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Additional evidence of early hominid bone tools from South Africa. First attempt at exploring inter-site variability

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Introduction

There are four basic views of early hominid bone tool culture in South Africa: the first that there isn't one (Kuman 2005), the second that bone tools were used to extract tubers as part of a vegetarian dietary adaptation (Brain & Shipman 1993, 2004), the third that they were used mainly to forage for termites in mounds (Backwell & d'Errico 2001; d'Errico *et al.* 2001), and the fourth that they were involved in both tuber- and termite-digging activities (van Ryneveld 2003). The use of bone tools by early hominids was first proposed by Schmidtgen (1929). The idea was seconded by Breuil (1932, 1938) and Bastin (1932), and culminated in Dart's (1957) 'Osteodontokeratic culture of *Australopithecus'*. Later research contested the 'Osteodontokeratic' hypothesis (Klein 1975; Shipman & Phillips 1976; Maguire *et al.* 1980), citing evidence that hyaenas were more likely the modifiers and accumulators of bones in caves. This created scepticism as to whether early hominids truly used bone tools, but at the same time stimulated a wide range of research. Taphonomic studies have revealed that a number of natural processes can produce pseudo bone artefacts, for example vascular grooves have been shown to mimic cut marks (Shipman & Rose 1984) and engravings (d'Errico & Villa 1997), and some types of wear on teeth have been misinterpreted as carved notches (Gautier 1986). Other mimics include natural breakage and wear of deer antler (Olsen 1989) and elephant tusk tips (Haynes 1991; Villa & d'Errico 2001), gnawing or digestion by carnivores, rodents or herbivores (Pei 1938; Sutcliffe 1973, 1977; Binford 1981; Villa & Bartram 1996; d'Errico & Villa 1997), fracture for marrow extraction by hominids and carnivores (Bunn 1981, 1983; Gifford-Gonzalez 1989; Backwell & d'Errico 2004), trampling (Haynes 1988; Olsen & Shipman 1988), root etching (Binford 1981), weathering (Brain 1967), and the abrasive action of sediment (Brain 1981; Lyman 1994). In order to distinguish between pseudo and true tools it is necessary to adopt an interdisciplinary approach that combines analysis of bones modified by known agents, taphonomic analysis of the fossil assemblages from which the purported bone tools derive, microscopic studies of possible traces of manufacture and use, experimental replication of purported tools, and quantification of wear patterns. Our ongoing research on minimally modified bone tools has led to the development of a number of diagnostic criteria that provide a useful framework in which to assess new potential evidence.

Here we focus on the site of Drimolen, located 7 km north of Sterkfontein. Discovered by Keyser in 1992 (Keyser 2000a,b; Keyser *et al.* 2000), the Drimolen cave deposits are estimated to date to between 1.5 and 2 Mya, based mostly on faunal correlation with Swartkrans Member 1 (Brain 1993). Excavations have yielded 79 hominid specimens of which only two are firmly attributed to *Homo* sp. The remainder are attributed to *P. robustus* and nearly half of these are juveniles. Other large mammal taxa represented at the site include cercopithecines, carnivores and bovids (Keyser *et al.* 2000). There is an abundance of small to medium-sized bovids, and notable absence of suids and equids. Twenty-three bone fragments were earmarked in the field as possible bone tools, and of these 22 were made available for study.

Materials and methods

We previously examined 35 reference collections of bone modified by known non-human agents (hyaena, dog, leopard, cheetah, porcupine, river gravel, spring water, plain flooding, trampling) in search of mimics of modifications recorded on the Swartkrans specimens interpreted as bone tools (Backwell & d'Errico 2001, 2004). Bones from these collections was analysed at macro- and microscopic scale using optical and scanning electron microscopy. Research on the recognition of shaping techniques includes the reproduction and microscopic analysis of marks produced with different techniques and motions (d'Errico *et al.* 1984; d'Errico & Backwell 2003; Backwell & d'Errico 2004). We have also created and microscopically analysed a reference collection comprising experimentally manipulated, transported (d'Errico 1993a,b) and utilized bones (Backwell & d'Errico 2004). Our comparative collection was recently increased to include material from the open-air site of Kalkbank (Mason 1958), which has yielded a bone assemblage described by Dart & Kitching (1958) as containing Osteodontokeratic tools. In our analysis of this collection we focused on shaft fragments morphologically and dimensionally similar to those identified as bone tools from Swartkrans and Drimolen, and analysed them with the same procedures used for the Drimolen purported bone tools. The tips of the Drimolen specimens and 14 pieces from Kalkbank were moulded with Coltene President light body dental elastomer, and cast using Araldite M resin. All original specimens from Drimolen and transparent replicas of their tips, as well as the Kalkbank specimens were examined microscopically, and selected pieces photographed with a motorized multifocus microscope equipped with a digital camera.

Results

Microscopic analysis of the Drimolen specimens revealed that 14 of the 22 pieces analysed bear the same wear pattern recorded on the Sterkfontein and Swartkrans bone tools (Backwell 2000; Backwell & d'Errico 2001, 2008; d'Errico *et al.* 2001), namely a single smoothed end covered with individual striations confined to an average

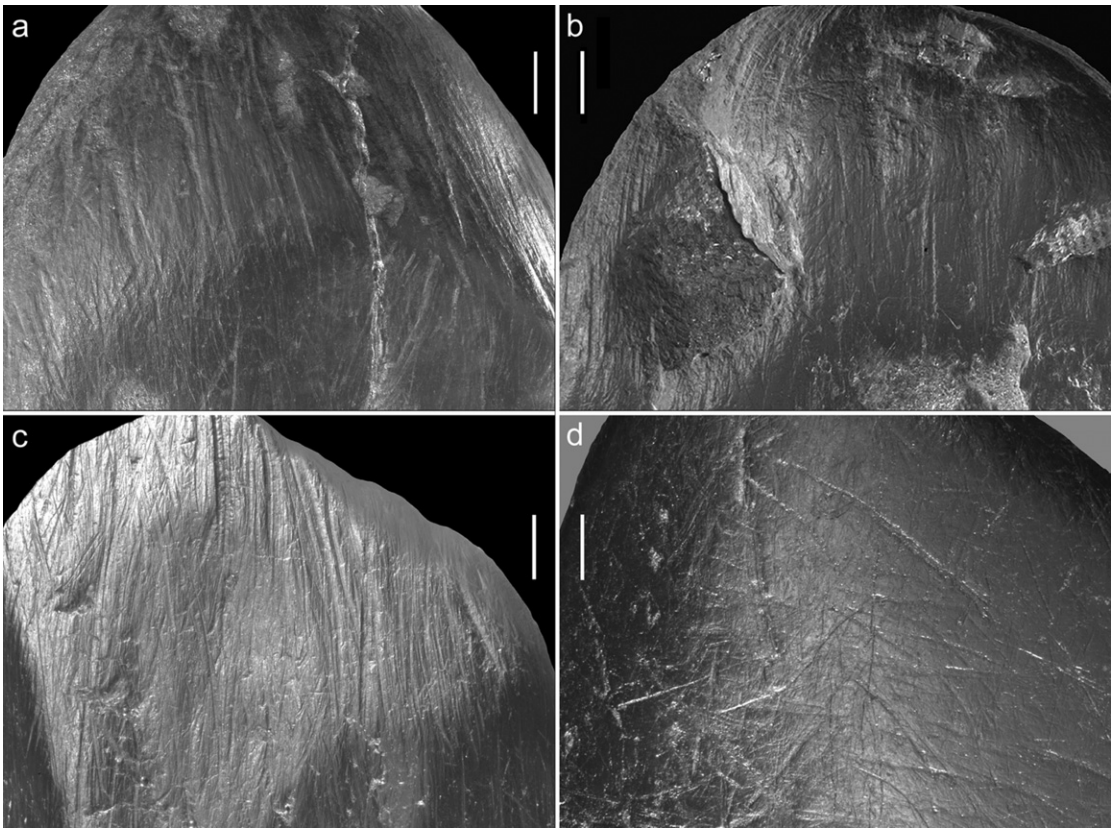


Figure 1. Transparent resin replicas of wear patterns on Swartkrans, Drimolen and experimental bone tool tips photographed in transmitted light. **a**, Bone tool from Swartkrans Member 2 (SKX 1142). **b**, Newly identified bone tool (DN 414) from the early hominid site of Drimolen showing rounded tip covered with longitudinal striations and flake scars smoothed by use wear. **c**, Experimental bone tool used to dig in a termite mound. **d**, Bone tool used in Brain's experiment to dig up *Scilla marginata* bulbs. Note the similarity in the orientation and width of the striations in (a), (b) and (c). Scale bars = 1 mm.

of *c.* 30 mm from the tip (Fig. 1). The pattern comprises striations oriented parallel or sub-parallel to the main axis of the object, decreasing in number away from the tip. A few striations oriented perpendicular to the main axis, generally posterior to the longitudinal parallel ones, are also recorded on some specimens. The eight Drimolen specimens interpreted as pseudo tools lack evidence of a wear pattern. Many shaft fragments from Kalkbank exhibit smoothing and rounding of the tips, but this generally extends over the entire piece. Microscopic analysis did not reveal a single piece from this site bearing the wear pattern observed on the Swartkrans and Drimolen bone tools. On the Drimolen specimens retained as tools we recorded the same variables as those taken on the 84 specimens from Swartkrans, and the single piece from Sterkfontein. These relate to mammal size class, type of bone used, fracture patterns, shape and size of the bone flake, including compact bone thickness and the length and position of the worn area, and orientation and position of striations on the worn tip.

At Sterkfontein and Swartkrans the tools derive mostly from mammal size classes II-III and III–IV. At Drimolen class III–IV is under-represented. The use of more robust bone fragments at Swartkrans is also reflected in the high number of fragments with a compact bone thickness in excess of 10 mm. As at Swartkrans, the large majority of Drimolen tools derive from long bone shaft fragments. The four exceptions – two mandible fragments, a rib and a horn core – are not unlike the trend observed at Swartkrans, where one mandible, seven ribs, and 14 horn cores out of 84 pieces were used as tools. The choice for weathered, elongated, straight bone flakes (as opposed to small spirally fractured fresh fragments) is also evident at Drimolen, where almost all the shaft fragments bear longitudinal breakage. As at Swartkrans, almost all Drimolen tools are represented only by their tips, which prevents analysis of intra- and inter-site length variation. However, analysis of the width and thickness of long pieces at 5, 10, 15 and 20 mm from the tip reveals a remarkable dimensional similarity between the three sites. The slightly more slender trend observed at Drimolen is in accordance with the low incidence of size class III–IV mammal shafts used as tools. The length of the worn area on the Drimolen specimens falls well within the range of that observed at Swartkrans, with the majority of the wear ranging between 20 and 40 mm. The lack of pieces with a very short or long worn area at Drimolen is most likely a function of the small sample size. At all three sites the occurrence and location of differently oriented striations shows an abundance of longitudinal relative to oblique, and rarity of transverse striations. Microscopic inspection of the worn tips has highlighted another feature that parallels what we have observed at Swartkrans. The only horn core from Drimolen records an area close to the tip covered with parallel striations perpendicular to the main axis. These closely match those described on six horn cores from Swartkrans (d'Errico & Backwell 2003), interpreted as possible evidence of grinding, for the purpose of

re-sharpening the functional area of the tool. Finally, among the pieces interpreted as bone tools, two have punctures probably produced by small carnivores and one piece shows damage consisting of shallow grooves reminiscent of porcupine gnawing. Carnivore damage is recorded on one of the bone tools from Swartkrans (d'Errico & Backwell 2003), where it is quite clearly covered with use-wear.

Discussion and conclusion

Besides the wear pattern, the Drimolen bone tools exhibit a number of features similar to those recorded on the Sterkfontein and Swartkrans bone tools. The only difference being the rarity of very robust pieces at Drimolen. This may be due to the small size of the sample, different availability of weathered shaft fragments, or a preference for slightly smaller fragments at Drimolen. Limited availability of large bone is supported by the few very large mammals reported for this site, but a preference for smaller bone tools is not supported, as indicated by the strong similarity in tool tip morphometry between sites, in spite of the use of thinner blanks at Drimolen. This may be clarified in future, when results of taphonomic analysis of the faunal assemblage from this site become available. More detailed contextual information may also elucidate why, in three instances, bone tools have been found in very close proximity, and why others cluster in a 4 m^2 area, within a 50 cm depth of each other. Spatial analysis of hominid and other mammal remains, bone and possible stone tools, is also required to help address the question of who used the Drimolen bone tools. The association of a high number of *Paranthropus* remains with bone tools, and the recovery of only two stone tools at Drimolen supports the hypothesis, first proposed by Brain & Shipman (1993) and followed by us (2001, 2003), that *P. robustus* may have used the South African bone tools. Based on the female aggregation practices present in chimpanzees and gorillas, and the fact that both are proposed as models for early hominid cultural and social behaviour (d'Errico *et al.* 2001; Lockwood *et al.* 2007), we hypothesize that if *P. robustus* was the user of the bone tools, the foraging activity in which they were used was conducted mainly by females.

The absence of knapped bone flakes in South Africa, and of digging implements in East Africa, lends support to the hypothesis that two distinct bone tool traditions existed in Africa between 1 and 2 Mya (Backwell & d'Errico 2004), either as variations of a single species behaviour (*Homo erectus*), or due to manufacture by different hominid taxa (*H. erectus* and *P. robustus*). Considering that only a single piece is reported from Sterkfontein, this hypothesis is based on the findings from only two sites, Swartkrans and Olduvai. The existence of an additional South African Plio-Pleistocene site yielding the same type of bone tools as those from Swartkrans demonstrates that the Swartkrans bone tools are not an isolated case, and that the digging activity in which they were used, which we posit was mainly termite foraging, was relatively widespread and well established in the region. Based on available information on fauna, geochronology and site formation processes at Swartkrans and Drimolen (Vrba 1982; Brain 1993; Watson 1993; Turner 1997; Keyser *et al.* 2000; Curnoe *et al.* 2001; de Ruiter 2003), this cultural tradition lasted unchanged for at least 300 000 and possibly as long as one million years.

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