Hunting with Howiesons Poort segments: pilot experimental study and the functional interpretation of archaeological tools

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ABSTRACT

For many decades the use of backed pieces from the Howiesons Poort, between about 70 ka and 55 ka ago, in South Africa has been a point of discussion. Recently direct evidence has been provided to associate these tools with Middle Stone Age hunting strategies. Yet, whether they were used to tip hunting weapons or as barbs remained an open question. In this paper we introduce a set of pilot experiments designed to test the effectiveness of Howiesons Poort segments, the type fossils of the industry, hafted in four different configurations as tips for hunting weapons. It is shown that the morphological type can be used successfully in this way. We present the results of a macrofracture analysis conducted on the experimental tools and compare these to results obtained from three Howiesons Poort backed tool samples. By correlating experimental outcomes, macrofracture data and the interpretation of micro-residue distribution patterns, we provide some insight into the functional variables that might be associated with Howiesons Poort segments.

1. Introduction

Few stone tool categories have received as much attention as the backed tools from the Howiesons Poort Industry in South Africa. From early on they were considered unusual. Initially, the backed tools drew attention because they seemed so similar to Later Stone Age and Upper Palaeolithic artefacts, but appeared much earlier in the archaeological sequence (e.g. Deacon, J., 1995). When debates about the origins of modern human behaviour became increasingly relevant, they were studied in terms of their symbolic or stylistic potential (e.g. Deacon, 1989; Wurz, 1999). Recently, a series of studies was launched to generate evidence about the functions and hafting technologies associated with Howiesons Poort segments, the backed tool category that is considered the type specimen for the industry (e.g. Delagnes et al., 2006; Gibson et al., 2004; Lombard, 2005a, 2006, 2007a, 2008; Pargeter, 2007; Wurz and Lombard, 2007).

This paper continues along this line of investigation, combining archaeological use-trace evidence with new macrofracture data from experimental work. We build upon previous interpretations of these tools as insets in composite (hafted) hunting weapons. As our methods are chosen explicitly to explore and assess this particular function we do not exclude the possibility that segments were also used for other activities. In fact, it is most likely their functional flexibility that contributes to the repeated appearances of similar blade-based technologies across the globe over the last 300 ka or so (Barham, 2002; Bar-Yosef and Kuhn, 1999; Bleed, 2002; Elston and Brantingham, 2002; Hiscock, 2002; Lombard and Parsons, in press; Marean et al., 2007; McDonald et al., 2007; Mitchell, 1988, 1995; Soriano et al., 2007; Wadley, 1996, 2005).

Increasing interest in Middle Stone Age hunting technologies and their role in modern or complex human behaviour stimulate discussions around all tool types that could have been used in weapon systems. One of the debates centres on the origins and antiquity of projectile weaponry, where weapons are not hand-delivered (spears), but projected with the aid of spear throwers or bows (darts and arrows) (e.g. Brooks et al., 2006; McBrearty and Brooks, 2000; Shea, 2006; Villa and Lenoir, 2006). Because of their morphology and/or the uncertainty about whether Howiesons Poort segments were used to tip hunting weapons or not, these tools are often excluded from morphometric studies concerned with the evolution of hunting technologies (e.g. Brooks et al., 2006; Shea, 2006). Our methods are not yet suitable to generate convincing evidence for or against either interpretation. However, with this paper we aim to provide and discuss some evidence that suggests Howiesons Poort segments could have been used to tip hunting weapons, and that stone-tipped hunting technology during this phase was variable and adaptable.
It has always been assumed that backed artefacts from the Holocene were hafted as parts of weaponry (e.g. Bocquentin and Bar-Yosef, 2004; Clark, 1977; Clark et al., 1974; Crombé et al., 2001; Nuzhnyi, 2000; Phillipson, 1976; Wadley, 1987). Previous experiments with backed microliths similar to those of the Eurasian Mesolithic have shown them to be useful when used to tip and/or barb hunting weapons (e.g. Barton and Bergman, 1982; Crombé et al., 2001). Conversely, an experiment by Binneman and Hall with replicated San (ethnographic hunter-gatherers) bows and arrows, where segments were hafted transversely or end-on, showed them ineffective for penetrating a calf carcass (Binneman, 1994). Seeing that most ideas about the possible uses of Howiesons Poort segments have been based on Later Stone Age/San ethnographic examples, the question of whether these segments could have been used successfully to tip hunting weapons remained open-ended. The Pargeter (2007) experiments are the first to focus specifically on testing whether Howiesons Poort-like segments, hafted in a variety of positions can be used effectively to tip hunting weapons. The resulting macrofractures therefore represent the first modern reference sample that is directly relevant to the study of Howiesons Poort segments that could have been used in this way.

2. A short background to the Howiesons Poort of South Africa

Lombard (2005b) provided a full review of research conducted since the Howiesons Poort was first identified elsewhere. Here we briefly highlight the most relevant points concerning the industry, its evolutionary themes and dating. The Howiesons Poort is characterised by a blade-based technology and found primarily in sub-Saharan Africa south of the Limpopo River (Fig. 1). The label was first used by Stapleton and Hewitt (1927, 1928) to describe a stone artefact assemblage from a small rock shelter in the Eastern Cape. They gave the main characteristics for the “Howiesons Poort Series” as the presence of burins, large segments, obliquely pointed blades, and trimmed points. However, the Stapleton and Hewitt assemblage is probably from a mixed context as more recent excavations at stratified sites show that points are absent or rare during the Howiesons Poort, and that the technocomplex is rather characterised by its distinctive backed pieces such as segments (also referred to as crescents or lunates) and trapezes made on blades (Singer and Wymer, 1982; Deacon, H.J., 1995; Deacon, J., 1995; Deacon and Wurz, 1996; Wadley, 2005, in press; Wurz, 1999, 2000, 2002).

The industry has been recorded at more than 20 sites in South Africa, a number of which have been comprehensively dated (Feathers, 2002; Grün et al., 1990; Grün and Beaumont, 2001; Miller et al., 1999; Parkington, 1999; Tribolo et al., 2005; Valladas et al., 2005; Vogel, 2001; Wadley and Jacobs, 2006). Age calculations obtained from various dating methods applied to samples from Border Cave, Klasies River, Rose Cottage Cave and Diepkloof point to the placement of Howiesons Poort assemblages firmly within the period of 70 ka to 60 ka ago. Recent thermoluminescence data support this consensus, indicating that the Howiesons Poort appeared about 70 ka ago and that it was still in use at 54 ka ago at sites such as Rose Cottage Cave (Valladas et al., 2005).

The age of the industry, its similarities to Holocene backed tool industries, and the use of unusual raw materials resulted in far-reaching behavioural hypotheses concerning the origins of human modernity (Lombard 2005b). Some of these models discuss aspects such as mobility patterns, gift exchange, symbolic behaviour, technical conventions and the origin of San languages (e.g. Ambrose, 2006; Ambrose and Lorenz, 1990; Deacon, 1989, 1992; Deacon, H.J., 1995; Deacon and Shuurman, 1992; Deacon and Wurz, 1996, 2001, 2005; Minichillo, 2006; Wurz, 1999). Most recently, hunting technologies other than those based on stone tools are tentatively associated with the Howiesons Poort. Faunal data from Sibudu Cave indicate a predominance of the small blue duiker (Philantomba monticola) in the Howiesons Poort assemblage, suggesting the use of traps to capture these small antelope (see Clark and Plug, in press; Wadley, 2006), and an argument for a bone-tipped bow-and-arrow technology at the site during the same period was presented recently (Backwell et al., 2008).

3. The experiments

It has long been acknowledged that not all variables can be tested with a single set of experiments, and that controlled experiments are most useful when variables are limited in order to isolate and address specific questions (e.g. Ingersoll and Macdonald, 1977; Mathieu, 2002; Odell and Cowan, 1986; Shea et al., 2002). Within this paradigm, Pargeter’s work (Pargeter, 2006, 2007) represents the pilot study in a series of experiments that will each seek to address specific questions regarding the use and hafting of backed tools from the Howiesons Poort. Shea (2006: 841) indicates that most researchers who have discussed Middle Stone Age backed pieces as possible weapon armatures have proposed they were mounted as barbs on the sides of spears and other weapons, rather than on the tip. Nevertheless, use-trace studies indicate that at least some pieces could have been used to tip hunting weapons and that there could have been variability in the preferred hafting configurations of such weapons (Lombard, 2005a, 2008; Wurz and Lombard, 2007).

Thus, for the purposes of this study we are not concerned with variability in aspects such as raw materials, velocity, weight, angle of impact or the stopping power of targets. Rather, the experiments were designed explicitly to investigate whether segments, hafted in four different configurations, could function effectively as tips for hunting weapons, and to provide some initial macrofracture data. Sylvain Soriano prepared 33 flint segments that were used to construct 27 hunting weapons. This is an average sample size for experimentation with a single morphological type used for a single function, and proved adequate for testing the effectiveness of the different hafting configurations. Although the sample size is too small for the statistical analysis of macrofracture frequencies, the initial macrofracture data raised interesting questions with regard to the interpretation of some archaeological pieces, and some of these aspects will be explored and assessed during future experimentation.

Fig. 1. Archaeological sites with the Howiesons Poort mentioned in the text.
The morphological characteristics of the replicated segments are comparable to Howiesons Poort backed tools excavated from sites such as Sibudu Cave, Rose Cottage Cave and Klasis River Cave. They are thus suitable for establishing whether Howiesons Poort segments, as a distinct morphological type, can be used effectively to tip hunting weapons. The segments were glued into slotted and weighted pinewood shafts in four different hafting positions. These positions included longitudinal \( (n = 7) \) (Fig. 2a), transverse \( (n = 7) \) (Fig. 2b), diagonal \( (7 = 1) \) (Fig. 2c), and back-to-back hafting \( (n = 6) \) (Fig. 2d). The weapons were launched at a suspended impala (Aepyceros melampus) carcass using a machine built for this purpose. In this way variations in load, velocity and angles of delivery that can be expected during hand delivery was controlled (e.g. Shea et al., 2002). The weapons were each fired into the carcass ten times or until they became unusable. This was done to assess the robustness of the hafting configurations, and because it is likely that hunters would have re-used undamaged weapons until they needed re-hafting or became too damaged for effective use. For the full description and protocol of the experiments we refer to Pargeter (2007).

The 27 weapons were shot into the carcass 167 times. Eighty-five percent of the weapons were considered successful as they penetrated the target's hide and flesh. Of these successful weapons, 33% penetrated deep into the carcass (\( \geq 30 \text{ mm} \)), and a further 33% of these penetrations could have damaged vital organs. The remaining successful weapons caused less severe damage to the animal's hide or flesh. Only 15% of the replicated weapons were unable to penetrate the target. Thirty-seven percent of the weapons survived all ten shots. The various hafting configurations showed slight differences in success rates. Of the seven weapons hafted longitudinally, six successfully penetrated the carcass. The seven transversely hafted weapons lacerated, rather than penetrated the animal's hide and flesh. Three of these penetrated somewhat, but the other four deflected off the animal causing cuts to the hide and tissue. Although such wounds would not kill or cripple an animal, they are sufficient to create a blood trail for tracking down wounded prey or introducing poison into the bloodstream.

Five diagonally hafted weapons successfully pierced the animal's hide and flesh. The slicing action of the diagonal cutting edge caused deep penetrations and relatively wide lacerations. The depth of the cuts in combination with the barbs lodged these weapons firmly in the carcass (Fig. 3). Of the six back-to-back hafted weapons five penetrated the carcass's hide and flesh. Again, the slicing action caused by the cutting edges of the segments proved to be very effective. These weapons created large gaping wounds in the carcass (Fig. 4). Although we do not consider these experimental results as direct evidence for the interpretation of archaeological material, we believe that they clearly indicate that Howiesons Poort-type segments, hafted in various positions, could function successfully as tips for hunting weapons. In order to start building a comparable database we conducted a macrofracture analysis on this first experimental sample.

4. Macrofracture analysis

4.1. Background

Many fractures on archaeological tools no doubt resulted accidentally, but some fractures are the result of use (Barton and Bergman, 1982; Bergman and Newcomer, 1983; Moss and Newcomer, 1982; Shea, 1988). There is a wide degree of variation in fracture patterns (combinations of fracture types and positions) associated with impact damage because hunting weapons are subject to a wide range of targets, velocities, angles of impact and fracture initiations (e.g. Odell, 1981). Thus, even though “typical patterns” cannot always be reliably defined, there are certain aspects of fracture mechanics that can allow the elimination of other causes (Odell, 1981; Dockall, 1997). For example, when isolated, some fracture types produced by impact have certain traits that distinguish them from those caused under other circumstances (Geneste and Plisson, 1993; but also see Shea et al., 2002).

In order to establish a tightly defined and replicable analytical method, and to build a directly comparable database, we closely follow Fischer et al. (1984). They conducted experiments to isolate and define types of fractures that could be considered diagnostic for impact use of stone-tipped hunting weapons. The term “diagnostic impact fracture” (DIF) refers to evidence for impact use in the form of fracture types that could hardly have originated in any other way than through forceful longitudinal collisions (Fischer et al., 1984). These wear traces are also diagnostic of the fracture mechanics of brittle solids subjected to both static and dynamic loadings (Cotterell and Kamminga, 1987).

Many other researchers have conducted hunting experiments with stone tools and have discussed resulting fractures (see Dockall, 1997 and references therein), and although terminology frequently differs, it seems that the formation of the fracture types is similar regardless of the type of hunting experiment (Dockall, 1997).
spin-off fractures can have considerable dimensions (only one broad side to a limited extent. But on artefacts used as the dorsal and ventral sides of the objects will result in spin-offs on 1984). Bending fractures that result from pressure perpendicular to bending fractures from which ‘spin-offs’ initiate (see Fischer et al., 1984). These fractures usually occur along either one of the lateral edges (Barton and Bergman, 1982; Bergman and Newcomer, 1983). They are difficult to distinguish from intentional burination, but usually lack the negative bulb of percussion at the burin initiation or Herzian ripples usually associated with intentional removals (Lombard et al., 2004; Paola Villa, pers. commun., 2004). Dockall (1997) describes these fractures as lateral macrofractures, and reports that it was documented on several experimental samples used to replicate hunting activities and many archaeological samples associated with hunting (see Dockall, 1997: 326). We are unaware of such fractures having been recorded in association with other use-related activities. Other fracture types that occur on broken stone tools such as snap terminating and hinge or feather terminating bending fractures are recorded and presented in the data. These fracture types could result from impact-use, but have also been recorded as a result of trampling or accidental breakage and are therefore not considered unambiguous evidence for stone-tipped hunting weapons.

We follow Fischer et al. (1984), using only the four DIF types (step terminating bending fractures, unifacial spin-off fractures ≥ 6 mm, bifacial spin-off fractures and impact burination) as analytical criteria. Some adaptations have been made to the Fischer et al. (1984) method in an effort to further reduce the margin of interpretative error on archaeological samples. For example, flakes manufactured using the bipolar technique are exposed to forces similar to those that tips of hunting tools are exposed to. Odell and Cowan (1986) addressed this problem, and established the major differences between use-impact fractures and bipolar knapping fractures, the most important being that the location of bipolar damage coincides with other knapping characteristics. Normally these traces are not located along the distal ends of the piece, and are not in association with a usable sharp tip or edge that could have functioned as the business end of a hunting tool (Odell and Cowan, 1986). Therefore, DIFs occurring in close association with striking platforms, ripples and bulbs of percussion are not included in the data. During the analysis of archaeological samples, consideration is also given to the morphology of the pieces, and whether the tools could have been used for other impact functions such as chopping (Fischer et al., 1984).

Fischer et al. (1984) showed that the morphology of the stone pieces did not affect the fracture types that developed as a result of hunting use. DIFs were recorded on 39% of their experimental arrowheads, ranging from transverse to acutely angled in shape, and 55% of the points that were used as tips for throwing spears. A large number of prehistoric flint points from various sites, differing in age, size and shape, also displayed DIFs, suggesting that the defined characteristics of impact function are universal for stone tips of flint and related raw materials (Fischer et al., 1984). Experiments conducted with convergent flakes made from South African raw materials, and with considerable variation in proportions, demonstrated that local stones of various grain sizes and dimensions develop similar frequencies of DIFs (57%) when all the pieces were used as stabbing or throwing spears (see Lombard et al., 2004). The seeming differences between DIF frequencies from experimental samples that have been hand-delivered (55–57%) and those that were used as projectiles (30–40%) could possibly indicate variation between the two weapon systems. While this might be a future possibility we are, however, not confident that the current data can be used in this way. Continued experimentation with this question in mind is needed.

4.2. Method

The simplest DIFs are step terminating bending fractures. These result from longitudinal pressure from the distal and proximal ends of the objects. In the case of occasional damaging processes, such as trampling, bending fractures will initiate by means of transverse pressure more or less perpendicular to the dorsal and ventral sides of the objects. Probably the most easily recognisable DIFs are bending fractures from which ‘spin-offs’ initiate (see Fischer et al., 1984). Bending fractures that result from pressure perpendicular to the dorsal and ventral sides of the objects will result in spin-offs on only one broad side to a limited extent. But on artefacts used as impact tools, where the forces run parallel to the broad sides, the spin-off fractures can have considerable dimensions (≥ 6 mm), and long spin-offs can occur on one, or even both, sides. Spin-off fractures on both sides, initiating from the same bending fracture, can in practice occur in hardly any other way than through use as a hafted impact implement. This type of fracture is therefore considered diagnostic for impact use, irrespective of the dimensions of the fractures (for further fracture definitions and illustrations see Fischer et al., 1984; Ho Ho Committee, 1979).

Another fracture associated with impact use sometimes resembles the effect of a burin blow (pseudo burination or impact burination). These fractures usually occur along either one of the lateral edges (Barton and Bergman, 1982; Bergman and Newcomer, 1983). They are difficult to distinguish from intentional burination, but usually lack the negative bulb of percussion at the burin initiation or Herzian ripples usually associated with intentional removals (Lombard et al., 2004; Paola Villa, pers. commun., 2004). Dockall (1997) describes these fractures as lateral macrofractures, and reports that it was documented on several experimental samples used to replicate hunting activities and many archaeological samples associated with hunting (see Dockall, 1997: 326). We are unaware of such fractures having been recorded in association with other use-related activities. Other fracture types that occur on broken stone tools such as snap terminating and hinge or feather terminating bending fractures are recorded and presented in the data. These fracture types could result from impact-use, but have also been recorded as a result of trampling or accidental breakage and are therefore not considered unambiguous evidence for stone-tipped hunting weapons.

4.3. Results

Of the replicated segments used in this experiment (n = 33), 30 tools were analysed for macrofractures. The remaining three were unusable because of severe fracturing in the carcass. This observation may account for the presence of many broken stone tool fragments excavated from archaeological sites associated with the processing and consumption of hunted prey. Also, it might be of interest to note that even though stone tips or insets are prone to such severe fracturing, some ethnographically-known hunters believe that they are more lethal when they break up in the prey as the fragments increase tissue damage and bleeding (e.g. Rudner, 1979).

Forty percent of the analysed pieces developed DIFs and many more had non-diagnostic fractures. While the non-diagnostic
fracture types are not indicative of hunting on their own, when combined with the DIFs recorded in this analysis, they represent a useful indication of fracture patterns that might occur on stone tipped hunting weapons. Table 1 provides the results of the detailed macrofracture analysis according to hafting configurations summarised below:

- One longitudinally hafted segment developed an impact burination.
- Two transversely hafted pieces also developed impact burinations, while two smooth, semi-circular notches developed on the cutting edge on one of these tools (Fig. 5a).
- Five segments hafted back-to-back developed DIFs in the form of impact burinations (Fig. 5b), unifacial spin-off fractures >6 mm (Fig. 5c), and a step terminating fracture (Fig. 5d).
- The diagonally hafted segments developed the highest DIF frequencies (66%), three of which are impact burinations (Fig. 5e). One of the impact burinations has an associated unifacial spin off fracture >6 mm (Fig. 5f).

These results verify previous conclusions that DIFs develop on stone tools used to tip hunting weapons regardless of raw material, tool morphology, dimension or mode of delivery. Macrofracture results obtained from archaeological samples such as Howiesons Poort segments can thus be compared successfully with results from other tool types and industries to generate comparable data for hunting technologies and their associated behaviours across time and space (e.g. Lombard, 2007b). The frequencies of impact burination on the experimental tools, and the development of smooth, semi-circular notches on one of the transversely hafted segments have implications for the interpretation of archaeological assemblages and deserve some consideration.

5. Discussion

5.1. Impact burination and impact notching

The experimental sample shows a relatively high frequency of impact burination (26%). Impact burination were documented on 4% of the backed tool sample from Sibudu Cave (n = 132), 10% on the sample from Umhlatuzana (n = 101) and only 2% of the sample from Klasies River Cave 2 (n = 85) (Table 2) (Fig. 6c, f). This could be due to the fact that all of the experimental tools were shot into the carcass multiple times, testing them towards the upper limits of their stress tolerance. Therefore, they could have developed such fractures more frequently than the archaeological samples, some of which may also have been used as barbs, cutting insets, functions other than hunting or not used at all. It is further possible that nuances in DIF type frequencies may reflect aspects of variables such as haft weight, velocity of delivery, angle of impact and resistance on impact. For example, impact burination has been attributed to a direct hit on a hard object (Bergman and Newcomer, 1983; Shimelmitz et al., 2004). This would be consistent with Pargetter’s experiment where the weapon launcher was placed in a direct line with the unmoving carcass and all weapons were launched from the same spot resulting mostly in direct hits into the ribcage of the animal. Of course, real hunting scenarios are more variable, and will therefore probably result in different combinations and frequencies of DIF types.

Segments with burination from the Howiesons Poort layers at Diepkloof are interpreted as having been handheld and used to score the surfaces of ostrich eggshell water containers (Parkington et al., 2005). It is not clear whether the removals on the Diepkloof segments have characteristics indicating intentional burination, or whether impact burination was considered. Even though there now exist multiple strands of evidence that some segments at other Middle Stone Age sites were hafted and used in hunting weapons (Lombard, 2005a, 2008; Wurz and Lombard, 2007), we encourage consideration of multi-faceted explanations. For example, where negative bulges of percussion are lacking, pieces damaged during hunting could have been employed subsequently to mark the surfaces of other materials. Use-trace analyses should be able to give a glimpse into such recycling behaviour practiced in the past. This could add interesting dimensions with regard to behavioural comparisons between contemporaneous groups who had access to resources such as ostrich eggshells (e.g. Diepkloof, Western Cape),

Table 1

<table>
<thead>
<tr>
<th>Fracture types</th>
<th>Vertical (n = 6)</th>
<th>Horizontal (n = 7)</th>
<th>Back-to-back (n = 11)</th>
<th>Diagonal (n = 6)</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step terminating</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Bifacial spin-off</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Unif. Spin-off &gt; 6 mm</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Impact burination</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Unif. Spin-off &lt; 6 mm</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Snap terminating</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Hinge/feather term.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Impact notching</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Note that more than one diagnostic impact fracture can occur on a single tool, therefore DIF frequencies do not necessarily correlate to the number of tools with diagnostic impact fractures.
Table 2
Results of the experimental sample compared to the results obtained for three archaeological samples from Howiesons Poort contexts

<table>
<thead>
<tr>
<th>Fracture types</th>
<th>Pargeter experiments (n = 30)</th>
<th>Sibudu Cave HP (n = 132)</th>
<th>Umhlatuzana HP (n = 101)</th>
<th>Klasies River Cave 2 HP (n = 85)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n %</td>
<td>n %</td>
<td>n %</td>
<td>n %</td>
</tr>
<tr>
<td>Step terminating</td>
<td>1 3</td>
<td>13 10</td>
<td>15 14</td>
<td>12 14</td>
</tr>
<tr>
<td>Bifacial spin-off</td>
<td>0 0</td>
<td>6 4.5</td>
<td>0 0</td>
<td>2 2</td>
</tr>
<tr>
<td>Unif. spin-off &gt;6 mm</td>
<td>3 10</td>
<td>9 7</td>
<td>0 0</td>
<td>2 2</td>
</tr>
<tr>
<td>Impact burination</td>
<td>8 26</td>
<td>5 4</td>
<td>10 10</td>
<td>2 2</td>
</tr>
<tr>
<td>Unretouched notches</td>
<td>2 7</td>
<td>5 4</td>
<td>4 4</td>
<td>No rec.</td>
</tr>
<tr>
<td>Unif. spin-off &lt;6 mm</td>
<td>0 0</td>
<td>9 7</td>
<td>1 1</td>
<td>No rec.</td>
</tr>
<tr>
<td>Snap terminating</td>
<td>6 20</td>
<td>51 39</td>
<td>42 42</td>
<td>24 28</td>
</tr>
<tr>
<td>Hinge/feather term.</td>
<td>3 10</td>
<td>21 16</td>
<td>3 3</td>
<td>3 4</td>
</tr>
<tr>
<td><strong>Tools with DIFs</strong></td>
<td><strong>12 40</strong></td>
<td><strong>29 22</strong></td>
<td><strong>24 24</strong></td>
<td><strong>18 21</strong></td>
</tr>
</tbody>
</table>

and those who occupied environmental niches where such resources were absent (Sibudu, KwaZulu-Natal), but, none the less used similar stone tool industries.

An unexpected outcome relates to the development of the semi-circular impact notches on one of the experimental pieces. Notches are often observed on backed tools from the Howiesons Poort, and sometimes they are intentionally retouched (Singer and Wymer, 1982; Wurz, 2000). Some segments from Sibudu Cave and Umhlatuzana, however, also have smooth (un-retouched), semi-circular notches similar to those documented on the experimental tool (Fig. 6a,b,e). On the Sibudu sample subjected to microresidue analysis, combinations of bone, fat, collagen and animal tissue residues were documented in close approximation to the notches on five tools, supporting a hunting hypothesis. While intentionally retouched notches could have been used for functions such as shaping bone or wood points and shafts, Pargeter’s experiments show that smooth notches could also develop inadvertently as a result of impact. As in the case of impact burination, we are not aware that impact notching has previously been described as a use-trace or a result from trampling. Future experimentation will investigate these possibilities. Again, we propose that intentionally manufactured notches will probably display small negative bulbs of percussion or Herzian ripples, analogous to retouch scars, while impact notches lack them. It is not yet apparent whether these notches are similar to those recorded as “simple notches” on tools from European Middle Palaeolithic sites such Combe Geral, La Quina, Combe-Capelle and Pech de l’Azé (Hiscock and Clarkson, 2007; Holdaway et al., 1996).

5.2. Variability in Howiesons Poort hunting technology

When compared to the macrofracture results from Pargeter’s and other experiments, percentages for Howiesons Poort backed tool samples from Sibudu Cave, Umhlatuzana and Klasies River Cave 2 with DIFs seem relatively low—between 21% and 24% (Table 2). This is well within the range documented on European archaeological samples consisting of points or transverse artefacts from the Holocene known to have been used as weapon tips (Fischer et al., 1984). The Howiesons Poort archaeological samples included all the backed pieces, whole and broken, from the assemblages, as segment fragments are not always distinguishable from other broken backed pieces. Independent hunting experiments conducted with microliths comparable to those from the European Mesolithic might provide further explanation for the observed pattern. During these experiments conducted by Crombé et al. (2001), geometrically-shaped pieces such as segments, triangles and obliquely truncated points were used as barbs while microlithic points were used to tip arrows shot into sheep cadavers with a bow. More than 30% of the tools used as projectile tips developed DIFs as a result of these experiments. Segments and triangles used exclusively as barbs, however, showed a low frequency of diagnostic impact fractures, only about 5% (Crombé et al., 2001).

Based on (a) the micro-residue and use-wear data from Sibudu Cave segments (see below and Lombard, 2008), (b) the macrofracture results from Sibudu, Umhlatuzana and Klasies River, and (c) Pargeter’s experiments demonstrating that segments, as a morphological type, are functionally effective as tips for hunting weapons, we suggest that segments were part of the Howiesons Poort hunting technology. Even though it cannot be expected that DIFs will form as a constant, the relatively low macrofracture frequencies might indicate that some of these tools could have functioned as cutting insets or barbs along the shafts of weapons or as insets in composite tools used for other tasks. This interpretation is supported by the low frequencies of DIFs (5%) recorded on segments used as barbs (Crombé et al., 2001), and other observations that seem to indicate that fractures usually associated with hunting...
often expendable (Bamforth and Bleed, 1997). Weapon systems or weapons are composite tools in which the stone component is prepared and stockpiled in anticipation of use. Stone-tipped tools (Shea et al., 2002). Tools used as daggers, butchery knives or chisels, or on trampled (but not necessarily DIFs) develop in much lower frequencies on cutting plant material have previously been suggested (Deacon, J., however, rule out multi-functionality for backed tools from the component comprising resin or gum, often associated with ochre (Lombard, 2008). In contrast, plant residues are concentrated on distinct and it is possible that some tools were hafted to bone (Lombard, 2008). In contrast, plant residues are concentrated on the backed portions of the segments, with 67% of the plant residue component comprising resin or gum, often associated with ochre (Lombard, 2007a). Additional use traces on the Sibudu sample, such as striations, polish, micro-damage to tool edges and edge rounding, show little indication of cutting, sawing or scraping. We do not, however, rule out multi-functionality for backed tools from the Howiesons Poort. Functions such as knives and implements for cutting plant material have previously been suggested (Deacon, J., 1995; Wadley and Binneman, 1995).

The distribution patterns of fatty and bone residues were less distinct and it is possible that some tools werehafted to bone (Lombard, 2008). In contrast, plant residues are concentrated on the backed portions of the segments, with 67% of the plant residue component comprising resin or gum, often associated with ochre (Lombard, 2007a). Additional use traces on the Sibudu sample, such as striations, polish, micro-damage to tool edges and edge rounding, show little indication of cutting, sawing or scraping. We do not, however, rule out multi-functionality for backed tools from the Howiesons Poort. Functions such as knives and implements for cutting plant material have previously been suggested (Deacon, J., 1995; Wadley and Binneman, 1995).

The distribution patterns of the micro-residues associated with hafting provided evidence for variability in hafting configurations. Two main clusters of hafting configurations could be identified. The first cluster represents tools with adhesive residues recorded all along the backed portions that could have been hafted transversely, back-to-back or longitudinally. The second cluster represents tools with adhesive residues restricted to one end of a tool. These tools could have been hafted end-on or in diagonal positions. During the oldest Howiesons Poort layer (PGS) at Sibudu, where segments were mostly made on hornfels and quartz and are generally smaller than during the younger layers, people seem to have preferred longitudinal, transverse or back-to-back hafting configurations. During the intermediate layers (GS and GS2) there seem to have been a shift towards diagonal or end-on hafting configurations, with no seeming preferences and a higher degree of variability during the youngest layers (GR and GR 2) (Lombard, 2008; Wadley, in press).

Wadley and Mohapi (Wadley, in press; Wadley and Mohapi, 2008) showed that the tip-cross-sectional area (TCSA) values (see Shea, 2006 for method) for Howiesons Poort segments from Sibudu Cave places them in the range of ethnographically known North American arrowheads. However, if we assume that some were hafted transversely there are differences in the TCSA values for the different morphometric groups that are correlated to raw materials. The short, deep and robust quartz segments, mostly present in the oldest Howiesons Poort layer at Sibudu, still have TCSA values falling within the arrow range. Hornfels segments fall within the range of North American darts, and dolerite segments, mostly from the youngest Howiesons Poort layers at Sibudu, are closer to experimental spears. Single TCSA values for the experimental sample also fall in the arrow range; however, when the values are calculated for back-to-back hafted weapons they fall in the spear range (Pargeter, 2007). Even though these values represent hypothetical functional possibilities, they might be a further indication of change and variability in Howiesons Poort hunting technologies. Increasing evidence for such shifts and variability is of foremost interest for Middle Stone Age behavioural studies, and could have been caused by adaptations to aspects of economy, demography, social and symbolic behaviour, procurement, maintainability, reliability, risk management, and the environment (e.g. Ambrose and Lorenz, 1990; Bleed, 1986; Costa et al., 2005; Fitzhugh, 2001). While direct evidence for or against stone-tipped projectile weaponry during the Howiesons Poort is still lacking, we suggest that tools such as segments could have been used successfully as tips or insets for both hand-delivered and projectile weapon systems in variable, adaptable and changing hunting technologies.

In this context it might be useful to consider real-life hunting scenarios. We do not suggest that recent hunter-gatherer behaviour can or should be indiscriminately mapped onto that of the Howiesons Poort. Yet, ethnographic case studies serve to illustrate that hunters operate in a real world of opportunity and risk, providing examples of the dynamics that could exist within a single social/temporal context (Kusimba, 2002). Such examples provide contextual variables for choices of weapon systems, hunting strategies and prey. More often than not, hunter-gatherer groups use a variety of weapon systems such as bow-and-arrow, spears, clubs, nets and snares. Although some variety in hunting behaviour and equipment may reflect social/group preferences (Bartram, 1997: Hitchcock and Bleed, 1997), the !Kung of the Kalahari and other San groups also vary hunting strategies and the associated weaponry according to season or prey type.

Schapera (1963) noted that the San would hunt certain antelope species during the rainy season by overtaking them and killing them with wooden clubs or spears. During the dry season they often made pitfalls in game paths, and animals trapped in the pits are killed with spears. Traps are also used mainly in the dry season to catch birds and small antelope. Many varieties of big game are run down until they are exhausted and killed with spears. Some game species such as giraffe, eland, hartebeest and springbok are, however, generally hunted with bow-and-arrow (Schapera, 1963). More recent work with the Kua and Tyua San of Botswana also shows that animal foods are obtained by methods that vary seasonally (Bartram, 1997; Hitchcock and Bleed, 1997). One of the noted differences between spear and bow hunting is that the former is an effective method throughout the year, whereas bow-and-arrow hunting is more restricted to particular seasons. The effectiveness of poisoned arrows is also dependent on season, mainly because of variability in the toxicity of the poison. Data collected amongst the !Kua in the eastern Kalahari indicate that the quality of the poison declined in the late dry season, and that during drought years and extremely wet years it was often not available at all (Hitchcock and Bleed, 1997). If we accept that people in southern Africa behaved in a modern way at least since the Still Bay technocomplex or earlier, we predict that evidence for variability and complexity in their hunting behaviours will become increasingly evident. Variation in the hafting configurations of Howiesons Poort segments might provide one such example.

6. Conclusion

Replication experiments produce a range of variability within parameters that can be controlled and understood. When such variability is compared with archaeological assemblages, we gain indirect insight into some aspects associated with the tool classes.
Understanding [Andrefsky, 2005], the Perger experiments showed that Howiesons Poort segments, as a morphological type, could function effectively as tips for hunting weapons held in a variety of positions. Although much larger Poort samples are needed to generate reliable macrofracture data, the initial comparisons between experimental and archaeological samples have highlighted interesting points with regard to impact burination, impact notching and variability in DIF frequencies. These observations can now be used to focus future research, and should lead to increased caution regarding some functional assumptions. It is our opinion that through a reflexive process between replication, experimentation, testing and examination of archaeological material, we are starting to gain insight into the intricacies of hunting behaviour during the Howiesons Poort. Together with the results from morphometric studies on segments (Wadley, in press; Wadley and Mohapi, 2008), faunal material (Clark and Plug, in press) and worked bone (Backwell et al., in press) from Sibudu Cave, the evidence suggests that Howiesons Poort hunting technologies and their associated behaviours were probably much more complex, varied and interchangeable than what has been accepted until recently.

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