu repertoire of HP and post-HP bone tools to seven possible classes, including the oldest known pressure flakers and *pièces esquillées*. This previously unknown and diverse bone working tradition supports a scenario of regional continuity in bone tool technology on the east coast of southern Africa and adds a new dimension to our understanding of MSA cultural diversity.

2. Archaeological context

The rock shelter known as Sibudu is on a cliff above the uThongathi River, KwaZulu-Natal, South Africa, about 15 km inland from the Indian Ocean and just over 100 m above sea-level (Fig. 1). Ongoing excavations, conducted under the direction of one of us (LW) since 1998, cover a maximum surface area of ca. 21 m². The cultural sequence (Fig. 1) comprises a pre-Still Bay (pre-SB), Still Bay (SB), Howiesons Poort (HP), post-Howiesons Poort (post-HP), late MSA, final MSA, and Iron Age occupations (Wadley, 2005, 2006, 2007; Wadley and Jacobs, 2006; Wadley and Mohapi, 2008; Villa et al., 2005; Cochrane, 2006; Villa and Lenoir, 2006; Delagnes et al., 2006). No Later Stone Age (LSA) layers are represented at the site; MSA occupations occur directly below the Iron Age layers. The lithic assemblages are manufactured predominantly on dolerite and hornfels, but quartz and quartzite are occasionally used.

Optically stimulated luminescence (OSL) age estimates from single quartz grains (Fig. 1) situate the pre-SB layers between ~77.2 and 72.5 ka. The upper-most SB layer has provided an age of 70.5 ka, similar to ages obtained at Blombos for the same cultural horizon (Jacobs et al., 2008a). The Sibudu HP layers have ages of 64.7 ± 1.9 to 61.7 ± 1.5 ka (Jacobs et al., 2008b, c). The age estimates obtained for the post-HP layers range between 59.6 and 57.6 ka (Jacobs et al., 2008b, c). Final and late MSA layers are dated to between 49.9 and 38 ka.

It is important for the arguments in this paper to discuss the contexts from which the bone tools were recovered. The stratigraphy at Sibudu is complex, but clear and well-preserved. Geo-archaeological investigations at Sibudu demonstrate that the site's stratigraphic layers have integrity and that there is minimal vertical mixing between the anthropogenically-formed layers (Goldberg et al., 2009; Wadley et al., 2011). The preservation of layers is so good that laminated, articulated phytoliths occur and centimetre-thick layers of undisturbed, carbonized bedding are easily recognisable, sometimes across several metres of sediment. However, as in most archaeological sites, there has been both anthropogenic and natural disturbance to some parts of the site and three types have been recognized at Sibudu: deliberate digging of pits, burrowing by animals and rockfall. The juxtaposition of Iron Age and MSA layers has caused some localized damage to stratigraphy because Iron Age pits were, in places, dug into the MSA layers. The worst disturbance occurs in the southern portion of the excavation grid where pits were excavated through the 38 ka and 48 ka layers into the youngest of the ~58 ka layers, SPCA and BSp2 (see Fig. S1). Fortunately the pits are clearly defined and it was simple to recognise them and to excavate their grey, ashy, rubble-filled contents to expose the undisturbed, clear, yellow, brown and/or black MSA layers. The areas that have been affected by the pits are

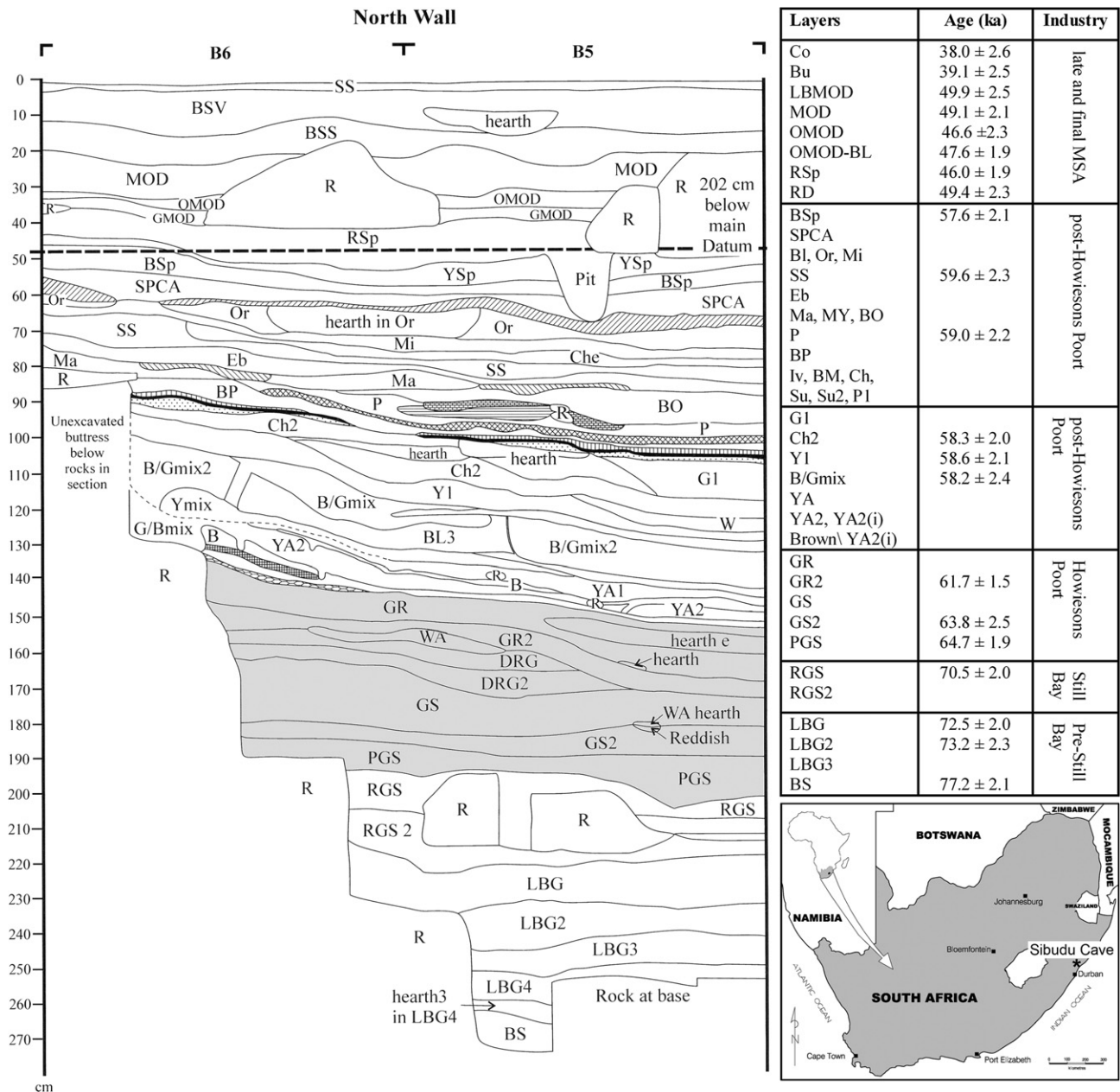


Fig. 1. Geographic location (bottom right), stratigraphy (left), and OSL age estimates for Sibudu Cave archaeological layers (modified after Wadley, 2007; Jacobs et al., 2008b, c; Backwell et al., 2008). Note that R = rock in the stratigraphy.

well-controlled and documented and present no contextual difficulties for the worked bone described here. Only two of the bone tools listed in this study are in layers young enough, and high enough in the sequence, to have been potentially affected by Iron Age pits. They are (Table 1) from square C2b, layer Co (with an OSL age of 38.0 ± 2.6 ka) and square E2a, layer BSp2 (with an OSL age of 57.6 ± 2.1 ka). However, neither bone tool was found in or near an Iron Age pit (the approximate proveniences of the bone tools are marked by * in Fig. S2). Furthermore, bone tools of the kind found in the MSA layers are not present in the Iron Age layers and unknown in Iron Age contexts. Burrows are sometimes present (e.g. Fig. S3 on which **bu** = burrow), but they are easily recognisable when they occur and we do not consider that any of the bone tool proveniences are explained by burrowing animals. Rockfall occurs in the pre-65 ka layers (Fig. 1 and Fig. S3) and there is no doubt that the impact of a rock falling into soft sediment causes some

displacement. Nonetheless, no bone tools have yet been found in the ~ 72 – 70 ka SB layers directly below the 65–62 ka HP layers with a rich bone tool assemblage. This suggests that HP bone tools are unlikely to have migrated downwards post-depositionally. Bone tools do occur in the 77–72 ka pre-SB layers and the two described here, from layer LBG, were excavated *in situ* from an undisturbed context by LW. One of the tools was recovered from a well-preserved hearth.

A few pieces of worked bone from Sibudu have been previously reported (Cain, 2004; Backwell et al., 2008), including two pointed implements from HP layers and the notched piece directly dated by AMS to $28,880 \pm 170$ BP (GrA-19670) from the post-HP in layer BSp2 (the piece mentioned at the beginning of this section). The direct date is almost certainly a minimum age, and the notched piece, which is partly burnt (with a carbon wt% of 20.6%, a nitrogen wt% of 0.6% and a C:N of 28.7), is more likely to have the same age

Table 1
Contextual data on the worked bones from Sibudu Cave.

Fig. (No.)	Exc. date	Square	Layer	Layer code	Cultural attr.	OSL (ka) ^a	References
2 (1)	11/08/1999	C2b	Coffee	Co	Final MSA	38.0 ± 2.6 ^b	Cain, 2004
2 (2)	21/08/2001	E2a	Brown Speckled 2	BSp2	Post-HP		Cain, 2004
2 (3)	13/03/2007	C5a	Black Magic	BM	Post-HP		–
2 (4)	–	B5a	Black Magic	BM	Post-HP		–
2 (5)	15/03/2006	C6c	Yellow Ash	YA1	Post-HP		–
2 (6)	28/02/2007	C6d	Yellow Ash 2	YA2	Post-HP		–
3 (1)	01/03/2007	C5a	Grey Rocky	GR	HP		–
3 (2)	16/11/2008	B4a	Grey Rocky	GR	HP		–
3 (3)	16/11/2008	B4a	Grey Rocky	GR	HP		–
3 (4)	01/03/2007	C5c	Grey Rocky 2	GR2	HP	61.7 ± 1.5	–
3 (5)	–	B5d	Grey Rocky 2 (hearth B)	GR2 (hB)	HP	61.7 ± 1.5	Backwell et al. 2008
3 (6)	–	B5d	White Ash under Grey Rocky 2	GR2	HP	61.7 ± 1.5	Backwell et al. 2008
3 (7)	02/03/2007	C5b	Grey Rocky 2	GR2	HP	61.7 ± 1.5	–
4 (1)	04/03/2007	C5a	Grey Sand hearth 1	GS (h1)	HP		–
4 (2)	07/03/2007	C6d	Grey Sand 2	GS2	HP	63.8 ± 2.5	–
4 (3)	06/03/2007	C5c	Grey Sand 2 (hearth)	GS2 (h)	HP	63.8 ± 2.5	–
4 (4)	04/11/2004	B5c	Pinkish Grey Sand	PGS	HP	64.7 ± 1.9	Backwell et al. 2008
4 (5)	08/03/2007	C5b	Pinkish Grey Sand	PGS	HP	64.7 ± 1.9	–
4 (6)	19/11/2009	C4d	Pinkish Grey Sand, hearth 3 base	PGS2	HP		–
4 (7)	21/11/2009	C4d	Pinkish Grey Sand	PGS2	HP		–
4 (8)	13/11/2009	B4a	Pinkish Grey Sand	PGS3	HP		–
4 (9)	21/02/2010	B4b	Light Brownish Grey	LBG	Pre-Still Bay	72.5 ± 2.0	–
4 (10)	16/02/2010	B4c	Light Brownish Grey	LBG	Pre-Still Bay	72.5 ± 2.0	–

^a Jacobs et al. 2008a,b.

^b Object directly dated to 28,880 ± 170 BP (GrA-19670).

(57.6 ± 2.1 ka) as the layer (BSp2) in which it was found. The notched bone is clearly not from the Iron Age and there is also not a single LSA tool at the site, so it is not from the LSA either. One of the HP pointed artefacts has been tentatively interpreted as an arrow head based on its morphological similarity to un-poisoned San arrow points (Backwell et al., 2008).

Other Sibudu tools suggest use as weapons. Use wear and residue analysis of stone tools (Lombard, 2006a) have revealed that some tips of SB lithic points bear animal residues (collagen, muscle tissue, fat, bone). These objects also have residues of adhesives composed of ochre and plant gum (Lombard, 2006b; Wadley, 2010a). Many segments from HP layers also have ochre and plant adhesive traces on their curved backs where they would have been hafted to shafts or handles (Lombard, 2008). Some lack ochre and instead have fat mixed with plant material (Wadley et al., 2009). Impact fractures, design and residues indicate that some segments are likely to have functioned as arrow heads (Lombard, 2011; Lombard and Partridge, 2008; Lombard and Phillipson, 2010). Points from post-HP layers seem to have been consistently used as parts of weapons for hunting, most likely as the tips of spears, as suggested by impact fractures and animal residues on their tips (Villa et al., 2005; Lombard, 2004, 2005). Massive quantities of red and yellow pigmentaceous material in the form of unworked fragments, ground pieces, and patches of ground powder are found in the MSA layers (Hodgskiss, 2010). Cemented hearths from 58 ka have been recently interpreted as pigment working surfaces or receptacles for ochre powder (Wadley, 2010b).

The site features exceptionally good preservation of faunal remains. Large bovinds such as buffalo, eland and wildebeest are present in low frequencies (Clark and Plug, 2008). Bushpig are well represented in the HP and zebra are well represented in the post-HP. The predominance of small animals in the HP and SB (blue duiker, monkey, rodents, small carnivores) has been interpreted as evidence for the use of traps and snares (Wadley, 2010c). Marine shell, thought to have been collected as a raw material (Plug, 2006), occurs in relatively low frequencies, though the amount of shell is greater in the SB than elsewhere, and the discovery of putative beads made from small *Afrolittorina* shells (d'Errico et al., 2008) lends support to Plug's interpretation. No detailed study of the SB fauna is published yet, but preliminary investigation suggests that

people at ca. 70 ka captured the same range of animals as their successors during the HP (Plug pers. comm. 2010).

3. Materials and methods

Over a hundred potential bone tools recovered during excavations, including those previously described by Cain (2004) and Backwell et al. (2008), were examined under a binocular low power reflected light microscope in search of anthropogenic modifications. This resulted in the retention of twenty-three pieces bearing compelling traces of manufacture and/or use (Figs. 2–4). The distinction between natural and anthropogenic modifications is based on criteria defined in the literature and the analysis of modern and Pleistocene reference collections (Shipman and Rose, 1988; Fisher, 1995; Bonnichsen and Sorg, 1997; Hannus et al., 1997; Villa and d'Errico, 2001; Backwell and d'Errico, 2001, 2005). Identification of shaping techniques and use-wear on archaeological specimens is based on: 1) data from experimental bone tool manufacture and use (Newcomer, 1974; d'Errico et al., 1984; Bergman, 1987; Shipman and Rose, 1988; Campana, 1989; Choyke and Bartosiewicz, 2001; d'Errico and Backwell, 2003; Backwell and d'Errico, 2005); 2) experimental reproduction and microscopic analysis of sequential marks produced with different tools and motions (d'Errico, 1995, 1998). In addition, the interpretation of ambiguous bone tool categories required an experimental approach and consideration of ethnographic data (see below).

Each bone artefact was examined and photographed with a Leica Z6 APO stereomicroscope fitted with a DFC420 digital camera and equipped with a Leica Application Suite (LAS), or with an Olympus SZX16 Zoom Stereo Microscope. These microscopes have a multifocus module. Once digital images have been acquired at different heights, adapted algorithms combine them into a single sharp composite image that significantly extends the depth of field. This equipment was also used to produce fully in focus images of the cross sections of notches on one piece from the final MSA and measure distances between adjacent notches. Selected artefacts were examined at a higher magnification using a Leica DM 2500 M reflected light microscope and a variable pressure ZEISS EVO 50 scanning electron microscope with a voltage of 15 kV. The following parameters were recorded for each tool: anatomical and species



Fig. 2. Bone artefacts from final MSA (n. 1) and Post-Howiesons Poort layers (n. 2–6) at Sibudu Cave.

origin of the blank, blank extraction and shaping technique, type and technique of incision, traces of use and resharpening. The location and extent of worked areas and the sequence of the technical actions based on microscopic examination were systematically recorded for each bone artefact. Morphometric data were collected with digital callipers and included, when possible, the length, width and thickness of each object.

3.1. Ethnographic and experimental data

The functional interpretation of bone tools bearing minimal traces of modification and use, such as pressure flakers, required experimental replication and gathering information from the ethnographic literature. Bone pressure flakers – bone implements used to retouch lithics by exerting pressure on their edges – have

often been reported in the ethnographic literature for North (see Wilke et al., 1991: 268 for references; Binford, 1979) and South America (see Nami and Scheinsohn, 1997: 256 for references), and numerous archaeological sites from these and other regions have yielded bone objects morphologically similar to the ethnographic specimens, which have been interpreted as having the same function (Jordan, 1980; Lavallée et al., 1985; Julien, 1986; Nami, 1987, 1988; Massone and Prieto, 2004; Kimball and Whyte, 1992; Janetski et al., 1992; Jackson, 1989–90; Jackson et al., 2004; Borella and Buc, 2009). They take the form of elongated fully shaped tools with a robust curved tip, or marginally shaped pointed bone flakes. Long bone and ivory bevelled objects, found in Clovis caches, are interpreted as handles of hafted bone pressure flakers used to manufacture Clovis points (Wilke et al., 1991, but see Lyman and O'Brien, 1998). However, no detailed description of the traces left by use is available for the



Fig. 3. Bone artefacts from the Upper Howiesons Poort layers at Sibudu Cave.



Fig. 4. Bone artefacts from the lower Howiesons Poort (n. 1–8) and the Pre-Still Bay layers (n. 9–10) at Sibudu Cave.

ethnographic objects. Few authors have experimentally reproduced these tools (Wilke et al., 1991) or documented the resulting traces of use (Peltier and Plisson, 1986; Nami and Scheinsohn, 1997). In our experiments, a 'green' tibia of a wildebeest (*Connochaetes taurinus*) (harvested two weeks after death) and a dry impala (*Aepyceros melampus*) tibia (harvested three months after death) were broken with a quartzite pebble. Resulting elongated splinters representative of the herbivore size range present at Sibudu, were shaped using an ESC 300 GTL polishing machine with a sand paper grain size of 180. The shaping was conducted in a manner that led to the production of tips similar in size and shape to the archaeological specimens interpreted as pressure flakers, that is, pieces with a slightly pointed tip, rectangular or elliptical in section, and of ca. 7×4 mm in diameter at 5 mm from the tip. Fresh cow limb bones were submitted to the same treatment and were shaped into bone tools similar to those identified at Sibudu. Unlike the archaeological specimens, however, the experimental tools displayed small facets homogeneously covered by fine parallel striations. This manufacturing procedure obliterates previous natural surface modifications and allows for the easy recognition of traces produced by the experimental use of the tool (d'Errico, 1993). Fifteen experimental bone tools, five made of antelope and five of cow limb bones were used by three people, two of which are experienced knappers, to retouch by means of pressure four flakes/blades of dolerite and four flakes/blades of hornfels from reworked layers at Sibudu, five flakes of flint and five flakes of fine grained quartzite. Each tool was used in this task for 15–20 min, or less if a micro-flake removal appeared, making further use in the task less effective. Three parameters were changed

during the experiment: the aspect of the bone tool tip in contact with the lithic blank (broad or narrow aspect), its relation to the lithic blank's long axis (perpendicular or oblique), and its position, on the vertical plane, against the blank's edge (steeply or slightly inclined). Five additional bone tools were used in the attempt of piercing fresh and dry goat and cow skins and as pegs to stake fresh skin into a gravel matrix. The second activity was performed hundreds of times, and the resulting wear periodically checked under the microscope during its development.

To identify the function of wedge-shaped bone tools we referred to published accounts of the experimental use of similar bone objects (Rigaud, 1984; Peltier and Plisson, 1986; Campana, 1989; d'Errico, 1993; Griffiths, 1993; LeMoine, 1997; Scheinsohn, 1997; Camps-Fabrer et al., 1998; Tartar, 2003; Maigrot, 2003; Legrand, 2007; Buc, 2011), ethnographic accounts (Miles, 1963; Semenov, 1973; Yorga, 1980; Stewart, 1984; Cattelain, 1989) and wear patterns obtained by us when using fresh bone flakes for flaying and cutting fresh meat from an adult male eland, working fresh hides with the addition of sand, dry hides with the addition of salt, digging in soil to extract tubers and grubs, and removing bark from trees (Backwell and d'Errico, 2005).

4. Results

Twenty-three pieces identified as artefacts were retained after analysis (Figs. 2–4). Two specimens described by Cain (2004: 194, Figs 3 and 4) are not included in this collection because they do not show compelling evidence of being artefacts. The bone tools

(Table 1) come from four (pre-SB, HP, post-HP, final MSA) of the five main MSA cultural horizons identified at this site (Fig. 1). Fifteen pieces come from HP, five from the post-HP, two from the pre-SB, and one from the final MSA layers. No bone tools come from SB layers. Nineteen of the identified artefacts served utilitarian functions, the remaining three bear sequences of notches and no apparent evidence of use. The pieces used as tools are classified for the sake of description into broad typological classes: pins, notched pieces, smoothers, *pièces esquillées*, pressure flakers, a projectile point, awls and wedges. Most of the tool classes straddle different cultural horizons, in particular the HP and post-HP.

4.1. Pins

Two specimens, one from the final MSA (Fig. 2 n. 1; Tables 2 and 3), and the other from the HP (Fig. 4, n. 4; Tables 2 and 3), fall within this category. The first (Cain, 2004: 196, Fig. 5) is a sturdy piece solely of cortical bone, triangular in section, and displaying a recent proximal break and an ancient distal oblique break. The surface of this object shows traces of shaping by scraping with a retouched flake (Fig. 5a), however, the production of such a straight and fine blank certainly involved either abrasion, perhaps in a v-shaped groove, or extraction by two longitudinal adjacent grooves created by the to-and-fro movement of a lithic point. The oblique break shows evidence of subsequent use, as demonstrated by the polished appearance of the fracture (Fig. 5a). The second object (Fig. 4, n. 4) is a mesial fragment of a small mammal ulna shaped by scraping to produce four flat aspects resulting in a pointed tool, rectangular in section. On one aspect the scraping has exposed the medullary cavity (see Backwell et al., 2008: 1572–3, Fig. 5).

4.2. Notched pieces

Four objects, bearing a sequence of notches, come from upper post-HP layers (Fig. 2 n. 2 and 4; Tables 2 and 3), HP (Fig. 3 n. 7), and possibly a pre-SB layer (Fig. 4 n. 10; Tables 2 and 3). The first object (Cain, 2004: 195, Fig. 1) presents ten deep notches from what was probably a longer sequence originally (Fig. 2 n. 2). Three notches are incomplete. By comparison with experimentally made incisions

(d'Errico, 1991, 1998), these notches were made by a repeated to-and-fro movement of a broad lithic cutting edge. Microscopic analysis of the notches' orientation, outline, section and internal morphology (Fig. 6a) identifies a sub-set of six notches (Fig. 6a n. 1–6) equally oriented and made sequentially by the same cutting-edge. Notch n. 7, showing a cleaner morphology, probably belongs to the same sub-set and represents the first incision made. The remaining three notches (Fig. 6a n. 8–10) have a different orientation, are not located on the same plane and present a different internal morphology, which either results from being made by a different cutting edge or, perhaps, by inverting the orientation of the bone between the carving of the two sub-sets. The periosteal surface between the notches displays slight smoothing, similar to that reproduced experimentally by handling (d'Errico, 1993). The second object (Fig. 2 n. 4 and Fig. 6b) is a fragment of the caudal border of a small mammal scapula on which five long notches, one of which is half broken, have been incised on the internal aspect, perpendicular to the edge. Originally belonging to a longer sequence, the notches on this bone are carved by the same cutting edge. The third object (Fig. 3 n. 7 and Fig. 6c) is a small fragment of an ulna or fibula of a small carnivore bearing three notches, two of which are parallel. All of them were made by the same unretouched cutting edge. The last object (Fig. 4 n. 4 and Fig. 6d), probably a fragment of the transverse process of a small mammal vertebra, records five close notches made sequentially by the same cutting edge. Considering the spongy nature of the bone and the location of the incisions we are not certain about the intentionality of the notching on this piece. Numerous rib fragments from Sibudu MSA layers bear incisions which may appear at first sight similar to those recorded on the above specimens (Fig. 6e–f). The latter differ however from the pieces that we have selected in that the incisions appear to have been made with a single cutting motion, and distances between incisions are significantly uneven compared to those interpreted as intentionally notched (Fig. 7).

4.3. Smoothers

The first of the three objects falling into this category is a fragment of a mandible recovered in a post-HP layer, poorly preserved

Table 2
Archaeozoological, morphometric and technological data for bone artefacts from Sibudu Cave.

Fig. (No.)	Taxon	Element	Mammal size class	Compact bone thickness (mm)	Length (mm)	Width (mm)	Thickness (mm)	Modification	Description
2 (1)	indet	limb bone	indet	2.34	(47.98)	2.34	2.08	sc	pin
2 (2)	indet	rib	I	1.21	(22.81)	(4.41)	(2.30)	inc	notched piece
2 (3)	indet	mandible	II	3.93	(20.46)	(11.75)	4.28	na	smoother
2 (4)	indet	scapula	I	(5.85)	(32.30)	14.9	5.92	ret	notched piece
2 (5)	indet	limb bone	I/II	0.99	(20.96)	(17.63)	(3.71)	inc	<i>pièce esquillée</i>
2 (6)	indet	mandible	III	5.25	(44.01)	14.44	5.86	sc & gr	pressure flaker
3 (1)	indet	limb bone	II	2.66	(17.95)	9.50	3.22	ret	<i>pièce esquillée</i>
3 (2)	indet	limb bone	III	(7.85)	(61.98)	25.65	9.39	gr	pressure flaker
3 (3)	indet	indet	I	3.25	(25.97)	(12.45)	(5.02)	gr	pressure flaker
3 (4)	carnivore	ulna	II	na	(64.17)	6.52	3.81	sc	–
3 (5)	indet	limb bone	II	(4.58)	(18.58)	7.52	4.59	pol	smoother
3 (6)	indet	limb bone	II/III	5.12	(49.34)	5.61	5.51	sc	point
3 (7)	indet	indet	I	2.63	(10.05)	4.85	2.63	inc	notched piece
4 (1)	indet	limb bone	I/II	2.88	(13.28)	10.34	3.35	sc & ret	<i>pièce esquillée</i>
4 (2)	indet	limb bone	II	4.29	(12.14)	(9.18)	(4.69)	ret & gr	<i>pièce esquillée</i>
4 (3)	indet	metapodial	III	4.28	122.46	4.73	3.76	sc	awl
4 (4)	indet	limb bone	I/II	2.06	(15.79)	3.20	2.91	sc	pin
4 (5)	aves	radius	na	1.41	61.98	15.05	4.64	sc & gr	awl
4 (6)	indet	limb bone	III	10.58	(19.90)	(20.08)	10.81	sc	smoother
4 (7)	indet	limb bone	II	3.91	(50.44)	(6.59)	3.91	sc	awl
4 (8)	indet	mandible	IV	16.88	(61.35)	(16.61)	13.84	–	wedge
4 (9)	indet	limb bone	III	9.50	(21.45)	18.64	9.50	sc & gr	wedge
4 (10)	indet	vertebra	I	na	(11.39)	(8.04)	(3.13)	inc	notched piece?

Abbreviations: sc: scraped; inc: incised; ret: retouched; po: polished; gr: ground; marg. point: marginally pointed; ins: insect gnawed; exf: exfoliated. Brackets indicate measurements on broken specimens.

Table 3
Data on use wear and taphonomy for bone tools from Sibudu Cave.

Fig. (No.)	Usage flake scars			Crushing		Polish		Striations			Breakage from use	Pigment	Burnt
	Location	Type	Intensity	Location	Intensity	Location	Intensity	Location	Intensity	Orientation			
2 (1)	—	—	—	—	—	tip	mod.	—	—	—	tip	?	?
2 (2)	—	—	—	—	—	—	—	—	—	—	—	—	?
2 (3)	—	—	—	—	—	left, tip, right	high	left, tip, right	high	perp.	—	—	?
2 (4)	—	—	—	—	—	—	—	—	—	—	—	—	?
2 (5)	end	bifacial	high	—	—	end	mod.	—	—	—	mesial	—	?
2 (6)	—	—	—	tip	mod.	—	—	—	—	—	mesial	—	—
3 (1)	end	bifacial	mod.	—	—	end	mild	—	—	—	mesial	—	?
3 (2)	—	—	—	—	—	—	—	—	—	—	mesial ?	—	—
3 (3)	—	—	—	tip	mod.	—	—	—	—	—	mesial ?	—	—
3 (4)	—	—	—	—	—	—	—	—	—	—	prox. & dist.	—	?
3 (5)	—	—	—	—	—	tip	high	tip	high	random	—	—	?
3 (6)	—	—	—	—	—	—	—	—	—	—	mesial ?	—	?
3 (7)	—	—	—	—	—	—	—	—	—	—	—	—	—
4 (1)	end	bifacial	mild	—	—	—	—	—	—	—	distal	—	?
4 (2)	end	bifacial	high	tip	mod.	—	—	—	—	—	mesial	—	?
4 (3)	—	—	—	—	—	tip/edge	high	—	—	—	—	—	?
4 (4)	—	—	—	—	—	body	mod.	—	—	—	—	—	?
4 (5)	—	—	—	—	—	—	—	tip	light	perp.	—	?	?
4 (6)	—	—	—	—	—	tip	high	tip	high	random	?	?	—
4 (7)	—	—	—	—	—	tip	high	—	—	—	—	—	—
4 (8)	—	—	—	—	—	tip	high	—	—	perp.	—	—	—
4 (9)	end	unifacial	mild	—	—	tip	mod.	—	—	—	—	—	?
4 (10)	—	—	—	—	—	—	—	—	—	—	—	—	—

mod.: moderate; perp.: perpendicular to the active edge.

due to burning (Fig. 2 n. 3; Tables 2 and 3). Both edges and the tip are highly polished (Fig. 8a). At microscopic scale the polished area is covered by sub-parallel striations 1–5 µm wide and oriented perpendicular to the tool edge, suggesting prolonged movement against a soft material covered with fine similarly-sized abrasive particles. Similar wear is recorded on the second piece (Fig. 3 n. 5, Tables 2 and 3), described in a previous publication (Backwell et al., 2008: 1573, Fig. 6). It consists of the distal fragment of an elongated small tool with a thumbnail-shaped active area. A third possible “smoother” (Fig. 4 n. 6; Tables 2 and 3), made of a thick large mammal cortical bone, comes from a basal HP layer.

4.4. Pièces esquillées

Four limb bone shaft fragments, one from post-HP and three from HP layers (Fig. 2 n. 5; Fig. 3 n. 1; Fig. 4 n. 1–2; Tables 2 and 3), are identified as broken *pièces esquillées* or scaled pieces (Hayden, 1980; Demars and Laurent, 1989; Villa et al., 2005). One of their ends has a chisel-like edge with bifacial thin flake scar removals oriented with the long axis of the bone, probably resulting from splintering due to the use of the bone flake as an intermediate piece to split hard material. The fragment from the post-HP horizon (Fig. 2 n. 5) consists of a longitudinally split flake removed from a large mammal limb bone. The ridges of the step fractures are highly smoothed, probably due to contact with the worked material (Fig. 9a). All three pieces from the HP layers come from similarly small/medium size limb bones. Their similar width suggests that the blanks were carefully selected. Two of them (Fig. 9b–c) show clear evidence of scraping on the lateral margin, further supporting their artefactual nature. The third one reveals evidence of marginal grinding on the active edge, subsequent to a first use, probably to reinforce the working edge (Fig. 9d).

4.5. Pressure flakers

Three broken bone flakes with naturally pointed ends show stout tips quadrangular in section. One comes from the bottom of the post-HP (Fig. 2 n. 6; Tables 2 and 3), and two from upper HP layers (Fig. 3 n. 2–3; Tables 2 and 3). It is worth noting that the

latter were found on the same day and in the same quarter of square metre. Traces of use and resharpening on the tips consist of a few oblique striations on the periosteal aspect close to the tip (Fig. 10a–b), crushing on the apex (Fig. 10a–c), micro-flake removals (Fig. 10a and c), and small flat or slightly convex adjacent facets covered by parallel striations due to marginal grinding (Fig. 10a–c).

Our experimental attempts to use similar bone tools in piercing different types of skin reveal that due to the stoutness of their tips they are ineffective in this task. We succeeded in using them to pierce fresh hide, but this resulted in some polish of the tip and none of the features observed on the tip of the archaeological specimens. An intense use as pegs to stake skins into a gravel matrix developed a wear pattern consisting of individual striations either sub-parallel to the tool main axis, or more randomly oriented according to the type of motion exerted during the inserting motion. This wear pattern, which is very similar to that produced experimentally when using elongated bone splinters to dig up tubers or termite mounds (d'Errico and Backwell, 2009: 1769, Fig. 4) is different from the association of features observed on the Sibudu tools described above. Also, in order to be effective as pegs and sustain the tension of the skin, these implements need to be inserted quite deeply, which causes the development of the use-wear on a much wider area than that on which the wear pattern is present on the Sibudu tools.

Striations similar in size, orientation and internal morphology to those recorded on the periosteal aspect of the archaeological specimens appeared on experimental tools used as pressure flakers when the narrow aspect of the tip was used as the active area, and the tool was oriented at an angle approximately 45° to the lithic blank on horizontal plane (Fig. 10d). Use of the tool in the same manner, but at a 90° angle to the horizontal plane (Fig. 10e), resulted in marked abrasion of the tip and no striations on the broad aspect. Crushing and flake removals originating from the tip appeared when the broad aspect of the tool was applied perpendicular to the lithic edge and the tool was held almost upright during use (Fig. 10f–g). Using the tool in the same way, but holding it horizontally, produced abrasion of the tip and a single facet covered by large striations (Fig. 10h; Fig. 11a–b). No significant



Fig. 5. Manufacture and use-wear traces on pins and awls from Sibudu Cave.

differences in use-wear pattern were observed between pressure flakers made of bone from domesticated and wild species. The use of our experimental pressure flakers to produce contiguous first generation removals on the dorsal aspect of coarse-grained flint flakes resulted in semi-abrupt denticulated retouch (Fig. 10i). When used on the fine-grained dolerite from Sibudu, experimental pressure flakers proved effective in bifacially trimming the edge of small flakes (Fig. 11c) and refining the edge of backed pieces. Their use on hornfel flakes (Fig. 11d) and coarse-grained dolerite (Fig. 11e) also succeeded in creating an invasive retouch, though this appeared more difficult with the latter.

In light of the experimental results, the combination of features observed on the archaeological specimens suggests their use as pressure flakers, whereby the aspect of the tip and the pressure angle were changed during working, and the tip was periodically reinforced by grinding facets oblique to the tool axis on the narrow aspect of the tip.

4.6. Possible projectile point

A single specimen (Fig. 3 n. 6; Tables 2 and 3), a broken pointed implement from a HP layer may fit this category, though the absence of the proximal end hinders a definitive interpretation (Backwell et al., 2008: 1572, Fig. 4). It has been shaped by carefully scraping a small mammal limb bone with a burin spall or an unretouched flake edge to produce a circular cross section and symmetrical point. No obvious traces of use in a perforating action are recorded.

4.7. Awls

Three bone tools from the oldest HP layers have been modified to create pointed implements used in piercing activities. The first awl (Fig. 4 n. 3; Tables 2 and 3) was made on a large mammal metapodial fragment by scraping with an irregular cutting edge on

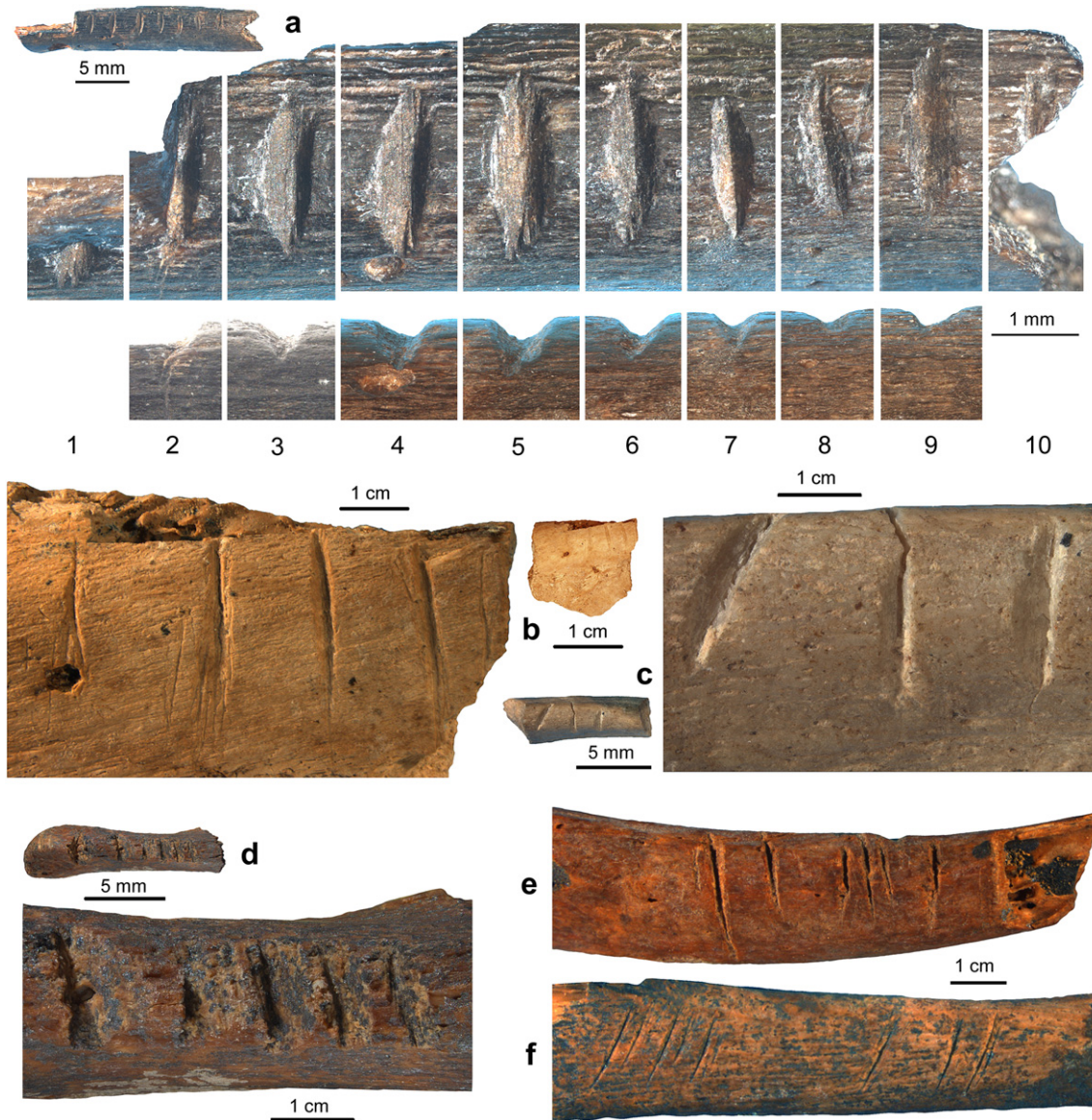


Fig. 6. Notched bone fragments from Post-Howiesons Poort (a–b), Howiesons Poort (c), and Pre-Still Bay (d) layers at Sibudu Cave compared to cut-marked rib fragments (e–f).

the periosteal, medullary and one of the lateral surfaces (Fig. 5c). The other lateral surface was shaped by grinding it obliquely to the tool main axis. The intense use-wear affecting the tip of the tool has smoothed the traces of manufacture for a distance of 5 mm from the tip and developed in this area an intense polish. The second awl (Fig. 4 n. 5), the only almost complete bone tool found at Sibudu, is a bird radius whose diaphysis has been marginally modified through scraping, and whose distal epiphysis has been shaped into a point by grinding (Fig. 5b). The last awl (Fig. 4 n. 7), made on a flat fragment of a medium size limb bone, was modified over the entire surface through scraping, and heavily used, as demonstrated by the blunt polished tip (Fig. 5d).

4.8. Wedges

We attribute to this broad tool category (Provenzano, 1998) two robust, fully shaped implements from the oldest HP (Fig. 4 n. 8; Tables 2 and 3) and the pre-SB layers (Fig. 4 n. 9; Tables 2 and 3). The former, shaped on the body of a very large mammal mandible, is broken longitudinally at its base. It originally had

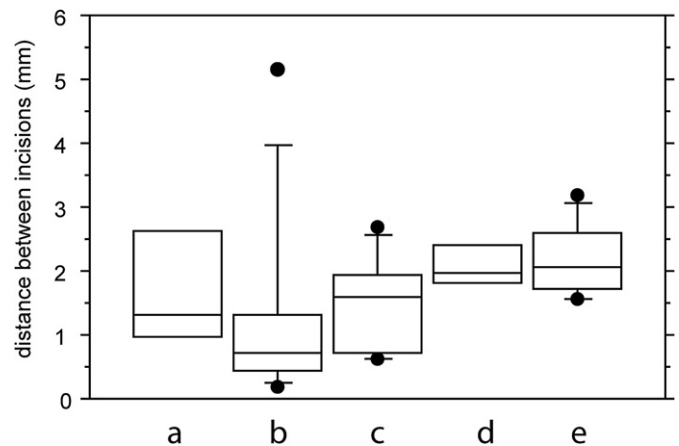


Fig. 7. Distances between sequential incisions recorded on cut-marked bone fragments (a–c) and two pieces interpreted as intentionally notched (d: see Fig. 6b; e: see Fig. 6a).

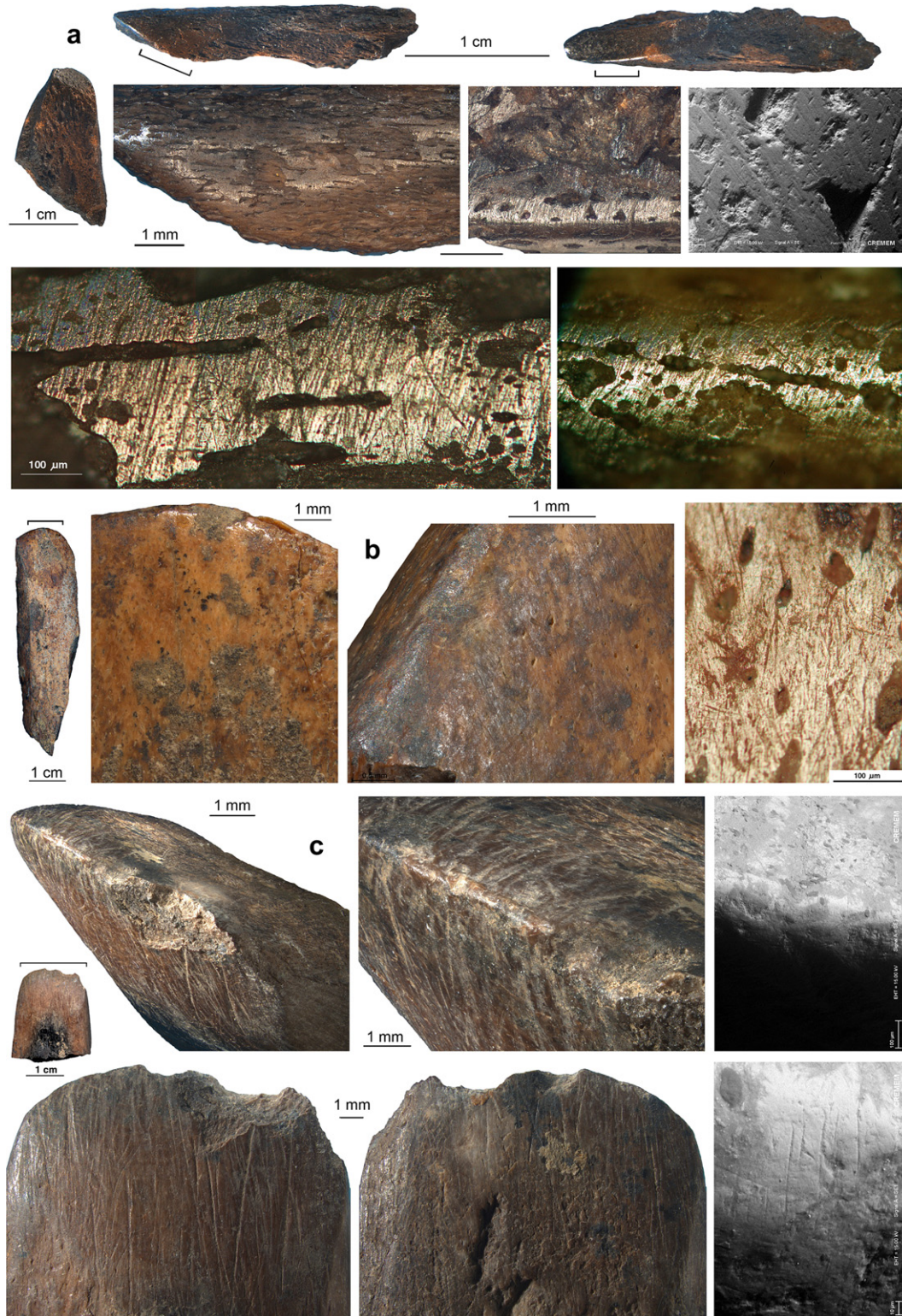


Fig. 8. Use-wear traces recorded on bone tools from Post-Howiesons Poort (a), Howiesons Poort (b) and Pre-Still Bay (c) layers interpreted as smoothers and wedges.

a curved edge and an ogival section. The facets forming the working edge no longer show evidence of manufacture; they are highly smoothed and covered with fine striations sub-perpendicular to the working edge (Fig. 8b). Absence of flake damage on the tool edge and polishing suggest its use on a soft material. The other piece, made on a large mammal limb bone, is

the broken tip of an adze-like implement. Originally shaped by grinding, the two facets creating the linear working edge are now covered by large striations stemming from the edge. The presence of flake removals on both aspects indicates its use on a hard abrasive material. Where preserved, the edge is smoothed and compacted (Fig. 8c).

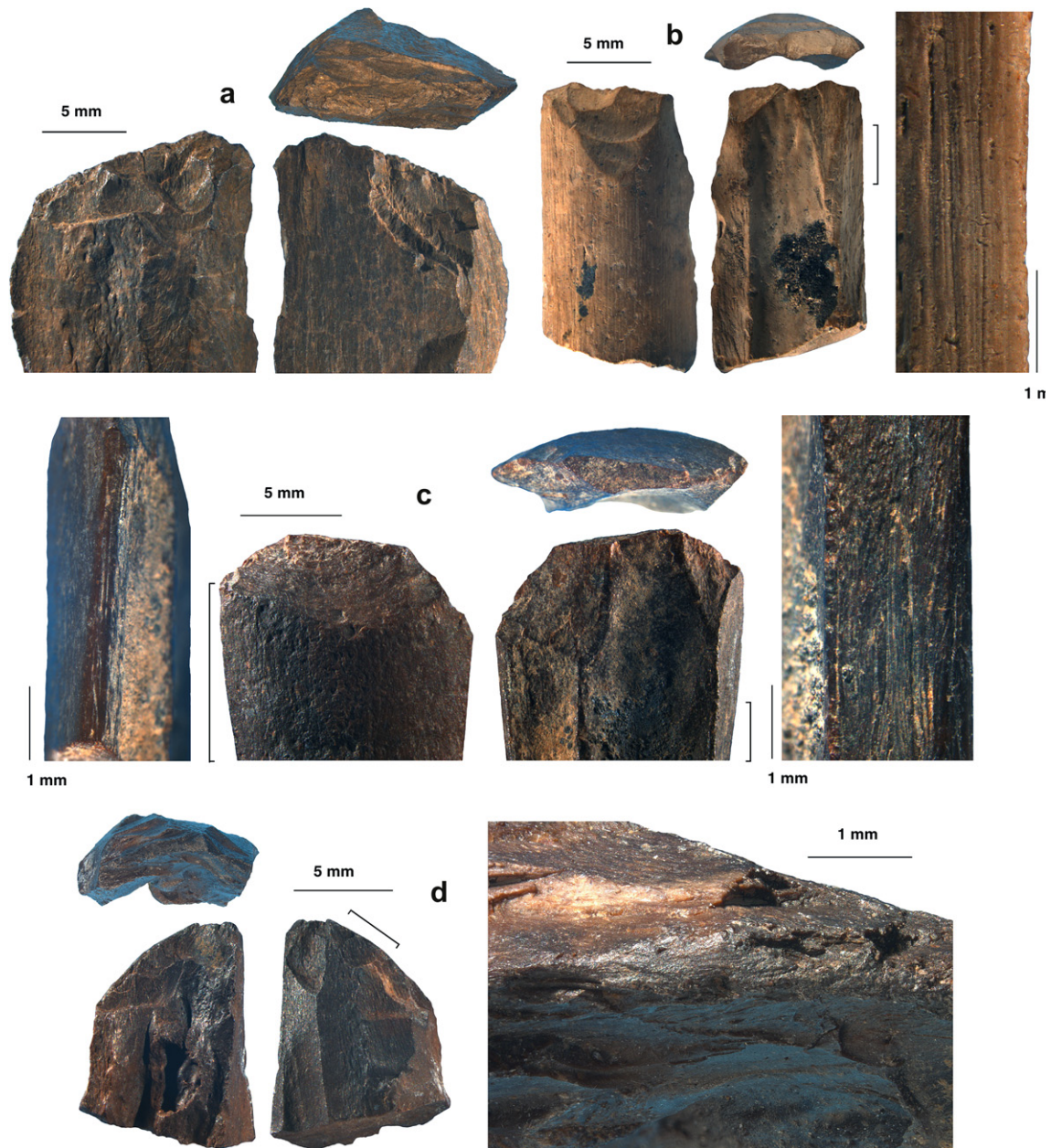


Fig. 9. Traces of modification and use recorded on bone tools from Post-Howiesons Poort (a), and Howiesons Poort (b–d) layers interpreted as *pièces esquillées*.

5. Discussion

Analysis of the enlarged bone artefact assemblage from Sibudu Cave significantly improves our knowledge of the origin of formal bone tool technology, specific bone tool types, the range of bone tool types associated with the MSA, the activities they were involved in, and synchronic and diachronic variations in the production of artefact types leading to the identification of patterns of regional continuity and discontinuity across and within technocomplexes. At present, the oldest evidence of the deliberate modification of bone for the purpose of shaping a tool comes from the early hominin sites of Swartkrans, Drimolen and Olduvai Gorge, dated to between 1 and 2 Ma (d'Errico and Backwell, 2003; Backwell and d'Errico, 2005). At Swartkrans and Drimolen this takes the form of marginal grinding to point or resharpen the tips of digging implements. At Olduvai it entails knapping to shape large bone flakes most likely used for butchery. None of the pieces

recovered from these sites, however, can be considered as “formal” bone tools, i.e. implements fully modified with techniques specific to bone material such as grinding, scraping or cutting. Three bone tools, a point or an awl, and two bone flakes bearing at one end bone polish due to use and striations produced by scraping, come from the Broken Hill deposits, which are tentatively attributed to the early MSA (Barham et al., 2002). The uncertain provenance of these objects within the Broken Hill cave system makes it difficult to draw definitive conclusions about their age, and significance. The barbed and unbarbed bone points from the Katanda sites in the Semliki Valley, Democratic Republic of the Congo, are at present the oldest known formal bone tools. The layer from which they originate has been attributed an age of ca. 90 ka (Brooks et al., 1995; Yellen et al., 1995). Although considered by some as possibly younger (Ambrose, 1998b; Klein, 1999, 2008), the more recent dating of the site confirms an old age, at least in excess of 60–70 ka, and certainly no younger than 50 ka (Feathers and Miglierini,

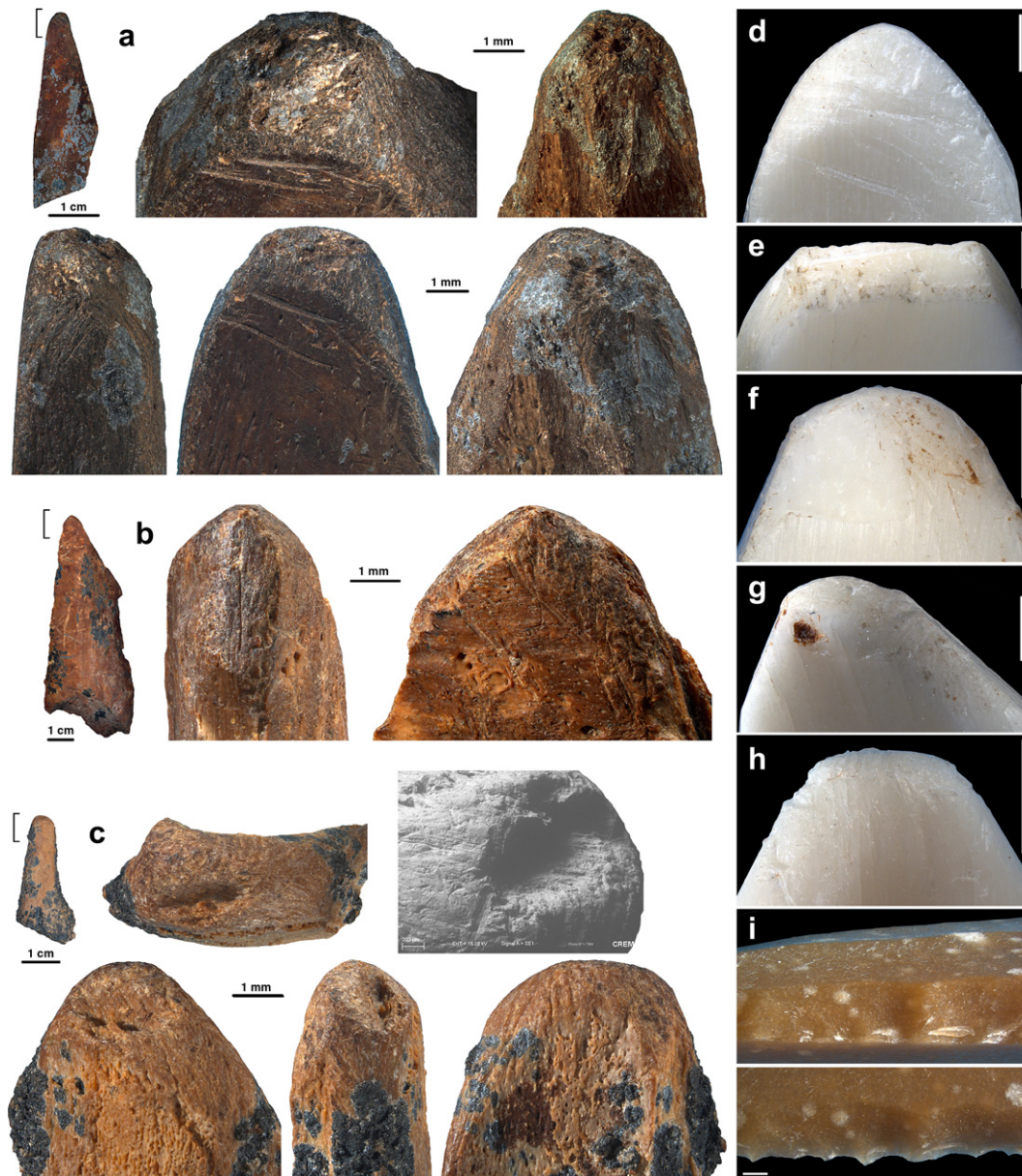


Fig. 10. Traces of modification and use recorded on bone tools from post-Howiesons Poort (a), and Howiesons Poort (b–c) layers interpreted as pressure flakers, compared to those produced experimentally in this task (d–h) to retouch lithics (i).

2001). Four awls were found at Blombos Cave in layers immediately underlying the SB horizons (M2 Phase, levels CG), and one in the upper M3 Phase (Henshilwood et al., 2002; d'Errico and Henshilwood, 2007). The discovery of a wedge-like implement in a Sibudu pre-SB layer (Fig. 4 n. 9) confirms the presence of formal bone tool production in southern Africa before the SB, and represents the earliest known example of an implement of this type. This is more-so considering that no bone tools are found at Sibudu in SB levels, which eliminates the possibility of migration from upper layers. By comparison with ethnographic examples, results of experimental replication, recorded use wear, and considering the sharpness of the functional area, this tool may have been used in a splitting activity, and applied to vegetal material such as wood or bark (LeMoine, 1997; Scheinsohn, 1997). This hypothesis, however, needs to be tested in the future using a dedicated experimental protocol. Although broadly similar in morphology, wedge-shaped pieces and the smoother from HP and post-HP layers (Fig. 2 n. 3; Fig. 3 n. 5; Fig. 4 n. 6 and 8) may have been used for a different

function, involving contact with a softer material associated with finer abrasive particles, another interpretation that requires further testing. The abundance of small animals and in particular duiker and small carnivores in the HP layers where these tools come from raises the possibility that they may have been used to process soft skins, as documented among Kalahari Bushmen (Lee, 1979; Yellen, 1991). The same applies to the four marginally shaped *pièces esquillées* from HP and post-HP layers. The oldest known lithic scaled pieces, variably interpreted in the literature as wedges or reduced cores, are found at Olduvai in Middle and Upper Bed II containing developed Oldowan assemblages (Jones, 1994), and in younger Acheulean, MSA and Middle Palaeolithic deposits (Hayden, 1980). They are present in the SB, HP, post-HP, and the final and late MSA layers at Sibudu (Wadley, 2005, 2007; Villa et al., 2005). The Sibudu specimens represent to our knowledge the first case of the production of this object in bone. The small size of some of these specimens, and the fact that they were deliberately shaped through scraping and reinforced through grinding after splintering of the

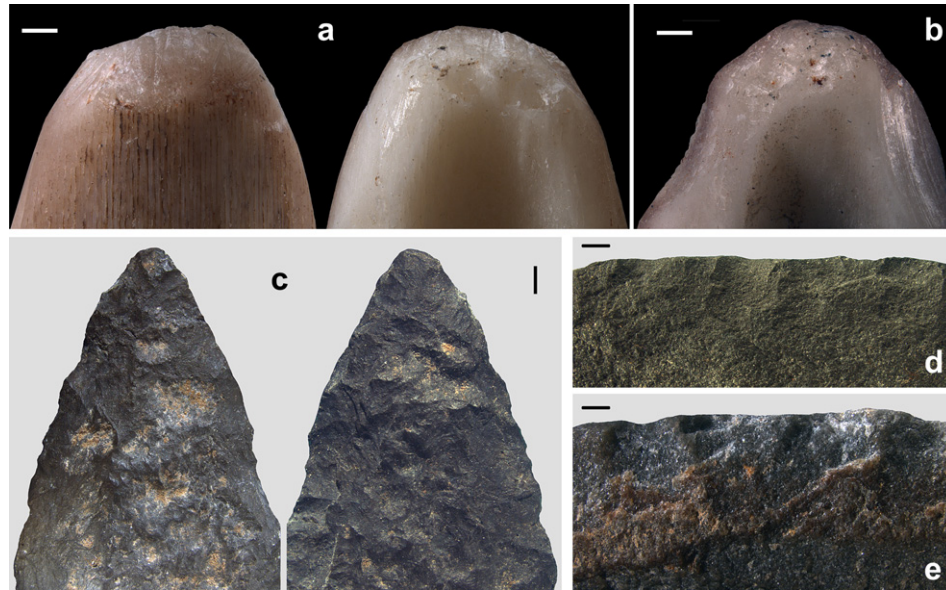


Fig. 11. Experimental pressure flakers made from an impala metacarpal, held with their broad aspect in contact with the lithic edge when used to retouch flakes of dolerite (a, showing both aspects) and hornfels (b); tip showing both aspects of a small bifacial point in a fine grained dolerite, produced with a pressure flaker made of an impala metacarpal (c); invasive retouch produced on the edge of a fine-grained hornfels (d) and coarse-grained dolerite (e) flake. Scales = 1 mm.

edge, suggests that their use is likely to have been similar to the use of the tool class called wedges, and do not represent waste products. Uniformity in bone width and thickness among the HP pieces suggests a task-specific use, perhaps one for which the use of bone was more effective than stone.

Traces of use recorded on Sibudu artefacts interpreted as pressure flakers are very similar to those produced experimentally by us and others (Nami and Scheinsohn, 1997). They also bear a striking similarity, at both morphological and microscopic scale, with the numerous tools of this type recently identified at San Antonio Bay, Patagonia, a coastal site dated to ca. 440 BP (Borella and Buc, 2009; Figs. 8–11). We believe this makes a strong case for our functional interpretation of these artefacts. The ethnographic literature documents pressure flakers of various sizes and stoutness of the active area. The more robust flakers are associated with the production of relatively large bifacial artefacts or blades, whereas the smaller forms are used to shape smaller lithic artefacts. The bone pressure flakers from Sibudu, which fall within the latter category, may have been used, perhaps in addition to other techniques, to shape small lithics such as the backed pieces characteristic of the HP in which layers they first occur.

Traditionally considered as an innovation taking place in Europe 20 ka, bifacial shaping of lithic projectile points by pressure flaking has been recently identified at Blombos Cave in Still Bay layers dated to 73 ka (Mourre et al., 2010). The tools used at Blombos to perform this activity remain, however, unknown. They may have not been made of bone considering that no evidence of such tools is found in the rich bone tool assemblage from Still Bay layers at this site (Henshilwood et al., 2001; d'Errico and Henshilwood, 2007).

The oldest known use of pressure flaking to produce bladelets is thought to occur in North East Asia, where it was applied to Yubetsu cores at sites as old as 35 ka (Inizan, 1991). The use of pressure to shape lithic projectile points is well attested (Aubry et al., 2006) during the Solutrean of France and Spain (23–17 ka). It has been suggested that this technique was also used earlier, to thin the base of Gravettian (28–24 ka) points on their ventral face (Bordes, 1974; Kozłowski and Lenoir, 1988). The identification of pressure flakers in a HP layer from Sibudu dated to >60 ka pushes back the first evidence of this finishing technique by at least 30,000 years.

Ambrose (2002) shows that HP blades are compatible with their being produced by indirect percussion. It is now necessary to explore what role pressure flaking played in HP lithic technology.

The enlarged bone tool sample confirms the presence of pointed implements in the HP layers and their absence from pre-SB and SB as well as post-HP deposits. The single pointed tool from the final MSA layer Co (Fig. 2 n. 1) is markedly different from HP specimens because of the sophisticated manner in which the blank was obtained. The new pointed tools from the HP layers are all awls. None of them conforms to the symmetry recorded on the artefact interpreted as a projectile point (Fig. 3 n. 6). Highly variable in bone type, size and robusticity, the HP awls suggest the use of piercing tools in a variety of tasks, and they likely represent only a small sample of the tools used in such activities at Sibudu during the HP.

Notches carved on pieces from post-HP and HP layers (Fig. 2 n. 2 and 4; Fig. 3 n. 7) and possibly on one piece from the pre-SB (Fig. 4 n. 10), cannot be reasonably interpreted as resulting from carcass processing due to the depth of the incisions, indicating that they were systematically produced by the to-and-fro movements of a cutting edge. Their location is different from that generally observed on butchered bone. In addition, comparison with butchery marks on similarly sized fragments from the same layers indicates that the regularity in distance between marks observed on these pieces is not found on cut-marked bone. Their fragility and the lack of use wear on these objects indicate, contrary to what has been suggested for notched artefacts from Klasies (d'Errico and Henshilwood, 2007), that they did not serve an obvious utilitarian function. Although their fragmentary state of preservation prevents analysis of the original pattern, a degree of intentionality is implied for at least two of the pieces (Fig. 2 n. 2 and 4). Considering that the same tool was sequentially used to produce the notches, an interpretation as a recording device based on the accumulation of marks through time is rejected for one of the pieces (Fig. 2 n. 4). The possible change of notching tool identified on the rib (Fig. 6a) leaves this possibility open for this object. However, the fragility of the bone on which the set of notches were cut makes such an interpretation unlikely when compared with Upper Palaeolithic objects interpreted as probable systems of notation (Marshak, 1972; d'Errico, 1998). A “decoration”, with

a degree of symbolic intent, represents the most reasonable explanation for these marks.

When observed in a broader context, the Sibudu bone tools begin to shed light on previously undetectable regional variations in bone tool technology and use. An apparent mismatch appears when comparing the cultural affiliation of sites based on lithics and the presence/absence of bone tools or the associated bone artefact types. Apart from Sibudu, no formal bone tools are known from other pre-Still Bay contexts in southern Africa. No bone tools are found in recently excavated SB layers at Sibudu and Diepkloof, but they do occur in abundance at Blombos from the very beginning of the SB, and a few perhaps from the preceding levels. Numerous bone tools are found in the HP and post-HP layers at Sibudu. They are absent, apart from four possible objects from Klasies, from the many HP sites excavated so far in southern Africa, including the recently and meticulously excavated site of Diepkloof. Other significant differences appear when considering the tool types represented. Pointed artefacts, awls or projectile points, represent virtually the only MSA bone tool type found outside of Sibudu, whereas at this site they account for less than half of the bone artefacts. The only exception, the stout notched pieces from Klasies HP layers interpreted as abraders, are so far a unique find. Sibudu bone tools are not only more varied in their conception, morphology, and the variety of tasks and material for which they were used, some categories such as splitting tools (scaled pieces, wedges) and smoothers are peculiar to this site, and straddle the HP and post-HP technocomplexes. Such a pattern cannot be attributed to preservation factors because well-preserved faunal assemblages were recovered from MSA sites with no bone artefacts. Raw material availability is also not a viable proposition as a large variety of animal size and type are recorded at MSA sites. Site function cannot account for these differences as many, if not all, of the MSA sites discussed were residential in nature, and therefore the place in which most of the subsistence and social activities were performed. Differences in available resources may of course have stimulated the creation of different bone tool traditions in different regions in response to local need, but we find the environmental explanation alone unsatisfactory. This does not explain why similar regional differences do not emerge in the lithic technology. Moreover, regional differences are now emerging in categories of material culture that are less linked to environment. Engraved ostrich eggshells are only found in the upper HP layers of Diepkloof (Texier et al., 2010) in spite of the abundance of this material at other HP sites, and engraved hematite fragments, abundant at Blombos, are absent in Diepkloof and Sibudu SB and pre-SB layers. Numerous shell beads are found at Blombos in the SB layers and at a number of sites in north Africa and the Near East, but none is recorded at Diepkloof in the same cultural horizons, and the few possible shell beads from Sibudu SB layers belong to a different taxon in spite of the availability at Sibudu of the species used at Blombos. The Katanda bone harpoons, exhibiting an unparalleled precocious technological sophistication in a different sub-Saharan region, probably reflect the same trend, i.e. the localised emergence and loss of a significant innovation. The above supports a scenario in which, beyond broad similarities in lithic technology, and in particular in hunting lithic armatures on which the definition of MSA technocomplexes has until recently been based, significant differences between regions and trends of continuity at a local scale emerge in other aspects of the technical system, and in the symbolic domain. Although it is premature to identify clear boundaries between regions it is reasonable to wonder what the mechanisms responsible for such a diversification are. Recent multi-agent based models (Powell et al., 2009) have highlighted the role of population size and cultural exchange rates in the spread, and maintenance of cultural innovations. When read in the light of these authors' predictions, the situation that we have depicted above may be

explained as an intermediate phase in which demographic increase and consequent innovations emerge. Some innovations are only maintained locally while others are disseminated over larger areas. This would happen either due to an unbalanced population size between regions, or because of insufficient cultural exchange between groups. It is also possible that other less quantifiable factors, not considered in their models, may have played a role in the southern African MSA. Different cultures have different attitudes towards innovations and the way in which they are shared and transmitted (Bar-Yosef and Belfer-Cohen, 2011). It is possible that in a number of instances, demographic increase was not always enough, or was not the main driving force for the maintenance of innovations. Factors such as social skills and learning practices, and the way they are transmitted and retained in distinct populations, may have been responsible for the variable pattern that we have brought to light.

6. Conclusion

In this paper we have shown that a number of bone tool types previously known only from the Upper Palaeolithic and more recent periods were manufactured and used at least 30,000 years earlier at Sibudu Cave. These tools appear to be part of a local tradition because many of them are absent at contemporaneous or more recent southern African sites. Attention of most researchers working on the African MSA has been focussed on the modern/non-modern behaviour debate, and insufficient effort has been put into documenting, in detail, regional material cultural differences and their evolutionary trends, and into understanding the role of this variability in the creation of modern cultures. The archaeological record is revealing a complexity that prevents evaluation of the modern character of MSA cultures in antinomic terms and, at the same time, this opens the door to questions that are more interesting. We argue here that it is the detailed analysis of cultural variation that enables us to test current models for the origin of modernity, and will contribute in the long run to explaining how and when crucial cultural innovations became established in human history.

Acknowledgements

We thank William Banks for participating in the pressure-flaking experiment and Dominique Armand, Thierry Aubry, Natacha Buc, Michèle Julien, Michel Lenoir, Pat Shipman, and Joao Zilhão for helpful discussions and constructive comments. Amafa/Heritage AkwaZulu Natali issued a permit to use eight lithics found out of context to conduct knapping experiments. We acknowledge financial support from the European Research Council (FP7/2007/2013)/ERC Grant TRACSYMBOLS n°249587), the PROTEA programme of the French Ministry of Higher Education and Research, the National Research Foundation of South Africa, the University Research Council of the University of the Witwatersrand, the Institut Français d'Afrique du Sud, and the Project Origine II of the Aquitaine Region.

Appendix. Supplementary material

Supplementary data associated with this article can be found, in the online version, at [doi:10.1016/j.jas.2012.01.040](https://doi.org/10.1016/j.jas.2012.01.040).

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