Bone tools from the early hominid sites, Gauteng: An experimental approach.

Karen van Ryneveld

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A thesis submitted to the Faculty of Science,
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Declaration

I declare that this thesis is my own, unaided work. It is being submitted for the degree of Masters of Science (by coursework and thesis) in Palaeoarchaeology at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

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Karen van Ryneveld

Submitted on the ____ day of _____________, 2003.

**Dedicated to my parents,
Harry and Magda van Ryneveld.**

Project abstract

This project was inspired by the identification of 108 bone tools (dated roughly to between 2 and 1 Mya) from sites in the Cradle of Humankind World Heritage Site, Gauteng.

An experimental study was undertaken in an attempt to answer the basic question of "what caused modification marks on early hominid bone tools?" Five experimental tools were used in each of seven different task oriented experiments. The purpose of this project was to broaden the existing database of experimentally employed bone tools and the associated process-pattern relationships. Analysis was based on an optical comparison of primarily microscopically, but also macroscopically visible use-wear patterns observed on the experimental tools. The experimental data were then used to make inferences on a middle range theoretical level regarding the use of the fossil specimens and comment on the currently held opinions.

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Abbreviations used

Bov.	Bovid
B. P.	Before the present
cm	Centimeters
cm^2	Square centimeters
ESA	Earlier Stone Age
Fig.	Figure(s)
kya	Thousands of years ago
LSA	Later Stone Age
mag.	Magnification
min.	Minutes
mm	Millimeters
MSA	Middle Stone Age
Mya	Millions of years ago
Pers. comm.	Personal communication
pp	Page(s)
µm	Microns
vs.	Versus
ya	Years ago

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Chapter 1
Introduction

1.1) Introduction to the project

A hundred and eight identified bone tools from Sterkfontein, Swartkrans and Drimolen, situated in the Cradle of Humankind World Heritage Site, Gauteng, turned scientific attention to the function of these tools (Robinson 1959; Brain & Shipman 1993; Keyser 2000b; Backwell & d'Errico 2001; d'Errico *et al.* 2001a).

Backwell and d'Errico's microscopic and MICROWARE image analysis of the Swartkrans and Sterkfontein specimens proved that the tips of these tools exhibit a discrete wear pattern (Backwell 1999; Backwell & d'Errico 2001; d'Errico *et al.* 2001a). According to them the tools are characterised by:

1) A single rounded end with smoothing/polishing confined to an area of between 5 to 50 mm from the tip (see Fig. 36a).

2) Individual striations covering the worn tip, including any recessed areas. These striations are between 5 and 40 μm wide and run parallel or sub-parallel to the long axis of the bone (see Fig. 37 & 42a). Striations decrease in number away from the tip. And,

3) The absence of similar striations from the remainder of the bone. (A very small number of striations oriented perpendicular to the main axis of the bone, generally posterior to the longitudinal parallel striations and ranging between 100 and 400 μm in width were recorded on some specimens.)

In attempting to identify bone tools and their possible function(s) the archaeologist is confronted with some critical questions: Can hominid produced assemblages be distinguished from those produced by other processes? And can the activity of hominids on particular bones, producing particular kinds of modification be identified?

Backwell's (1999) study included an analysis of non-hominid modification agents (such as hyaenas, dogs, leopards, cheetahs and porcupines, also river gravel, spring water, flood plain and wind processes and trampling) on bone in discriminating the true tools from possible pseudo tools. She also combined a taphonomic analysis of the associated fossil assemblages with microscopic studies of possible traces of manufacture and use. I accepted Backwell's identification of tools and no reanalysis of the fossil specimens was undertaken.

In addressing the question of the function of the early hominid bone tools from Gauteng, scientists have focussed on a low powered microscopic analysis of the wear patterns observed on the tips of the fossil and experimental tools.

The employment of experimental tools by scientists in scenarios of supposed use by the hominids will produce a wear pattern on the tips of the tools. The process or experiment in which the tool was used is thus known, providing a known process-pattern relationship. If the fossil and experimental tools exhibit similar wear patterns scientists can infer that a similar process caused the observed pattern, thereby attempting to establish the function of the bone tools in the early hominid toolkit.

Interpretations regarding the function of the South African bone tools are divided.

Brain's experimental digging for the subterranean bulbs of the *Scilla marginata* and *Hypoxis costata* led Brain & Shipman (1993) to believe that the bone tools were primarily used for such digging activities. Backwell (Backwell & d'Errico 2001) and d'Errico *et al.* (2001a) are of the opinion that the bone tools were used to extract termites from their nests.

Brain's initial hypothesis that the early hominid bone tools were employed to dig for subterranean plant food sources had a dual origin. After some hours of employing screwdrivers to dig in the partially calcified sediment at Swartkrans, Brain realised that the worn appearance of the screwdriver tips very closely resembled that of the worn bone tool tips (see Fig. 36a & 42). Brain & Shipman (1993) therefore emphasise the importance of a digging action in the similarity observed morphologically between the tips of the screwdrivers used in excavations and the bone tool specimens.

Brain also observed chacma baboons (*Papio hamadryas ursinus*) in the John Nash Nature Reserve (15 km north east of Swartkrans) digging for edible bulbs during the dry winter months when vegetable foods are much less abundant than during the summer months. Brain (Brain & Shipman 1993) noticed that the baboons focused their attention primarily on the *Scilla marginata* and the *Hypoxis costata*. The baboons dug these plants out using only their hands. Bulbs were therefore only foraged in areas where the ground was sufficiently soft, restricting their excavations to the alluvium of the valley bottoms. Baboons are unable to excavate the plants in the rocky dolomitic hillsides.

Brain & Shipman (1993) argue that if hominids had access to some sort of digging tool, they would have been able to exploit the *Scilla*, *Hypoxis* and other underground storage organs on the rocky dolomitic hillsides unobtainable by baboons, which would in their words have been "a quite significant advantage."

Their interpretation is based on the overall morphology of the experimental tools, the wear patterns they published in SEM micrographs (Brain & Shipman 1993). Despite their claims for parallel and sub-parallel striation marks on experimental tools, wear patterns observed on SEM micrographs often displayed perpendicularly angled criss-cross striation compositions (see Fig. 42b) with transverse striations situated further away from the tips of the tools.

Backwell (Backwell & d'Errico 2001) and d'Errico *et al.* (2001a) are of the opinion that the bone tools were used to extract termites from their mounds. Their hypothesis originated from the supposed longitudinally oriented striation pattern they expected on experimental termite foraging bone tools. Their initial idea was also inspired by the nutritional value of termites as a food source and evidence for termite foraging traditions by certain groups of chimpanzees (*Pan troglodytes*) (Backwell: Pers. comm.).

Backwell & d'Errico's experimental tools displayed primarily longitudinally oriented striations marks, according to them very similar to the striation pattern observed on the fossil tools (see Fig. 37 & 42a,d). Their more rigorous approach towards microwear analysis involved an optical comparison of SEM micrograph images as well as MICROWARE image analysis of the tips of the tools (see Fig. 38). This software program enables them to measure the exact width, length and orientation of individual striae.

No MICROWARE image analysis software was available for this study, which instead focussed on broadening the existing experimentally employed bone tool database and associated process-pattern vocabulary. Analysis was based on an optical comparison of primarily microscopically, but also macroscopically visible use-wear patterns observed on the experimental tools. The experimental data were then used to make inferences on a middle range theoretical level regarding the use of the fossil specimens and to comment on the currently held opinions.

In my study I used five experimental tools (three in a weathered and two in a fresh state) in each of seven different task oriented experiments. Experiments included:

The G1 experiments: Digging for subterranean plant foods (bulbs) on a hill/hillslope.

The G2 experiments: Digging for subterranean food sources (rootlets, worms and insects) in a riverbank environment.

The B1 experiments: Debarking of the *Maytenus undata* (Koko) tree.

The B2 experiments: Debarking of the *Celtis africana* (White Stinkwood) tree

The H1 experiments: Processing the inner side (burnishing) of a *Bos taurus* (cattle) hide.

The H2 experiments: Processing the inner side (burnishing) of a *Bos taurus* (cattle) hide with the aid of sediment, and

The T1 experiments: Extraction of termites from their mounds.

The experimental study undertaken was essentially twofold in character, attempting to address two specific issues rising from the question of "what caused modification marks on early hominid bone tools?" Firstly were all the bone tools used for similar tasks or were several tasks involved? And can the possible variety of tasks be identified through comparative analysis with experimentally worked tools? Secondly and perhaps more indirectly I also attempted to make inferences regarding the manufacturing of these tools. Were bones intentionally broken by the hominids or were bones used as tools fractured in ways similar to naturally broken bones as Backwell (Backwell & d'Errico 2001) suggests? And were these tools used in a fresh or weathered state?

Chapter 2
Early hominid bone tools – a literature review

2.1) Raymond Dart and the osteodontokeratic

Shortly after the description of the Taung child, the first recognised australopithecine, Dart (1925), referring specifically to the Makapansgat australopithecines, described in a series of 39 papers their proposed osteodontokeratic (bone, tooth and horn) culture (Dart 1949a,b, 1957a,b, 1964). Dart (1957a) identified "deliberately inflicted fractures" on the bones and assigned a possible use to each modification pattern that he found.

Dart's description of the osteodontokeratic tools included scapulae and humeri, argued to be splitting and pounding tools, bovid metapodials made into scoops or spatulate tools and composite tools, in which a bone, tooth or stone fragment, which served as a replaceable cutting blade, was wedged into the cleft between the two articular processes at the distal end of a bovid cannon bone. He described mandibular tooth rows as saws, maxillae as scrapers, and horn cores as daggers (Dart 1949a,b, 1957a,b, 1964).

Many aspects of Dart's work had been severely challenged and in part discredited by subsequent and contemporary workers (Hughes 1954; Wolberg 1970; Hill 1986). Brain (1989) demonstrated that the osteodontokeratic culture taken in its entirety is almost certainly wrong, but he also cautioned against overreacting to Dart and showed that some bones from the South African sites are almost certainly tools. Contrary to these and other similar minded scientists, others believe that bone collecting animals, particularly the hyaena and porcupine, are responsible for the bone accumulations and modifications interpreted as hominid derived (Hughes 1958; Mills & Mills 1977; Maguire *et al.* 1980; Hill 1989; Skinner & van Aarde 1991; Skinner *et al.* 1997).

2.2) Bone tools – a current understanding

The Cradle of Humankind World Heritage Site, situated in the Gauteng Province of South Africa and described by Tobias (1999) as "one of South Africa's most internationally valued scientific treasure houses", is the home of at least twelve fossil-rich cave sites, within a distance of only 15 km. Seven of these sites have yielded remains of the human family, the importance of which are well known (Broom & Schepers 1946; Hughes & Tobias 1977; Tobias 1978; Clarke 1988; Keyser 2000a; Keyser *et al.* 2000). These include both the famous Mrs. Ples (Sts 5) cranium (Broom *et al.* 1950) and the StW 573 skeleton, the first discovery of a well-preserved skull and associated skeleton of *Australopithecus*, dated to 3.3 Mya (Clarke 1998; Patridge *et al.* 1999).

Systematic excavations in more recent years have revealed a wealth of associated artefacts and have greatly aided interpretations of early hominid culture (Mason 1962; Brain 1970; Leakey 1970; Kuman 1994a,b, 1998; Kuman *et al.* 1997). Continued excavations have also brought to light new bone tool specimens (Robinson 1959; Brain & Shipman 1993; Keyser *et al.* 2000). Sterkfontein, Swartkrans and Drimolen, three of the major hominid sites, have yielded a total of 108 bone tools (Backwell & d'Errico 2001; d'Errico *et al.* 2001a).

These tools, dated to between 2 and 1 Mya (Backwell 1999; Backwell & d'Errico 2001) are morphologically very different from those initially included in Dart's osteodontokeratic culture. They are generally small, longitudinally shaped pieces, tapering to a point at one end and made primarily from the long bones of animals (Brain & Shipman 1993; Backwell 1999). According to Backwell (1999), typical features of the bone tool collection from Swartkrans and Sterkfontein include: "... the presence of a rounded or pointed tip at one end of the specimen, and smoothing or polish confined to an area of between 5 mm and 50 mm from the tip, with a mean length of 27.5 mm. Microscopically, features include: individual striations which cover the tip, but which are absent from the remaining surface of the bone; striations oriented parallel or sub-parallel to the main axis of the bone and which decrease in number and intensity away from the tip and vary in width from 20 to 100 μm; and very few striations oriented perpendicular to the main axis of the bone. The latter are generally posterior to the longitudinal parallel striations and range between 100 and 400 μm in width". From the descriptions given by Brain & Shipman (1993) and Backwell (1999), it is further worthwhile to note that many of these specimens were originally part of a larger tool. According to Backwell & d'Errico (2001) and d'Errico *et al.* (2001a) the original size of these tools varied between 130 mm to 190 mm.

Bone tools from the South African collections are furthermore unique in that they vary in modification from those of East Africa (primarily from Beds I and II, Olduvai Gorge, Tanzania), the only bone tool collection comparable to the South African collection in terms of age (Shipman 1989). The East African bone tools are described by Shipman (1989) as "often fractured using flaking techniques borrowed from stone tool working". Modification of bone by flaking is absent from the South African examples.

Interpretations regarding the function of the South African bone tools are divided. Brain & Shipman (1993) are of the opinion that they were used by the early hominids to dig for edible bulbs, while Backwell & d'Errico (2001) and d'Errico *et al.* (2001a) propose that they were used to extract termites from their nests.

Brain & Shipman's (1993) interpretation rests primarily on the overall morphology of the experimental tools. Contrary to their claims for parallel and sub-parallel striations, tools used in the extraction of subterranean plant foods (bulbs) have produced a perpendicular angled criss-cross composition of striations on the tool tips with transverse striations situated further away on the bodies of the tools. Backwell & d'Errico's (2001) experimental tools used in the extraction of termites from their nests have produced a more longitudinally oriented composition of striations, more or less parallel to the long axis of the tools. They emphasise striation size and orientation as a functionally distinct use-wear pattern in their interpretation (Backwell & d'Errico 2001; d'Errico *et al.* 2001a).

2.3) The co-occurrence of bone and stone tools

I will restrict the following discussion to the African record with particular emphasis on southern Africa. In South Africa Goodwin and van Riet Lowe (1929) classified the Stone Age record into an Earlier (ESA), Middle (MSA) and Later (LSA) Stone Age, based on the technological and typological analysis of stone tools. Undisputed southern African bone tools appear first in association with MSA assemblages and become much more important in the LSA record. However the authenticity of bone tools in association with the ESA remains problematic.

The ESA is represented by two culture stratigraphic units, from the very first appearance of stone artefacts (the Oldowan) until the disappearance of the Acheulean large cutting tools (hand axes and cleavers) from the record (Volman 1984). Though ESA stone tools from Kada Gona in the Hadar region of Ethiopia have been dated to between 2.6-2.5 Mya (Semaw 2000), the ESA in southern Africa can broadly be dated to between 2-1.7/1.5 Mya for the Oldowan and between 1.7/1.5 Mya until about 250 kya and no later than 200 kya for the Acheulean (Klein 2000). The succeeding MSA, characterised by a variety of prepared cores and retouched flakes, lasted broadly until 40 kya (Volman 1984), though in southern Africa dates of 27-23 kya are probably more accurate (McBrearty & Brooks 2000). The following LSA, generally identified by the more formal properties of the stone tool assemblages are often in association with new items of material culture (Volman 1984; Deacon & Deacon 1999).

The material culture associated with the LSA wider range of specialised stone tools include evidence for the formal burial of the dead often associated with grave goods, symbolic and representational art (paintings and engravings) and items of personal adornment such as ostrich eggshell, marine and freshwater beads. Very often decorated bone beads, pendants, amulets and even decorated bone tools form part of the industrial complex. Bone was also used to manufacture specialised hunting and fishing equipment including bone points, linkshafts and fishing hooks. Bone needles and awls are also often found at sites with LSA records (Deacon 1984, Deacon & Deacon 1999), such as at Heuningneskrans and Border Cave (Beaumont *et al.* 1978; Beaumont 1981), Boomplaas, Nelson's Bay Cave, Melkhoutboom (Deacon 1969, 1978,1979) and Byneskranskop (Schweitzer & Wilson 1978).

These material cultural associations are not generally associated with either the MSA or ESA (Volman 1984), and even though McBrearty and Brooks (2000) emphasise their gradual introduction throughout the MSA, the use of faunal remains as tools over most of the Pleistocene seems to have been rather casual (Volman 1984).

Several MSA bone tools from Bambata Cave and Redcliff (Walker 1980), a bone point from Klasies River mouth (Deacon & Geleijnse 1988), pig tusk "daggers" from Border Cave (Beaumont *et al.* 1978) and a variety of bone fragments with several small notches from Klasies River mouth, Border Cave and Apollo II (McBrearty & Brooks 2000) reflect the sparse presence of bone tools in the MSA record.

The most striking find of bone tools in association with a MSA stone tool assemblage comes from Blombos Cave (Henshilwood & Sealy 1998). Twenty six shaped bone awls, a bone peg, two bone points, a bone fragment used as a retoucher and a deliberately engraved bone fragment were found (d'Errico *et al.* 2000b) in association with the Still Bay MSA complex (Henshilwood & Sealy 1998). Despite the questionable context of many other MSA bone tool finds, such as at Klasies River mouth (Thackeray 1992; Klein 1995), the association of bone artefacts with MSA deposits at Blombos Cave is relatively secure (Henshilwood & Sealy 1997, 1998).

The two bone points from Blombos Cave were described as both having been broken at one end with the remaining end partially shaped by utilization and both were also made from animal long bones (Henshilwood & Sealy 1997). In morphology these tools thus resemble the bone tool specimens from the Gauteng sites.

The Blombos Cave TOB tool, probably originally part of a composite tool is described as "61 mm long, with a maximum diameter of 7 mm. It was smoothed to a point by grinding and striations are clearly visible, especially near the tip. The tip is darker in colour than other parts of the artefact and may have been fire hardened". Specimen AI on the other hand is "55 mm long with a maximum diameter of 7 mm… it is ground to a point and highly polished. Patches of what appears to be ochre are visible in the polish. A longitudinal groove runs from the butt end almost to the point. Under magnification minute scratches on the bone surface are suggestive of use wear. There is no evidence of burning or charring on this bone point" (Henshilwood & Sealy 1997).

Despite the morphological similarities between these MSA bone points and the bone tools from the Cradle of Humankind World Heritage Site, Henshilwood (Pers. comm.) is of the opinion that the MSA tools are technologically and typologically very different from the early hominid bone tools. Techniques of whittling, grinding and fire hardening were used to manufacture the MSA tools, while the bone points were typologically part of composite tools. The mere morphological resemblance between the MSA and ESA bone tools should be questioned.

Besides the bone tools associated with the ESA stone tool assemblages in Gauteng, the occurrence of bone tools in association with ESA deposits is often questioned such as in the case of the bone point and two bone "gouges" from Kabwe, Zimbabwe (Clark 1975). However evidence does exist that ESA hominids made use of various other materials from the environment besides stone to manufacture tools, as exemplified by finds at Kalambo Falls, Zambia (Clark 1975) and Amanzi Springs, South Africa (Deacon 1970) where clear evidence for woodworking exists. Both Kuman (1998) and Klein (2000) are of the opinion that early hominids could probably have made use of a wide variety of materials from the environment to manufacture tools. Klein (2000) explains that besides the fact that ESA artefacts are found throughout southern Africa, only about 20 sealed, excavated sites exist. Kuman (1998) furthermore emphasises unfavourable ESA preservation conditions, thereby highlighting the importance of bone and stone tool associations at sites where artefacts are essentially found in secondary contexts and where preservation is mostly the result of karst environments such as at the dolomitic caves in Gauteng.

At Olduvai Gorge, Tanzania, Acheulean people apparently occasionally produced bone bifaces (Leakey 1975). Acheulean bifaces remain unknown in southern Africa and no evidence exists that Acheuleans cut, carved, or ground bones into points, awls or other readily recognisable, standardised or formal artefact types (Klein 2000).

2.4) Hominid tool makers

2.4.1) Hominids and tools in context

Despite the problems inherent in cladogenesis and species identification (Tobias 1978, 1983, 2001; Kimbel & Rak 1993), evidence from Sterkfontein clearly indicates the presence of *Australopithecus* in the area at 3.3 Mya (Clarke 1998; Partidge *et al.* 1999), with *Australopithecus africanus* well represented in the southern African record, dating back to 3/2.8 Mya (Clarke 1988,1994; Kuman & Clarke 2000). It is generally accepted that the australopithecines were in time replaced by *Homo* (Tobias 1994, 2001; Kimbel & Rak 1993), however, opinions as to how this occurred vary. In this regard Tobias published in 1978 that *Australopithecus africanus* "could have been" ancestral to *Homo*. Later Tobias (1983) states that "between 2.5 and 2 Mya evidence suggests that a previously single hominid lineage (*Australopithecus africanus*) underwent cladogenesis or a splitting into several lineages", referring specifically to those of *Paranthropus robustus* and an early form of *Homo*. Clarke (1988,1994) however is of the opinion that two different morphological complexes are represented by the current grouping of *Australopithecus africanus*, one with smaller teeth, a possible ancestor of the *Homo* lineage, and one with larger teeth, ancestral to *Paranthropus robustus*. *Paranthropus robustus* and *Homo* lived side by side according to the evidence from the Gauteng sites.

Within the 6 Members identified at Sterkfontein (Patridge 1978), Members 4 and 5 are primarily of interest here. Member 4 is generally associated with *Australopithecus africanus* finds and contains no artefacts. Within Member 5, *Paranthropus robustus* is largely associated with the Oldowan infill (dated to 2-1.7 Mya), containing an assemblage classified as Oldowan. *Homo ergaster* is associated with the Member 5 Acheulean (1.7-1.4 Mya) (Clarke 1994; Kuman 1994a,b; Kuman & Clarke 2000). The bone tool specimen SE 612, found by Robinson in the (Member 5) West Pit is therefore associated with early Acheulean artefacts (Robinson 1959). Brain's later (1985) re-identification of three bone tool specimens from Sterkfontein were all associated with Member 5. Backwell (1999) discarded Brain's re-identification, including only one bone tool specimen from Sterkfontein in her analysis.

Five Members have been identified at Swartkrans, with Member 1 being the oldest (Brain 1976). Clark (1993) classified the Member 1 (1.8-1.5 Mya) and Member 2 (1.5-1 Mya) artefacts as Developed Oldowan. However he clearly states that Member 2 is contemporary with the Acheulean. Member 3 (dated to approximately 1 Mya) has been classified as Acheulean. Field (1999), however, classified Members 1, 2 and 3 as Developed Oldowan/Early Acheulean. Both *Paranthropus robustus* and *Homo* have been found in all three Members, with *Paranthropus robustus* fossils dominating the assemblage (Grine 1993; Susman 1993). From the 68 bone tools initially identified by Brain and Shipman (1993), seventeen came from Member 1, eleven from Member 2 and forty from Member 3. However Backwell (1999) identified 84 bone tool specimens. The tools' distribution has been questioned and Blackwell (Blackwell *et al.* 1998) suggests that the bone tool pieces from Member 2 and Member 3 may have originated in Member 1, thereby limiting the time span of their occurrence to between 1.8 and 1.5 Mya.

Drimolen, dated to between 2.5 and 1.6 Mya, is once again associated with two hominid species, namely *Paranthropus robustus* and an early form of *Homo* (Keyser 2000a,b;

Keyser *et al.* 2000). To date at least 23 (undescribed) bone tools have been recovered from the site (Backwell & d'Errico 2000). This number recently dropped to 22 after Clarke refitted two of the pieces. Any attempt to associate these bone tools with a stone tool tradition is hampered by the extremely weak presence of only two identified stone tools at the site (Kuman: Pers. comm.).

Kromdraai, another Plio-Pleistocene site situated in the Cradle of Humankind World Heritage Site, is divided into two main sections, namely Kromdraai A and Kromdraai B. Kromdraai A, the artefact bearing site has an assemblage ascribed to the Developed Oldowan/Early Acheulean Industry (2 – 1 Mya) and has to date borne no hominid fossils (Kuman *et al.* 1997). At Kromdraai B deposits bearing *Paranthropus robustus* fossils have been found in association with stone tools in a deposit dated to between 2 and 1.5 Mya. However too few artefacts have been found in association with the hominid bearing deposits to safely ascribe them to any Industry. To date no bone tools have been recovered from either Kromdraai A or B (Kuman *et al.* 1997).

Site	Age	Hominids	Stone tool industry	Bone tools
Sterkfontein	1.7-1.4 Mya	• *Paranthropus robustus* • *Homo ergaster*	• Developed Oldowan/ Early Acheulean • Acheulean	1
Swartkrans	1.8-1.0 Mya	• *Paranthropus robustus* • *Homo*	• Developed Oldowan/ Early Acheulean	84
Drimolen	2.5-1.6 Mya	• *Paranthropus robustus* • *Homo*	Unidentified	23/22
Kromdraai	2.0-1.5 Mya	• *Paranthropus robustus*	• Developed Oldowan/ Early Acheulean	0

Table I: **The Gauteng sites: a hominid-industrial association**

2.4.2) Who made the tools?

A spatio-temporal association of hominids and material culture from the Gauteng Plio-Pleistocene sites attests to the fact that except for Drimolen with its small stone tool component and the Oldowan at Sterkfontein, stone tool assemblages at Sterkfontein, Swartkrans and Kromdraai can be assigned to the Developed Oldowan/Early Acheulean Industries (Field 1999). Except for Kromdraai all of the sites are associated with both *Paranthropus robusus* and *Homo*. Furthermore all the sites except Kromdraai have produced bone tools. Since both *Paranthropus robustus* and *Homo* are associated with tools, and for the purpose of this research specifically with bone tools, the question remains as to who made these tools.

From an early date *Homo* has been credited for its stone tool-making abilities (Mason 1962; Tobias 1965), an opinion that remains predominant (Clarke 1985, 1988; Kimbel &

Rak 1993; Kuman 1998; Kuman & Clarke 2000; Tobias 2001).

The post cranial morphology of *Paranthropus* (Susman 1989; 1993), together with dental evidence for a largely vegetarian diet (Grine 1981) associated with changing climatic conditions (Vrba 1989), led Brain (*et al.* 1988) to postulate that both *Paranthropus* and *Homo* were involved in a long-standing tradition of implement assisted food procurement and perhaps food processing strategies.

Crediting a specific hominid with the use or manufacture of the bone tools remains an uncertain endeavour. Despite spatio-temporal associations and anatomical evidence the secondary contexts of all of these sites should not be disregarded. Assigning these tools to any specific hominid will therefore not be within the scope of this project and I will rest with the fact that both *Paranthropus* and *Homo* should be regarded as possible candidates.

2.5) Behavioural interpretations

The reconstruction of early hominid behaviour is in itself problematic (Jolly 1970; Isaac 1971; Joulian 1996) and as yet no established conceptual framework exists for the study of human behavioural evolution (Blumenshine *et al.* 1994). However Quinney (1997) recognises two broad lines of inference according to which models of early hominid behaviour can be classified, namely socio-ecological and palaeo-taphonomic models.

2.5.1) Socio-ecological models

Socio-ecological models depart from the principle that naturalistic observations of living systems would enhance our understanding of extinct ones. The underlying logic to this analogical approach suggests that because two cases share some features, they will also share other features not necessarily related to the common feature (Quinney 1997).

On the one hand observations of the contemporary Stone Age cultures of the aboriginal Australian (Berndt 1972) and African San (Lee 1972) are used to elicit causal links between observed archaeological traces and the behaviours that produced them.

On the other hand scientists make use of research from the field of ethology, especially primatology. The field of molecular biology has set forth strong evidence for the close relationship between primates, especially that of the human and chimpanzee lineages (Kimbel & Rak 1993; Tobias 2001). A comparison between their cultures furthermore emphasizes the many deep similarities, strongly suggesting that they share evolutionary roots (Boesch & Tomassello 1998; Whithen *et al.* 1999). Researchers have directed their attention towards studies of the common chimpanzee (*Pan troglodytes*), the non-human primate who makes the greatest use of tools in the wild, almost on a daily basis, primarily employing these in the extraction of food resources. Some chimpanzee tools (in particular stone hammers and anvils) are identical to prehistoric tools (Joulian 1996). While more laboratory-controlled studies into the stone tool making and tool using capabilities of a pygmy chimpanzee (*Pan paniscus*) are attracting continuous interest (Schick *et al.* 1999), research directed towards other primate cultures - such as the savanna baboon (Jolly 1970; Dunbar 1975) - continues to enrich and expand our current understanding and reference base of early hominid culture. However, as yet the use of bone tools has not been recorded among any wild primates (Volman 1984).

- Backwell & d'Errico's theory (2001) finds inspiration from the termite fishing traditions of certain groups of chimpanzees. The chimpanzees make the greatest use of grass stalks to extract termites from their mounds. As yet no chimpanzee community has been recorded to extract termites with bone tools (Joulian 1996; Boesch & Tomassello 1998). While biologically further afield, Brain also observed chacma baboons (*Papio hamadryas ursinus*) in the John Nash Nature Reserve (15 km north east of Swartkrans) digging for edible bulbs during the dry winter months (Brain & Shipman 1993). (Here tradition should be separated from culture, where culture can be defined as the "whole set of ideational rules necessary to exist" (Godelier 1992), a tradition (Joulian 1996) reflects a "part of culture stabilised and transmitted at least over one generation".)

2.5.2) Palaeo-taphonomic models

Any palaeo-taphonomic model centers as a point of departure on burial and preservation processes. Problem solving can follow either a direct or indirect approach (Quinney 1997).

The **direct analysis** and interpretation of fossils, palaeotaphonomy, is concerned with the direct content and context of faunal assemblages, the skeletal part representation and patterns of modification (Quinney 1997), such as has been done by Behrensmeyer (1978), Brain (1981) and Klein (1978, 1988).

The **indirect approach** concentrates on modern findings and the extrapolation thereof back into the past. Knowledge of causal relationships in modern processes is used to establish diagnostic effects or "signature" criteria. When these are detected in the archaeological assemblage, inferences regarding the events that might have caused them can be made (Quinney 1997). Nomenclaturally divided, scientists refer to this approach as actualism (Lyman 1994), functional analogies (Shipman 1989) and middle range theory (Binford 1981). Methods of research also vary:

1) Naturalistic research uses behavioural studies of modern animals (ethology) and humans (ethnography) as a basis for reconstructing the past (Quinney 1997). Naturalistic studies that have contributed to the identification of early hominid bone tools vs. pseudotools include the effects of hyaena scavenging (Mills & Mills 1977; Hill 1989; Skinner & van Aarde 1991), porcupine (Hill 1989) and chimpanzee gnawing (Pickering & Wallis 1997) and trampling (Brain 1967; Fiorillo 1989).

2) Experimental archaeology is concerned with the replication of artefacts by modern *Homo sapiens*, the employment of artefacts by modern humans in scenarios of supposed use by their original makers, or a combination of these. Some sceptics argue that the great mimicry potential of modern humans, as well as conscious and unconscious bias can lead to the production of preconceived results (Wylie 1985). However the supplementary value of experimental archaeology cannot be overlooked. In support of the supplementary value of experimental archaeology Backwell (1999) states: "As the descendants of early hominids, anatomically modern humans are arguably the best models available for the study of prehistoric behaviours and the material cultures they produced."

2.6) Identifying bone tools

In order to identify a "bone tool" as a true or pseudotool analysts have to discriminate the products of human behaviour from those produced by the earth's physical, chemical, geological and biological subsystems. In doing so scientists make use of the principles of taphonomy.

Taphonomy, a term coined from the Greek words *taphos* (burial) and *nomos* (laws), can directly be translated as the science of the "laws of embedding or burial" (Lyman 1994). The study of taphonomy emphasises the reconstruction of the history of fossils from the time of an organism's death to the time of its recovery, focussing therefore on the accumulation as well as the modification of osteological assemblages (Bonnichsen 1989b). Lyman (1994) defines taphonomy further as "the study of processes of preservation and how they affect information." In recent years bone modification in itself has graduated to the level of a quantitatively and qualitatively based subdiscipline of taphonomy (Marshall 1989), whether incidental or deliberate in nature (Hill 1989).

Humans, carnivores, insects, rock falls, fluvial transport and geochemical solutions are only a few of the many agents that can alter faunal assemblages. Some agents furthermore use more than one mechanism to alter bone, for example tool-making hominids can cut, polish and flake bone, while hyaenas may use their teeth, claws and tongue to puncture, flake, scratch and polish bone (Mills & Mills 1977; Brain 1981; Bonnichsen 1989a,b; Marshall 1989; Skinner & van Aarde 1991; Skinner *et al.* 1997). The accurate identification of agents and causal mechanisms therefore forms the critical basis upon which taphonomic systems should be modeled (Bonnichsen 1989b).

2.6.1) Process-pattern relationships

The general premise taken is that all modifications to bone (any alteration in size, structure or texture) are produced by the interaction of external agents or processes and internal factors, or the properties of bone. The investigator must therefore establish a process-pattern relationship. Here "process" refers to the activity, agent or cause by which patterns came to be produced on a bone while the "pattern" refers to the effect or the resulting change on the bone caused by the process (Hill 1989; Marshall 1989).

2.6.1.1) Modification patterns

Two basic types of modification patterns are recognised namely fractures and marks (Bonnichsen 1989b; Marshall 1989)

Fractures: Both the general high degree of fractured bones in assemblages (Bunn 1989) and the fact that any attempt to manufacture bone tools will result in broken bones establishes the necessity of bone fracture in any discussion of bone tools.

A fracture can be defined as a "localised mechanical failure" (Lyman 1994). Bone is not a steady-state material, but occurs in fresh, weathered and mineralised states (Bonnichsen 1989b). Patterns of bone breakage or fractures are therefore related to the length of time that a bone has been exposed to the elements and the amount of weathering that has occurred (Marshall 1989) as this influences the gross structure, water and fat content and elasticity of the bone. Fractures are also related to the post-depositional context of a bone. Local environmental and depositional contexts cause the properties of bone to change (Bonnichsen 1989b), while sediment load can also fracture bone (Marshall 1989).

Classical fresh or green bone fractures on long bones (Bov. size II, III & IV) produce a morphologically helical or spiral fracture outline. Fracture surfaces tend to be smooth and at an acute or obtuse angle to the bone's cortical surface. Dynamic impacts leave conical scars from which the helical fractures radiate. The presence of a spiral fracture demonstrates only that the bone was broken in a fresh state, a result of the properties of the bone itself. Breakage patterns on fresh or green ribs (Bov. size II, III & IV) yield irregular fractures (Marshall 1989; Lyman 1994).

As bones become less fresh, develop split lines and lose their organic content there is a greater tendency for fractures to be straight (whether diagonal, longitudinal or transverse). Fracture surfaces tend to be perpendicular to the cortical surface. A rough texture is characteristic of these fractures. All these features tend to be present to their fullest extend on mineralised bone fractures (Marshall 1989; Lyman 1994).

The hammerstone and anvil technique for breaking long bones yields a high degree of limb shaft fragmentation and impact notches on long bone fragments. However carnivores' teeth or angulates' hoofs can produce bone fracture patterns that are quantitatively similar to those produced by a hammerstone (Bunn 1989).

Multiple percussion blows and multiple impact locations along bone shafts typify marrow processing by the hammerstone and anvil technique. Despite variation in the number of blows and the impact locations the technique commonly results in extensive fragmentation of the entire limb shaft when the point of impact is positioned a third of the way along the shaft of either epiphysis. Fracture lines appear to originate from the lateral and medial sides and radiate spirally around the anterior and posterior sides of the bone.

Resulting shaft fragments therefore consist predominantly of spirally fractured anterior and posterior portions of the original bone shaft (Bunn 1989).

Fracture angle, fracture outline and fracture edge texture are therefore the most important factors in the development of a “Fracture Freshness Index” (FFI) (Outram 2001). This offers a guideline to analysts who need to determine if fractures occurred on fresh or weathered bone, taking into account the taphonomic processes involved. Evidence for fracture type can also be assessed on unidentifiable shaft fragments, highly represented in the bone tool collections from Gauteng. Backwell & d’Errico (2001) deduced from the Gauteng bone tools that hominids selected for a certain type of bone in the landscape. All tools were weathered and displayed weathered fractures, whereas the remainder of the collection was dominated by fresh spiral fractures.

Marks: The act of using bone tools will create marks or use-wear patterns on the surface of the tool (Bonnichsen 1989b, Marshall 1989). Accurate interpretation of the marks observed will of necessity result from careful distinction between marks that have been caused by hominid use as opposed to marks caused by other taphonomic processes. Marks include all non-fracture patterns on the surface of a bone such as designs, cuts, furrows, lines, pits, polish, smoothing, rounding, scars, scrapes, scratches, slices etc. A specific process or agent will produce diagnostic criteria. Recognising unique process-pattern relationships is important when studying assemblages accumulated and modified by multiple processes or agents. For the correct interpretation of bone tools, one must also consider unimagined events that can mimic modifications of more common events or processes, an occurrence termed equifinality (Marshall 1989).

2.6.1.2) Modification processes

Three major categories of processes are recognised namely hominid, animal and physical. Natural or non-hominid modification includes animal and physical processes as well as the modification background of an assemblage. Hominid modification is restricted to modification with an anthropic origin (Bonnichsen 1989b; Marshall 1989).

Processes that can cause modification to bone will be discussed under these headings of physical, animal and hominid processes. Although this discussion focuses primarily on marks produced by these processes, fractures and marks are often co-incidental results of a specific process. Both fractures and marks therefore often need to be simultaneously analysed in order to arrive at an informed interpretation of their origin.

In order to determine which process caused a specific modification to a bone surface scientists need to familiarise themselves with a variety of processes and their resulting patterns. Only a large process-pattern relationship database will enable a scientist to securely eliminate certain processes or call for caution.

2.6.1.2.1) Physical processes

Weathering often results in broken and fractured bones. Weathering and accompanying dissolution may alter the bone surface. Scratches may also be accentuated or details may be lost (Bonnichsen 1989b).

Abrasion caused by wind-borne particles can result in smoothing, polishing or rounding of fracture edges or surface areas of bone (Bonnichsen 1989b), while abrasion resulting from water transport often produces a uniform pitting (Shipman 1989).

Bone transported by water also often displays small flakes, spiral fractures, scratches, smoothing, slight polishing and edge rounding due to rolling and tumbling. Further attrition by fluvial processes may result in the removal of alteration features or patterns produced by other processes (Marshall 1989).

Some modification marks are produced after embedding or deposition in sediments. Fractures and marks may be caused by bioturbation, cryoturbation and diagenesis once a bone has been deposited (Marshall 1989). Coarse-grained sediments or hard objects deposited adjacent to bones may produce scratches or pseudo-cutmarks. Scratches and fractures may also be the result of crushing caused by compaction, compression and sediment loading. Soil acids may cause the loss or alteration of surface features, including patterns produced by other processes and pitting. Acids from plant roots can cause fractures and rounding of fracture edges, etching, chemical weathering, the loss of organic surface features and generally display shallow, curvilinear grooves on the surfaces of bones (Bonnichsen 1989b). Calcium carbonate in sediments is often the cause of bone mineralisation, associated with fractures, staining and discolouration to bone (Irving *et al.* 1989). Carbonic acids generally associated with lime rich caves (such as in the case of the Gauteng caves) may weaken extremities of bone to make these bones more susceptible to breakage (Oliver 1989).

The result of fire or heating will here in short be discussed as a natural physical process since the bone tools from the Gauteng sites, and therefore processes that could have affected their modification, date largely to pre-fire using hominid times.

Heating produces modifications to a bone's microstructure but not necessarily to its macrostructure. Embedding and weathering can mimic patterns produced by natural heating. Embedding can cause modification of discolouration while weathering can result in discolouration and cracking. Colour is therefore an unreliable characteristic in deciding if a bone has been heated or burned. Differences between colouration and heating are only detectable on a microscopic level (Shipman 1989).

Brain & Shipman (1993) explain that some of the Swartkrans Member 3 bones are associated with fire. Their assumption is indirectly discarded by Blackwell *et al.* (1998), who are of the opinion that the Member 2 and Member 3 bone tools originate in Member 1. They based this interpretation on a colouration characteristic of the Swartkrans bone tools. This colouration is not ascribed to fire or heating. They are of the opinion that the colour of the tools is the result of the original *in situ* context of the bone tools in Member 1.

Rock or roof falls in a cave can dynamically load bone, producing fractures and marks that in some cases are qualitatively similar to those produced by other processes, including hominid processes. These potential mimics result from the fact that falling rocks load bone dynamically in very much the same way as hominids using a hammerstone to produce a tool or to extract marrow from a bone. Potential patterns produced by both rock falls and hammerstone percussion marks include impact initiated green breaks, impact flake scars and flakes, and scrapes and slices (Oliver 1989).

2.6.1.2.2) Animal processes

Animal processes include all non-hominid biological agents that directly or indirectly produce modification patterns to bones (Marshall 1989). Modification caused by animals is usually predepositional in nature (Backwell 1999). Some examples of animal processed modification include:

Porcupine gnawing: Relatively broad, shallow marks, either flat or slightly rounded in cross-section are characteristically produced by the incisors of porcupines (Newman 1993). These marks lie parallel to each other with pairs often overlapping. Marks can be oriented perpendicular to the axis of the shaft or longitudinally at the ends of a bone where chewing can result in smoothly rounded or tapering tabular shaft pieces (Brain 1981; Hill 1986).

Small rodent gnawing: These marks are similar to those produced by porcupines, but on a smaller scale (Backwell 1999). They are described by Fiorillo (1989) and Newman (1993) as parallel paired, broad, shallow, flat bottomed, vertical sided grooves produced by the incisors of the rodents. Marks are generally situated perpendicular to the axis of the shaft. Striations appear directional in the tapering of grooves from the relatively deep, broad tooth penetration sites to finer more linear lines.

Carnivore feeding: In the context of the Gauteng sites this category will include patterns produced by carnivores such as modern spotted hyaenas (*Crocuta crocuta*), brown hyaenas (*Hyaena brunnea*) and striped hyaenas (*Hyaena hyaena*), as well as various cats such as leopards (*Panthera pardus*). Findings of patterns produced by modern populations are used to make inferences regarding patterns produced by extinct populations.

Carnivores, such as hyaenas generally crush and destroy bone using a quasi-static loading technique in bone reduction, producing consistent modification patterns (Mills & Mills 1977; Brain 1981; Hill 1986, 1989; Skinner & van Aarde 1991). Carnivore gnawing is characterised by the scouring of cortical bone around articular ends (Brain 1981; Skinner *et al.* 1997). Gnaw marks and furrows (tooth grooves) produced primarily by carnassials pressing on green bone are usually isolated, broad grooves, which are U-shaped or V shaped in cross-section and on occasion gnawing produces fragments of bone crushed inwards. Gnaw marks are usually found on the articular ends or broken shaft ends of long bones (Newman 1993). Puncture and pressure pits produced by the pointed tips of canines and carnassials appear as "circular or oval depressions with fragments of bone crushed inwards toward the bottom of the depression" (Brain 1981; Hill 1989; Lyman 1994). Irregular fractures or fracture planes result from the removal of cancellous bony tissue, often with punctures or furrows associated, causing a characteristic "chipped back" or "scooped out" appearance on the shafts (Brain 1981; Hill 1986, 1989; Newman 1993). Shredding can be defined as "the splintering of the broken edge of a bone" (Newman 1993; Hill 1989). Shredding is often due to carnivores chewing on ribs. Sinuous gnawed edges are produced by the chewing of the ends of limb bones. Flakes and flake scars result from breakage caused by pressure of bite (Brain 1981, Hill 1986; 1989, Newman 1993; Lyman 1994).

Carnivores typically concentrate gnawing on epiphyseal ends of long bones and then proceed towards the center of the diaphyses. Non-long bones show preferential points of gnawing, for example on the neural spines, on the transverse processes of vertebrae, on the blade of the scapula and on the illiac crest of the innominate (Gifford-Gonzalez 1989).

Bones of immature animals show higher frequencies of carnivore gnawing than do those of adults because they are more easily chewed and more nutritious (Gifford-Gonzalez 1989).

Leopards do not gnaw bone and for this reason produce low frequencies of identifiable elements. They do however produce marks and fractures on bone during primary consumption of prey (Gifford-Gonzalez 1989).

An experimental study undertaken on captive chimpanzees showed that chimpanzee (*Pan troglodytes*) mastication on bones produce crenulated edges, step fractures, the peeling back of cortical bone layers, shallow tooth pits, linear tooth scores, tooth notches (including the chipping back of bone edges) and puncturing and crushing of cortical bone (Pickering & Wallis 1997). Pickering & Wallis (1997) caution that chimpanzee induced modification is probably very similar to modification patterns produced by early hominids of a similar size and with comparable dentition and bite force such as the australopithecines and the *Homos*. Chimpanzees, and therefore probably also the early hominids, were capable of inflicting the same range and degree of damage to bones as carnivores. Care should thus be taken when analysing archaeological bones, rather than automatically attributing all such damage to carnivores.

Trampling: Trampling includes modification resulting from either the direct or indirect contact of the feet of animals with bone. It therefore also sometimes acts as a process of bone burial (Hill 1986; Fiorillo 1989). Trampling in soft substrates often produces bones with high angles of plunge in the original *in situ* context. In hard substrates bones are more likely to break (Fiorillo 1989). Characteristic modification caused by trampling includes spiral fractures, flakes, pitting and scouring, rounding, polishing and splintering as well as parallel and isolated scratches, usually situated on the shafts of long bones (Brain 1981; Hill 1986; Fiorillo 1989; Lyman 1994). According to Fiorillo (1989), trample marks can easily be distinguished macroscopically from carnivore and rodent gnaw marks, but they are even on a microscopic level very similar to marks produced by hominid processes.

Accidents: An animal falling into a sinkhole or cave opening can sustain bone fractures due to the fall. Such falls often cause spiral fractures that result in patterned breaks. The bones of animals surviving such falls may produce antemortem polish on the fracture surfaces caused by continuous bone on bone movements (Brain 1981; Oliver 1989; Lyman 1994)). In this regard Oliver (1989) cautions that "polished fracture edges... might easily be interpreted as bone tools".

2.6.1.2.3) Hominid processes

If a tool or implement can be defined as an entity "used to process other substances" (Shipman 1989) then, within the context of bone tools, we can with certainty infer that modifications to bone are produced by hominids during the manufacture and/or use of bones as tools (Brain 1981; Hill 1989; Backwell 1999). Tools are thus task or use-related, a feature that results in the production of use-wear patterns which in turn reflects their function (Lyman 1994). The authenticity of a tool must therefore be determined on the basis of use-wear characteristics and not only on gross-morphology (Runnings *et al.* 1989; Shipman 1989; Backwell & d'Errico 2001).

Use-wear patterns generally occur on pieces of broken bone (Brain & Shipman 1993;

Shipman 1989; Backwell 1999) because unbroken bones are, with only a few exceptions to the rule not suitable as tools as they seldom display a sharp or pointy end (Shipman 1989). Yet caution needs to be taken when identifying broken bone fragments as tools. Once identified the scientist needs to determine both the duration of use and the type of substance that has been worked (Shipman 1989; Oliver 1989). According to Oliver (1989) the three substances most commonly worked by hominids were flesh, hide and bone.

Two basic types of use-wear patterns are recognised, namely unintentional (consequential, accidental) and intentional (purposeful) patterns.

Unintentional patterns: Unintentional patterns such as cut and chop marks, recognised in the archaeological record as furrows, lines, grooves, scratches, scrapes, slices or striations, are produced by hominids using stone or bone implements (Bunn 1989; Shipman 1989; Lyman 1994). These marks are mostly found on the bones of large animals and are ascribed to hominid attempts of disarticulation or dismemberment of animal carcasses (Gifford-Gonzalez 1989). Macroscopically these marks can easily be confused with carnivore and rodent gnaw marks (Oliver 1989).

Cut marks are characterised by a cross-sectional V-shape with fine parallel striae along the channel wall if a stone tool has made the cut (fine parallel striations are absent in carnivore or rodent gnaw marks). Cut marks will be situated around areas of ligament attachment and usually occur in clusters (Fiorillo 1989; Oliver 1989). They are never common and occur on only a small portion of bones in early hominid assemblages (Brain 1989).

Chop marks are produced by hominids striking a bone with a tool (Shipman 1989) and can be seen as evidence of disarticulation during primary butchering (Gifford-Gonzalez 1989). Flaking, differential polish, angularity loss and micro-damage are additional unintentional use-wear categories restricted to fracture and adjacent surfaces. In this regard Shipman (1989) notes that unutilised fracture surfaces on tools show "considerable rounding, smoothing and loss of anatomical detail," features produced unintentionally during tool use.

Intentional patterns: Intentional modifications are purposeful by nature. They are repetitive, systematic, planned and controlled. Techniques such as whittling and grinding can be used to manufacture a tool, while the tools' subsequent use will display use-related patterns such as polish, grooving and striae (Bunn 1989; Shipman 1989; Lyman 1994).

Manufacturing modification, or the purposeful shaping of an object by hominids to produce a desired morphometry, can range in sophistication and degree. The production of a stone Solutrean biface or Clovis point requires extensive manufacturing modification while instant, impromtu or expedient tools more than often display a lack or absence of manufacturing modification. The more extensive the manufacturing modification the easier it will be to identify a specimen as a tool. Use-wear, because it is an incidental result of an object being used as a tool, may not be very extensive or obvious, but it serves as an important clue in identifying an object as an artefact (Lyman 1994). The problem of identifying bone tools thus clearly resides with those bones that have been minimally modified. Interpretations regarding minimally modified bone tools, as represented by the Gauteng collections, therefore rests primarily on correlating use-wear patterns produced experimentally with those observed on fossil specimens.

Lyman (1994) sets forth some criteria to guide analysts in their decisions:

1) Context: The context in which the supposed bone tool was found serves as the first clue. In other words does the context of the bone hold the potential of it being culturally deposited or modified (Lyman 1994).

2) Kind of bone: Only bones of appropriate structure, weight and strength were employed as tools (Bonnichsen 1989b; Marshall 1989; Lyman 1994).

3) Modification distribution: Shipman (1989) notes that intentionally utilised fracture surfaces show use wear patterns "only on areas which actually formed the working edge." Generally modification restricted to the working edge is use related. A clear distinction should also be visible between used and unused edges. If modification is the result of natural processes modification distribution will be less restricted (Lyman 1994). Shipman (1989) warns that the distribution of intentional patterns can easily be mimicked by weathering and sedimentary abrasion.

4) Modification patterns: Evidence of modification can take the form of chipped fracture edges, ground fracture edges (including striae) and the creation of detritus (small bone flakes) (Bunn 1989; Lyman 1994). Hominids can break bones in many ways. Virtually all of them use dynamic loading. Direct percussion often creates "point loading" percussion pits and few flake scars, easily mimicked by percussion pits caused by carnivores teeth (Brain 1981; Bunn 1989; Lyman 1994).

In the context of the early hominid bone tools from Gauteng where supposedly no manufacturing modification was involved (Brain & Shipman 1993; Backwell 1999; Backwell & d'Errico 2000), the scientist needs to discriminate between the breakage patterns of fresh and weathered bone in order to determine whether hominids fractured fresh or weathered bone to produce bone tools or if they selected weathered bone pieces from the landscape to be used as tools.

Use-wear modification is restricted to the attritional loss of bone tissue and can consist of polish, rounding, smoothing and micro flaking of fracture surfaces (Lyman 1994; Shipman 1989). These modifications may be macroscopically visible but microscopic examination of them is important (Brain & Shipman 1993; Shipman 1989; Backwell 1999; Backwell & d'Errico 2000; d'Errico *et al.* 2001a).

Utilised edges can develop a macroscopically visible gloss or polish. Under microscopic examination wear is restricted to raised areas of the edge (rugosites) that actually come into contact with the substance being worked. These initially raised areas become rounded, glassy in texture and smooth as surface detail is lost progressively with continued utilisation (Lyman 1994). Natural abrasion does not seem to produce the fine, glassy polish often seen on use-worn specimens (Runnings *et al.* 1989). But to help distinguish artificial wear from natural abrasion the sedimentary context of the specimen should be examined (Shipman 1989).

Use wear patterns may also show a preferred axis of motion based on micro-striae (Lyman 1994). Shipman (1989) explains that if the substance being worked is of a mixed texture the use-wear pattern will be a "fine, glassy polish crossed by many coarse and fine scratches". Irregularly spaced and sized pits may also be produced on the surfaces of a tool if the tool was used to strike harder particles.

2.7) Determining the function of a tool

Archaeologists have long been interested in the use of prehistoric tools. Determining the function of these tools, however, proved to be a querysome endeavour and there is great difficulty in distinguishing style from function. Purely typological analysis has proved not to be the answer (Keeley 1974; Shafer & Holloway 1979). Broadly speaking, scientists have in recent years directed their attention to two specific methods of analysis in addressing this question.

2.7.1) Methods of analysis

1) **Residue analysis** focuses attention on the identification of specific residues or substance remains that a tool's working surface came in contact with during the course of use (Briuer 1976; Shafer & Holloway 1979). Residue studies conducted on collections from sites in the Cradle of Humankind World Heritage Site have already served to change the face of functional interpretations.

A residue analysis on stone artefacts from the Sterkfontein collection conducted by Prof. T. Loy (Pers. comm.) proved that these tools were probably used to work both animal and plant substances as predicted (Kuman 1998).

Currently B. Williamson is analysing the Drimolen bone tool residues. Examples of her analysis include yet again the identification of associated plant and animal residues on individual tools (B. Williamson: Pers. comm.).

Williamson, emphasising the fact that her analysis is still in a preliminary stage, pointed towards the sparse remains of residues on the tools, thereby highlighting the importance of a wider range of comparative material, exact analytical methods, a very critical scientific approach and the need for a complimentary method of functional analysis.

2) **Micro-wear analysis** can be defined as the study of micro-patterns left on tools after use or manufacture (Clemente & Gebaja 1998). Tools, which can be made from a variety of materials including bone and stone, often display use-wear in the form of micro-fractures (Tringham *et al.* 1974; Shea 1992), striations (Fedje 1979) and polish (Fullagar 1991) on the working edge. The basis upon which micro-wear analysis rests is analogy – the pattern on the archaeological tool is compared with a known pattern from either ethnographic or experimental tools in order to determine the function of the archaeological tool (Shea 1992).

2.7.2) Microwear – an overview

Microwear analysis or the analysis of use-wear patterns was born of a variety of studies conducted on stone tools (Tringham *et al.* 1974; Fullager 1991; Shea 1992). Both high and low powered magnification microscopy was used form the very initial stages (Fedje 1979; Ilkjaer 1979).

In 1964 Semenov's groundbreaking microwear research of the 1930's was translated into English (Semenov 1964). But even before 1964 other researchers attempted to determine lithic tool functions directly from tool surfaces. These initial methods of analysis were done largely without, but occasionally with, microscopic techniques. In the early 20th century scientists studied wear patterns in the form of sickle gloss or polish (Curven 1930, 1935; Goodman 1944). Especially Witthoft (1955) and Sonnenfeld (1962) advocated the use of microscopic analysis to determine the use of lithic tools, even before Semenov was translated.

After the introduction of Semenov's ideas to the western world and increased scientific acquaintance with the principles of microwear analysis, research in the late 1960's and 1970's was marked by a large scale increase in experimental microwear studies. These studies addressed both the techniques involved and the contributions thereof (Keller 1966; Hayden & Kamminga 1973; Tringham et al. 1974; Odell 1975). In 1977 and 1978 three doctoral dissertations appeared on microwear, setting the stage for the three approaches of analysis still largely followed today:

1) In 1974 Keeley already noted that microwear polishes were diagnostic for determining the substance against which the stone tools were used and claimed that polish variability could only be determined at high magnification levels. His (1977) dissertation on a British stone tool assemblage supported the idea that microwear analysis was most effective when a high magnification (≥ x 500 mag.) was used.

2) Odell's (1977) research on a Dutch lithic assemblage was based on what has been referred to as the low powered magnification (< x 100 mag.) approach. Odell's (1977) analysis aimed to determine the action of use such as slicing, boring and sawing and the density of the substance, the softness or hardness of the material against which the tools were used.

3) Unlike Keeley's or Odell's research, Kamminga's 1978 dissertation did not focus on experiments to verify use-wear patterns on prehistoric lithic artefacts. Kamminga

(Hayden & Kamminga 1979) used low powered magnification microscopy to recognise functional differences from Aboriginal stone tools with ethnographically verifiable functions.

Although the number and composition of microwear studies have increased rapidly, research still centers on the three basic approaches of high and low powered magnification microscopy and ethnographic analysis, none without its own inherent problems.

High powered microscopy is reported to be successful in determining the substance being worked. However, even some of the original blind tests have shown high power microscopy to be problematic, particularly when a tool was used to work more than one substance (Fullager 1991; Clemente & Gebaja 1998). Some researchers strongly disagree that the high power approach can discriminate tool function at all (Levi-Sala 1986; Shea 1992; Clemente & Gebaja 1998). Tests of low powered microscopy have proved that the technique has never been precise enough to determine the kinds of substances or materials on which the stone tools were used. The low powered microscopic approach emphasises the action of the tool and the relative density of the material being worked (Odell 1977, 1979; Shea 1992). The ethnographic approach is hampered by the fast disappearance of Stone Age cultures and the subsistence time frames of these peoples vs. time frames of archaeological inquiry (Hayden & Kamminga 1979).

Post depositional alteration of a tool, raw material colour and replicability of wear signatures (Levi-Sala 1986) have been suggested as factors that reduce the effectiveness of functional identifications in microwear studies and therefore call for caution in analysis. All events that can influence an object, including its diagenesis, activities in which it was engaged, alteration of its form or nature and its discard or depositional context need to be taken into account in any attempt of a microwear or use-related analysis (Odell 1979).

The importance of the microscope in lithic use-wear analysis has been realised, with an emphasis on the Scanning Electron Microscope (SEM). Fedje (1979) and Ilkjaer (1979) explain that problems using the SEM center primarily on the size of the vacuum chamber vs. the size of the tools to be analysed. This problem has largely been solved by the casting of bits of a tool or object. The potential of analysing bits of an object under the SEM furthermore eliminates difficulties of depth of field generally encountered in conventional microscopy and also secures a positive image of the tool under question.

2.7.3) Microwear on early hominid bone tools

Regarding the early hominid bone tools from the Gauteng sites, scientists are inclined to use a low powered microscopic approach. Attention is focused on the orientation of observed striations after which inferences regarding the substance worked are made (Brain & Shipman 1993; Backwell & d'Errico 2001; d'Errico *et al.* 2001a).

Surfaces of tools are usually examined under an optical and scanning electron microscope (SEM) (Brian & Shipman 1993; Backwell & d'Errico 2001; d'Errico *et al.*2001a). Within the low powered microscopic approach, a low magnification (x 3-15 mag.) is regarded as enough to illustrate shapes and general patterns, whereas a high magnification (x 30-40 mag.) is needed to detect characteristic features of individual striae. Observations are described in terms of the general appearance of sets of striae, taking into account the degree of magnification (d'Errico *et al.* 1984; Backwell 1999).

Interpretations regarding the function of the South African bone tools are divided. Brain & Shipman (1993) are of the opinion that they were used by the early hominids to dig for edible bulbs, while Backwell & d'Errico (2001) and d'Errico *et al.* (2001a) propose that they were used to extract termites from their nests.

Brain & Shipman's (1993) interpretation rests primarily on the overall morphology of the tips of the experimental tools. Contrary to their claims for parallel and sub-parallel striations, tools used in the extraction of subterranean plant foods (bulbs) have produced a perpendicular angled criss-cross composition of striations on the tool tips with transverse striations situated further away on the bodies of the tools. Backwell & d'Errico's (2001) experimental tools used in the extraction of termites from their nests have produced a more longitudinally oriented composition of striations, more or less parallel to the long axis of the tools. They emphasise striation size and orientation as a functionally distinct use-wear pattern in their interpretation (Backwell & d'Errico 2001; d'Errico *et al.* 2001a).

The SEM has proved capable of supplying a vast amount of information on bone modification marks (Runnings *et al.* 1989). Transmitted light on the gold-palladium mixture used to coat casts of the tool tips clearly show striation marks, while the problem of the restraining size of the vacuum chamber is also eliminated. However the fragile state of many bone points remains problematic.

Currently Backwell & d'Errico (2001) use the most advanced method of analysis: A transparent resin cast is made from silicone paste molds to replicate bone tools, true or experimental, after which optical and scanning electron microscopy are employed to identify surface modifications to the tools. MICROWARE image analysis software is then used to record the orientation and dimension of all visible striations. Final analysis rests on the comparison between microscopic studies of possible traces of manufacture and use on the fossil as well as the experimental tools. They further stress the necessity to combine these results with a taphonomic analysis of the associated fossil assemblages to determine whether the bone tools are discrete or lie within the range of naturally modified bone.

Because the casting method, necessary for tool examination under the SEM, remains essentially destructive to residues scientists should take caution not to use this method of analysis unless preceded by a residue analysis or confirmation that no residues are present on the specimens under question.

2.8) Model building

Model building refers to the full range of scientific ideas, methodologies and activities that allow scientists to develop realistic and testable hypotheses for explaining certain occurrences (Bonnichsen 1989a).

To achieve this goal scientists often use an interdisciplinary approach in seeking the answers to scientific questions (Bonnichsen 1989a,b; Marshall 1989). Addressing the question specifically asked in this research project: 'What caused modification marks on early hominid bone tools?' I believe that answers are to be sought in both the sciences of archaeology and taphonomy, which in turn are supplemented by a variety of studies such as ecology, geomorphology, ethnology and ethology.

The use of several integrative levels of theory as an organising framework is a further necessity for model building (Feibleman 1954). Feibleman emphasise the link between the highest and lowest levels of any organisation when he explains that the highest level of interpretation depends on the lowest level. The complexity of levels increases upwards, with the highest level depending on all lower levels. Lower levels are thus directed by higher levels. The mechanism for any level therefore lies in the level below and its purpose in the level above. At least three levels of organisation are needed, for example a high range or general systems theory is directly associated with a middle range or normative theory, which in turn reviews the assumptions and use of a low range theory (Bonnichsen 1989a).

2.8.1) High range theory

High range theory rests on the general systems assumption that the earth's astronomic, climatic, atmospheric, oceanographic, geologic, paleoecologic and cultural systems are interrelated, resulting in a multivariate record (Ruddiman & Wright 1978). The archaeological and fossil record is therefore not a simple mirror image of past cultural and biological systems but reflects the interactive result of several subsystems.

The need for high range theory in archaeology is attested by the realisation that Dart's original idea that early hominids were responsible for the accumulation and modification of bone assemblages was largely wrong (Dart 1957a; Brain 1989), emphasising the need for multivariate causation before assuming that a specific event led to a specific result. Another example of high range theory is proposed by Vrba (1989), who regards climatic change as the driving mechanism producing change in linked subsystems. She proposes that global climatic change produced habitat changes resulting in biological and cultural evolutionary responses. Most scientists accept the fact that the earth's subsystems are linked; however inquiry more than often centres on middle and low range theory.

2.8.2) Middle range theory

Middle range theory is used to explain how operations of past environmental and cultural subsystems have influenced a specific assemblage. Questions such as why specific modification patterns were produced, and what agents were responsible for a specific type of fracture or mark on a bone, are asked (Bonnichsen 1989a). Scientists rely on anthropological and palaeo-ecological uniformatarian assumptions to link the present to the past and create a systematic knowledge base (Wylie 1985). Middle range theory is thus largely involved with the construction of analogies (Bonnichsen 1989a), a risky endeavour in itself, where the lack of consistent procedures can easily lead to unsystematic knowledge (Wylie 1985; Bonnichsen 1989a,b).

2.8.3) Low range theory

The aim of low range theory is to provide clear, unambiguous statements of how the archaeological and fossil records are transformed into mutually exclusive patterns. The prime focus rests on the linking of patterns (Bonnichsen 1989a).

Low range theory functions as a bridge to middle range theory; it can be seen as a means to link empirical observations to statements about the organisation and operations of past systems. Without a low range theory all higher levels of inference become suspect (Bonnichsen 1989a).

Nature mimics most, if not all of the mechanical or chemical processes that humans use to modify bone. Natural processes can cut, fracture, grind, polish and burn bone (Bonnichsen 1989a; Marshall 1989). The scientist thus needs to take cognisance of decoding problems in determining which natural patterns mimic those produced by humans. The variety of forces that can cause identical patterns and the possibility of forces responsible for superimpositioning need to be addressed.

The diagnostic signature approach is often used to achieve the goals of low range theory. The premise of this approach is that each unique process will produce a unique morphological pattern. Once processes and patterns are securely linked, the discovery of similar patterns can safely be inferred to have been produced by the same cause. An assumption of this approach is that physical, chemical and mechanical mechanisms attributed to human and non-human agents altering bone remain the same throughout time (Bonnichsen 1989a; Marshall 1989). The limitation of this assumption has been realised (Shipman 1989). Shipman states that "process-pattern relationships are not universally applicable." The behaviour of each species and the variation of behaviour within a species need to be considered. This idea is echoed by Achinstien's (1965) S-model, which proposes that many assumptions are situation specific. To explain a given phenomenon one must understand what variables are important in a given situation. The S-model is thus based on the concept of "arguments of elimination". The analyst needs to consider all the mechanisms relevant, and only the mechanisms relevant to the situation under consideration.

- The research project undertaken is based on a low range theory. Use wear patterns observed on experimental tools were compared with patterns observed on the fossil tools. Comparable patterns inferred to result from similar processes were then used to make inferences on a middle range theoretical level regarding the use of the fossil specimens and comment on the currently held opinions.

Chapter 3
The project – an experimental approach

3.1) Project introduction

I decided to undertake an experimental study in an attempt to answer the basic question of "what caused modification marks on early hominid bone tools?" Five experimental tools were used in each of seven different task oriented experiments. The purpose of this project was to broaden the existing database of experimentally employed bone tools and the associated process-pattern relationships. Analysis was based on an optical comparison of primarily microscopically, but also macroscopically visible use-wear patterns observed on the experimental tools. The experimental data were then used to make inferences on a middle range theoretical level regarding the use of the fossil specimens and comment on the currently held opinions.

3.2) Project methodology

3.2.1) Tools and experiments

3.2.1.1) The tools

Experimental tools were made on both fresh (green) and weathered bone. Bones were fractured using the hammerstone and anvil technique. Hammerstone blows were directed mid-shaft or a third from either side of the epiphyses on the animal long bones. Natural stones from the Sterkfontein site area were used as hammerstones and anvils to fracture the bones in an attempt to keep the manufacturing of the experimental tools as close as possible to manufacturing methods and materials used in the past. All tools were made at the grounds of the Sterkfontein site in order to keep the manufacturing environment as natural as possible. The exact replication of bone tools was not attempted.

Five experimental tools, three in a weathered and two in a fresh state were used in each experiment. This count provided both comparison possibilities between the process-pattern relationships observed on the weathered and fresh tools used in a specific experiment and between process-pattern relationships observed on tools used in different experiments.

A minimum of two tools is necessary in any comparative study. This minimum adheres to the argument that if two tools display a similar use wear pattern after having been employed in a specific experiment more tools employed in the same experiment will continue to exhibit the use wear pattern observed. A single tool used in an experiment will leave the scientist with no comparative material, and it will run the risk of using data from the "exception to the rule". Naturally, the larger the experimental tool sample, the more secure the interpretation would be.

Weathered and fresh bones were intentionally broken to produce bone tools. This provided me with the opportunity to study the fracture patterns in an attempt to determine if the bone tools were made from fresh or weathered broken bones or if the hominids selected weathered bone pieces from the landscape, as suggested by Backwell (Backwell & d'Errico 2001).

3.2.1.2) The experiments

Seven different task oriented experiments were conducted. Experiments were chosen according to tasks envisioned to have been productive to the early hominids. The supposed likelihood of these tasks to produce wear patterns on the tools was also an important consideration.

The first two experiments, the digging for subterranean food sources, were done to test the results of Brain (Brain & Shipman 1993) in this method of food procurement. His experiments focused primarily on the excavation of *Scilla marginata* and *Hypoxis costata* bulbs often encountered in the hilly outcrops. The second experiment, the digging for subterranean food sources in a riverbank environment can be seen as an extension of his idea that the bone tools were digging implements used to extract subterranean food sources.

In the next two experiments tools were employed in the debarking of trees. The debarking of trees would have provided the hominids with wood from which they could have produced a variety of objects.

Hereafter tools were employed in the processing of hides. Processed hides could have served as an important raw material in, for example, the making of carry bags.

The last experiment, the extraction of termites from their nests was done largely to retest the results of Backwell (Backwell & d'Errico 2001) and d'Errico *et al.*'s (2001a) experimental work in the extraction of this protein rich food source.

The G1 experiments: In this experiment tools were used to dig for subterranean plant foods (bulbs) on a hill/hillslope. The purpose of this experiment was to extract the food source as quickly as possible.

Methods used to extract these food sources included poking, to break through the hard crust and penetrate deeper into the ground. The motion of direction used in poking was primarily vertical. Soil was also scraped and scratched out from the bottom and sides of the bulbs. Here the motion of action varied from 45 degrees to an almost horizontal angle. Tools were also employed in a wiggling motion to dislodge the bulbs, with angles of motion ranging from vertical to nearly horizontal.

The sediment was medium to coarse grained in particle size, often including small pebbles. Sharp angled dolomite and chert blocks were also encountered.

Bulbous plants were targeted without focusing on any particular species. Though Brain and Shipman (1993) specifically mention the *Scilla marginata* and *Hypoxis costata*, my approach, targeting bulbous plants in general, enabled me to extract bulbs without removing any code red or endangered species such as the *Scilla marginata* and *Hypoxis costata*. Furthermore the extraction of a subterranean bulb from a dolomitic habitat is expected to produce a very similar wear pattern on the tool used regardless of the specific plant species targeted.

The G2 experiments: Tools were used to dig for subterranean food sources in a riverbank area in order to determine the amount and variety of food sources encountered in such an activity.

A poking method was employed with a primarily near vertical action of motion. Soils encountered were fine grained and often clayey in character. In areas the soil on the riverbank was covered by a thin layer of foliage. Rootlets, worms and some insects were encountered. (Today local people from the area still dig in the riverbank to extract worms which they use primarily as bait for fishing.)

The B1 experiments: The experiment focused on the debarking of the *Maytenus undata* (Koko) tree. The *Maytenus undata* is an indigenous hardwood tree with a hard, smooth bark. The aim of the experiment was to remove as much bark as possible, thereby exposing the wood, in the shortest possible time.

A pecking method was found to be the only functional way in trying to break through the very hard bark of this tree. The motion of action was more or less 45 degrees in angle.

The B2 experiments: Here tools were employed to debark the *Celtis africana* (White Stinkwood) tree. The *Celtis africana* is indigenous to the area and known for its softer wood. The bark is relatively hard, but softer than that of the *Maytenus undata*, and smooth in texture.

The aim of the experiment was to remove as much bark as possible, thereby exposing the wood, in the shortest possible time.

A pecking method at a 45 degree angle was found to be the most functional way in trying to break through the bark of the tree. Once the bark was broken, a hard downwards scraping method, parallel to the tree trunk produced wood and bark shavings.

The H1 experiments: In this experiment tools were used to process the inner side of a *Bos taurus* (cattle) hide (a process called burnishing). Tools were used directly on the inner side of the hide. The purpose of this experiment was to process as large a part of the hide in the shortest possible time.

The hide was stretched using both my feet on the one side and my one hand on the other, lifting the hide slightly off the ground on this side. A hard scraping method was employed in an action away from my body.

The burnishing of hides is generally expected to produce a polish on the bone tools used (Shipman 1989), though Runnings *et al.* (1989) explain that striation marks were observed on their experimental tools used to process hides.

The H2 experiments: Tools were used to process the inner side of a *Bos taurus* (cattle) hide, making use of sediment in the burnishing process. The purpose of this experiment was to process as large a part of the hide in the shortest possible time.

The hide was covered with a thin layer of dry sediment, medium to coarse grained in particle size and containing small pebbles on occasion. Tools thus came into direct contact with the sediment and the hide.

The use of sediment had a dual purpose. Firstly it was expected to produce more striation patterns on the bone tools than during the H1 experiments where no sediment was used. Secondly the use of sediment was expected to make a functional difference, in other words to speed up the burnishing process.

The hide was stretched in the same way as during the H1 experiments, using both my feet on the one side and my one hand on the other, lifting the hide slightly off the ground on this side. A hard scraping method in an action away from my body was used.

The T1 experiments: In this experiment tools were employed to extract termites from their nests. Termite nests were broken as quickly as possible to expose the termites, the proposed food source.

A pecking method with vertical to 45 degree angles was used to break through the hard outer crust of the mound. Once the outer crust was broken, a vertically angled poking action was used to break up the inner, softer core of the termite nest.

The outer crust of the mound consisted of tightly compacted sediment. The sediment was fine to medium grained in particle size. The inner side of the mound, also composed of a fine to medium grained sediment, was much less tightly compacted and therefore softer, and it was often slightly moist. Breaking through the hard outer crusts of the mounds did not expose the termites but penetrating further into the softer inner cores of the mounds did.

3.2.1.3) Tool numbers and employment periods

A number was assigned to each experimental tool, such as W01-T1, which can be broken down to (1) W; (2) 01; (3) T1; where

(1) describes the weathered state of the specimen, thus either F (fresh) or W (weathered).

(2) Represents the number of the tool used in a specific experiment. For each experiment 3 weathered and 2 fresh bone tools were used (therefore the numbers 01, 02 or 03).

(3) Identifies the specific experiment conducted thus G1, G2, B1, B2, H1, H2 or T1.

Each tool was used for two employment periods. After an initial period of 10 min., tools were reused for a further 20 min. period, making a total of 30 min. for the final employment period

All experimental tools were made and all experiments conducted by the author.

Tool number	Tool state F-Fresh W-Weathered		Experimental tool			Experiment	Minutes used	
	W	F	01	02	03		10	30
W01-G1	✓		✓			**G1 Experiments** Digging for subterranean plant foods (bulbs) on a hill/hillslope.	✓	✓
W02-G1	✓			✓			✓	✓
W03-G1	✓				✓		✓	✓
F01-G1		✓	✓				✓	✓
F02-G1		✓		✓			✓	✓
W01-G2	✓		✓			**G2 Experiments** Digging for subterranean food sources (rootlets, worms and insects) in a riverbank environment.	✓	✓
W02-G2	✓			✓			✓	✓
W03-G2	✓				✓		✓	✓
F01-G2		✓	✓				✓	✓
F02-G2		✓		✓			✓	✓
W01-B1	✓		✓			**B1 Experiments** Debarking of the *Maytenus undata* (Koko) tree (indigenous hardwood).	✓	✓
W02-B1	✓			✓			✓	✓
W03-B1	✓				✓		✓	✓
F01-B1		✓	✓				✓	✓
F02-B1		✓		✓			✓	✓
W01-B2	✓		✓			**B2 Experiments** Debarking of the *Celtis africana* (White Stinkwood) tree (indigenous softwood).	✓	✓
W02-B2	✓			✓			✓	✓
W03-B2	✓				✓		✓	✓
F01-B2		✓	✓				✓	✓
F02-B2		✓		✓			✓	✓
W01-H1	✓		✓			**H1 Experiments** Processing the inner side (burnishing) of a *Bos taurus* (cattle) hide.	✓	✓
W02-H1	✓			✓			✓	✓
W03-H1	✓				✓		✓	✓
F01-H1		✓	✓				✓	✓
F02-H1		✓		✓			✓	✓
W01-H2	✓		✓			**H2 Experiments** Processing the inner side (burnishing) of a *Bos taurus* (cattle) hide with the aid of sediment.	✓	✓
W02-H2	✓			✓			✓	✓
W03-H2	✓				✓		✓	✓
F01-H2		✓	✓				✓	✓
F02-H2		✓		✓			✓	✓
W01-T1	✓		✓			**T1 Experiments** Extraction of termites from their mounds.	✓	✓
W02-T1	✓			✓			✓	✓
W03-T1	✓				✓		✓	✓
F01-T1		✓	✓				✓	✓
F02-T1		✓		✓			✓	✓

Table II: **Summary of tools and experiments**

3.2.2) Experimental tool documentation

Each tool was photographed with a Pentax MZ-30 camera, using a Pentax 28-80 lens. Documentary photographs were done freehand. All bones used to manufacture tools were classified to species level and the associated body part was stated in the description. Tools were then described according to the general shape of the tool, the maximum length, average cortical thickness and weathering stage.

The most advanced weathering stage covering a patch of more than $1cm^2$ on the shaft of the limb bone surface was recorded. The weathering stage recorded was done according to Behrensmeyer's (1978) classification:

Stage 0: No cracking or flaking visible on the bone surface. The bone is still greasy with marrow cavities containing tissue. Skin and muscle/ligament may cover part or all of the bone.

Stage 1: Cracking is visible, usually parallel to the fiber structure. Articular surfaces may show mosaic cracking of covering tissue and of the bone itself. Fat, skin and other tissue may or may not be present.

Stage 2: Flaking associated with cracks is visible on the outermost concentric thin layers of the bone. Long, thin flakes with one or more sides still attached to the bone as well as deeper more extensive flaking can be present. Crack edges are usually angular in cross-section. Remnants of ligaments, cartilage and skin may be visible.

Stage 3: Patches of rough, homogeneously weathered compact bone, resulting in fibrous textures covers the bone surface. In these patches all the external, concentrically layered bone has been removed. These patches can extend over the entire bone surface. Weathering penetrates 1-1.5 mm into the bone and bone fibers are still firmly attached to each other. Crack edges are usually rounded in cross-section. Tissue is rarely present.

Stage 4: A coarsely fibrous and rough texture is characteristic. Large and small splinters are present and may be loose enough to fall away when the bone is moved. Weathering penetrates into inner cavities. Cracks are open with splintered or rounded edges.

Stage 5: The bone is falling apart *in situ*. Splinters are fragile. The original bone shape may be difficult to determine.

3.2.3) Moulds, casts and micrographic documentation

Two moulds were made of each tool tip. One after the initial 10 min. working period and one after the final 30 min. working period.

Before the moulding process began all experimental tools were cleaned with a mild soap, water and a soft brush to remove any grease, dirt and dust from the bone surfaces. Once the bones were dry the moulding process began.

A compound mixing syringe was used to apply the Coltene® PRESIDENT microSystem™ light body surface activated paste, consisting of a silicone-based material and hardener, directly to the surface of the bone. The paste was applied covering the entire specimen tip up to a depth of no more than 25 mm from the tip. The compound was gently pressed onto the specimen surface to ensure the capturing of all topographic details of the tip surface. The mould was then left to set for 3-5 min., after which it was gently removed from the specimen to avoid tearing. Hereafter the mould was placed in a plastic bag to avoid contamination with dust particles and the specimen number was accordingly recorded on the plastic bag with a permanent marker. Moulds were left to set for a minimum of four days before the casting process was begun in order to avoid the formation of bubbles between the cast and mould, a feature common to newly made moulds.

Moulds were then base-mounted in Coltene® PRESIDENT microSystem™ clay, consisting of a soft catalyst and hardener mixed on a 1:1 ratio. A shoulder mounting of the same clay mixture was also applied to the lip of the mould. These mountings served to stabilise the moulds during the casting process.

Araldite®, the casting epoxy, consists of an epoxy resin and a catalyst. The Araldite® M resin and HY956 hardener were mixed in a ratio of 100:20, then gently stirred and poured into the moulds. A blunt pin was used to bring all visible air bubbles to the surface. The epoxy cast was then left to set for more or less 60 min., after which it was removed from the mould and mounted on a stub using a colloidal graphite mixture and a silver paint. Specimen numbers were recorded on the sides of the stubs. Hereafter specimens were sputter-coated with 200 angstroms of gold-palladium shading.

All moulds and casts were made by the author, all mounting preparations for SEM use was also done by the author except for the silver paint and gold-palladium shadow which was applied by Abe Seema from the Electron Microscope Unit.

A JSM 840 scanning electron microscope was used to examine the casts. An accelerating voltage of 10kv was used throughout the process of taking micrographs. All micrograph magnifications were standardised. A relatively low magnification of x 15 mag. was used to place attributes in the vicinity of the tip while a higher magnification of x 30 mag. was used to enhance these features. These standard magnification sizes were employed to correspond with the magnification sizes used by Backwell (Backwell & d'Errico 2001), thereby broadening the existing micrograph database of experimentally employed bone tools.

All work done on the SEM was undertaken by the author. Micrographs were developed by the WITS Central Graphics Service.

No MICROWARE image analysis software was available for this project. Exact lengths, widths and directions of striations could therefore not be measured. A scale bar is included in every micrograph and can be used for estimations. Note that the SEM focus is on the center of the micrograph, and a small scale-error margin can therefore be expected towards the frame of the micrograph.

Microscopic analysis was based on the optical comparison of the micrographs, focusing on striation compositions displayed on the tool tips. Tools were also examined macroscopically to detect general features not situated within the 25 mm. of the casted tips such as striations situated further away from the tool tips, and on the bodies of the tools. Polish was also examined macroscopically since a cast can not capture the degree of polish, although smoothing and rounding are visible on the casts.

NOTE: The SEM is capable of taking micrographs at exact scales, with no error-margin towards the frame of the micrograph. This feature was faulty during the course of my project and could therefore not be used. The rotation button on the SEM was also faulty, micrographs of a specific tool are therefore not always taken from the same angle, making interpretation sometimes difficult.

Tool number	Micrograph mag. after 10 min. use		Micrograph mag. after 30 min. use	
	x15	x30	x15	x30
W01-G1	✓	✓	✓	✓
W02-G1	✓	✓	✓	✓
W03-G1	✓	✓	✓	✓
F01-G1	✓	✓	✓	✓
F02-G1	✓	✓	✓	✓
W01-G2	✓	✓	✓	✓
W02-G2	✓	✓	✓	✓
W03-G2	✓	✓	✓	✓
F01-G2	✓	✓	✓	✓
F02-G2	✓	✓	✓	✓
W01-B1	✓	✓	✓	✓
W02-B1	✓	✓	✓	✓
W03-B1	✓	✓	✓	✓
F01-B1	✓	✓	✓	✓
F02-B1	✓	✓	✓	✓
W01-B2	✓	✓	✓	✓
W02-B2	✓	✓	✓	✓
W03-B2	✓	✓	✓	✓
F01-B2	✓	✓	✓	✓
F02-B2	✓	✓	✓	✓
W01-H1	✓	✓	✓	✓
W02-H1	✓	✓	✓	✓
W03-H1	✓	✓	✓	✓
F01-H1	✓	✓	✓	✓
F02-H1	✓	✓	✓	✓
W01-H2	✓	✓	✓	✓
W02-H2	✓	✓	✓	✓
W03-H2	✓	✓	✓	✓
F01-H2	✓	✓	✓	✓
F02-H2	✓	✓	✓	✓
W01-T1	✓	✓	✓	✓
W02-T1	✓	✓	✓	✓
W03-T1	✓	✓	✓	✓
F01-T1	✓	✓	✓	✓
F02-T1	✓	✓	✓	✓

Table III: **Summary of micrographic documentation**

3.3) Documentation and results

NOTE: In the descriptions of experimental use wear patterns, polish, rounding and smoothing are discussed separately from characteristics such as striations, pitting and chipping. Although all these features more than often result from wear, the distinction is made for convenience.

Polish, smoothing and rounding, wear characteristics that alter the overall morphology of the tools tips, are primarily macroscopically visible. These wear characteristics will be referred to as visual characteristics.

Wear characteristics such as striations, pitting and the chipping away of small flakes are referred to as diminishing characteristics since their occurrence is essentially reductionist in character to the surface of a bone tool. Striations, pitting and chipping can be macroscopically visible but microscopic examination of them is necessary.

3.3.1) The G1 tools: Digging for subterranean plant foods (bulbs) on a hill/hillslope

W01-G1

Description	A big sturdy looking tool in appearance with one flat end. The other end tapers to a V-shape. This working tip proved to be very functional in the digging for subterranean plant foods (bulbs) on a hill/hillslope environment. The large size of the tool rendered it very practical.
Faunal association	Shaft fragment of an *Equus ferus* (horse) tibia.
Length	201 mm
Cortical thickness	7 mm
Weathering stage	1

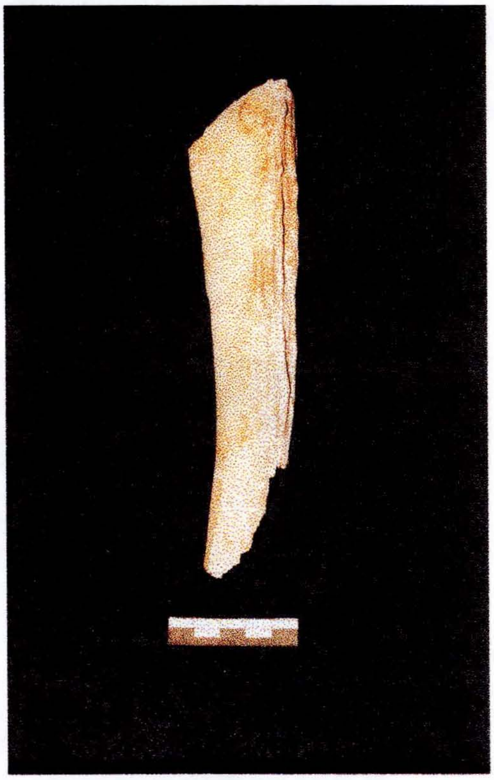


Figure 1.1: **Documentary photograph: Experimental tool W01-G1**

Figure 1.2.1:
SEM micrograph:
W01-G1: x 15 mag. after 10 min. use

Figure 1.2.2:
SEM micrograph:
W01-G1: x 30 mag. after 10 min. use

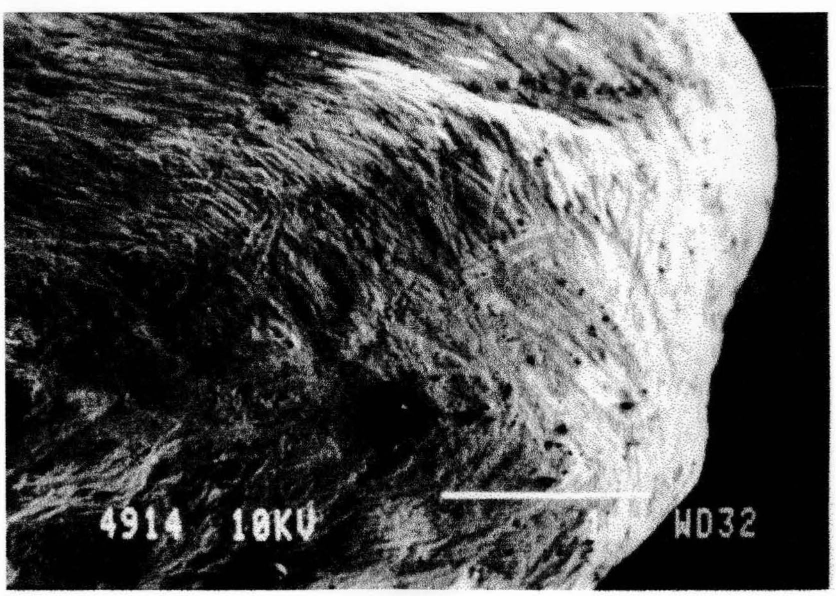


Figure 1.3.1:

SEM micrograph:
W01-G1: x 15 mag. after 30 min. use

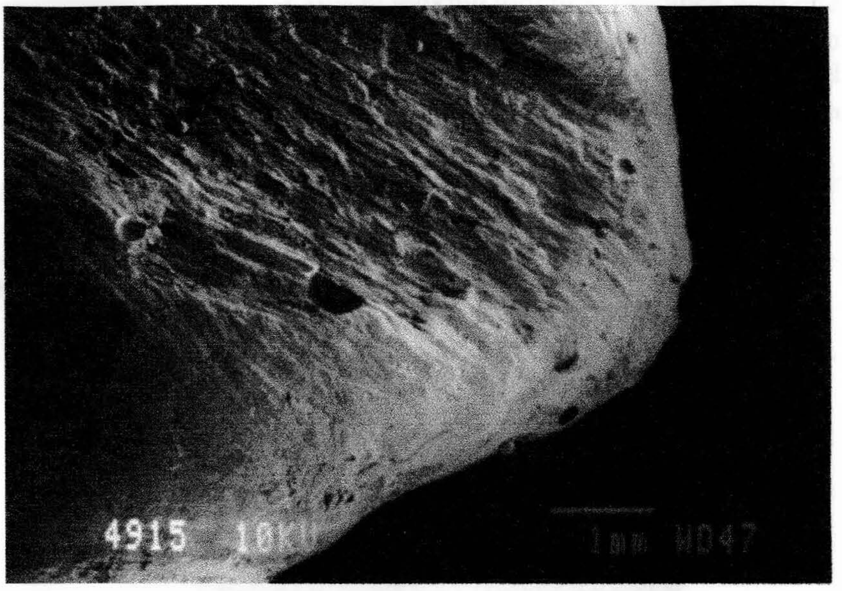
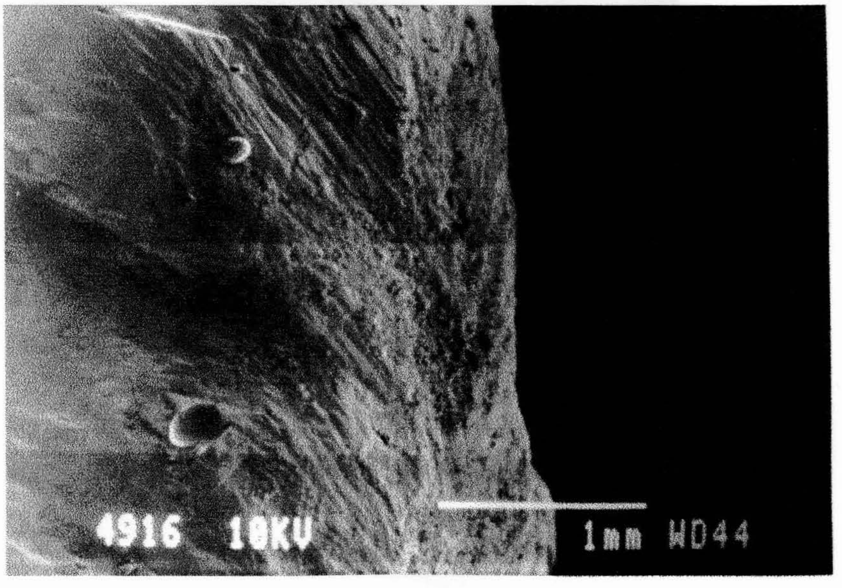


Figure 1.3.2:

SEM micrograph:
W01-G1: x 30 mag. after 30 min. use



W02-G1

Description	A sturdy looking tool in appearance with one flat ruggedly shaped edge, the other end tapers to a prominent V-shape. This working tip proved to be very functional in the digging for subterranean bulbs on a hill/hillslope environment.
Faunal association	Shaft fragment of an *Equus ferus* (horse) tibia.
Length	164 mm
Cortical thickness	11 mm
Weathering stage	3

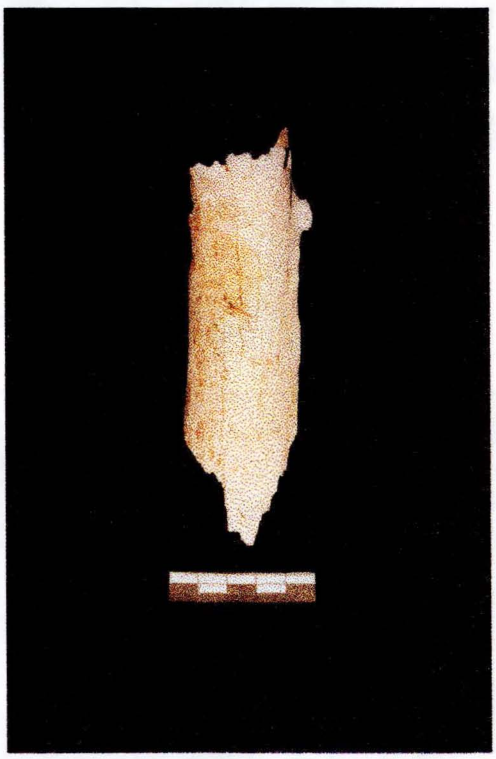


Figure 2.1: **Documentary photograph: Experimental tool W02-G1**

Figure 2.2.1:
SEM micrograph:
W02-G1: x 15 mag. after 10 min. use

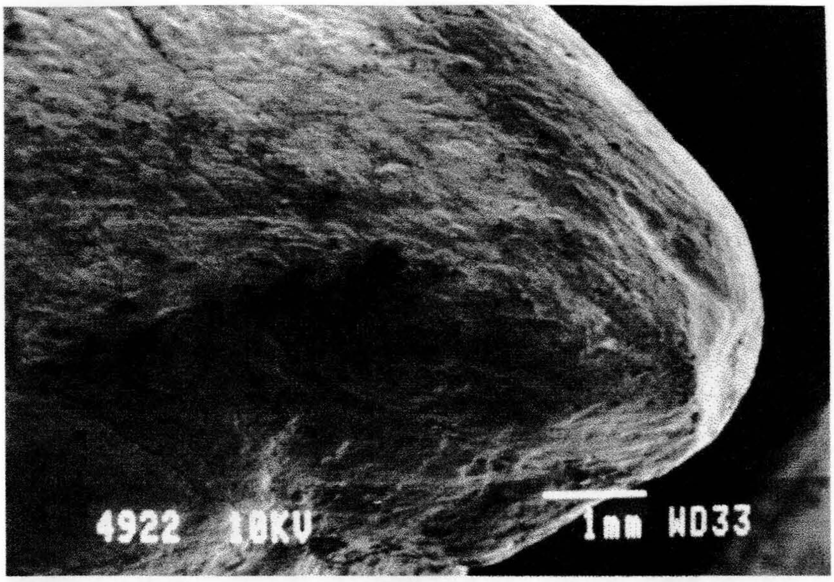


Figure 2.2.2:
SEM micrograph:
W02-G1: x 30 mag. after 10 min. use

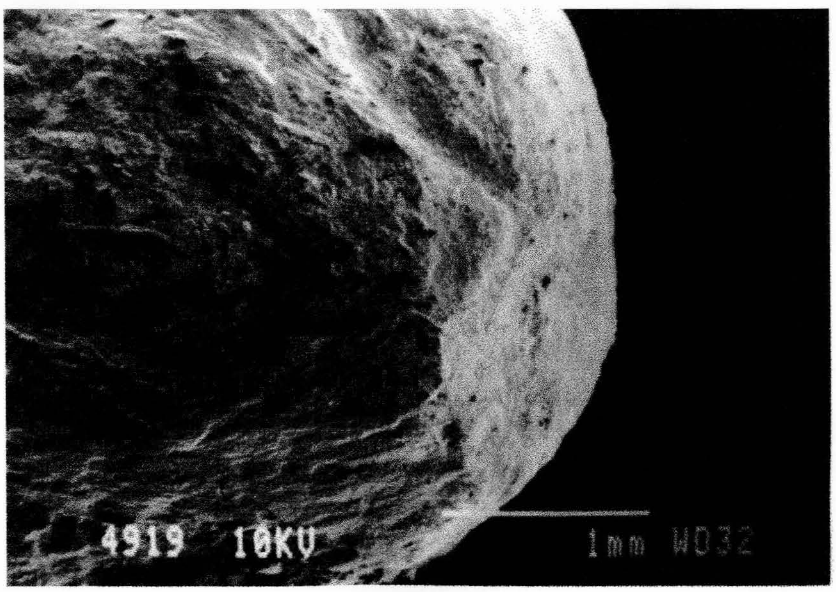


Figure 2.3.1:
SEM micrograph:
W02-G1: x 15 mag. after 30 min. use

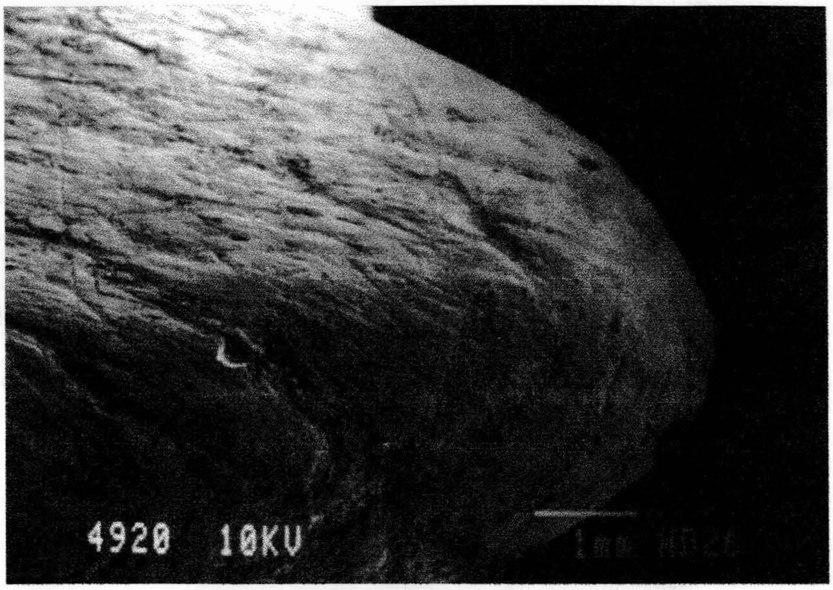
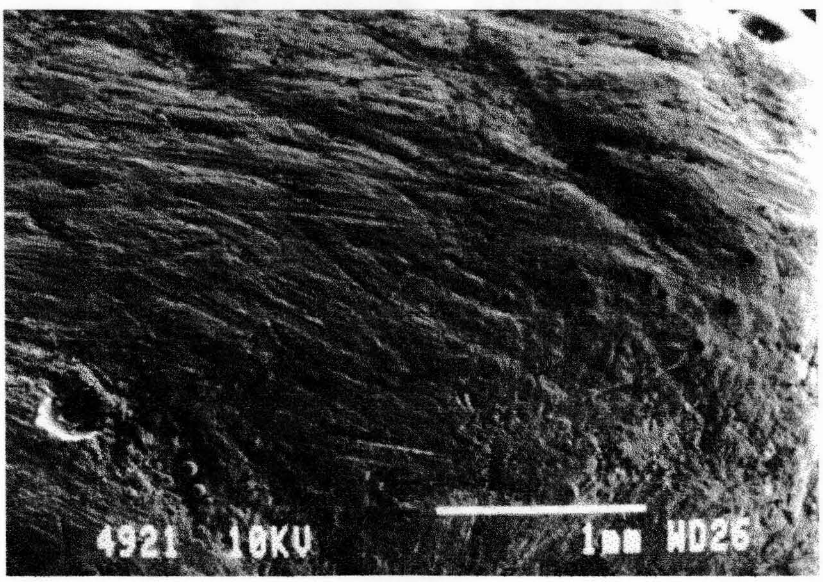


Figure 2.3.2:
SEM micrograph:
W02-G1: x 30 mag. after 30 min. use



W03-G1

Description	A slender, splintery looking tool in appearance, tapering to a point at both ends. The working tip of this tool was sharp and thin, which proved to be extremely functional in the digging for subterranean plant foods on a hill/hillslope environment.
Faunal association	Shaft fragment of a *Hippotigris grevi* (Grevy zabra) femur.
Length	151 mm
Cortical thickness	8 mm
Weathering stage	3

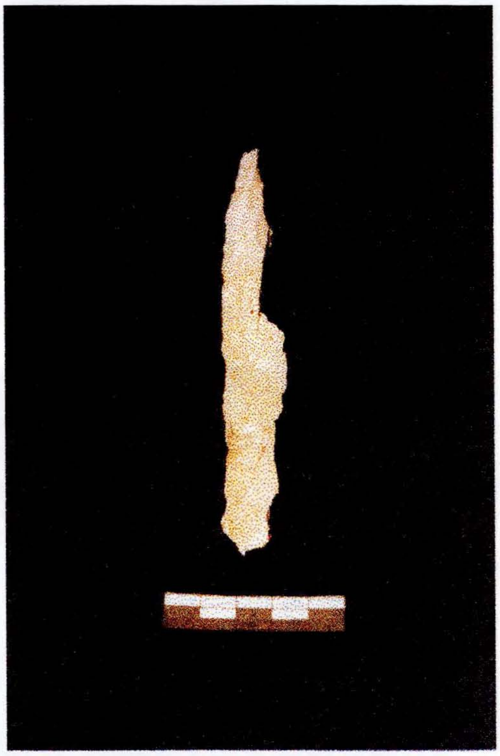


Figure 3.1: **Documentary photograph: Experimental tool W03-G1**

Figure 3.2.1:
SEM micrograph:
W03-G1: x 15 mag. after 10 min. use

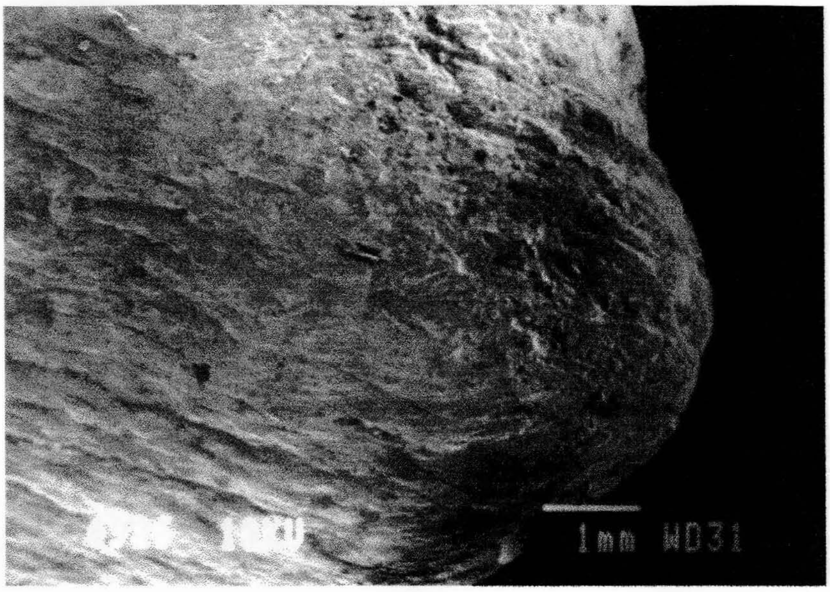


Figure 3.2.2:
SEM micrograph:
W03-G1: x 30 mag. after 10 min. use

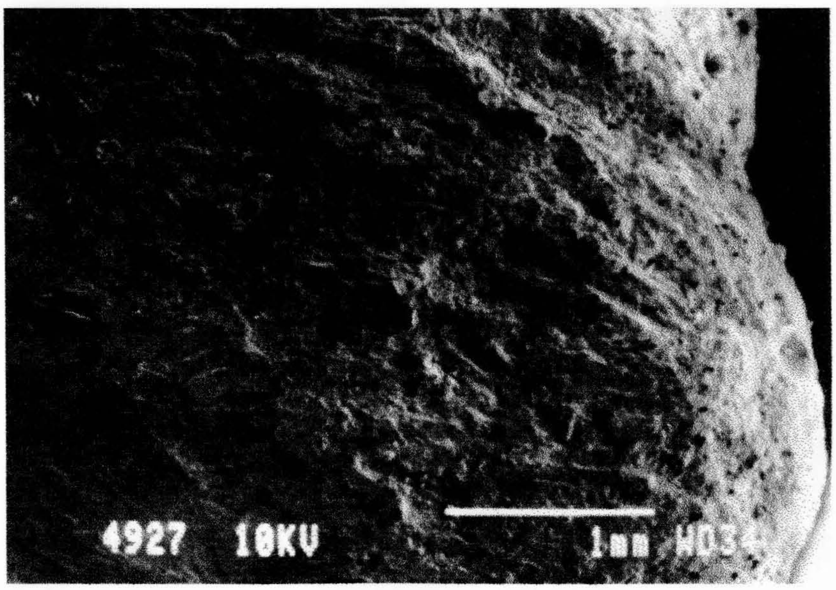


Figure 3.3.1:
SEM micrograph:
W03-G1: x 15 mag. after 30 min. use

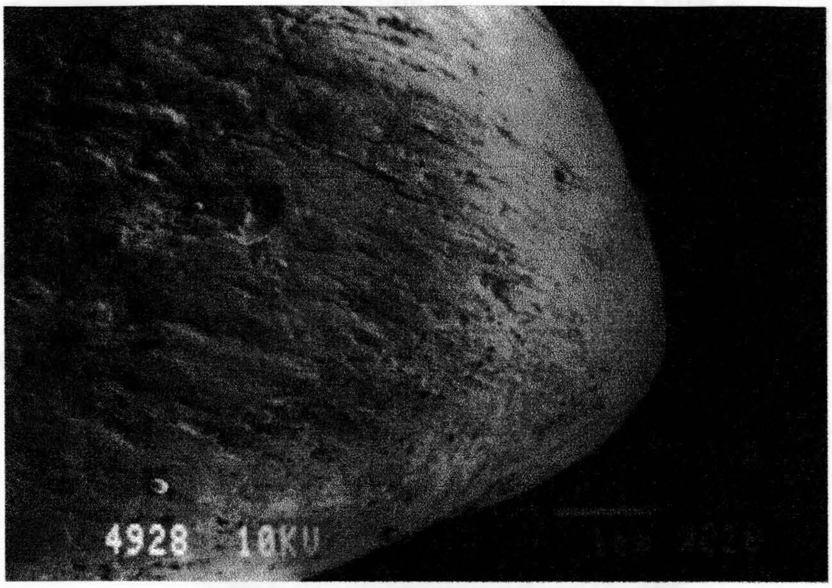
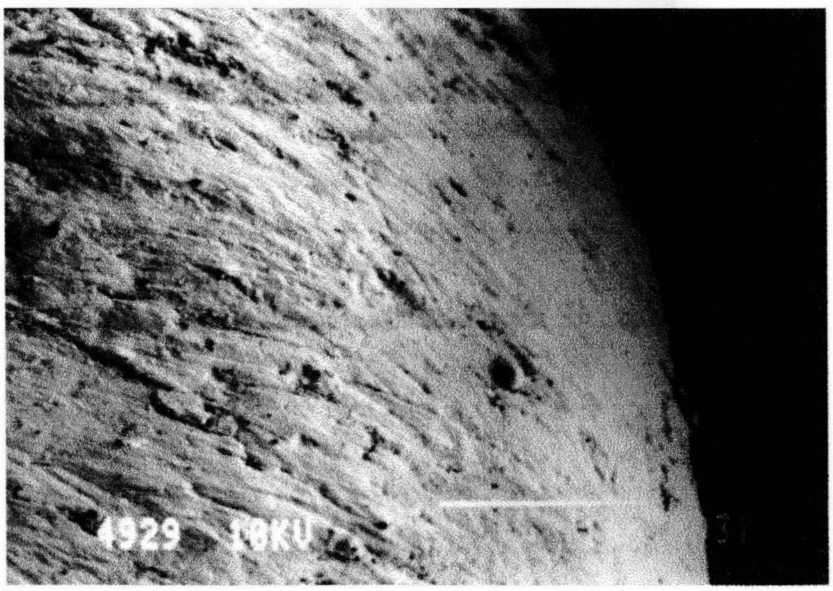


Figure 3.3.2:
SEM micrograph:
W03-G1: x 30 mag. after 30 min. use



F01-G1

Description	A long, thin tool tapering to a point at both ends. The working tip forms a steep point, which is slightly rounded. The tool proved to be extremely functional in digging for subterranean plant foods (bulbs) on hilly terrain, because of both the morphology of the tool, especially the tip, as well as the length of the tool.
Faunal association	Shaft fragment of a *Bos taurus* (cattle) tibia.
Length	94 mm
Cortical thickness	6 mm
Weathering stage	Fresh/Green

Figure 4.1: **Documentary photograph: Experimental tool F01-G1**

Figure 4.2.1:
SEM micrograph:
F01-G1: x 15 mag. after 10 min. use

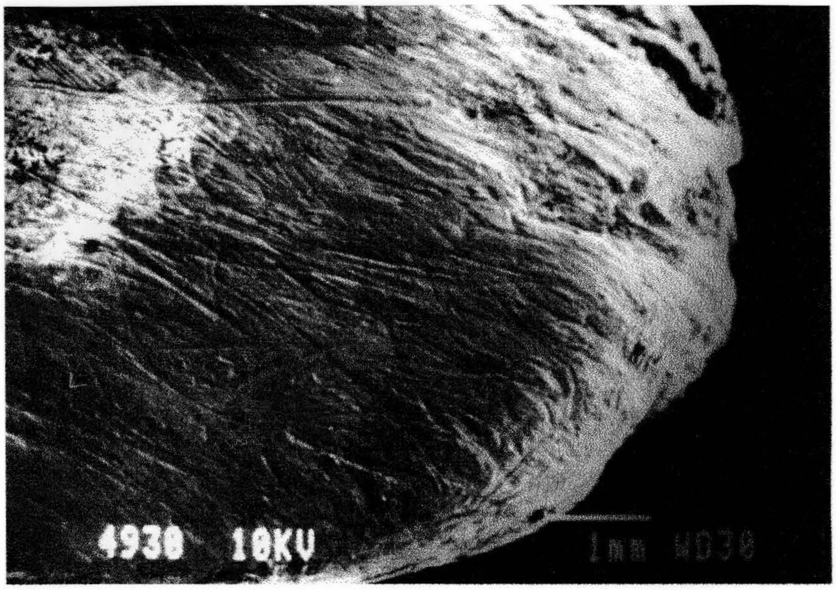


Figure 4.2.2:
SEM micrograph:
F01-G1: x 30 mag. after 10 min. use

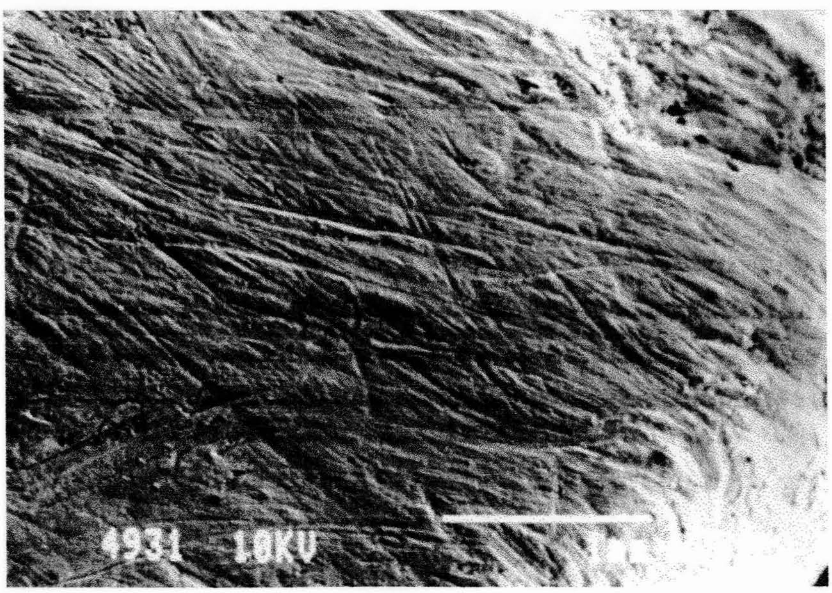


Figure 4.3.1:

SEM micrograph:
F01-G1: x 15 mag. after 30 min. use

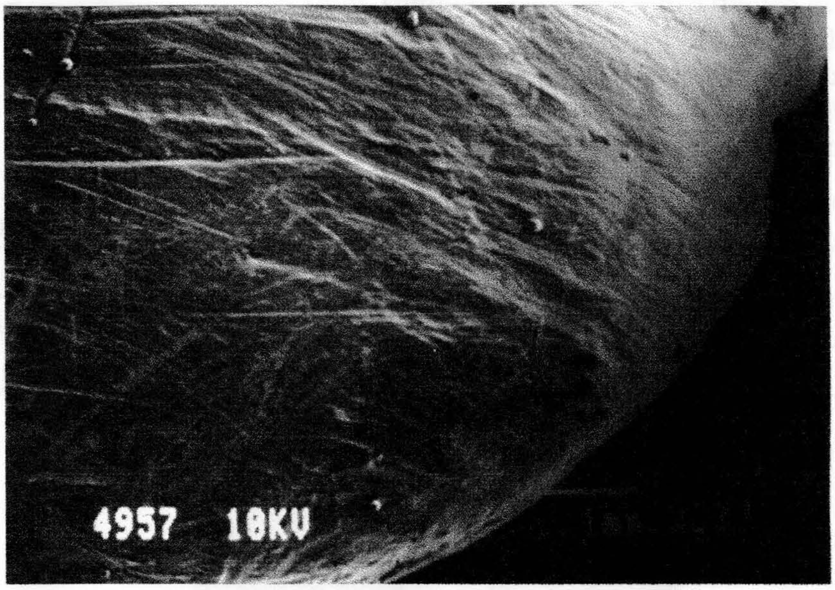
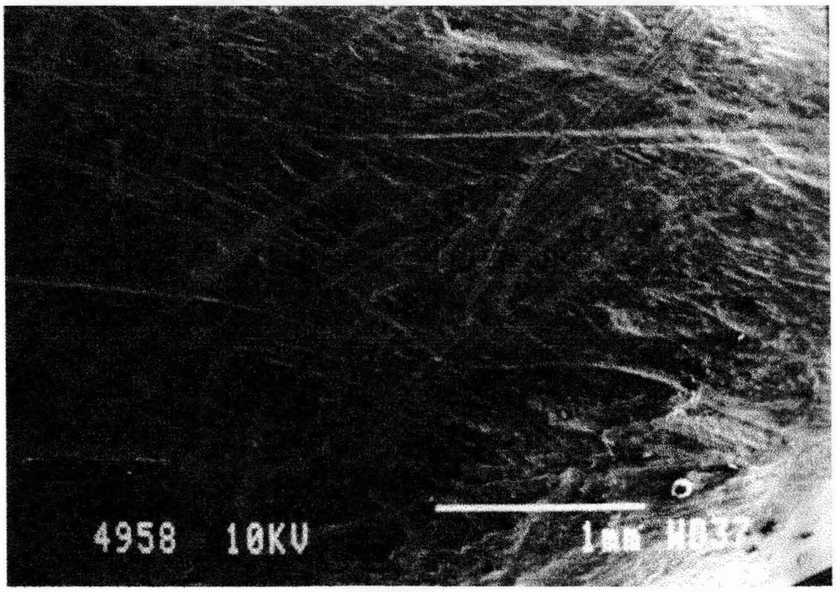


Figure 4.3.2:

SEM micrograph:
F01-G1: x 30 mag. after 30 min. use



F02-G1

Description	A short, sturdy looking tool with a rugged edge on one side and a relatively steep, but broad end on the other. This working tip proved to by quite functional in digging for subterranean plant foods on hilly terrain though the short length of the tool hampered its functionality.
Faunal association	Shaft fragment of a *Bos taurus* (cattle) tibia.
Length	50 mm
Cortical thickness	4 mm
Weathering stage	Fresh/Green

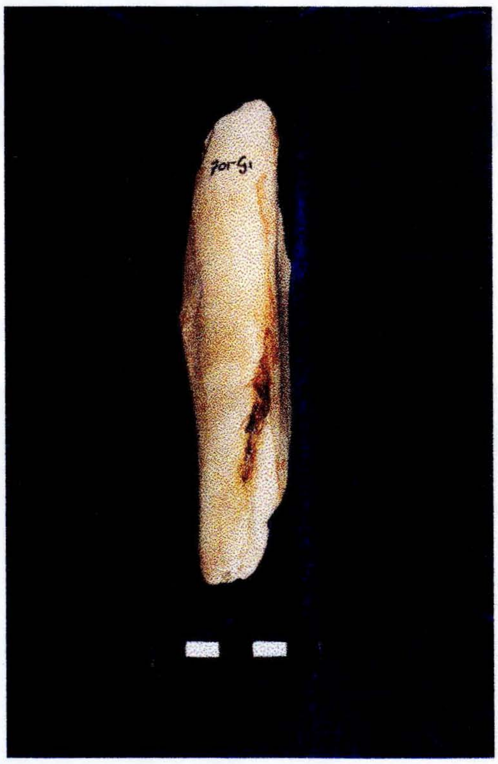


Figure 5.1: **Documentary photograph: Experimental tool F02-G1**

Figure 5.2.1:
SEM micrograph:
F02-G1: x 15 mag. after 10 min. use

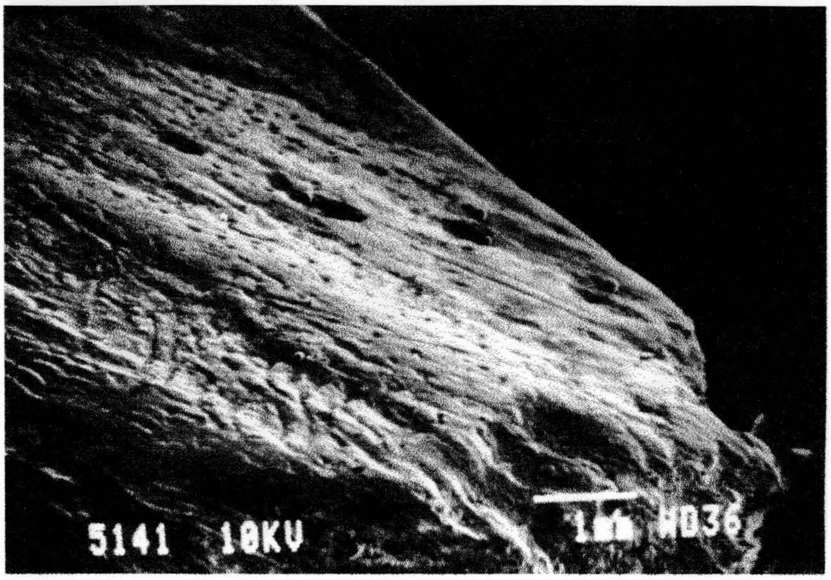


Figure 5.2.2:
SEM micrograph:
F02-G1: x 30 mag. after 10 min. use

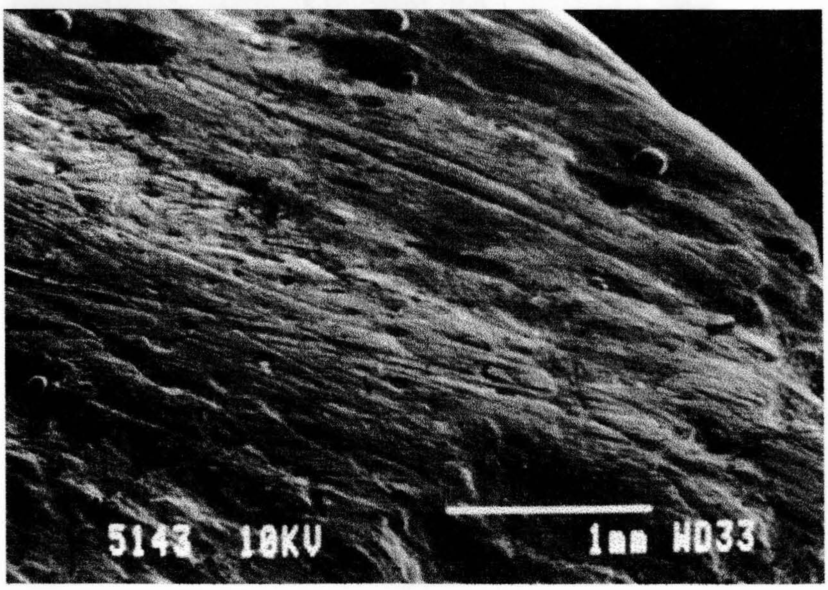
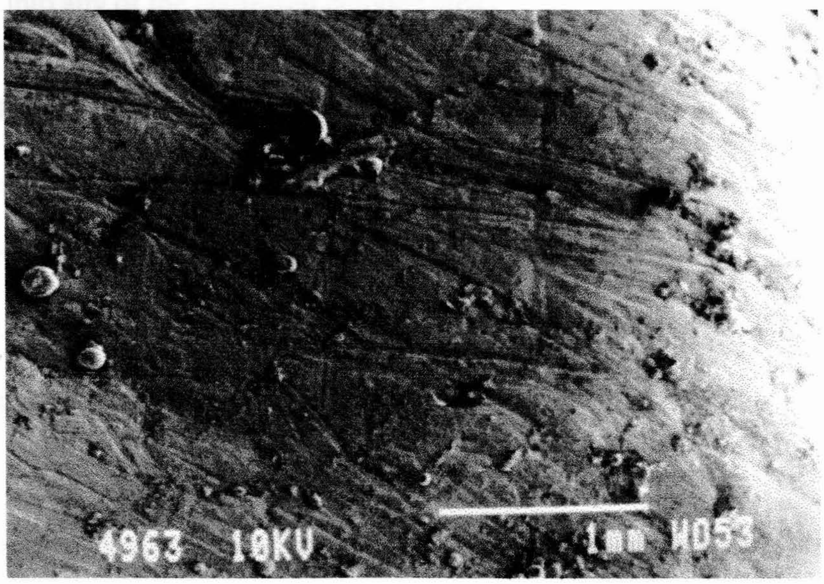


Figure 5.3.1:
SEM micrograph:
F02-G1: x 15 mag. after 30 min. use

Figure 5.3.2:
SEM micrograph:
F02-G1: x 30 mag. after 30 min. use



3.3.1) The G1 tools: Digging for subterranean plant foods (bulbs) on a hill/hillslope

3.3.1.1) The G1 tools- a short discussion

W01-G1: After 10 min. use multiple perpendicular angled criss-cross striations were observed on the working tip (Fig. 1.2.2), with the tip of the tool partially shaped and smoothed by working. Despite the fact that the tool received two relatively large chips during the final period of employment, some dominant longitudinal striations were observed. However perpendicular angled criss-cross and individual diagonal striations were much more prominent (Fig. 1.3.2). Striations observed were concentrated all around the surface of the tool tip. No striations were observed within the chipped depressions (Fig. 1.3.1). The tool tip was even more smoothly shaped after the final working period. A slight polish was also visible on the very tip of the tool. This polish did not extend into any of the depressed chipped areas.

W02-G1: Prominent diagonal striae and perpendicular angled criss-cross formations were observed on the surface of the tool together with fine perpendicular angled criss-cross striations on the very tip of the tool after the 10 min. working period (Fig. 2.2.2). Rounding and smoothing of the tip were already visible after 10 min. After 30 min. of employment this rounding and smoothing was much more prominent, with a clear polish at the tip. After 30 min. of employment the most prominent diagonal striations were partially erased. Many more perpendicular angled criss-cross striations together with transverse striations were observed on the surface of the tool (Fig. 2.3.1). Perpendicular angled criss-cross compositions covered the very tip and the edges of the tool tip (Fig. 2.3.2).

W03-G1: A few diagonal striations, forming rather perpendicular criss-cross angles, were observed after 10 min. of employment. These were primarily restricted to the smoothed area of the tool tip and the very tip of the tool (Fig. 3.2.2). While some of the 10 min. striations were erased on the 30 min. specimen, many more diagonal and acutely angled criss-cross striations were visible (Fig. 3.3.2). This occurrence is probably due to the larger smoothed tip area of the 30 min. specimen (Fig. 3.3.1). The 30 min. specimen was much more rounded and smoothed than the 10 min. specimen with a slight polish displayed over most of the working tip. All striations observed were restricted to the extent of the polish on both the 10 min. and the 30 min. specimen, and no striations were observed on the rough tool surface.

F01-G1: Some large diagonal striations forming perpendicular angled criss-cross formations on the surface of the tool tip together with a multitude of fine criss-cross striations at the working tip, more acute in angle, were observed after a 10 min. working period (Fig. 4.2.2). Within the 1st 10 min. working period the specimen chipped (1 medium chip with smaller chip fractures at the tool tip edge). Rounding and smoothing of the tool tip and a slight degree of polish was visible after the 1st working period. After 30 min. of employment many more large and fine primarily perpendicular angled criss-cross striations were visible (Fig. 4.3.2), with a number of transverse striations situated further away from the tip. Chipped edges were more smoothed in with the rest of the tool tip while definite modification and a high degree of polish to the tip was visible. The tool displayed a vast amount of clearly visible striations, perhaps the result of a relatively large tool with a very functional tip.

F02-G1: Despite the relatively broad tip of the tool, micro-striations were observed all around the tip. The 10 min. specimen had a few longitudinally oriented and clear acutely angled criss-cross striations at the tip (Fig. 5.2.2). Very little polish or modification to the tip was observed. After the 30 min. working period much more modification and polish was observed with clear perpendicular angled criss-cross striations covering the tip. A few transverse striations were also observed, situated very close to the tool tip (Fig. 5.3.2).

3.3.1.2) Summary of the G1 tools

The Gl tool tips displayed a marked increase in modification (both rounding and smoothing) from the 1st to the 2nd working period. This increase in modification extended to an increase in the polish observed on the tool tips. No clear demarcation could be observed between the working tips and the surfaces of these tools. Modification tended towards a smoothing of the complete tip to form gradually tapering points.

Modification marks observed can be described as primarily perpendicular angled criss-cross formations with only solitary longitudinal and diagonal striae interrupting this composition. Transverse striations observed were mostly situated slightly further away from the working tip. A clear degree of overprinting could be detected. Despite modification to the tool tips after every working period, the micro-striation compositions remained constant – recurring as predominantly perpendicular angled criss-cross shaped formations. No difference was detected in the striation composition between the fresh and weathered tools. Striations observed on the fresh tools were however more intense than those observed on the weathered tools. Some tools chipped during employment. No modification marks were observed on the inside of the chipped depressions. Chipped depressions were relatively quickly smoothed and erased by the rapid modification to the overall shape of the tool tips.

Larger tools proved to be more functional than their smaller counterparts.

3.3.2) The G2 tools: Digging for subterranean food sources (rootlets, worms and insects) in a riverbank environment

W01-G2

Description	A long, thin tool with a flat, rounded end on the one side. The other end tapers into an asymmetrical V-shape. This working tip proved to be very functional in the digging for subterranean food sources in a riverbank environment. The length of the tool largely complimented its functionality.
Faunal association	Shaft fragment of an *Equus ferus* (horse) tibia.
Length	212 mm
Cortical thickness	8 mm
Weathering stage	2

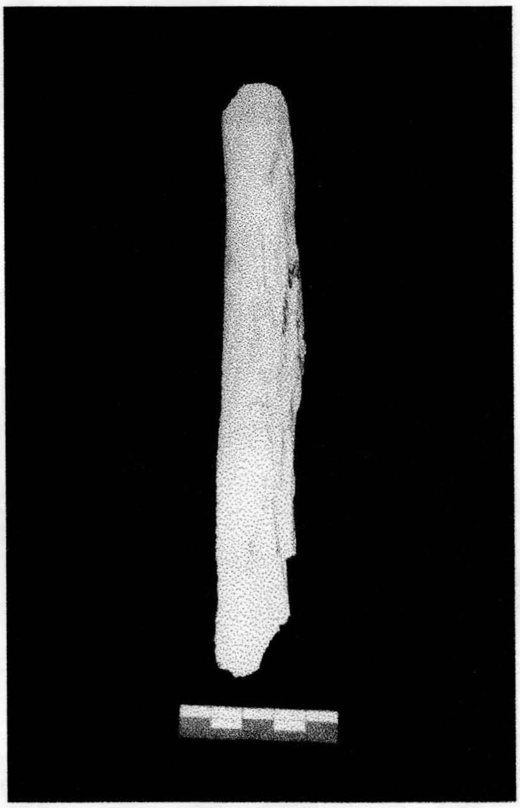


Figure 6.1: **Documentary photograph: Experimental tool W01-G2**

Figure 6.2.1:
SEM micrograph:
W01-G2: x 15 mag. after 10 min. use

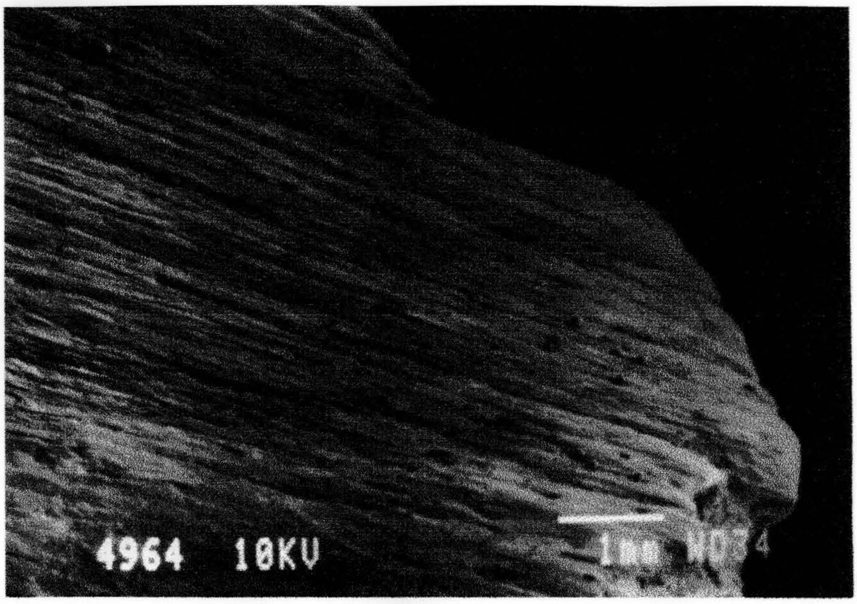


Figure 6.2.2:
SEM micrograph:
W01-G2: x 30 mag. after 10 min. use

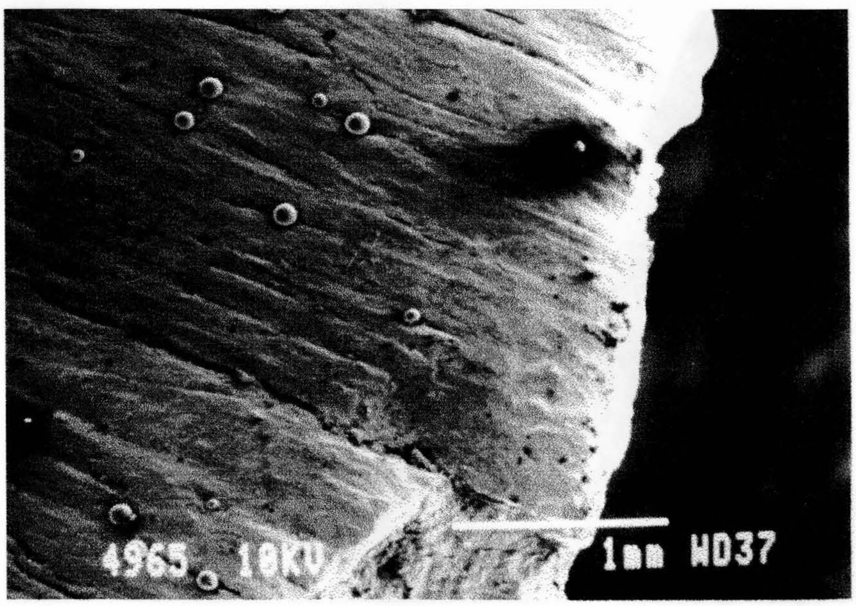


Figure 6.3.1:
SEM micrograph:
W01-G2: x 15 mag. after 30 min. use

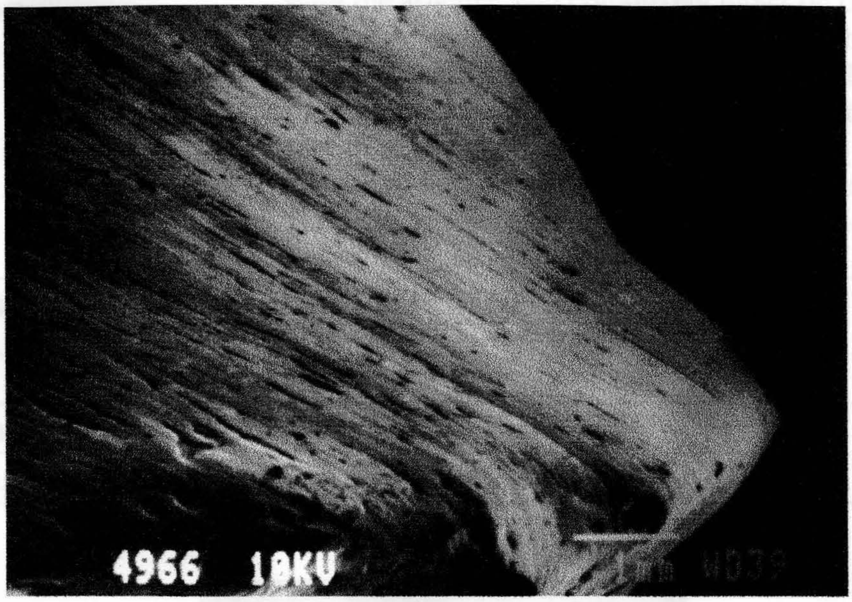
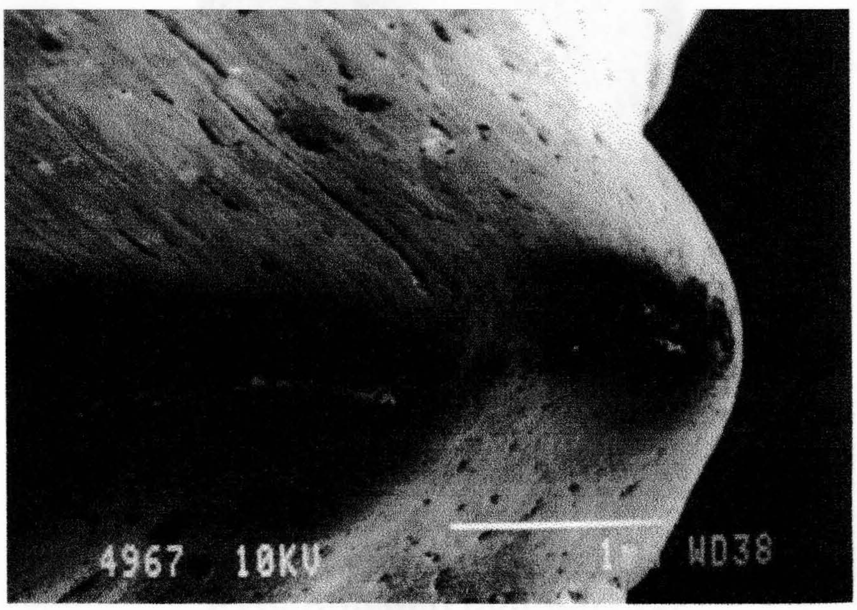


Figure 6.3.2:
SEM micrograph:
W01-G2: x 30 mag. after 30 min. use



W02-G2

Description	With the articular end completely intact on one end the tool tapers to a point at the other end. The tool has a narrow V-shaped morphology. A small split was observed on the tool tip. This working tip proved to be very functional in digging for subterranean food sources in a riverbed environment. The articular end also proved to be a very practical handle when working with the tool.
Faunal association	Fragment of an *Equus ferus* (horse) tibia with the proximal articular end intact.
Length	257 mm
Cortical thickness	6 mm
Weathering stage	2

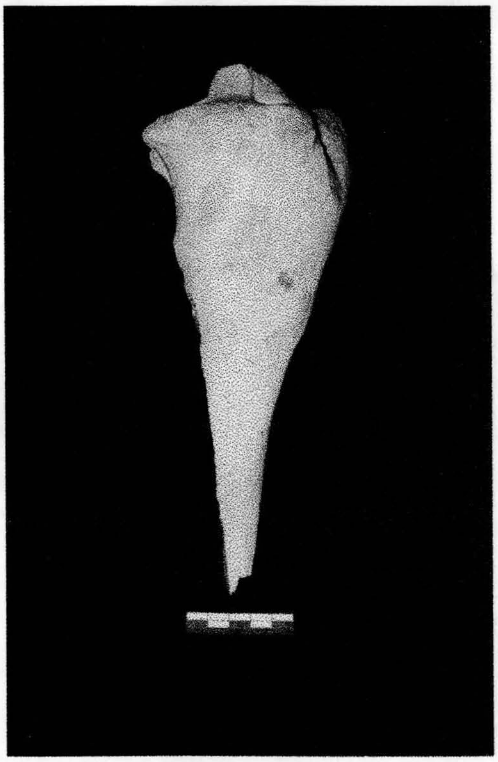


Figure 7.1: **Documentary photograph: Experimental tool W02-G2**

Figure 7.2.1:
SEM micrograph:
W02-G2: x 15 mag. after 10 min. use

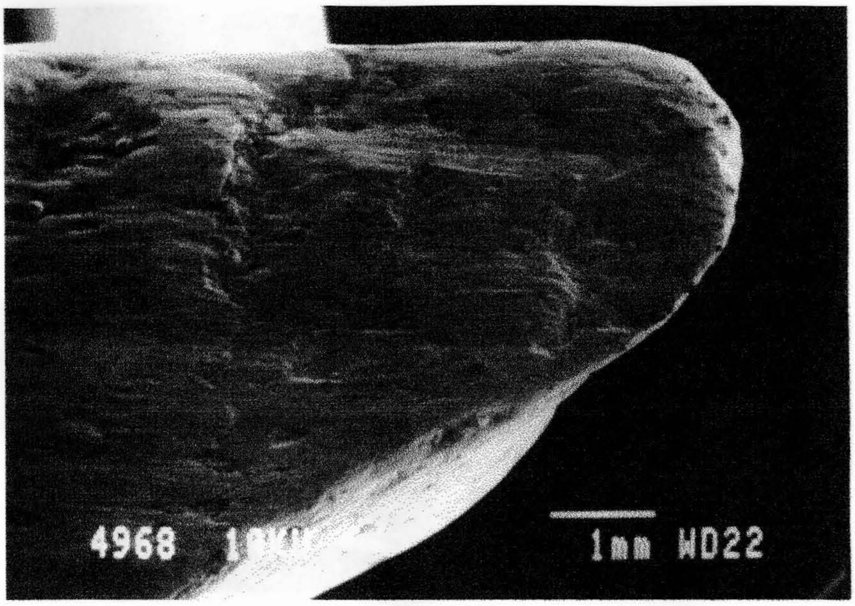


Figure 7.2.2:
SEM micrograph:
W02-G2: x 30 mag. after 10 min. use

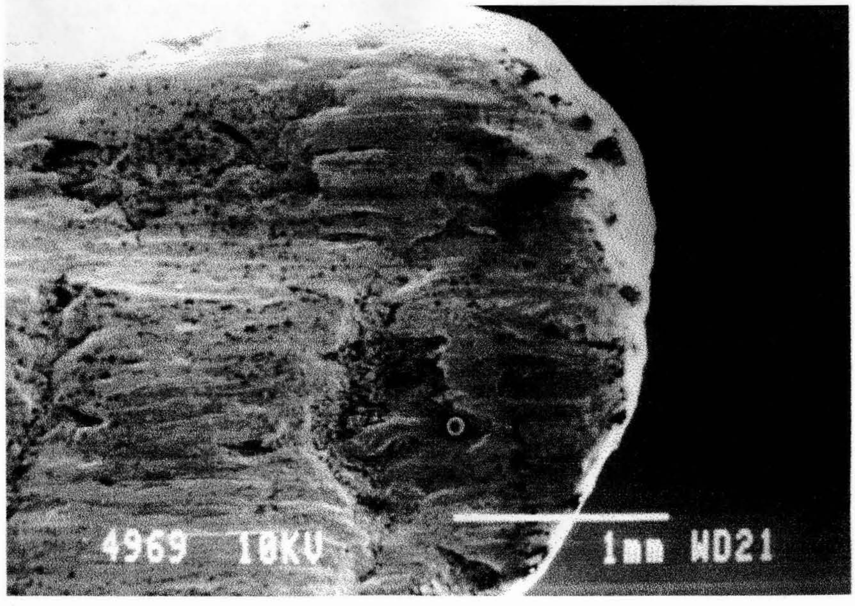


Figure 7.3.1:
SEM micrograph:
W02-G2: x 15 mag. after 30 min. use

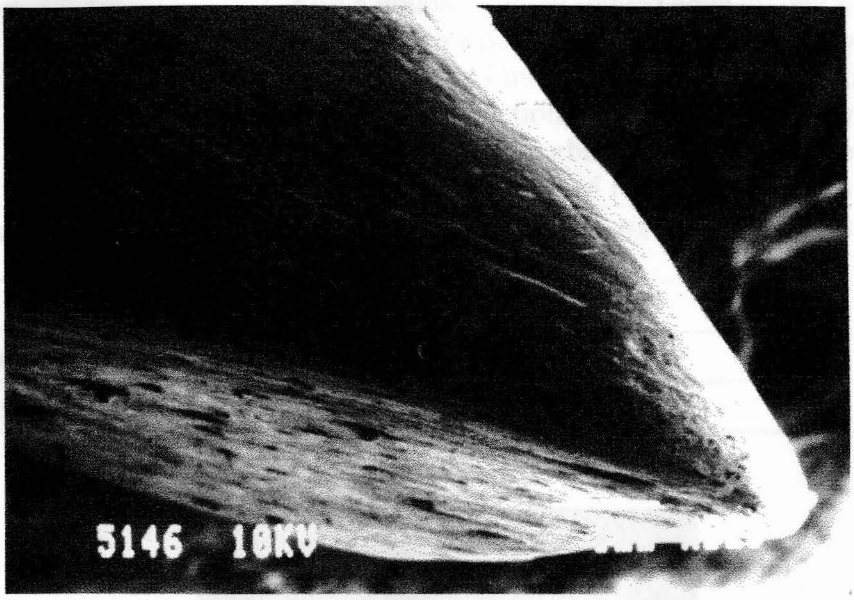
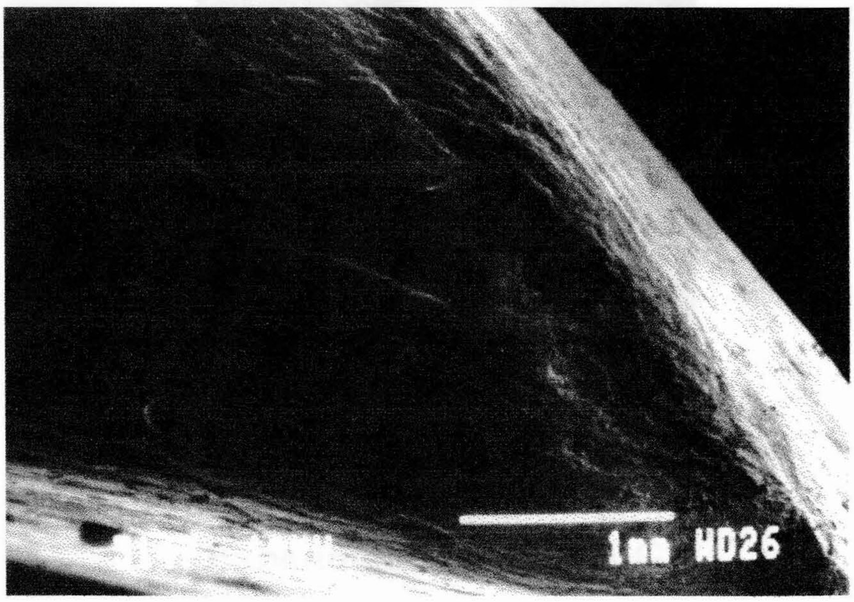


Figure 7.3.2:
SEM micrograph:
W02-G2: x 30 mag. after 30 min. use



W03-G2

Description	With a double pointed rugged edge on one side this tool tapers to a point at the other end. This working tip has a short (7 mm), flat end. The tool proved to be extremely functional in digging for subterranean food sources in a riverbank environment. Greater length would have added much to its functionality.
Faunal association	Shaft fragment of a *Hippotigris grevi* (Grevy zebra) femur.
Length	130 mm
Cortical thickness	7 mm
Weathering stage	2

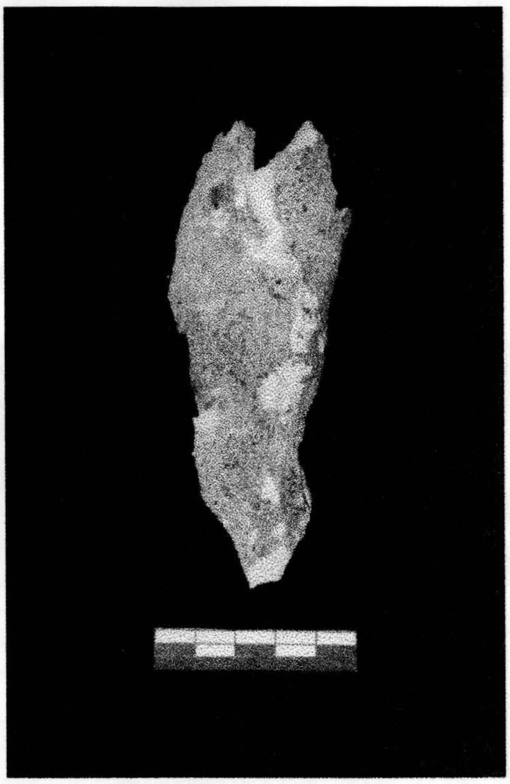


Figure 8.1: **Documentary photograph: Experimental tool W03-G2**

Figure 8.2.1:
SEM micrograph:
W03-G2: x 15 mag. after 10 min. use

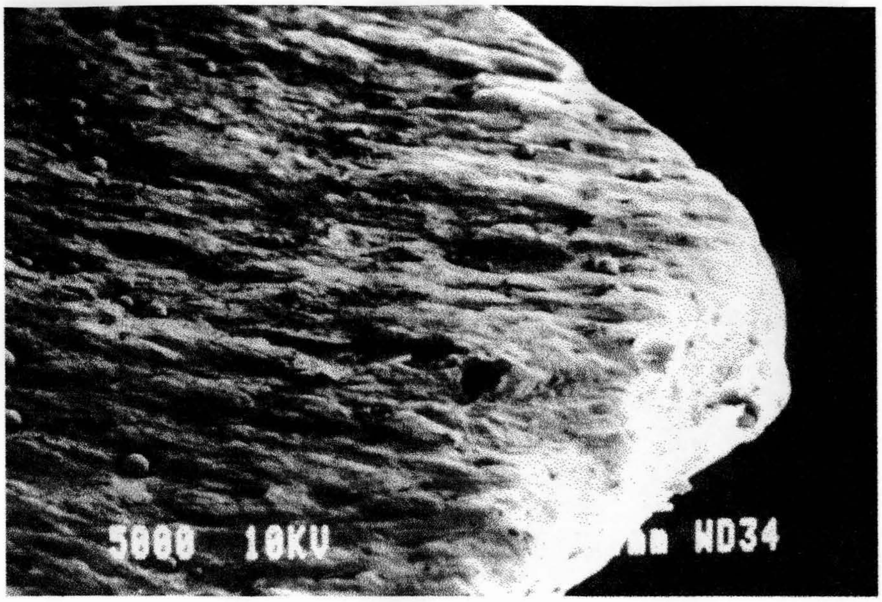


Figure 8.2.2:
SEM micrograph:
W03-G2: x 30 mag. after 10 min. use

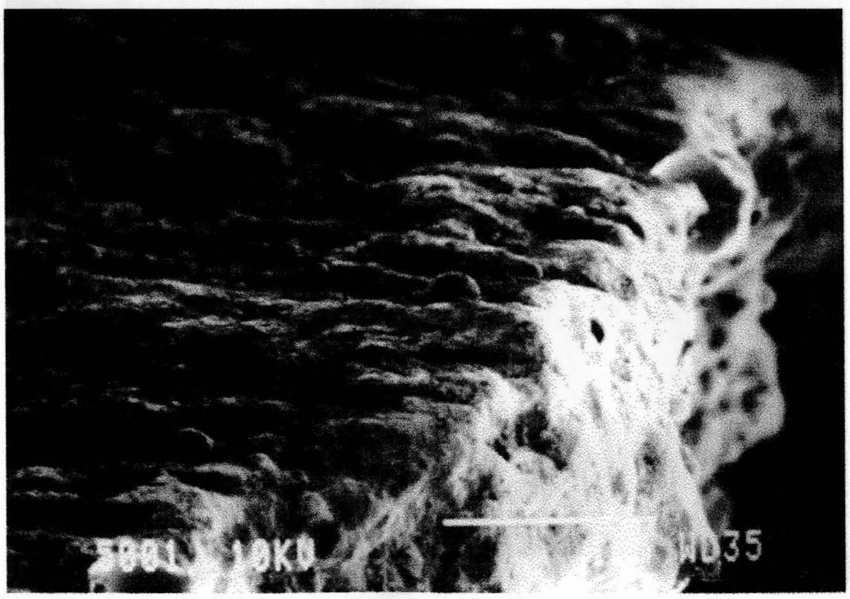


Figure 8.3.1:

SEM micrograph:
W03-G2: x 15 mag. after 30 min. use

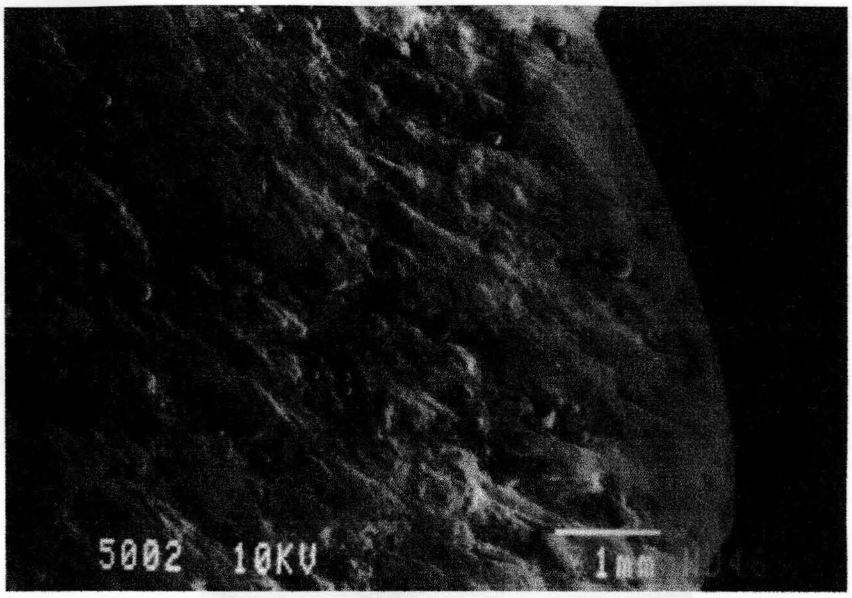
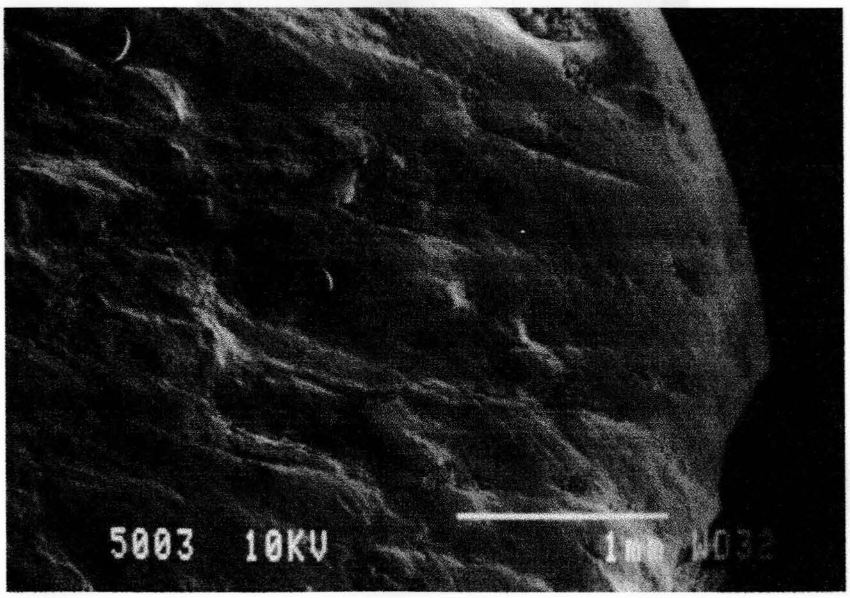


Figure 8.3.2:

SEM micrograph:
W03-G2: x 30 mag. after 30 min. use



F01-G2

Description	A short splintery looking tool ruggedly fractured at both ends. The working tip is steep and very slender. The tool was used to dig for subterranean food sources in a riverbank. The tip of the tool proved to be very functional though the short length of the tool caused it often not to break through the foliage which very often extended to the riverbank.
Faunal association	Shaft fragment of a *Bos taurus* (cattle) tibia.
Length	49 mm
Cortical thickness	3 mm
Weathering stage	Fresh/Green

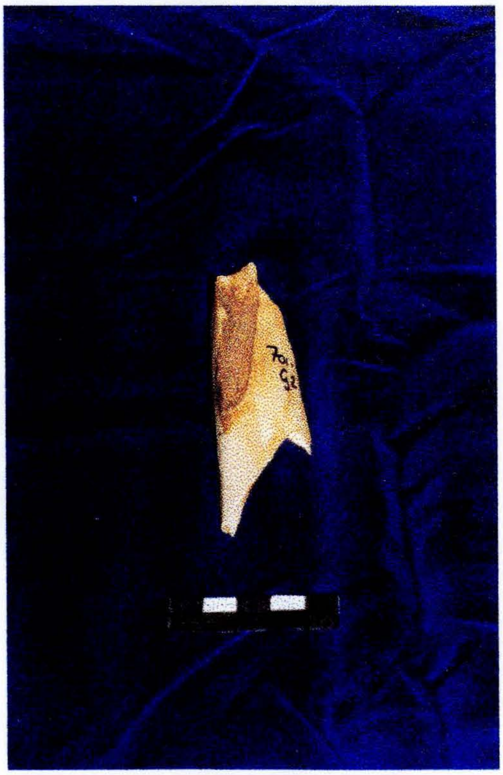


Figure 9.1: **Documentary photograph: Experimental tool F01-G2**

Figure 9.2.1:
SEM micrograph:
F01-G2: x 15 mag. after 10 min. use

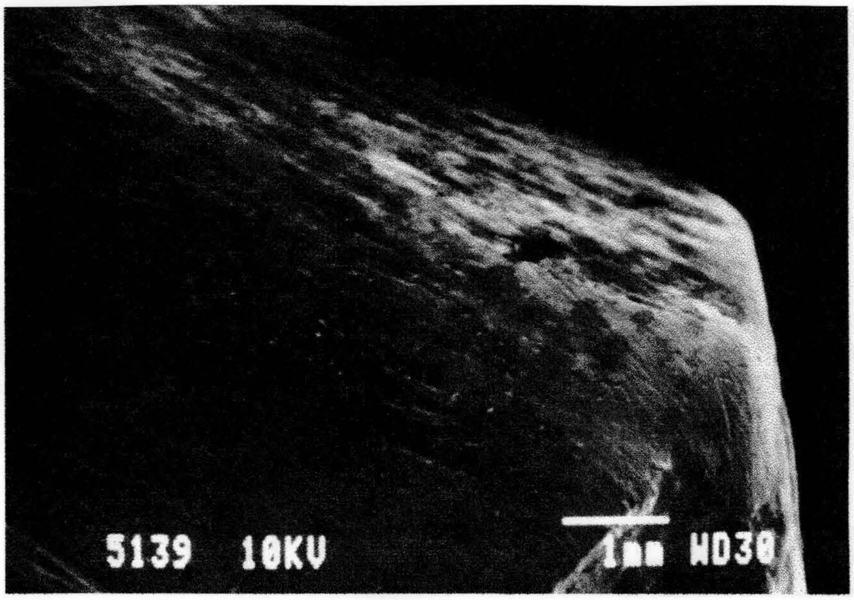


Figure 9.2.2:
SEM micrograph:
F01-G2: x 30 mag. after 10 min. use

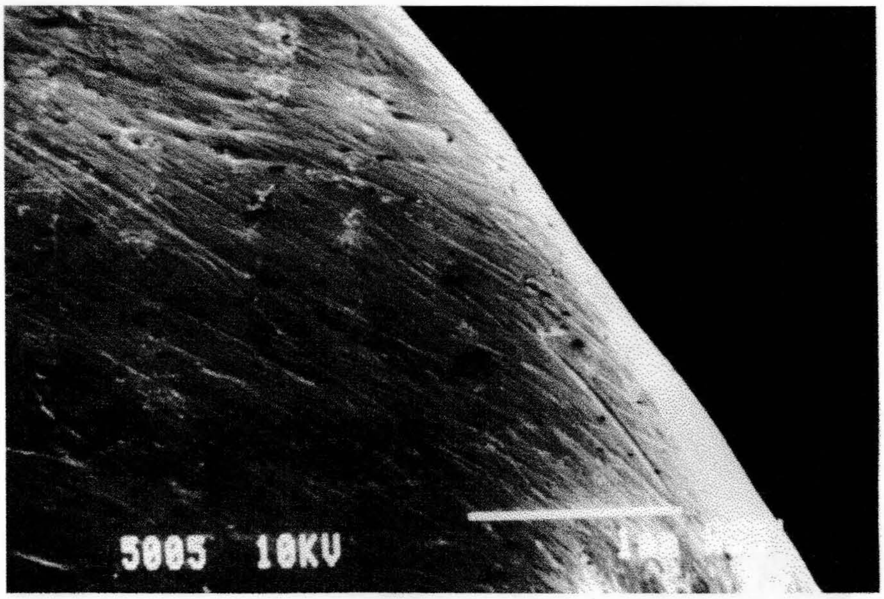


Figure 9.3.1:
SEM micrograph:
F01-G2: x 15 mag. after 30 min. use

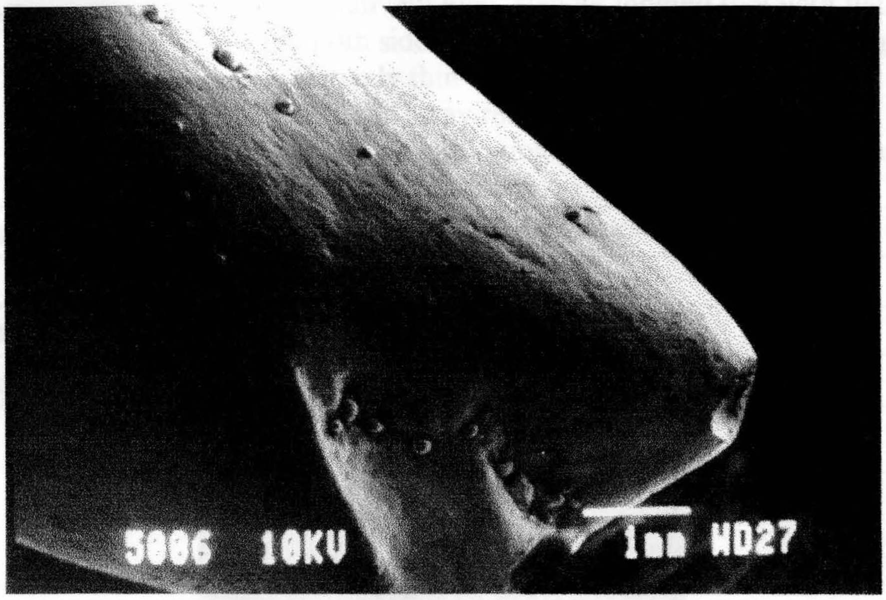
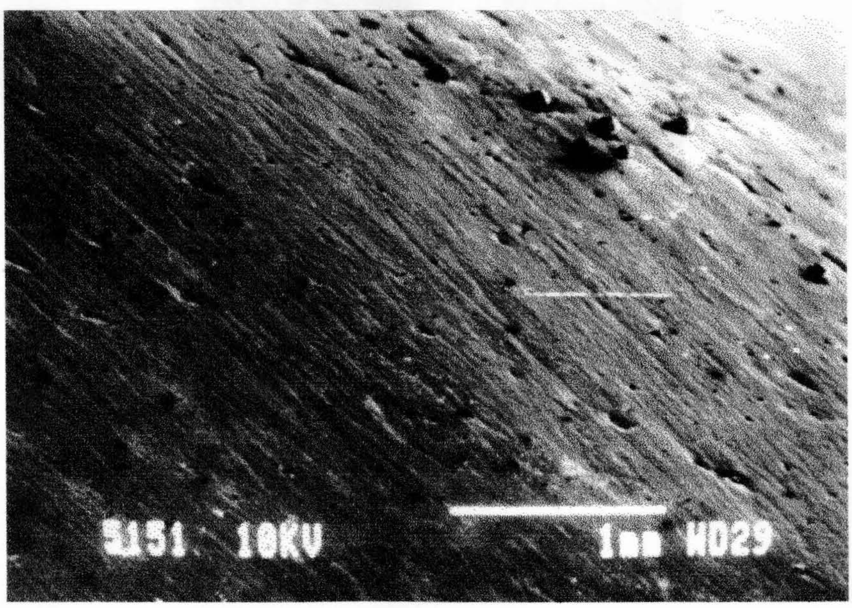


Figure 9.3.2:
SEM micrograph:
F01-G2: x 30 mag. after 30 min. use



F02-G2

Description	A relatively long, slender looking tool with flat ends at both sides. The flat, broad (20 mm) working tip is relatively thin because part of the inner cortex fractured away rendering the tool extremely functional in digging for subterranean food sources next to the riverbed.
Faunal association	Shaft fragment of a *Bos taurus* (cattle) tibia.
Length	63 mm
Cortical thickness	4 mm
Weathering stage	Fresh/Green

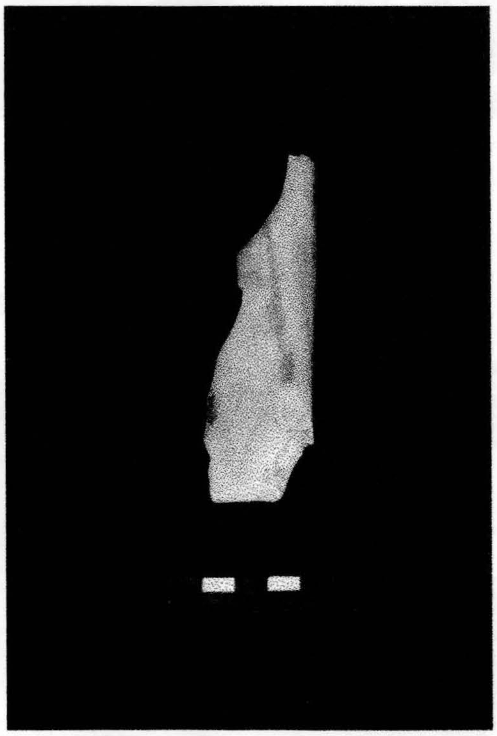


Figure 10.1: **Documentary photograph: Experimental tool F02-G2**

Figure 10.2.1:
SEM micrograph:
F02-G2: x 15 mag. after 10 min. use

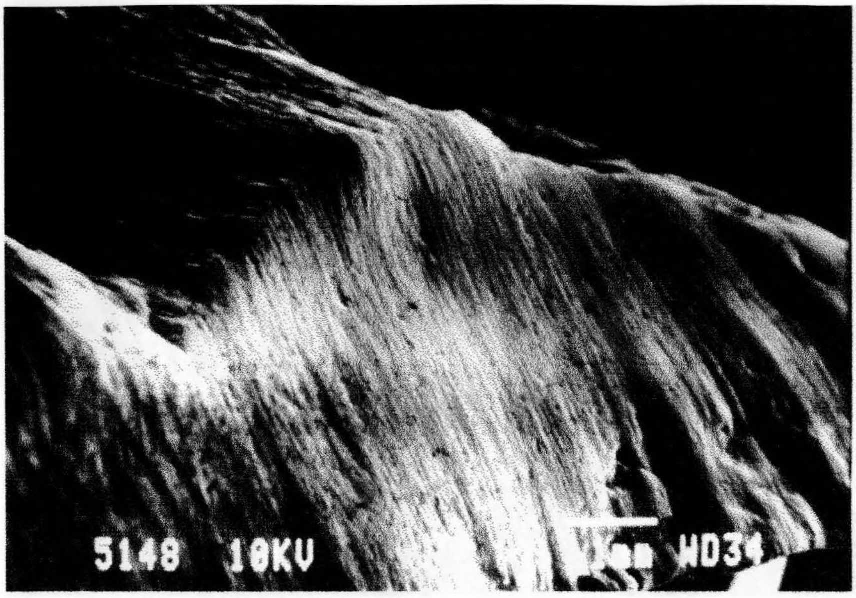


Figure 10.2.2:
SEM micrograph:
F02-G2: x 30 mag. after 10 min. use

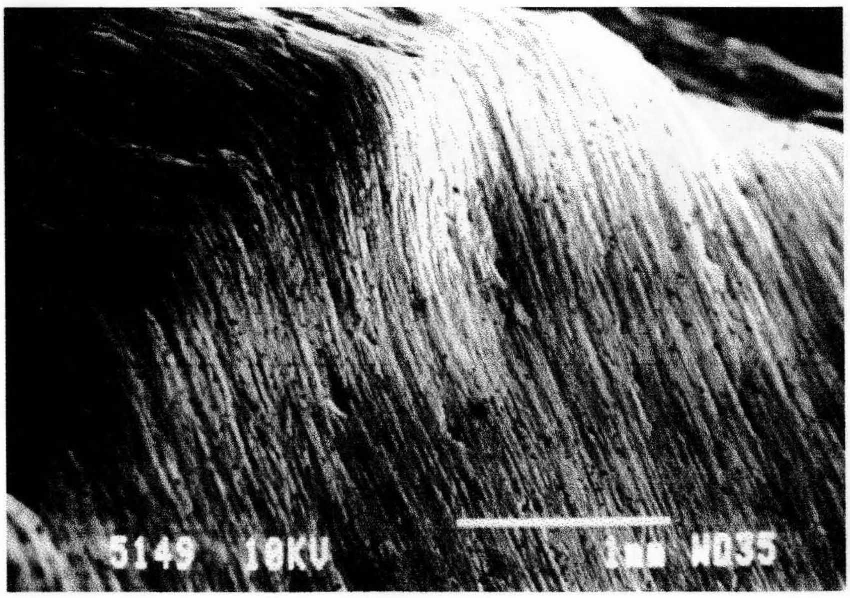


Figure 10.3.1:

SEM micrograph:
F02-G2: x 15 mag. after 30 min. use

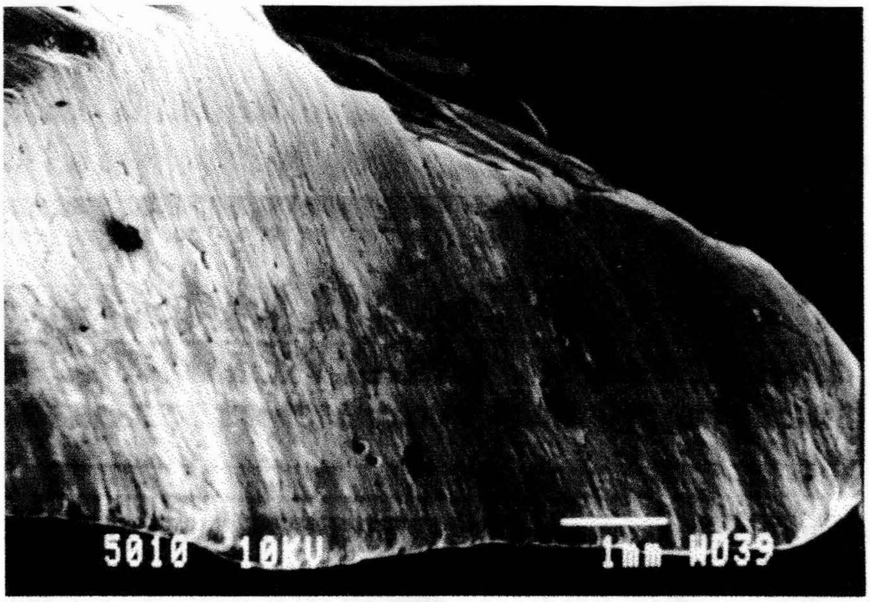
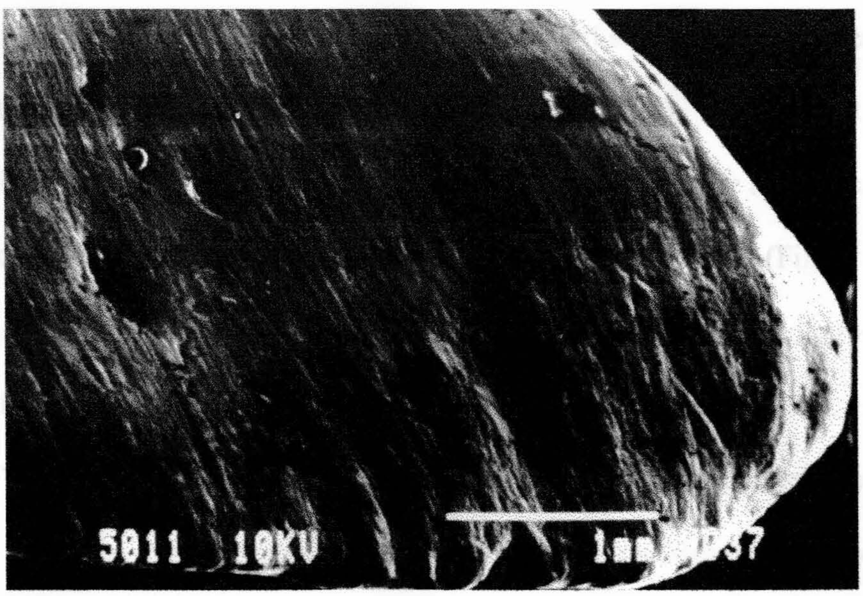


Figure 10.3.2:

SEM micrograph:
F02-G2: x 30 mag. after 30 min. use



3.3.2) The G2 tools: Digging for subterranean food sources (rootlets, worms and insects) in a riverbank environment

3.3.2.1) The G2 tools – a short discussion

W01-G2: The tip of the 10 min. specimen displayed no striations. A slight degree of rounding and smoothing to the tip features was the only modification due to employment (Fig. 6.2.2). After 30 min. of employment a few thin diagonally and longitudinally oriented striations were observed. These were widely scattered over both the inner and outer surface of the tool without any readily recognisable composition. The most remarkable characteristic of the 30 min. specimen is the high degree of rounding and smoothing at the tip, with a polish that reaches more than 50 mm back from the tip (Fig. 6.3.1).

W02-G2: After 10 min. of employment small longitudinally, diagonally and transverse oriented scratch marks were observed. These marks were widely dispersed all around the tool tip without any definite composition (Fig. 7.2.2). Only a slight degree of modification and polish on the tool tip was observed; however after 30 min. of employment rounding and smoothing of the tool tip was clearly visible (Fig. 7.3.1) together with a clear polish at the tip of the tool which faded further away from the tip. This polish was still visible 70 mm from the tool tip. The high degree of polish erased most of the observed small scratches on the 10 min. specimen. Scratch marks on the 30 min. specimen included small acutely angled criss-cross striations restricted to the very tip of the tool only.

W03-G2: On this relatively rough textured tool no striations were observed after 10 min. of employment, with virtually no degree of modification to the tip (Fig.8.2.1). On the 30 min. specimen only a few small longitudinally and diagonally oriented striations were observed (Fig. 8.3.1 & 8.3.2) with only a slight degree of modification by means of rounding and smoothing to the tip. Scratches observed were to a large extent restricted to the vicinity of this smoothly modified tip area.

F01-G2: After 10 min. of employment the tip of the tool was slightly modified by smoothing and rounding, accompanied by a slight degree of polish. Many acutely angled criss-cross striations were observed all around the tool tip, but limited to the vicinity of the tool tip (Fig. 9.2.2). The 30 min. specimen attested to a radical degree of smoothing and polish to the surface and tip of the tool. The polish was clearly visible up to 25 mm away from the tip. Though a few faint striations were still visible on the tool tip, most of the striations were either erased or partially erased by reworking.

F02-G2: No striations were visible on the specimen after the 1st working period (Fig. 10.2.2). A slight degree of rounding was observed. This rounding slightly increased after 30 min. of employment and a slight degree of polish was also visible on the tool tip. The 30 min. specimen displayed some longitudinally and diagonally oriented striations (Fig. 10.3.2). These striations were visible all around the tip – on both the inner and outer surfaces. Striations were too widely dispersed to ascribe their appearance to any readily recognisable composition.

3.3.2.2) Summary of the G2 tools

An increase in modification (both rounding and smoothing) to the G2 tool tips was clearly visible from the 1st to the 2nd working period. Degrees of polish also increased as tools were reworked. Polishes observed were much more prominent on the weathered than on the fresh bone tools. Employment of these tools caused the tips of tools to form gradually tapering points, with no clear distinction between the working tips and the surfaces of the tools.

Longitudinally, transverse and diagonally oriented striations, some forming acutely angled criss-crosses were observed on the tips. Striations were in general widely dispersed, all around the tool tips. No readily recognisable composition could be identified from the G2 tools' striation composition. Overprinting was probably the most characteristic feature of the G2 experiments. A sequence of striation formation, followed by striations being smoothed away before continued employment would produce new striations was easily recognisable. Each step in this seemingly circular process happened at different time intervals for each tool. Both the fresh and weathered tools displayed the same random, non-identifiable striation composition. Micro-striations were however more intense on the fresh than on the weathered tools.

Larger sized tools proved to be more functional than the smaller ones.

3.3.3) The B1 tools:
Debarking of the *Maytenus undata* (Koko) tree

W01-B1

Description	With a ruggedly fractured flat edge on one side tapering to a point at the other end this tool has a narrow V-shape. The working tip is relatively steep in shape. A concave curve in the shaft fragment however rendered this tool extremely impractical in the debarking of the *Maytenus undata* (Koko) tree.
Faunal association	Shaft fragment of an *Equus ferus* (horse) humerus.
Length	193 mm
Cortical thickness	6 mm
Weathering stage	1

Figure 11.1: **Documentary photograph: Experimental tool W01-B1**

Figure 11.2.1:
SEM micrograph:
W01-B1: x 15 mag. after 10 min. use

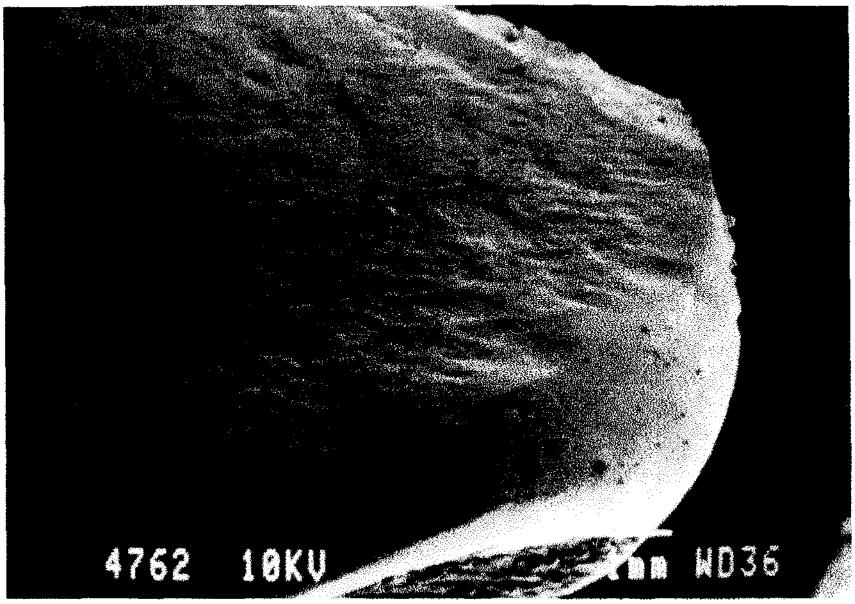


Figure 11.2.2:
SEM micrograph:
W01-B1: x 30 mag. after 10 min. use

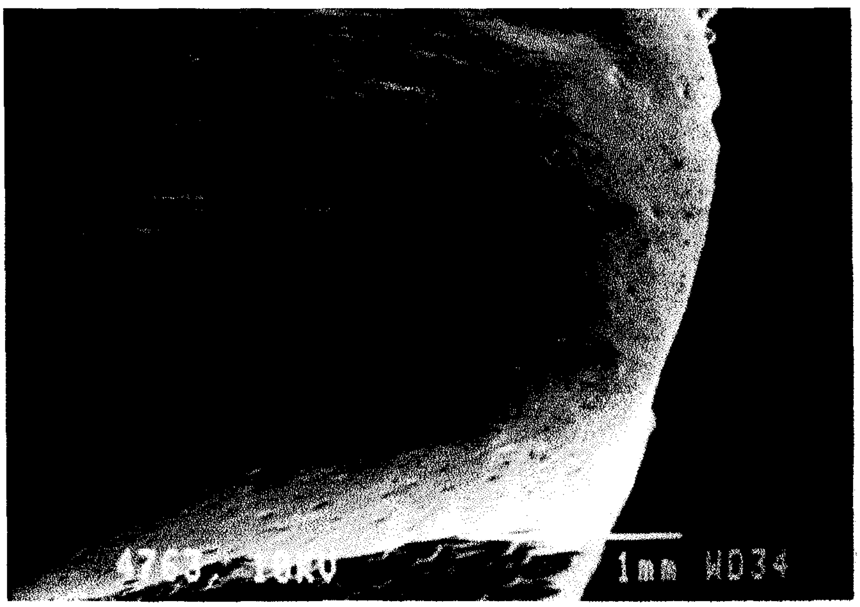


Figure 11.3.1:

SEM micrograph:
W01-B1: x 15 mag. after 30 min. use

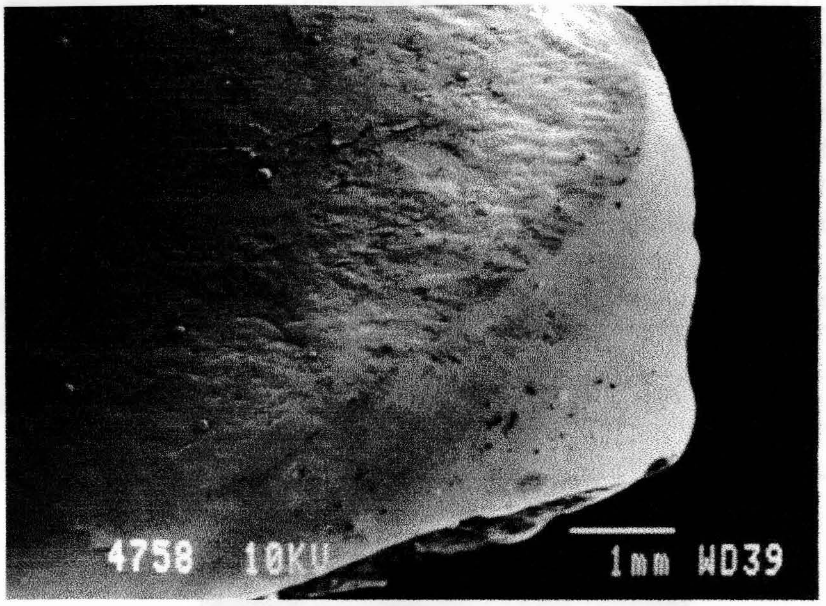
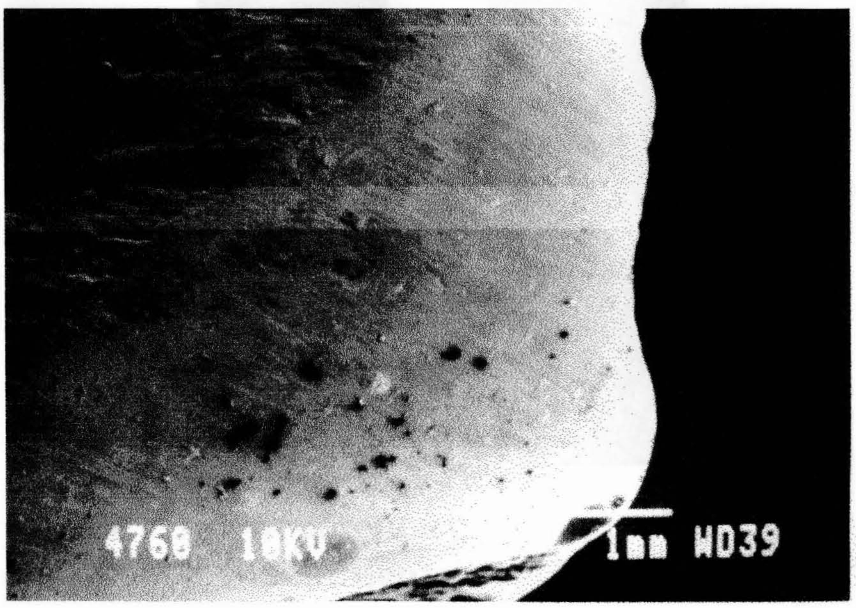


Figure 11.3.2:

SEM micrograph:
W01-B1: x 30 mag. after 30 min. use



W02-B1

Description	Relatively slender in appearance this tool tapers to a point at both ends. The working end of the tool is slightly angled in morphology. The working tip is flat and broad (15 mm) but relatively thin because some of the cortex was fractured away. This thin, flat tip proved to be relatively functional in comparison with the other tools used to debark the *Maytenus undata* (Koko) tree.
Faunal association	Shaft fragment of a *Tragelaphus oryx* (eland) femur.
Length	155 mm
Cortical thickness	10 mm
Weathering stage	2

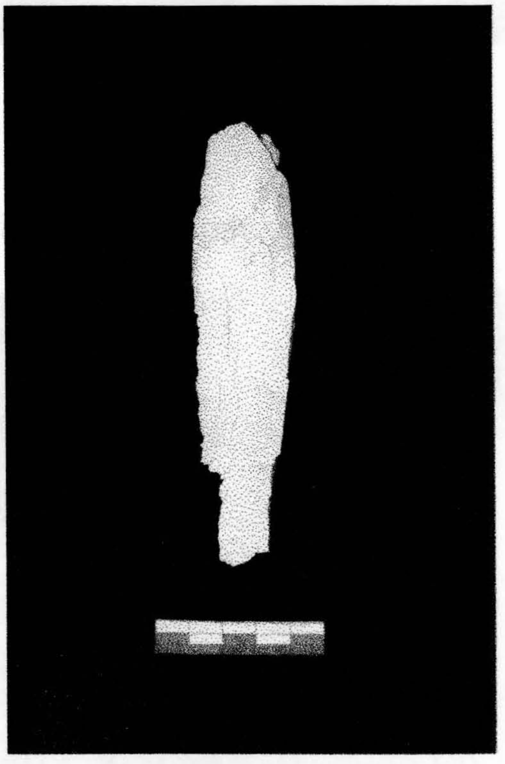


Figure 12.1: **Documentary photograph: Experimental tool W02-B1**

Figure 12.2.1:
SEM micrograph:
W02-B1: x 15 mag. after 10 min. use

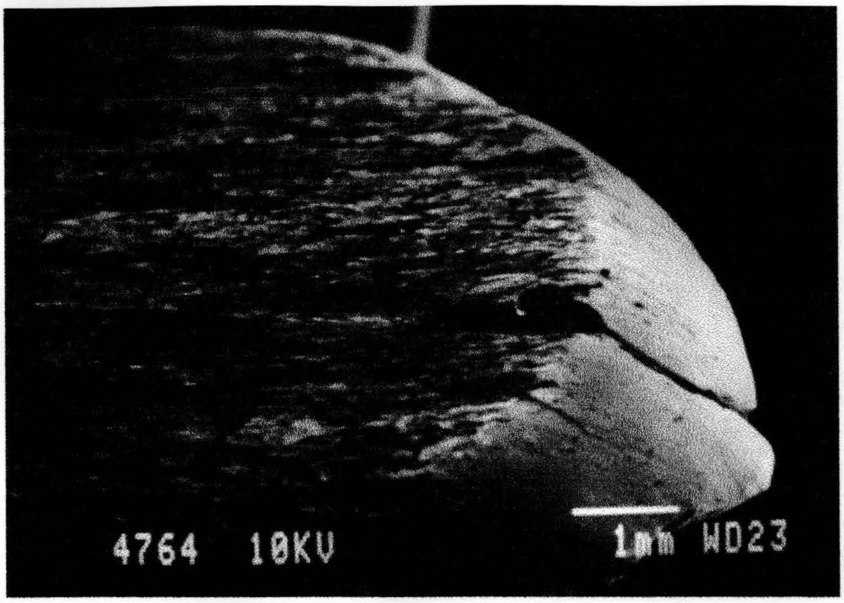


Figure 12.2.2:
SEM micrograph:
W02-B1: x 30 mag. after 10 min. use

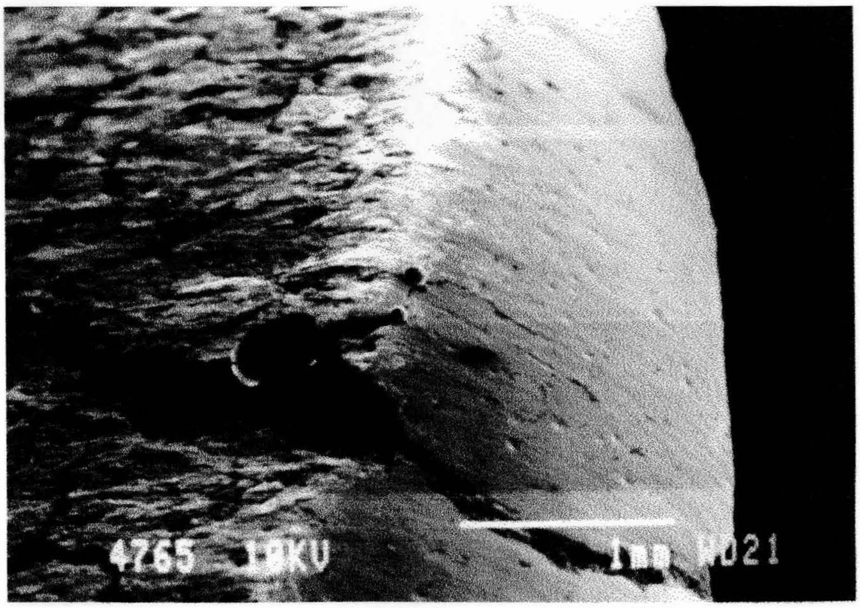


Figure 12.3.1:
SEM micrograph:
W02-B1: x 15 mag. after 30 min. use

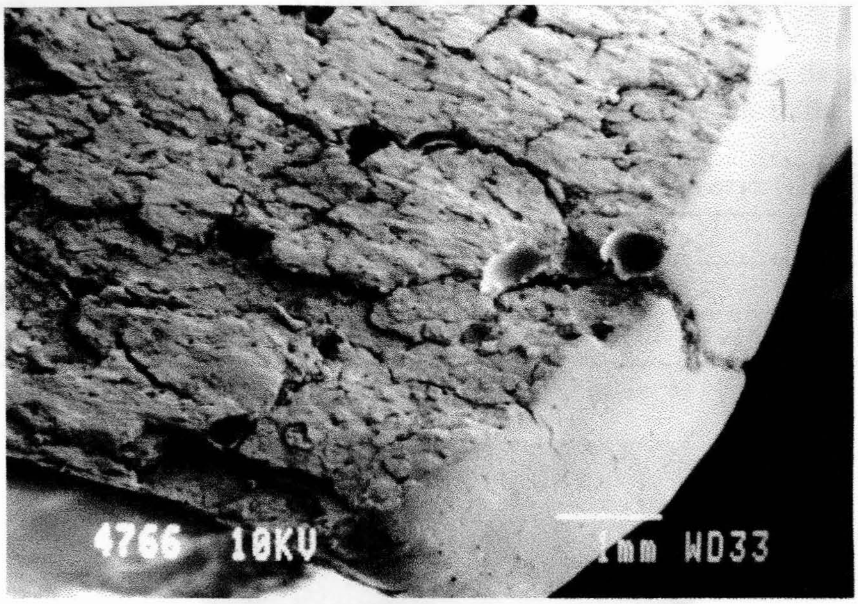
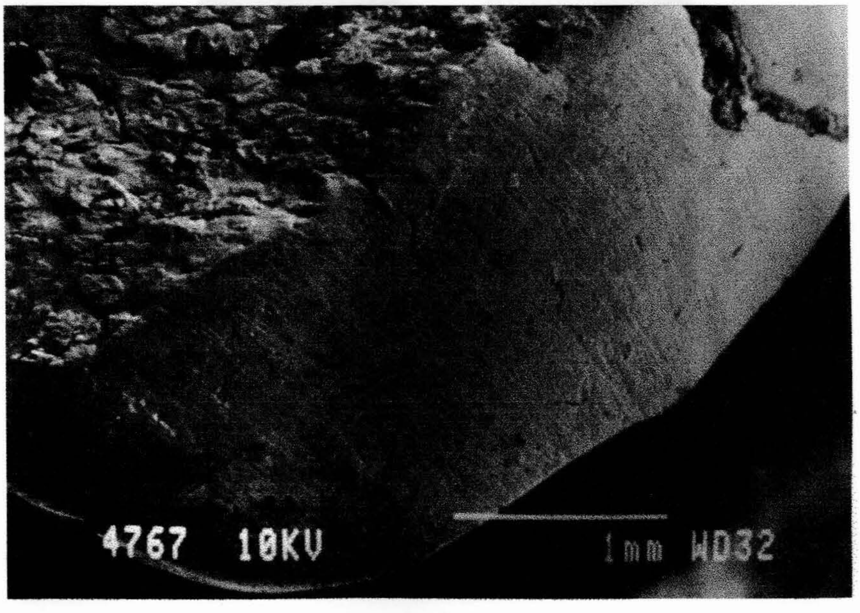


Figure 12.3.2:
SEM micrograph:
W02-B1: x 30 mag. after 30 min. use



W03-B1

Description	A relatively short, sturdy looking tool, tapering to a point at both ends. The working tip is V-shaped. The tool proved to be impractical in the debarking of the *Maytenus undata* (Koko) tree due to the extremely hard bark of the tree.
Faunal association	Shaft fragment of a *Tragelaphus oryx* (eland) femur.
Length	128 mm
Cortical thickness	12 mm
Weathering stage	3

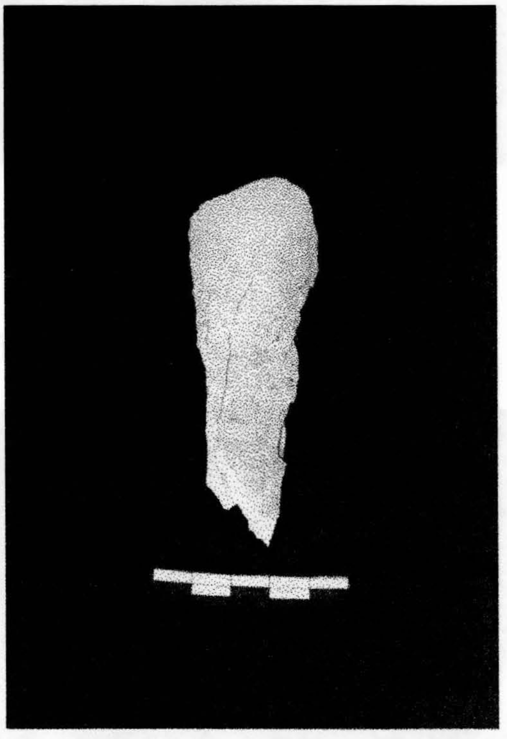


Figure 13.1: **Documentary photograph: Experimental tool W03-B1**

Figure 13.2.1:
SEM micrograph:
W03-B1: x 15 mag. after 10 min. use

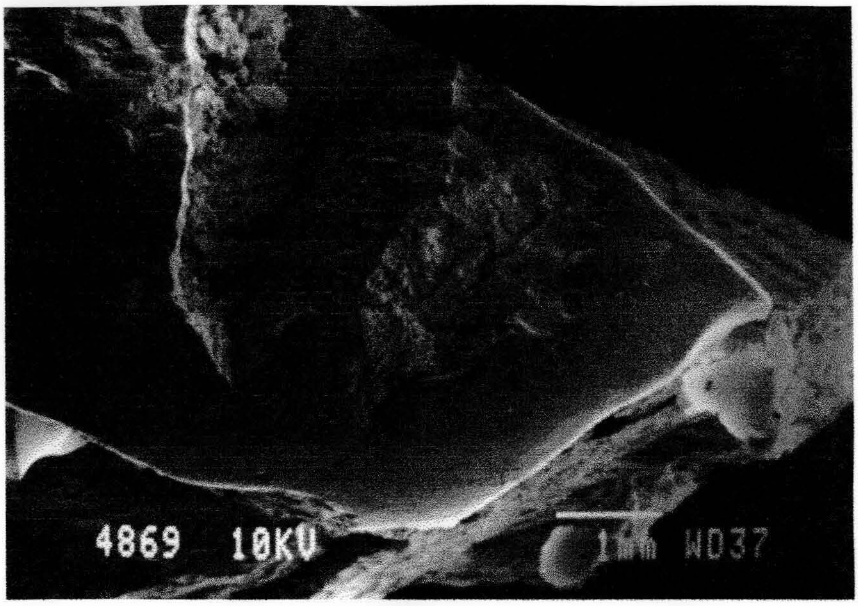


Figure 13.2.2:
SEM micrograph:
W03-B1: x 30 mag. after 10 min. use

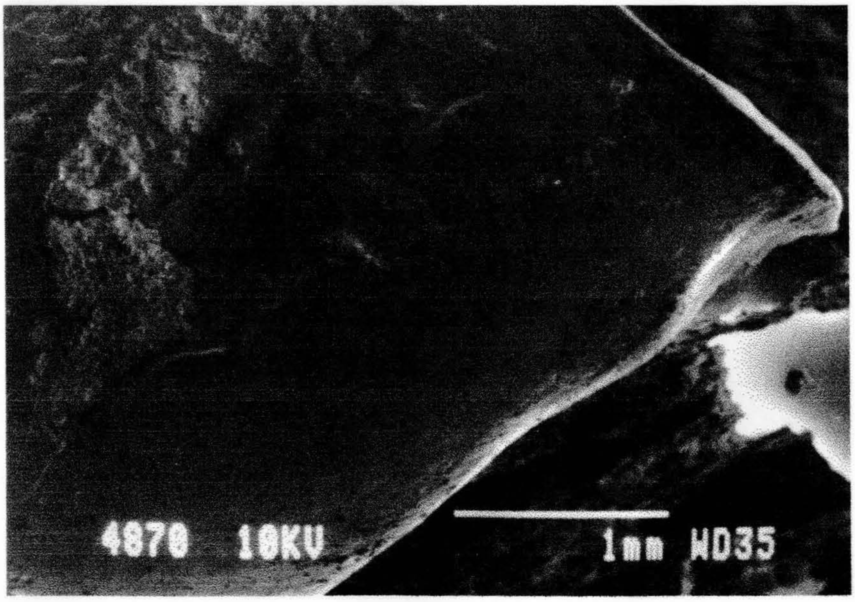


Figure 13.3.1:
SEM micrograph:
W03-B1: x 15 mag. after 30 min. use

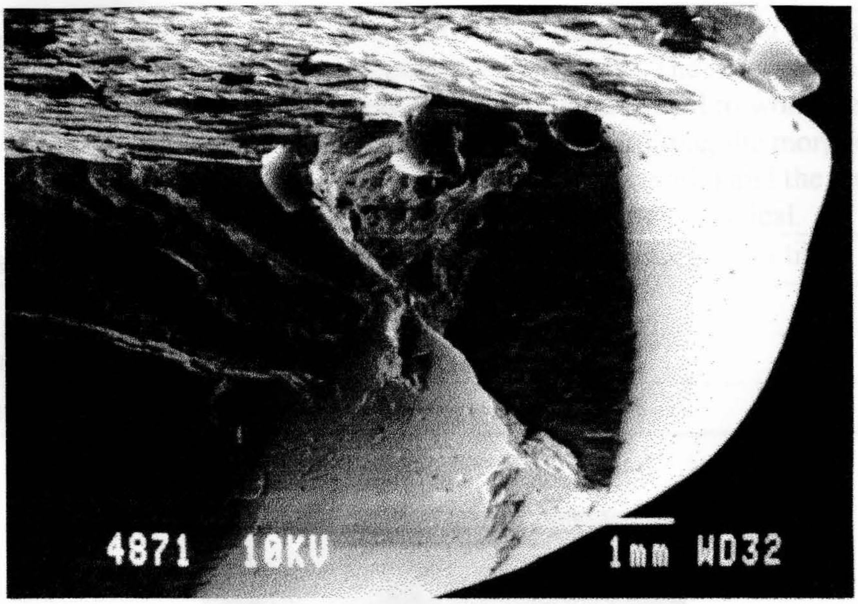
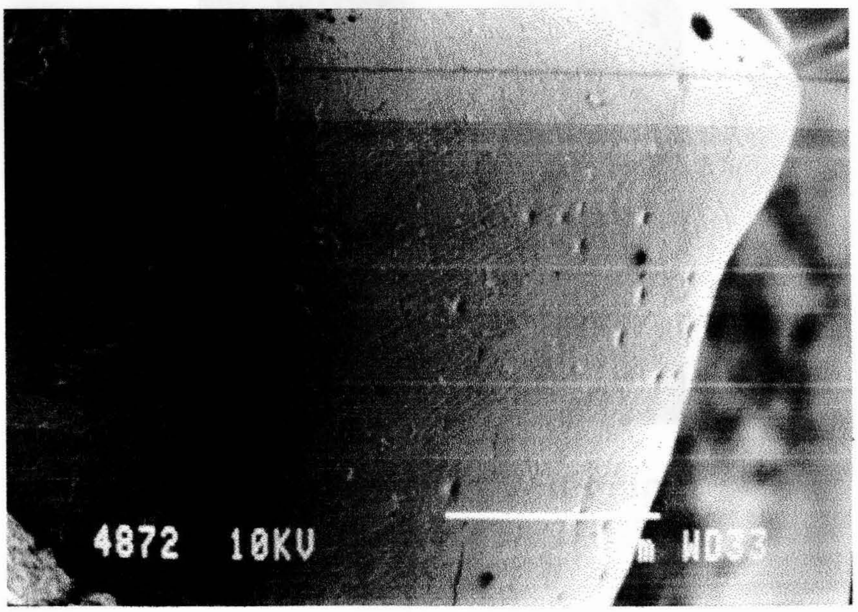


Figure 13.3.2:
SEM micrograph:
W03-B1: x 30 mag. after 30 min. use



F01-B1

Description	A short, sturdy bone fragment tapering to gently sloping points at both ends. The working tip is a relatively broad, flat point. Used to work the bark of the *Maytenus undata* (Koko) tree, the morphology of the tool, both the width (too wide) and the length (too short) rendered it not very practical.
Faunal association	Shaft fragment of a *Bos taurus* (cattle) tibia.
Length	49 mm
Cortical thickness	6 mm
Weathering stage	Fresh/Green

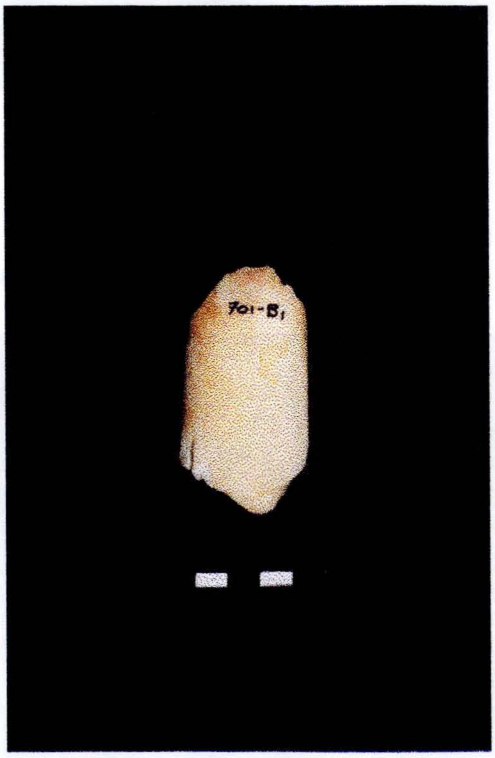


Figure 14.1: **Documentary photograph: Experimental tool F01-B1**

Figure 14.2.1:
SEM micrograph:
F01-B1: x 15 mag. after 10 min. use

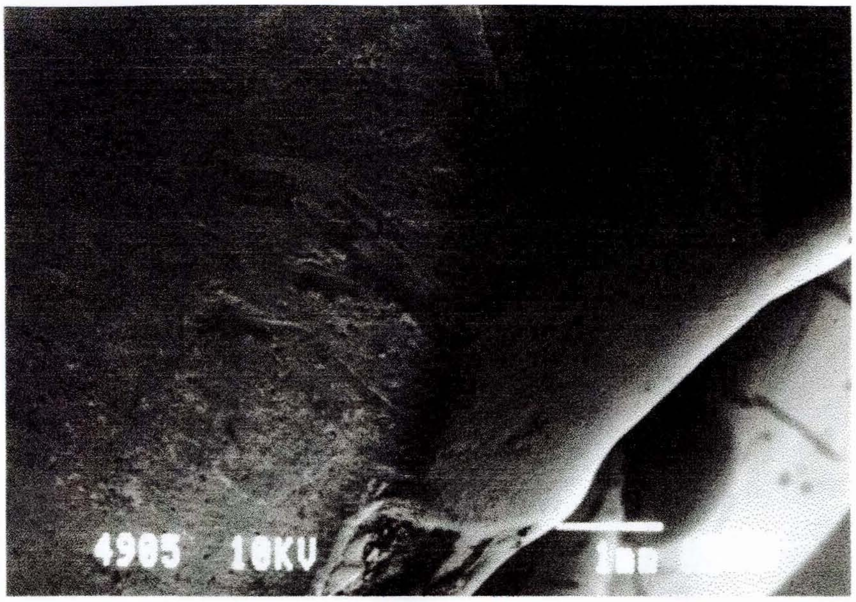


Figure 14.2.2:
SEM micrograph:
F01-B1: x 30 mag. after 10 min. use

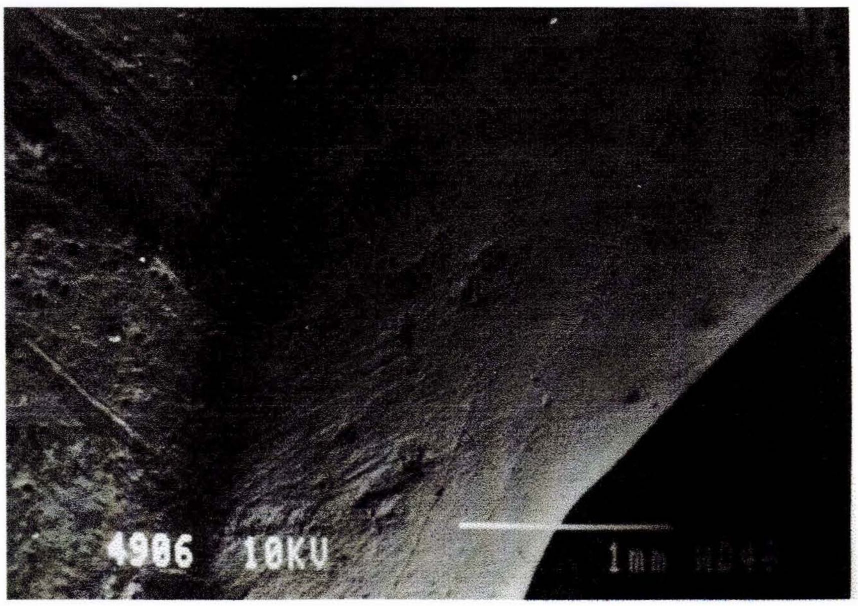
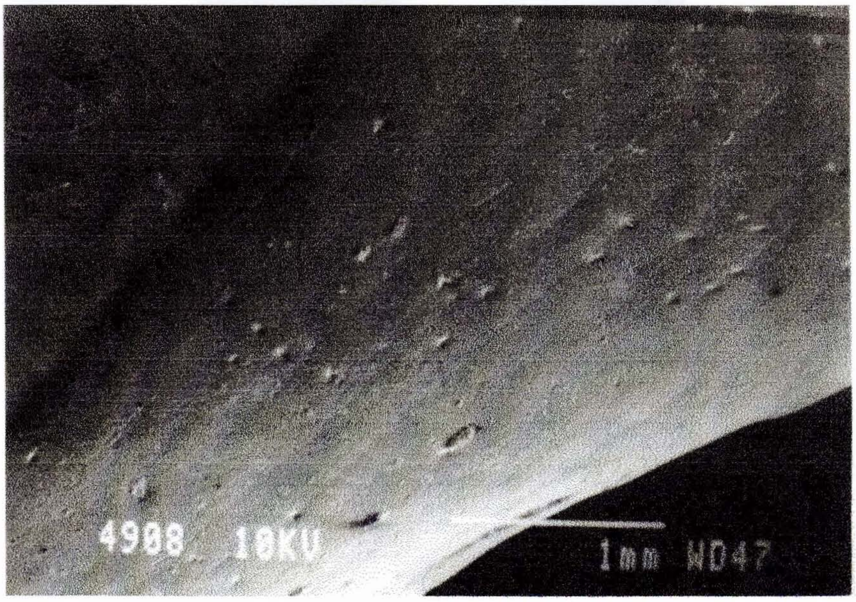


Figure 14.3.1:

SEM micrograph:
F01-B1: x 15 mag. after 30 min. use

Figure 14.3.2:

SEM micrograph:
F01-B1: x 30 mag. after 30 min. use



F02-B1

Description	A short, relatively broad tool tapering to a point at both ends. The working tip is relatively steep. Used to work the bark of the *Maytenus undata* (Koko) tree, this steep point proved to be quite functional. The length of the tool and the hardness of the bark hampered functionality.
Faunal association	Shaft fragment of a *Bos taurus* (cattle) femur.
Length	47 mm
Cortical thickness	4 mm
Weathering stage	Fresh/Green

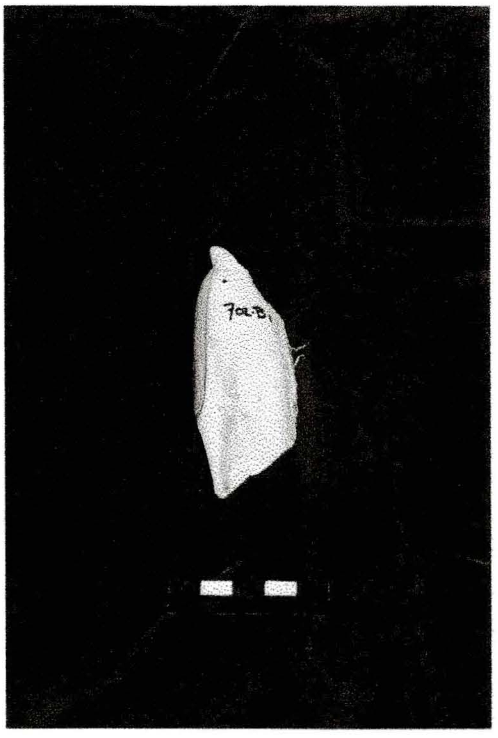


Figure 15.1: **Documentary photograph: Experimental tool F02-B1**

Figure 15.2.1:
SEM micrograph:
F02-B1: x 15 mag. after 10 min. use

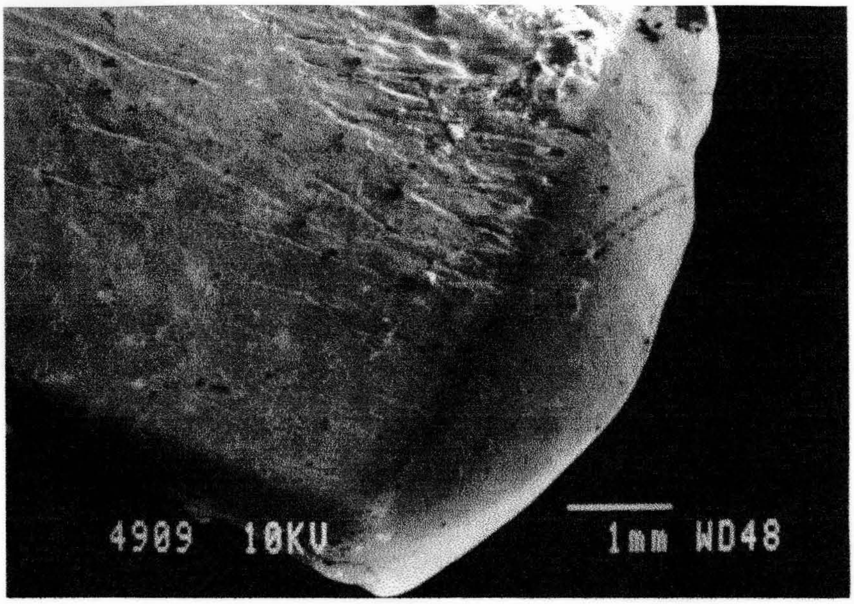


Figure 15.2.2:
SEM micrograph:
F02-B1: x 30 mag. after 10 min. use

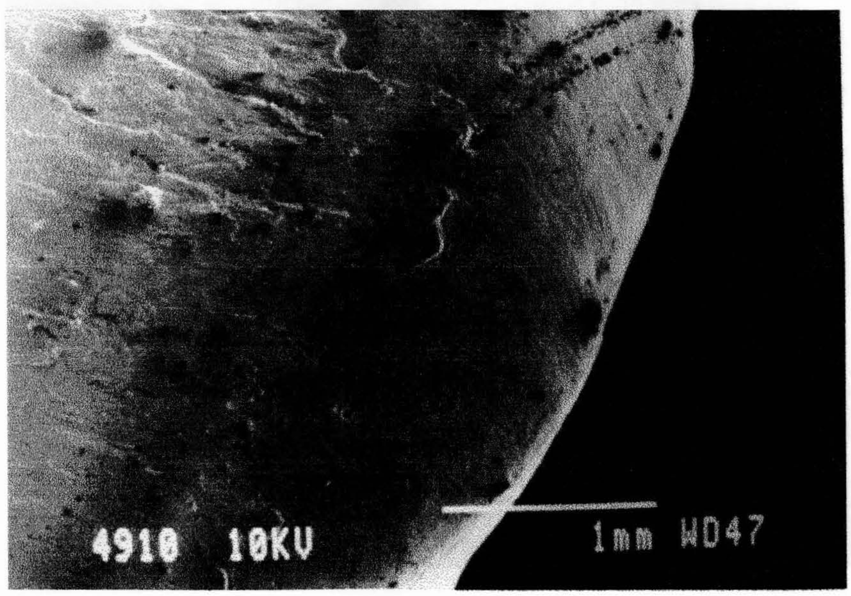


Figure 15.3.1:

SEM micrograph:
F02-B1: x 15 mag. after 30 min. use

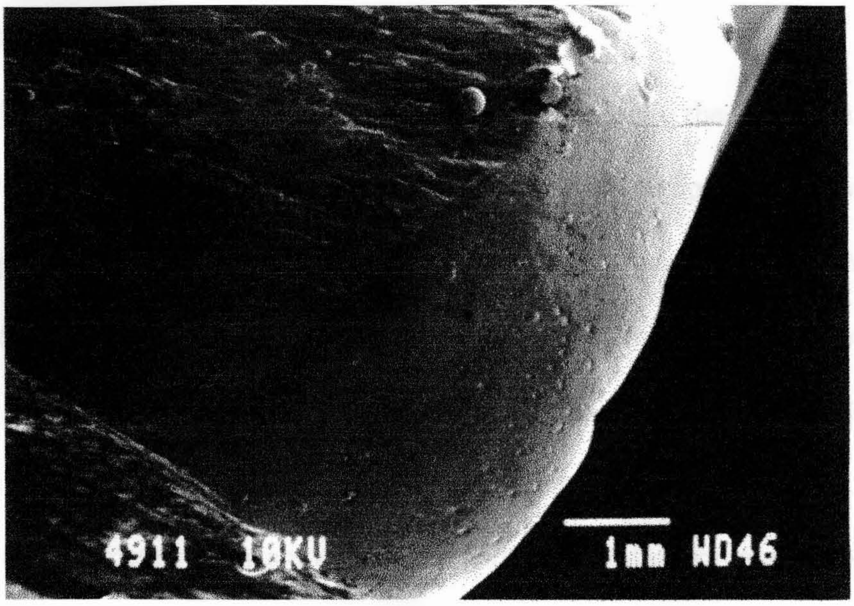
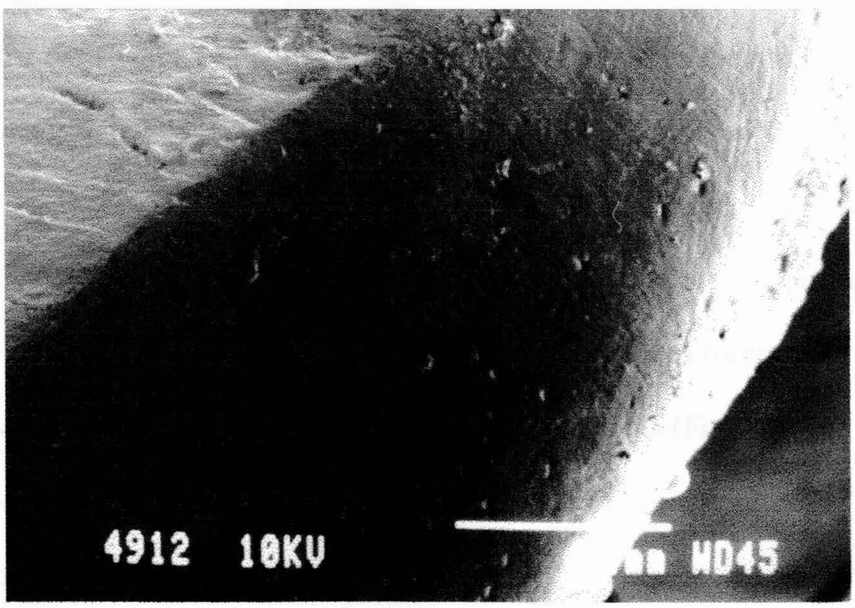


Figure 15.3.2:

SEM micrograph:
F02-B1: x 30 mag. after 30 min. use



3.3.3) The B1 tools: Debarking of the *Maytenus undata* (Koko) tree

3.3.3.1) The B1 tools – a short discussion

W01-B1: After the 1st working period slight modification to the tool tip, a smoothing at the very end of the tip and an edge of one side of the tip, was visible. A multitude of light, shallow, acutely angled criss-cross striations were observed on this smoothed edge (Fig. 11.2.2). An increase in the smoothing and rounding of the tool tip was visible on the 30 min. specimen (Fig. 11.3.1). Light, shallow, acutely angled criss-cross formations covered the whole of the increased smoothed area (Fig. 11.3.2). All striations were restricted to the smoothed area with no modification marks visible further away from the tool tip. Very little modification of the morphology of the tool tip could be detected.

W02-B1: No smoothing, polish or striations were observed on the surface of the tool for either the 10 min. or the 30 min. specimen. All modification marks were restricted to a small smoothly polished area on the very edge of the broad flat tool tip. Light, shallow, acutely angled striations were interrupted by a single perpendicular criss-cross formation on the 10 min. specimen (Fig. 12.2.2). The same composition of mostly acutely oriented striations alternating with diagonal striations forming perpendicular criss-crosses was observed on the 30 min. specimen (Fig. 12.3.2). Throughout the tenure of the experiment very little change could be observed on the overall shape of the tool tip.

W03-B1: The 10 min. specimen displayed light, shallow, longitudinally oriented striations restricted to the very tip of the tool. This tip was slightly modified by smoothing (Fig. 13.2.2). No striations were visible in the depressed areas of the tool tip (that resulted from fracturing) on either the 10 min. or the 30 min. specimen. Though still light and shallow, the 30 min. specimen displayed many more longitudinally oriented striations occasionally interrupted by a clear acutely angled criss-cross formation (Fig. 13.3.2). All striations were restricted to the smoothed areas of the tool tip. After 30 min. of working, this tool tip was observably more smoothed than after the 1st working period; overall however this smoothing had little influence on the shape of the tool tip.

F01-B1: A slight increase in modification to the very tip of the tool was visible between the 10 min. and the 30 min. working period. The 10 min. specimen showed a predominantly longitudinal orientation of striations, though very prominent diagonal striations were observed forming occasional perpendicular angled criss-crosses on the very tip of the tool (Fig. 14.2.2). The surface of the tool displayed solitary longitudinal, diagonal and transverse striations in a random fashion. After 30 min. of employment the multitude of longitudinally oriented striations on the very tip of the tool were partly erased. Prominent diagonal striations were still visible (Fig. 14.3.2). The surface of the tool seems to have undergone no important modification from the 1st to the 2nd working period. No prominent new longitudinal, diagonal or transverse striations were observed.

F02-B1: After the 1st working period the very tip of the tool displayed many striations in a perpendicular angled criss-cross pattern composed of longitudinal and transverse striations (Fig. 15.2.2). On the surface of the 10 min. specimen randomly positioned diagonal striations were prominent. This pattern of striae seemed unchanged on the 30 min. specimen, with few striations added during the final working period. The very tip of the 30 min. specimen, only slightly modified during the 2nd working period, displayed the same striation composition as the 10 min. specimen. Striations were, however, to a large degree smoothed away.

3.3.3.2) Summary of the B1 tools

Only a very slight increase in modification (both rounding and smoothing) was visible on the B1 tools from the 1st to the 2nd working period. Modification was restricted to the very tips of these tools, with very little influence on the overall morphology of the tool tips. Prolonged working increased the clear distinction between the working tips and the surfaces of the tool tips. Polish was restricted to the modified surfaces of the working tips only.

A patterned composition of longitudinally oriented and acutely angled criss-cross striae was identified. This striation composition was restricted to the smoothly modified working tips only. While the fresh bone tools attest to the fact that this striation composition was partly erased by reworking, the weathered tools displayed increased striation numbers on the working tips after the 2nd period of employment. Striation compositions on the weathered tools remained constant, occurring as predominantly longitudinally oriented striations alternating with acutely angled criss-cross formations after the final working period.

Smaller tools were very hard to work with. Medium to larger sized tools proved to be more functional, but the bark of the *Maytenus undata* was too hard and experimental working often made only a slight impact on the very outer surface of the bark.

3.3.4) The B2 tools: Debarking of the *Celtis africana* (White Stinkwood) tree

W01-B2

Description	The tool is large and slender in appearance with one end fractured to a double pointed edge and the working tip to a relatively steep asymmetrical V-shape. This tool proved to be very functional in the debarking of the *Celtis africana* (White Stinkwood) tree. The working tip became relatively quickly blunt.
Faunal association	Shaft fragment of an *Equus ferus* (horse) ulna.
Length	253 mm
Cortical thickness	9 mm
Weathering stage	1

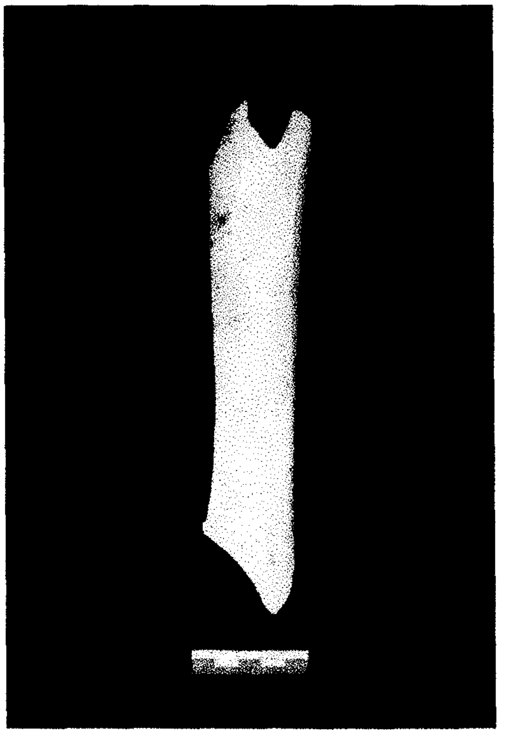


Figure 16.1: **Documentary photograph: Experimental tool W01-B2**

Figure 16.2.1:
SEM micrograph:
W01-B2: x 15 mag. after 10 min. use

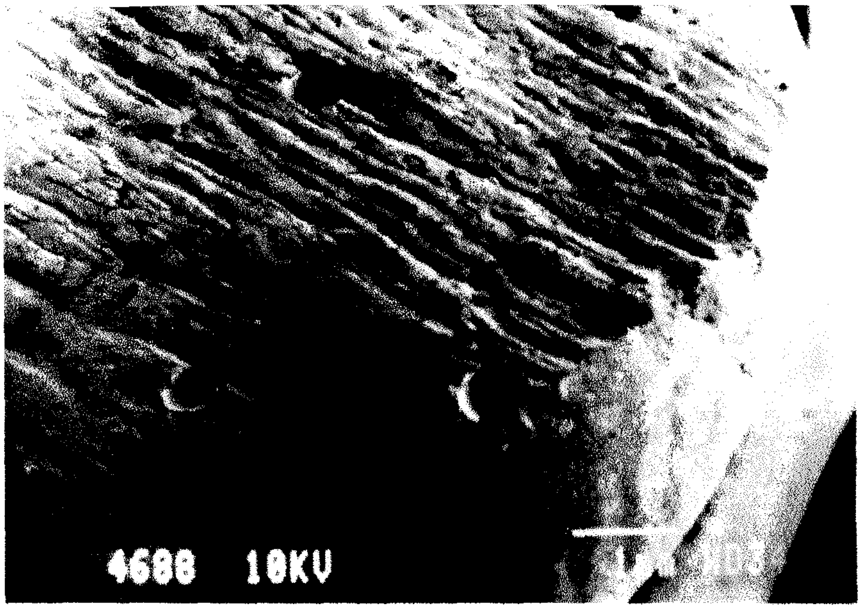


Figure 16.2.2:
SEM micrograph:
W01-B2: x 30 mag. after 10 min. use

Figure 16.3.1:

SEM micrograph:
W01-B2: x 15 mag. after 30 min. use

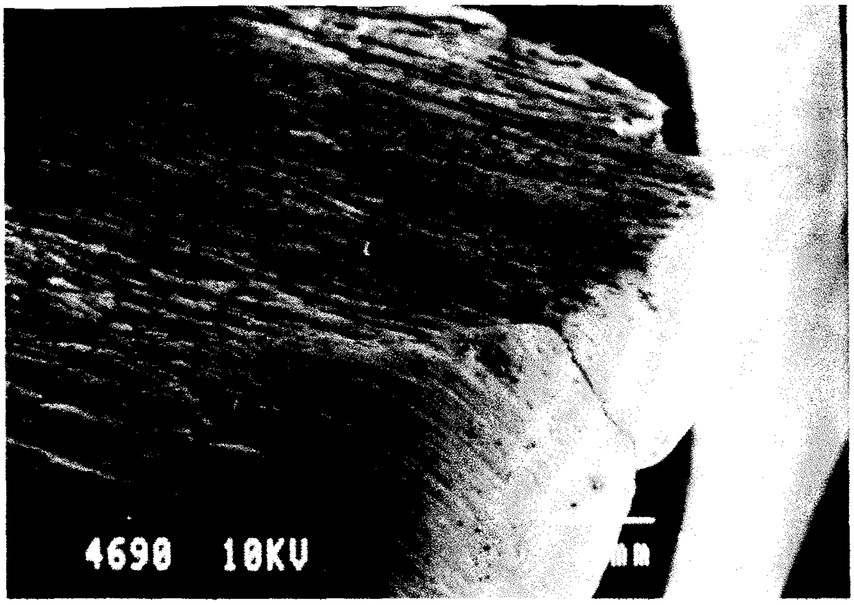
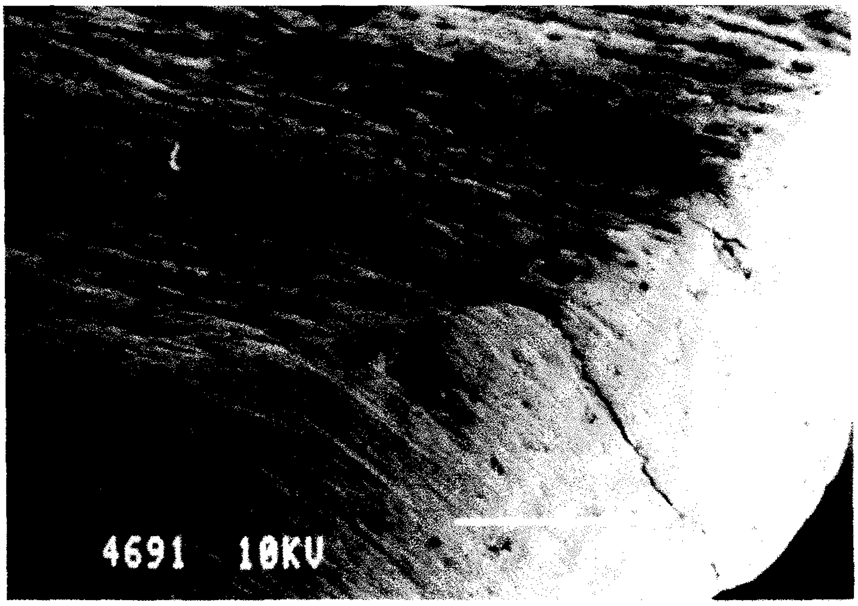


Figure 16.3.2:

SEM micrograph:
W01-B2: x 30 mag. after 30 min. use



W02-B2

Description	A relatively sturdy tool in appearance with one end ruggedly fractured and the other tapering to a V-shaped point. This point proved to be rather functional but splintered while the experiments were conducted. The tip also became blunt relatively quickly while debarking the *Celtis africana* (White Stinkwood) tree.
Faunal association	Shaft fragment of an *Equus ferus* (horse) tibia.
Length	167 mm
Cortical thickness	5 mm
Weathering stage	2

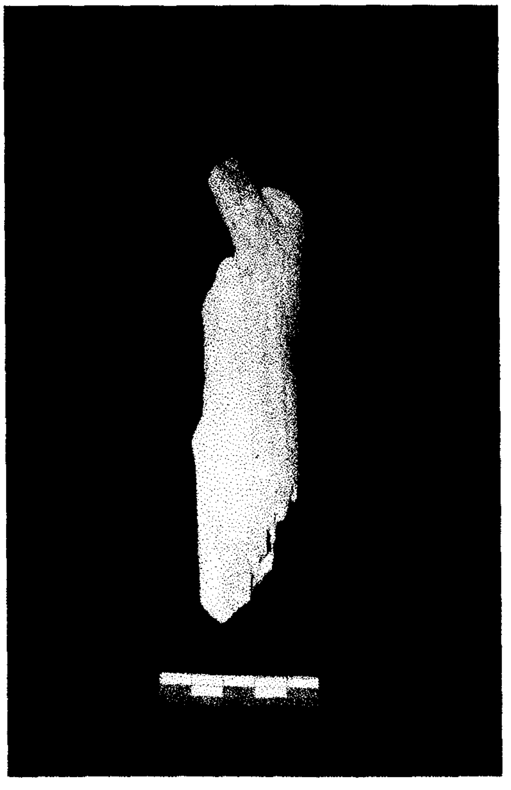


Figure 17.1: **Documentary photograph: Experimental tool W02-B2**

Figure 17.2.1:
SEM micrograph:
W02-B2: x 15 mag. after 10 min. use

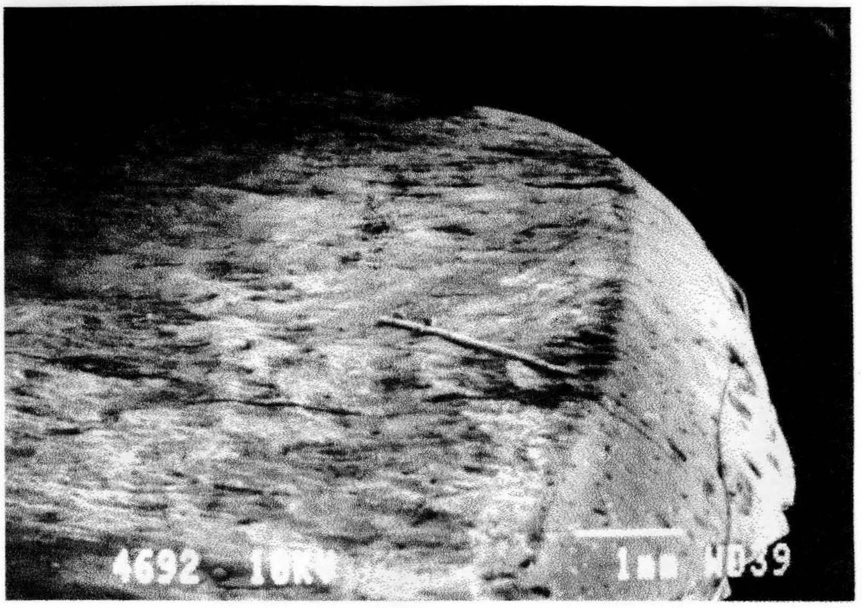


Figure 17.2.2:
SEM micrograph:
W02-B2: x 30 mag. after 10 min. use

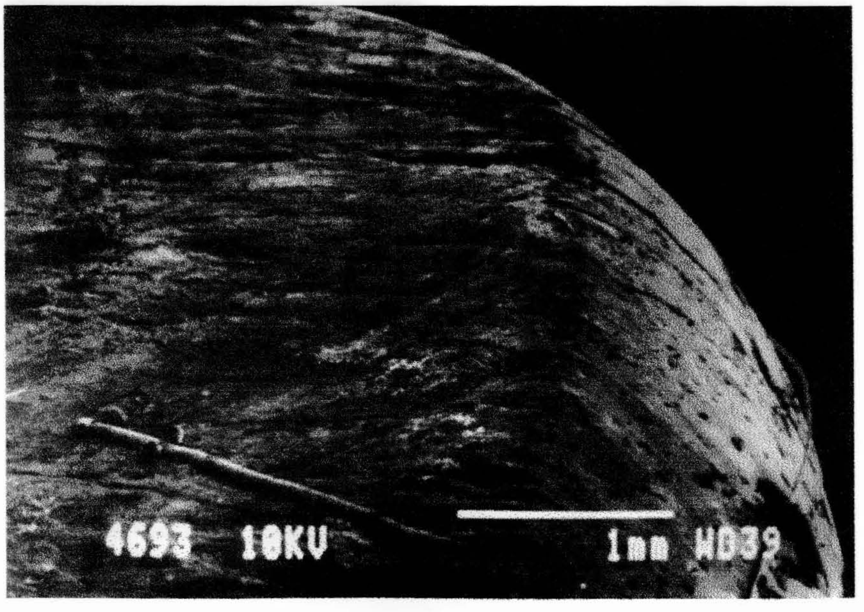


Figure 17.3.1:
SEM micrograph:
W02-B2: x 15 mag. after 30 min. use

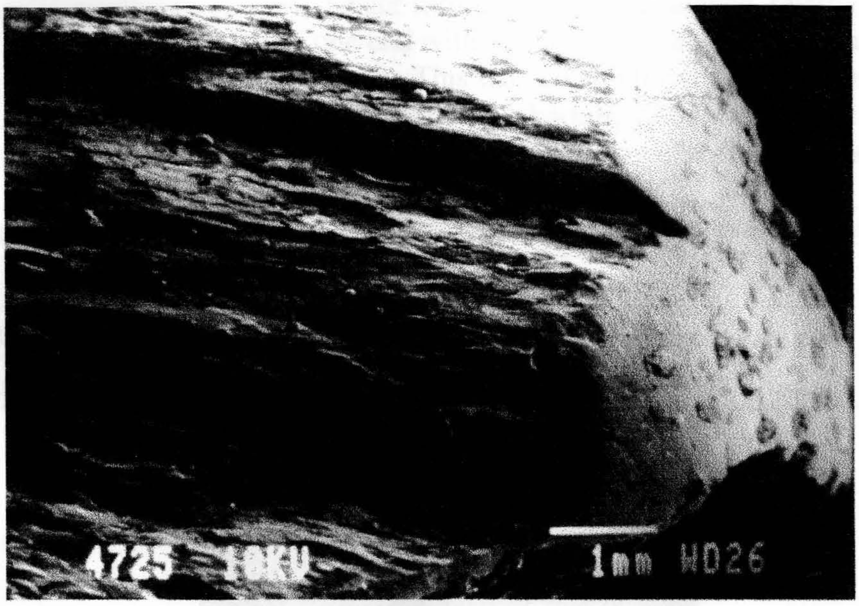
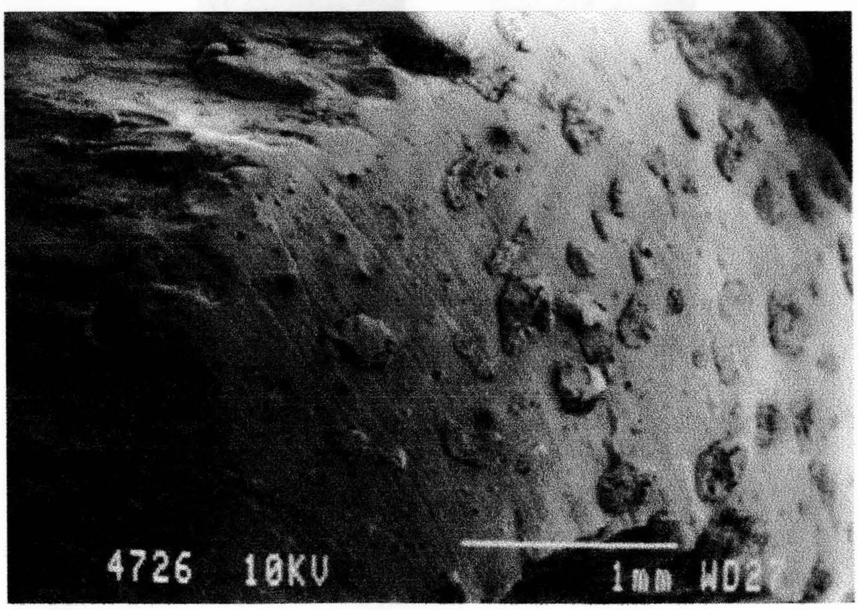


Figure 17.3.2:
SEM micrograph:
W02-B2: x 30 mag. after 30 min. use



W03-B2

Description	A slender looking tool in appearance, relatively flat at one end with the other end tapering gradually to a V-shape. This working tip proved to be quite functional in the debarking of the *Celtis africana* (White Stinkwood) tree, however the tip became relatively quickly blunt.
Faunal association	Shaft fragment of an *Equus ferus* (horse) tibia.
Length	121 mm
Cortical thickness	9 mm
Weathering stage	3

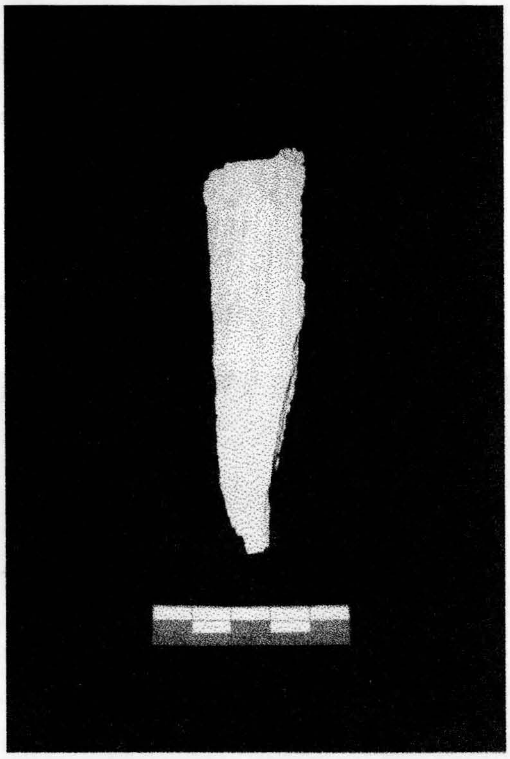


Figure 18.1: **Documentary photograph: Experimental tool W03-B2**

Figure 18.2.1:
SEM micrograph:
W03-B2: x 15 mag. after 10 min. use

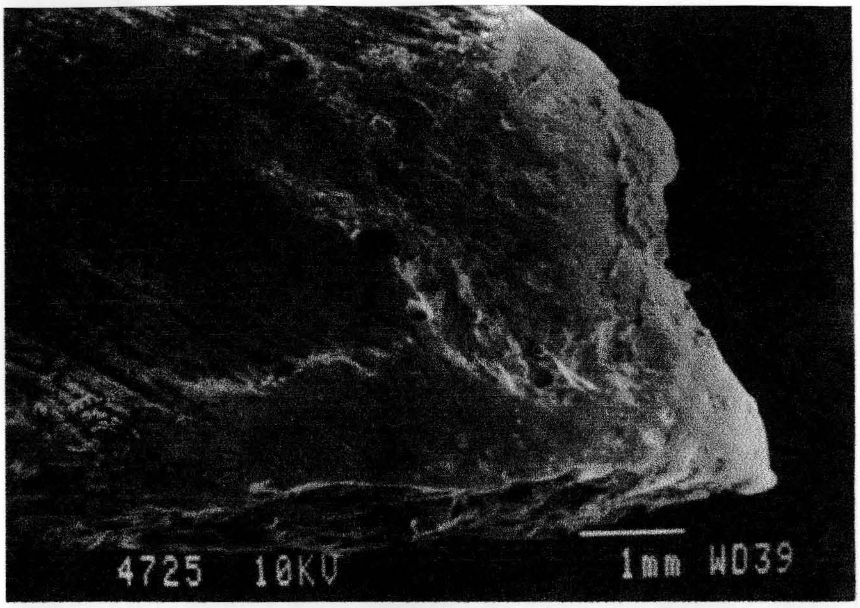


Figure 18.2.2:
SEM micrograph:
W03-B2: x 30 mag. after 10 min. use

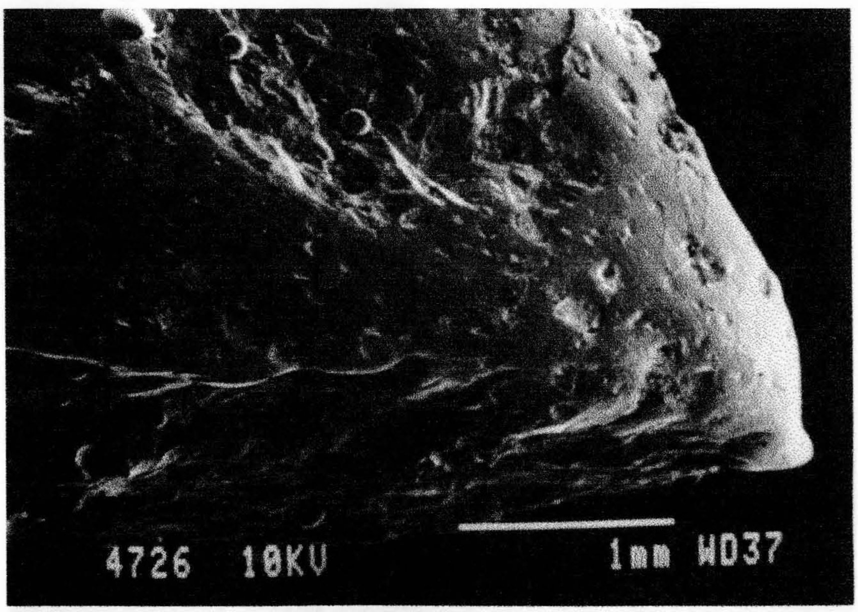


Figure 18.3.1:
SEM micrograph:
W03-B2: x 15 mag. after 30 min. use

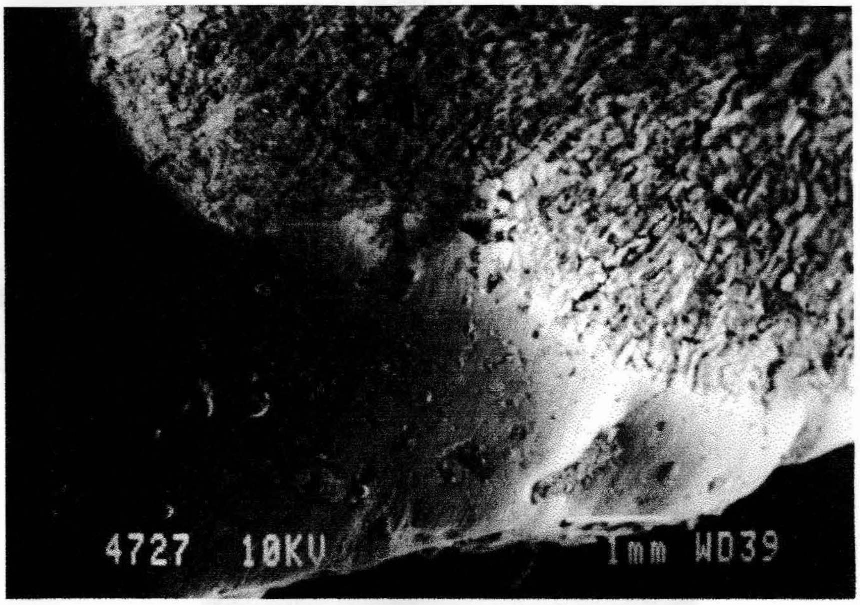
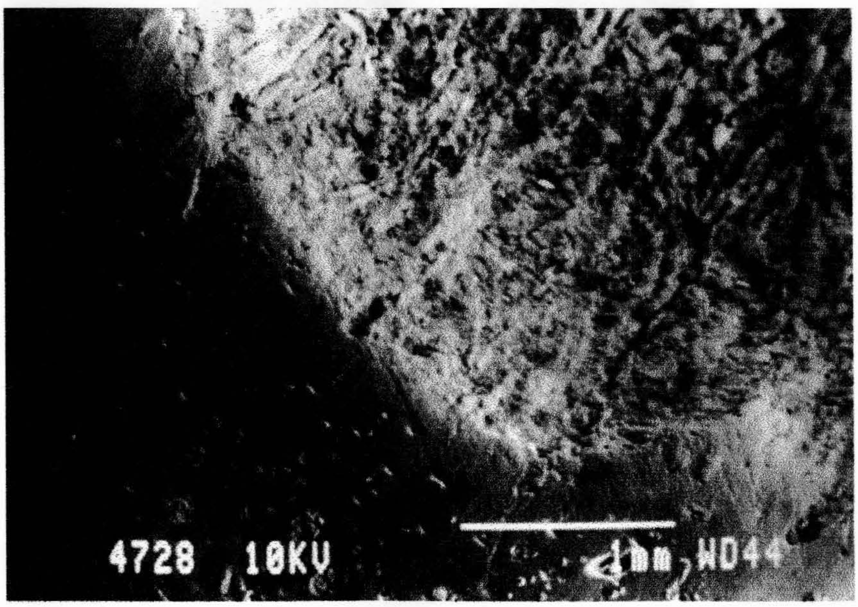


Figure 18.3.2:
SEM micrograph:
W03-B2: x 30 mag. after 30 min. use



F01-B2

Description	A very broad, sturdy looking tool, with a rounded shape at both ends. The working tip is therefore relatively broad and flat, which proved to chip easily during use. The rounded blunt point made this tool hard to use, despite the relatively soft bark of the *Celtis africana* (White Stinkwood) tree.
Faunal association	Shaft fragment of a *Bos taurus* (cattle) femur.
Length	55 mm
Cortical thickness	6mm
Weathering stage	Fresh/Green

Figure 19.1: **Documentary photograph: Experimental tool F01-B2**

Figure 19.2.1:
SEM micrograph:
F01-B2: x 15 mag. after 10 min. use

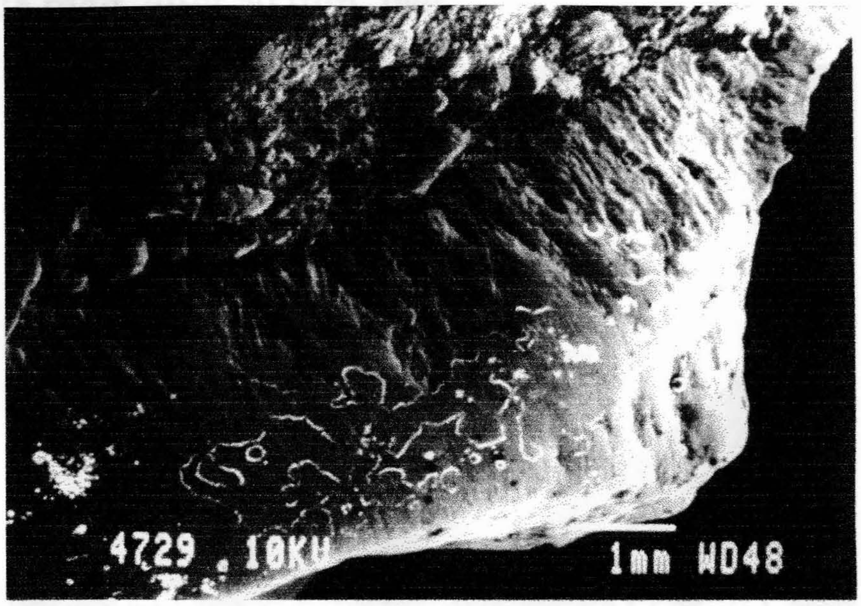


Figure 19.2.2:
SEM micrograph:
F01-B2: x 30 mag. after 10 min. use

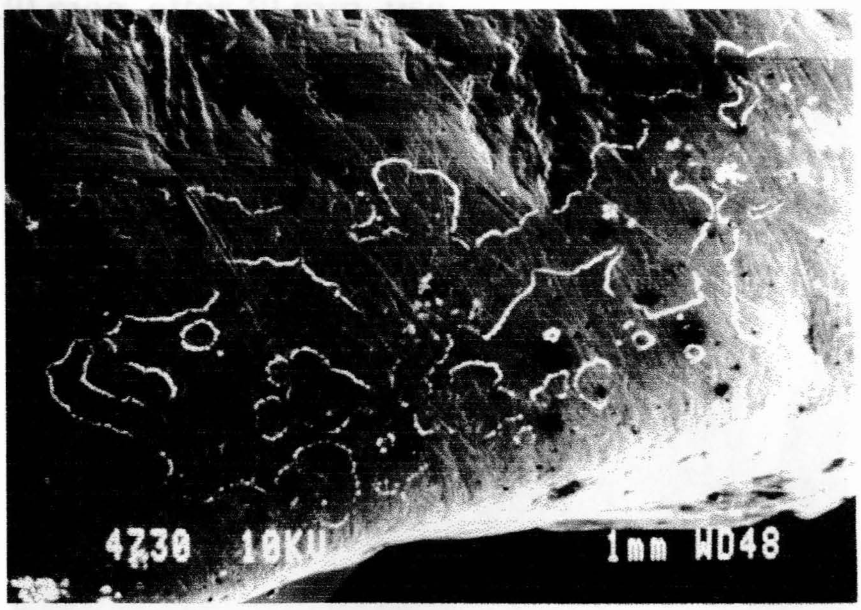


Figure 19.3.1:
SEM micrograph:
F01-B2: x 15 mag. after 30 min. use

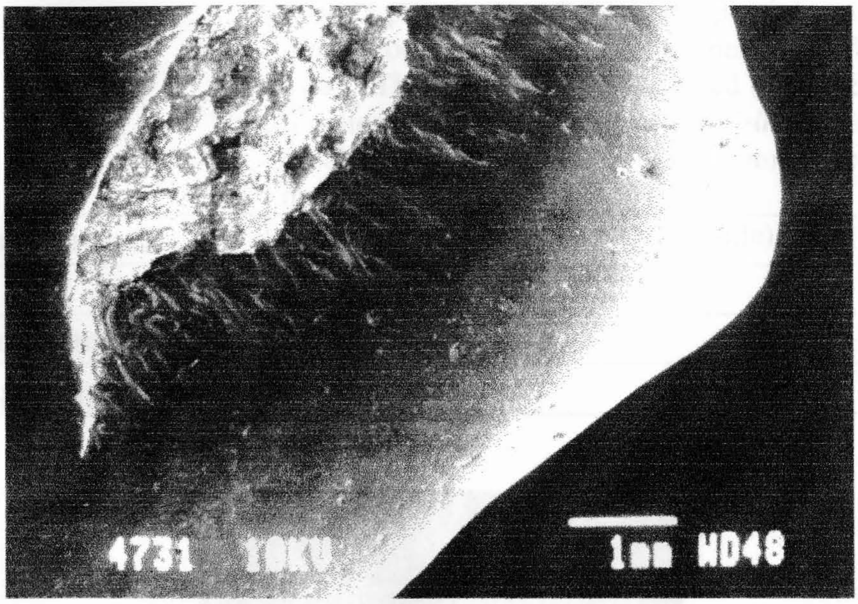
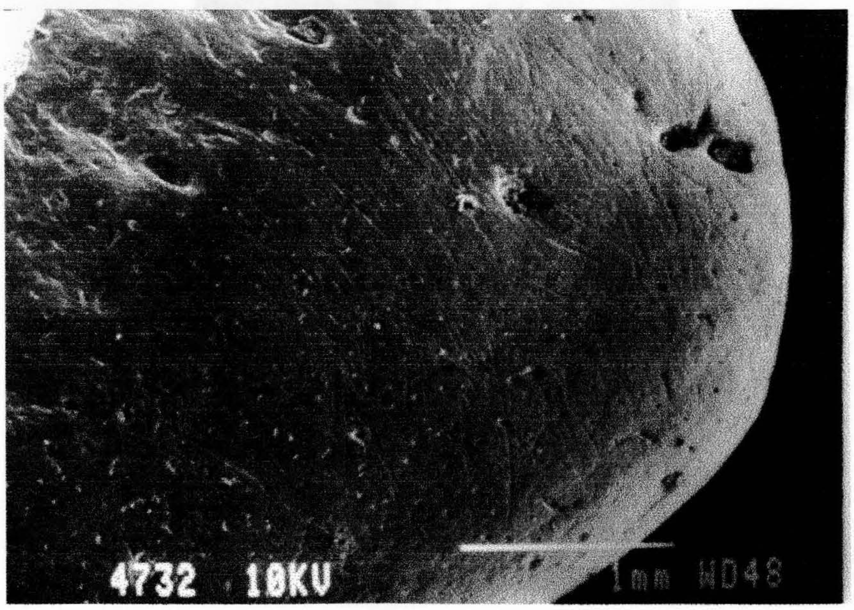


Figure 19.3.2:
SEM micrograph:
F01-B2: x 30 mag. after 30 min. use



F02-B2

Description	A short sturdy looking tool tapering to a point at one end with the other end quite flat. The working tip forms a prominent, relatively steep point and is thinned out because part of the inner cortex fractured away. This steep, thin point proved to be extremely functional in the debarking of the *Celtis africana* (White Stinkwood) tree. A stone hammer percussion mark is visible on the working tip.
Faunal association	Shaft fragment of a *Bos taurus* (cattle) femur.
Length	56 mm
Cortical thickness	4 mm
Weathering stage	Fresh/Green

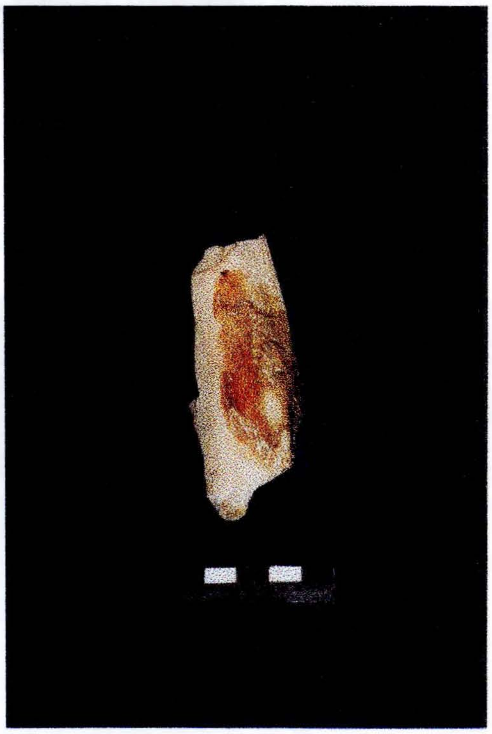


Figure 20.1: **Documentary photograph: Experimental tool F02-B2**

Figure 20.2.1:
SEM micrograph:
F02-B2: x 15 mag. after 10 min. use

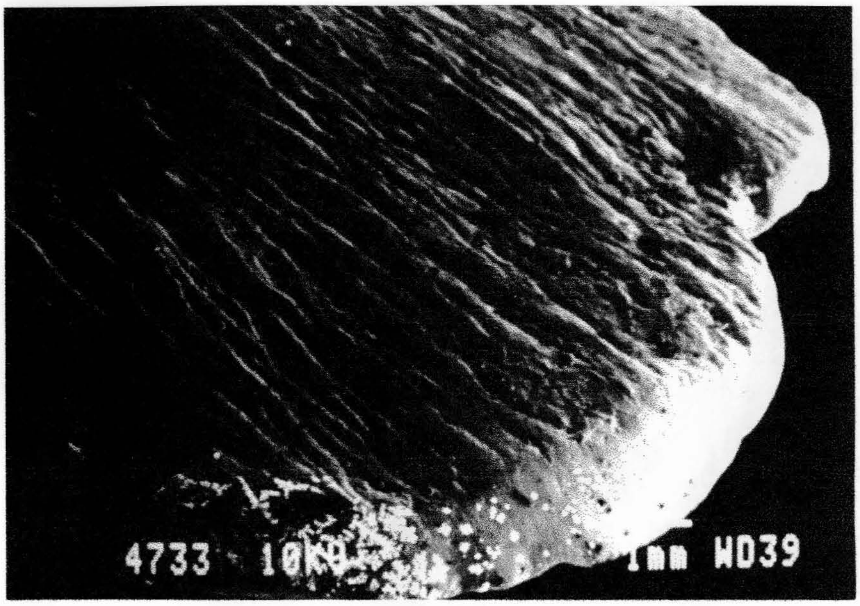


Figure 20.2.2:
SEM micrograph:
F02-B2: x 30 mag. after 10 min. use

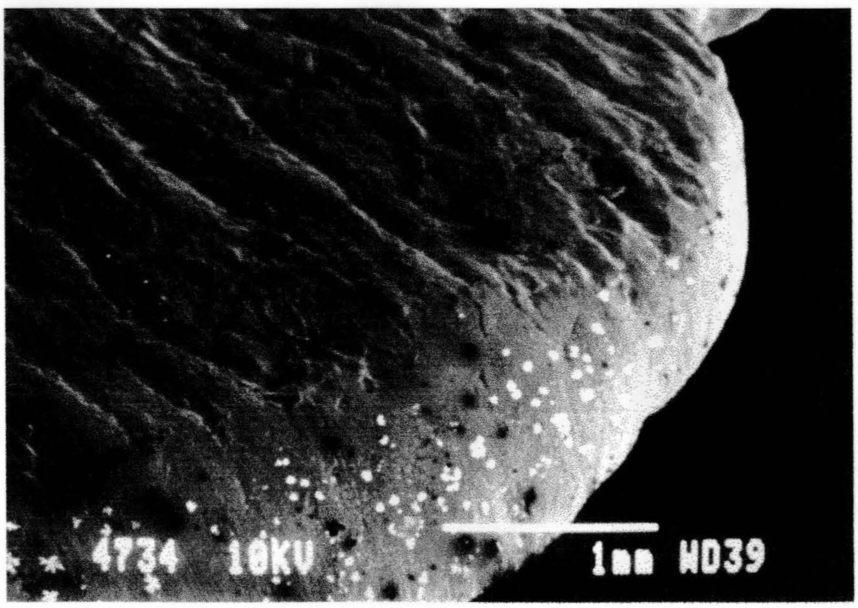


Figure 20.3.1:
SEM micrograph:
F02-B2: x 15 mag. after 30 min. use

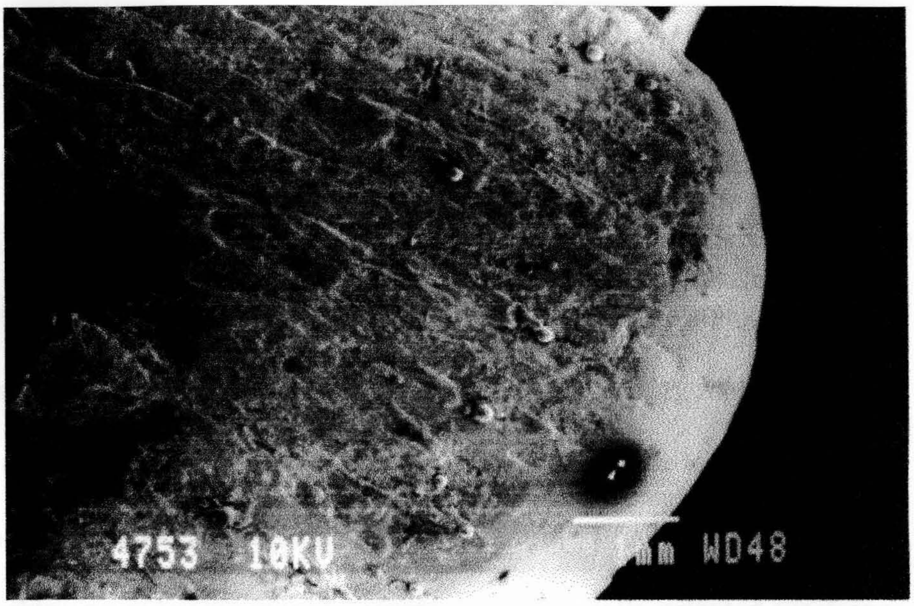
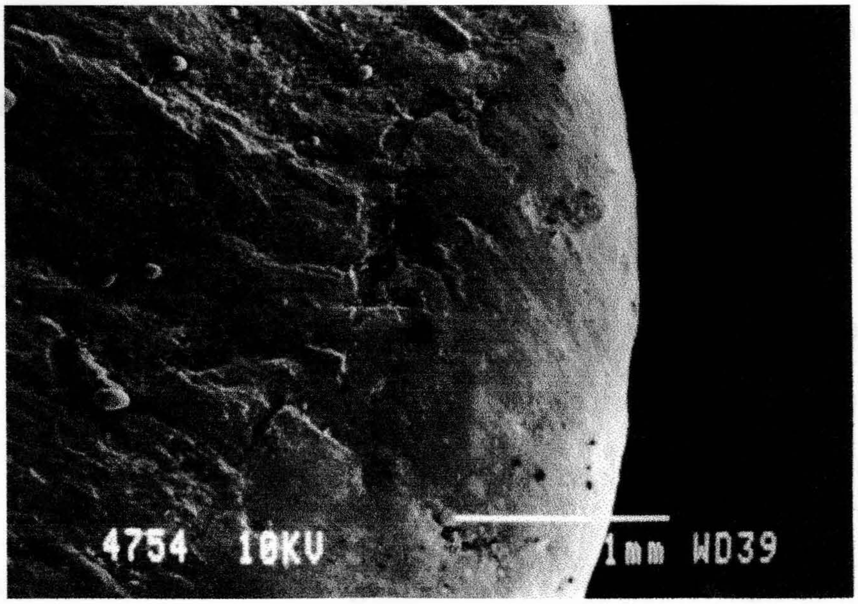


Figure 20.3.2:
SEM micrograph:
F02-B2: x 30 mag. after 30 min. use



3.3.4) The B2 tools: Debarking of the *Celtis africana* (White Stinkwood) tree

3.3.4.1) The B2 tools – a short discussion

W01-B2: With the very tip of the tool slightly modified by rounding and smoothing, a few faint longitudinally and diagonally orientated striations were visible on the modified tip (Fig. 16.2.2). On the surface of the 10 min. specimen a few transverse striations were observed. On the 30 min. specimen many more longitudinally oriented striations were visible on the very tip of the tool (Fig. 16.3.2). This tip was more smoothed and rounded than the tip of the 10 min. specimen. After the 30 min. working period some more transverse and diagonally oriented striations were observed on the surface of the tool, yet still too little to ascribe them to any recognisable composition.

W02-B2: The very tip of the 10 min. specimen and one edge of the side of the tip were slightly smoothed and rounded by working. Primarily longitudinally oriented striations were visible on this tip (Fig. 17.2.2). The surface of the 10 min. specimen displayed some transverse striations. After 30 min. of working the smoothly modified tip area was slightly enlarged (Fig. 17.3.1) with a multitude of mostly longitudinally oriented, but also diagonal striations visible on the modified tip area (Fig. 17.3.2). A few transverse striations were observed on the surface of the tool tip.

W03-B2: After 10 min. of working some rounding and smoothing occurred on the very tip of the tool. This tip also displayed some faint, mostly longitudinally oriented striations (Fig. 18.2.2). On the 30 min. specimen a noticeable increase in modification to the tip was noted (Fig. 18.3.1). An increase in the amount of longitudinally oriented striations accompanied by many diagonal striations forming some acutely angled criss-cross formations was also visible. On both the 10 min. and the 30 min. specimen only a few widely dispersed transverse striations were observed on the surface of the tool tip.

F01-B2: After 10 min. of employment a random composition of prominent acutely angled criss-cross striae was observed on the slightly modified broad, stepped tool tip (Fig. 19.2.2). The 30 min. specimen displayed a marked increase in smoothing and rounding of the tool tip. A random composition of clearly visible acutely angled criss-cross striations was visible on all modified areas of the tip (Fig. 19.3.2). No modification marks were observed away from the tool tip on the 10 min. or the 30 min. specimen. (White lines on Fig. 19.2.1 & 19.2.2 are the result of light reflection on the coated sample.)

F02-B2: The 10 min. specimen attests to a slight rounding and smoothing of the tool tip. On this smoothed area primarily acutely angled criss-cross composed striae were observed (Fig. 20.2.2). After 30 min. of employment, very little modification to the tip was visible, with a faint acutely angled composition of criss-cross striations restricted to the modified tip area (Fig. 20.3.2). Though a hammerstone percussion mark was visible on the surface of the tool, no other modification marks were observed further away from the tool tip on the surface of either the 10 min. or the 30 min. specimen. (White marks on Fig. 20.2.1 & 20.2.2 are the result of light reflection on the coated sample.)

3.3.4.2) Summary of the B2 tools

The B2 tools displayed only a slight increase in tool tip modification (both smoothing and rounding) from the 1st to the 2nd working period. This modification had virtually no impact on the overall morphology of the tool tips and was restricted to the very tool tip areas only. The definite distinction between the working tips and the surfaces behind the tool tips increased with prolonged working. Polishes observed were restricted to the modified surfaces of the working tips.

On all the weathered tools a readily identifiable composition of primarily longitudinally oriented striations were observed. Striations were restricted to the smoothly modified areas of the working tips only. Striation compositions remained constant from the 1st to the 2nd working period, recurring as a primarily longitudinally oriented striation composition after the final working period. On the surfaces of the weathered tool tips some striations were observed. These were too few and too widely dispersed to ascribe them to any readily identifiable composition.

Restricted to the smoothly modified areas of the working tips of the fresh tools, a recognisable composition of acutely angled criss-cross striations could be observed. This composition of striae remained constant after reemployment of the tools. No modification marks could be detected on the tool surfaces of the fresh bone tools. Striations observed on the fresh tools were more intense than those observed on the weathered tools.

Medium to larger sized tools were found to be handier than small tools.

3.3.5) The H1 tools: Processing the inner side (burnishing) of a *Bos taurus* (cattle) hide

W01-H1

Description	With one articular end completely intact, the tool appears steeply V-shaped in morphology. The working tip is steeply shaped. However the large size of this tool proved to be rather impractical in processing the inner side of a *Bos taurus* (cattle) hide.
Faunal association	Fragment of an *Equus ferus* (horse) tibia with the proximal articular end intact (sub-adult).
Length	240 mm
Cortical thickness	7 mm
Weathering stage	1

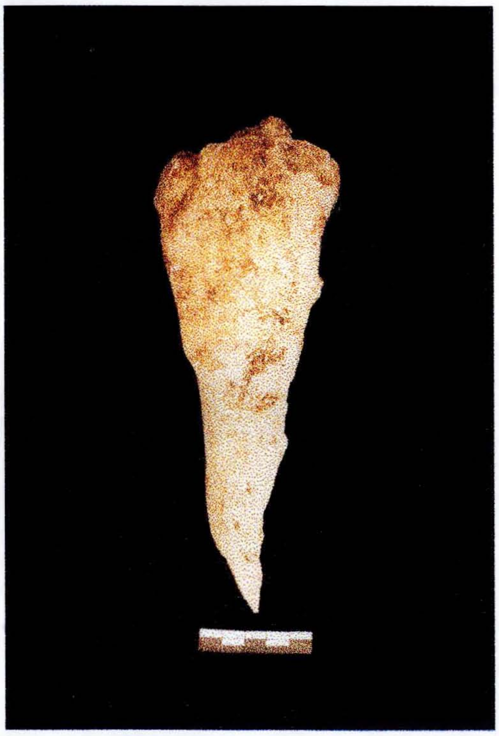


Figure 21.1: **Documentary photograph: Experimental tool W01-H1**

Figure 21.2.1:

SEM micrograph:

W01-H1: x 15 mag. after 10 min. use

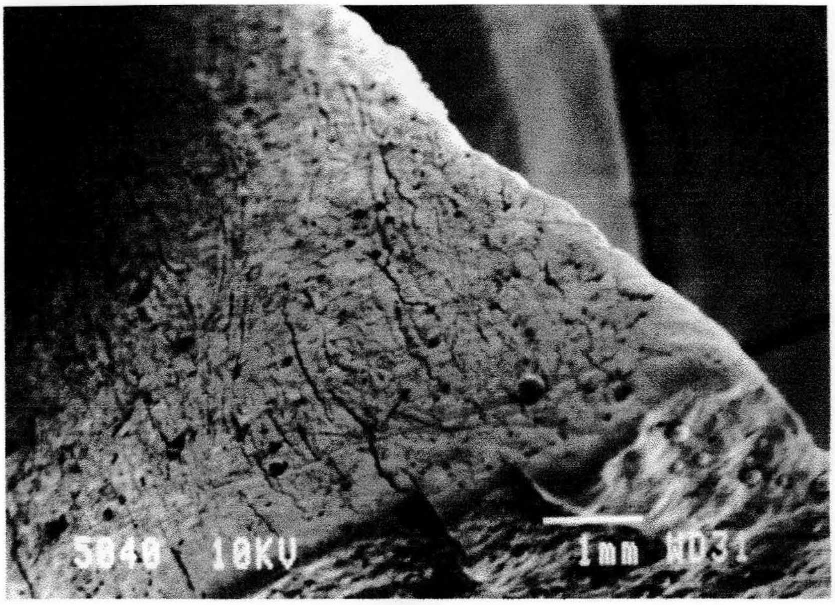


Figure 21.2.2:

SEM micrograph:

W01-H1: x 30 mag. after 10 min. use

Figure 21.3.1:

SEM micrograph:
W01-H1: x 15 mag. after 30 min. use

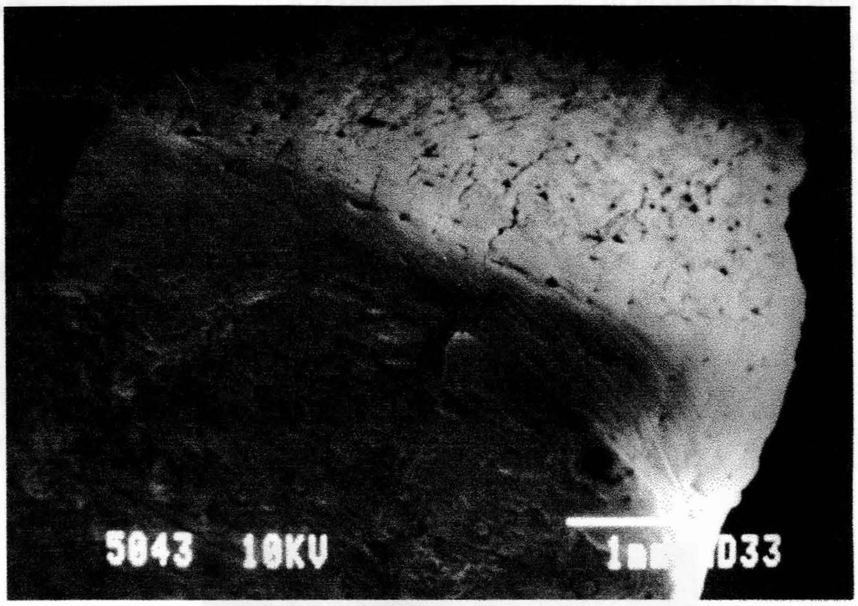
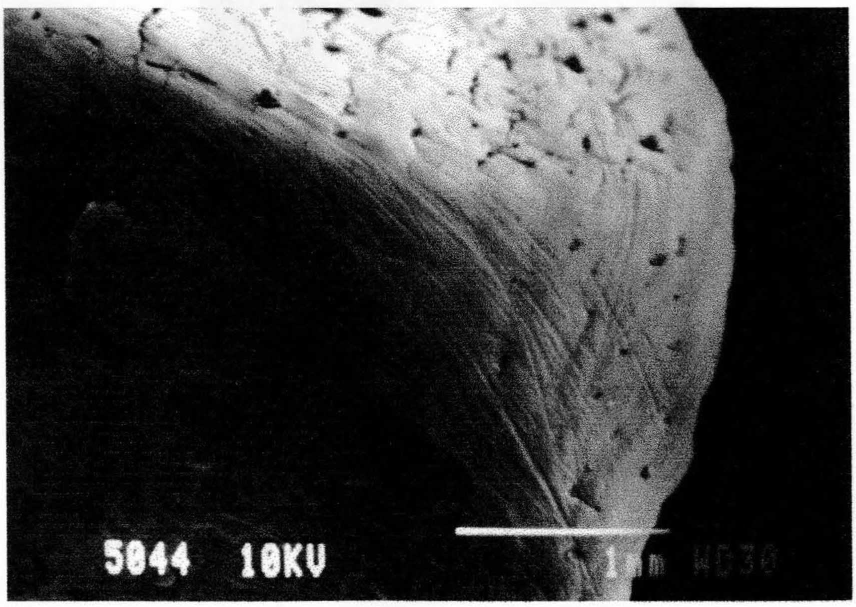


Figure 21.3.2:

SEM micrograph:
W01-H1: x 30 mag. after 30 min. use



W02-H1

Description	A relatively slender tool in appearance, tapering to a point at both ends. The working tip is relatively steeply V-shaped, but with a broad end, slightly fractured and therefore forming a small second tip to the tool. This tool proved to be quite functional because of the morphology of this tip in processing the inner side of a *Bos taurus* (cattle) hide.
Faunal association	Shaft fragment of an *Equus ferus* (horse) tibia (sub-adult).
Length	129 mm
Cortical thickness	9 mm
Weathering stage	1

Figure 22.1: **Documentary photograph: Experimental tool W02-H1**

Figure 22.2.1:

SEM micrograph:
W02-H1: x 15 mag. after 10 min. use

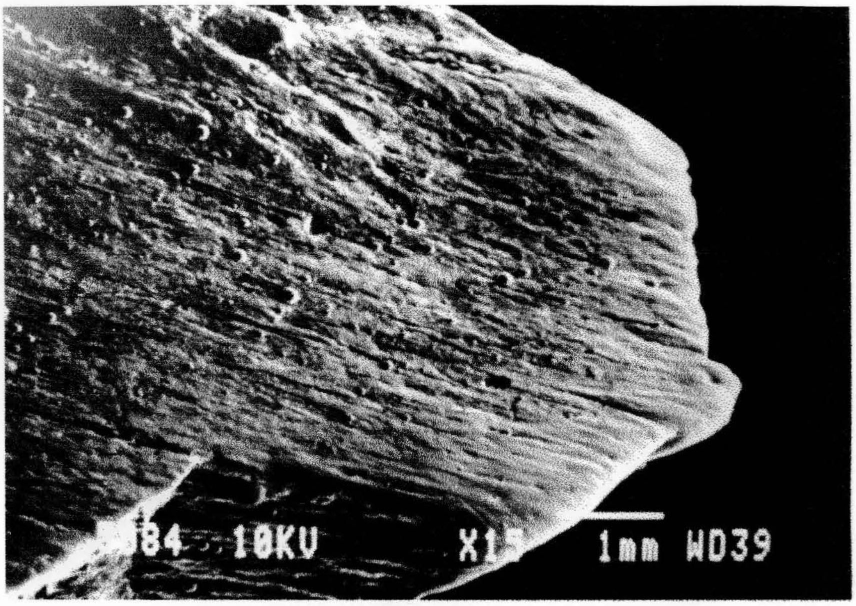


Figure 22.2.2:

SEM micrograph:
W02-H1: x 30 mag. after 10 min. use

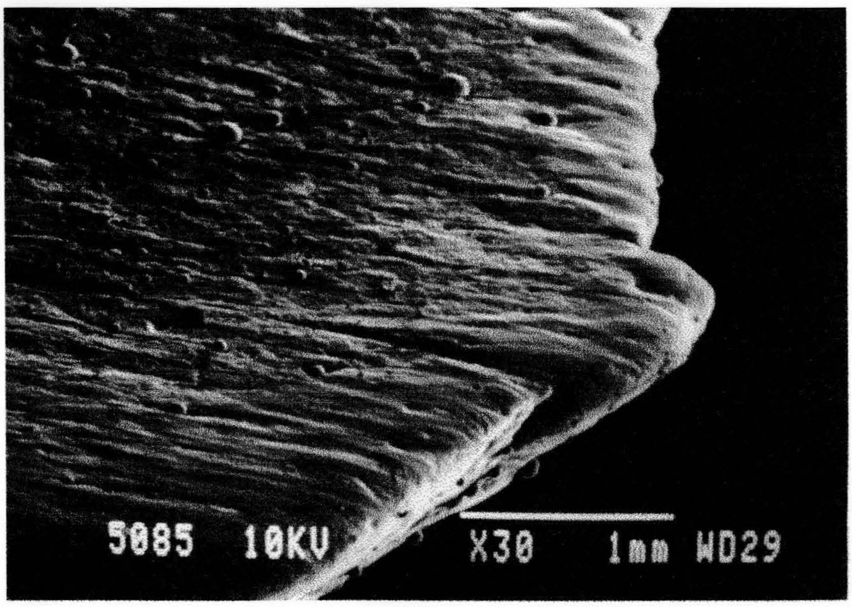


Figure 22.3.1:
SEM micrograph:
W02-H1: x 15 mag. after 30 min. use

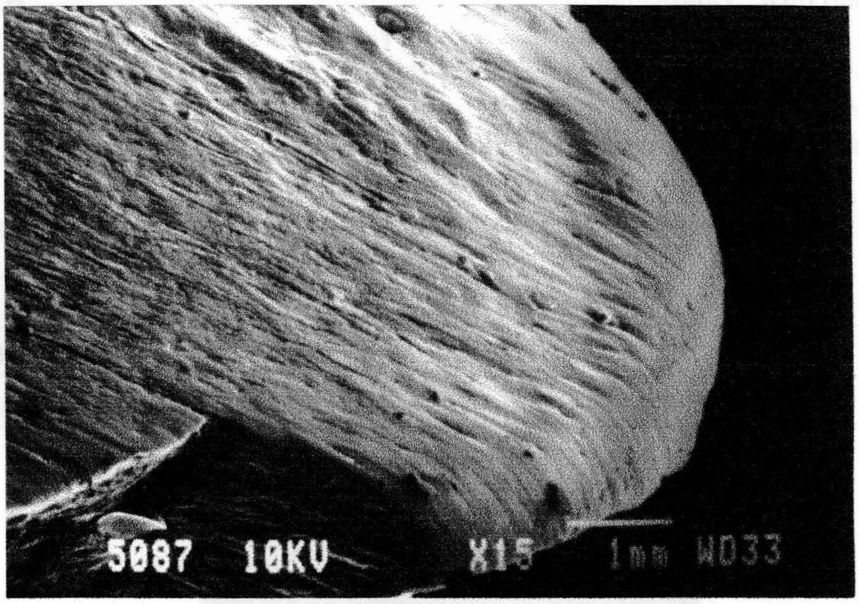
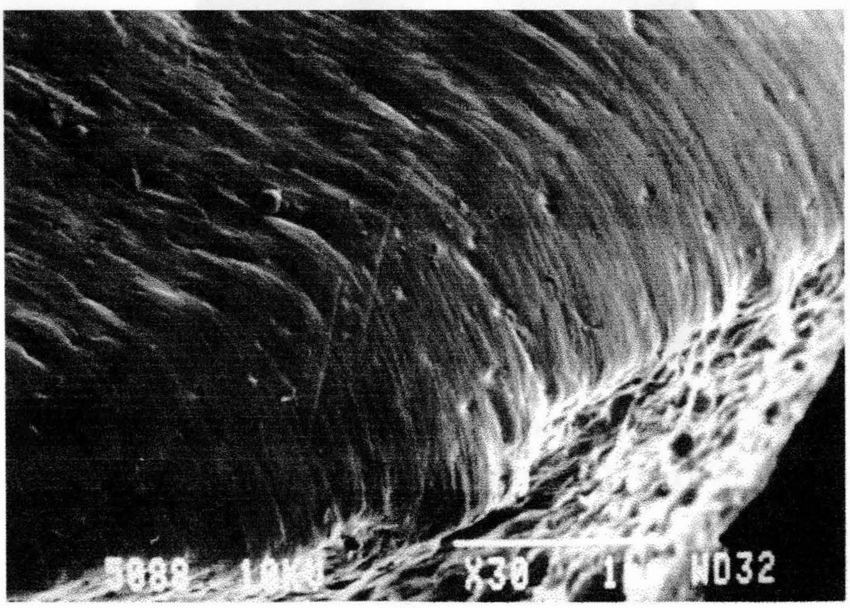


Figure 22.3.2:
SEM micrograph:
W02-H1: x 30 mag. after 30 min. use



W03-H1

Description	A sturdy looking tool in appearance, with one ruggedly shaped pointed edge, the other end slopes into a relatively steep point but with a relatively broad (20 mm), flat edge. This flat end proved to be not very functional in processing the inner side of a *Bos taurus* (cattle) hide.
Faunal association	Shaft fragment of a *Tragelaphus oryx* (eland) femur (slightly burned).
Length	121 mm
Cortical thickness	7 mm
Weathering stage	1

Figure 23.1: **Documentary photograph: Experimental tool W03-H1**

Figure 23.2.1:
SEM micrograph:
W03-H1: x 15 mag. after 10 min. use

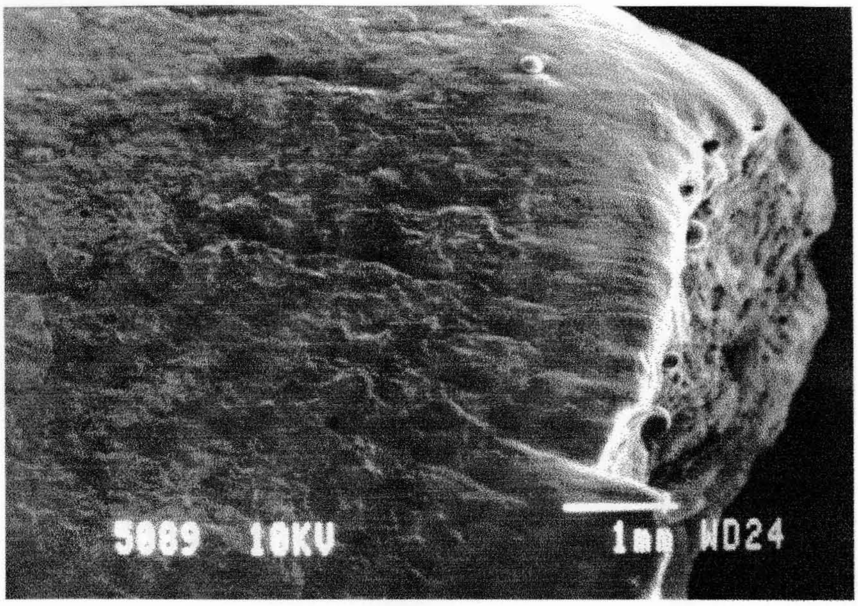


Figure 23.2.2:
SEM micrograph:
W03-H1: x 30 mag. after 10 min. use

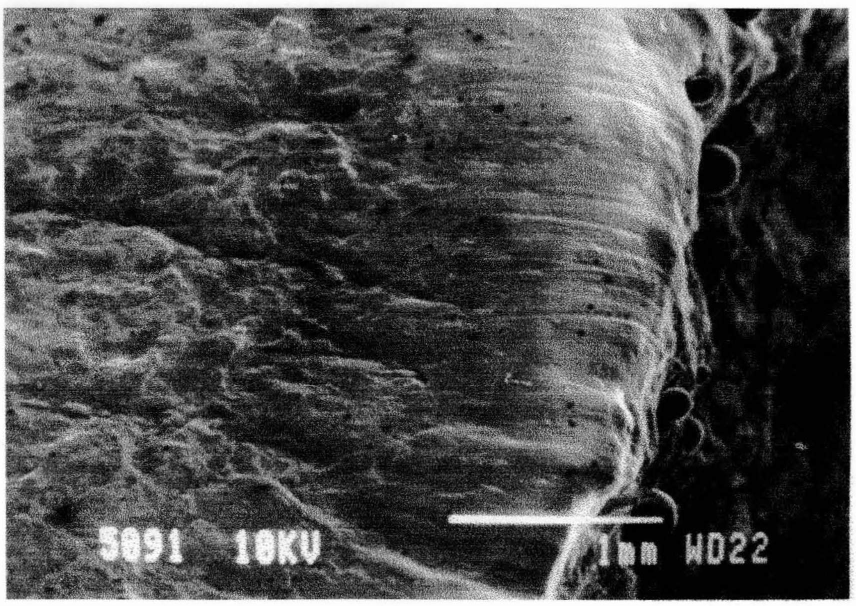


Figure 23.3.1:

SEM micrograph:
W03-H1: x 15 mag. after 30 min. use

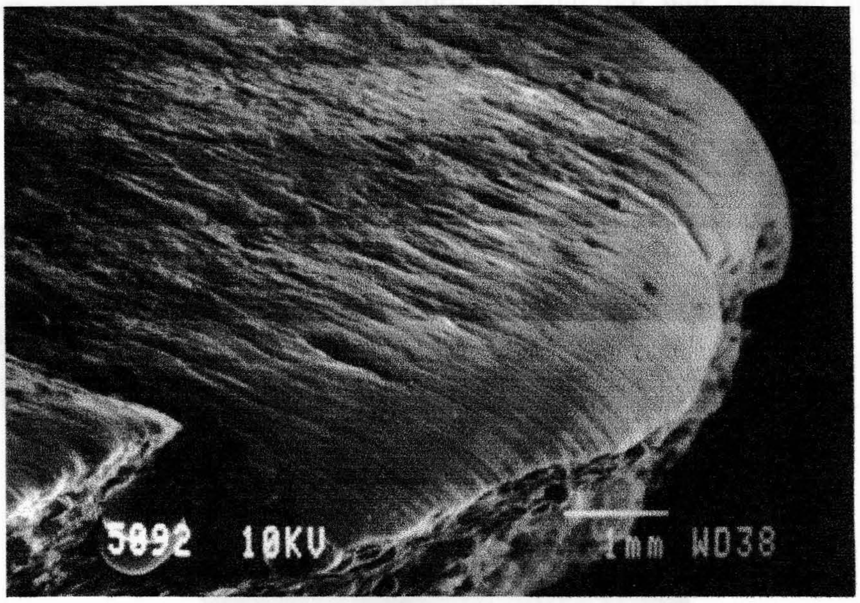
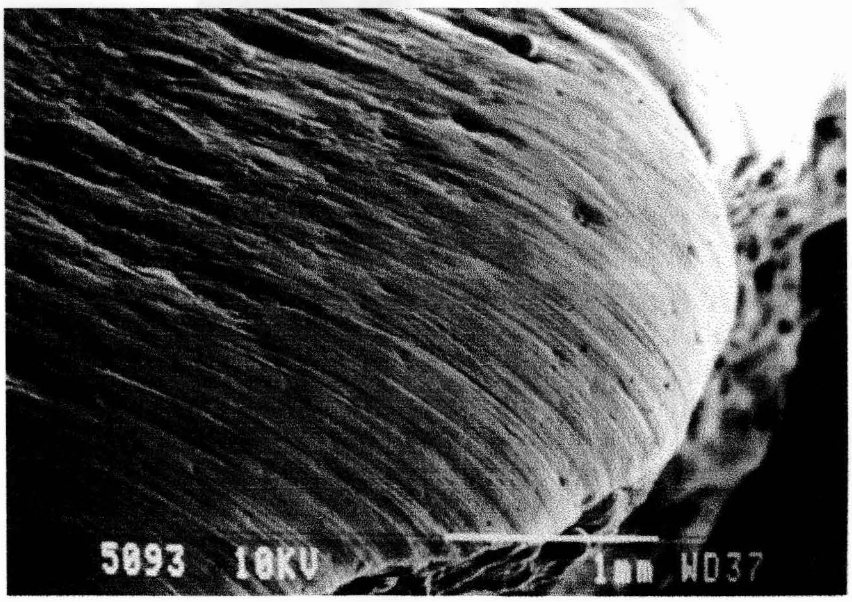


Figure 23.3.2:

SEM micrograph:
W03-H1: x 30 mag. after 30 min. use



F01-H1

Description	A broad, sturdy looking tool, with one end slightly rounded and the other end flat. The working tip, slightly rounded, has a notch forming a relatively pointed working edge that rendered the tool quite functional in processing the inner side of a *Bos taurus* (cattle) hide.
Faunal association	Shaft fragment of a *Bos taurus* (cattle) tibia.
Length	51 mm
Cortical thickness	6 mm
Weathering stage	Fresh/Green

Figure 24.1: **Documentary photograph: Experimental tool F01-H1**

Figure 24.2.1:
SEM micrograph:
F01-H1: x 15 mag. after 10 min. use

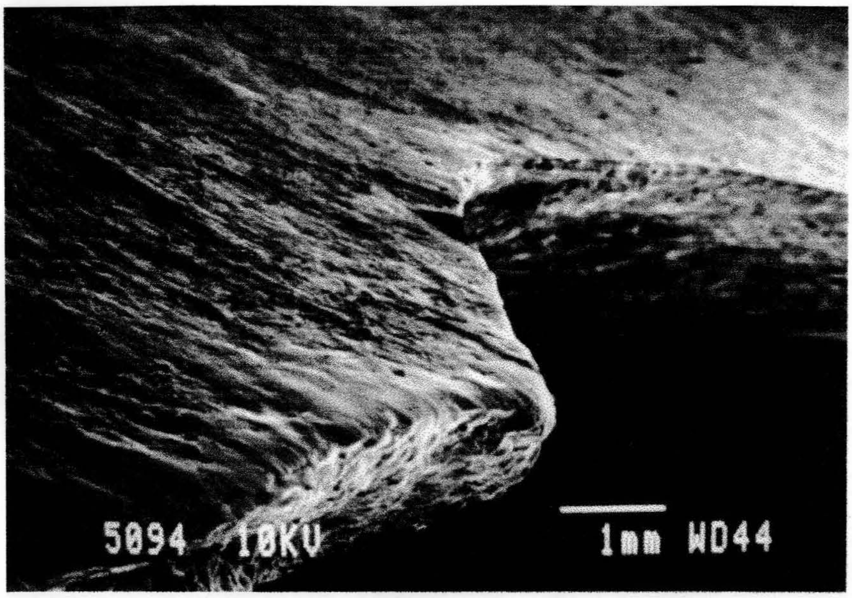


Figure 24.2.2:
SEM micrograph:
F01-H1: x 30 mag. after 10 min. use

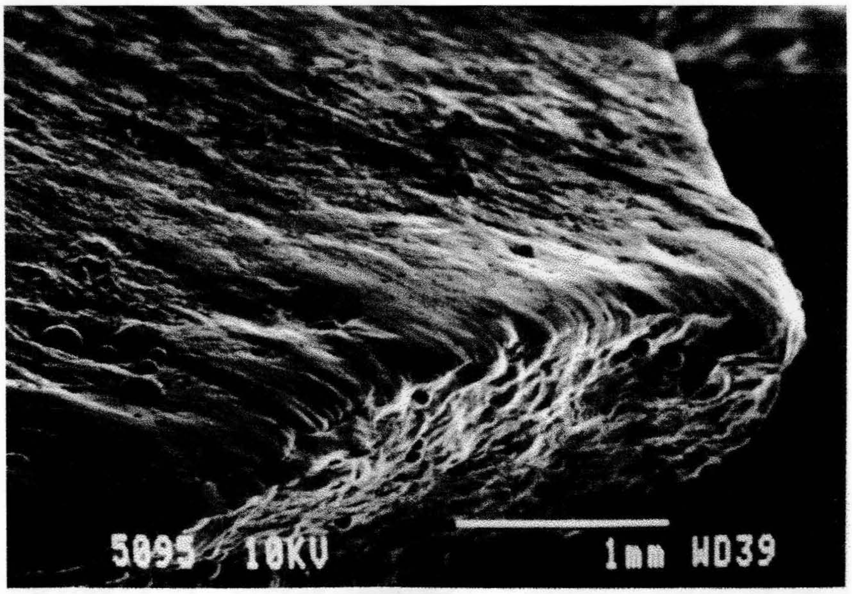


Figure 24.3.1:
SEM micrograph:
F01-H1: x 15 mag. after 30 min. use

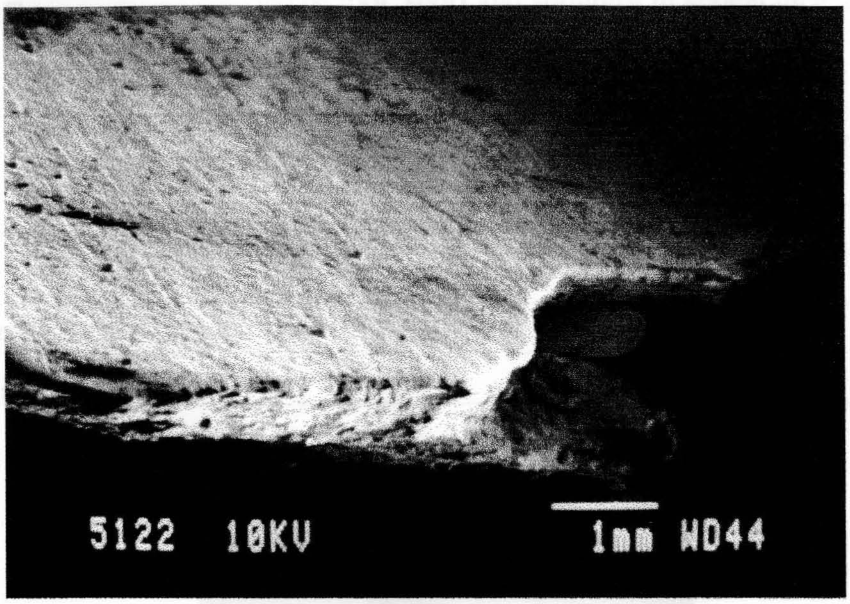
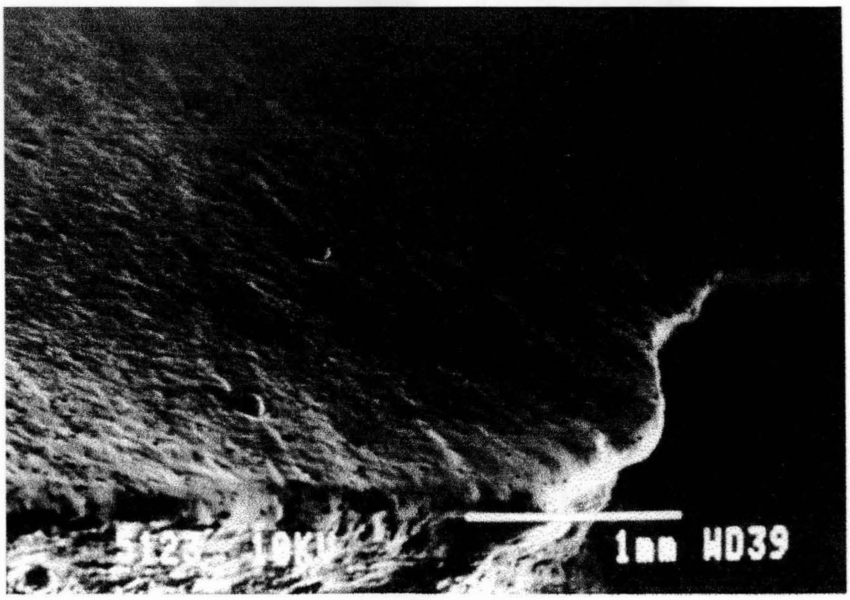


Figure 24.3.2:
SEM micrograph:
F01-H1: x 30 mag. after 30 min. use



F02-H1

Description	The tool, short and splintery in appearance, is slightly rounded at both ends. The working tip is short and flat. The thin cortical thickness of this tool proved to be a great aid towards functionality. The tool was used to process the inner side of a *Bos taurus* (cattle) hide.
Faunal association	Shaft fragment of a *Bos taurus* (cattle) tibia.
Length	39 mm
Cortical thickness	3 mm
Weathering stage	Fresh/Green

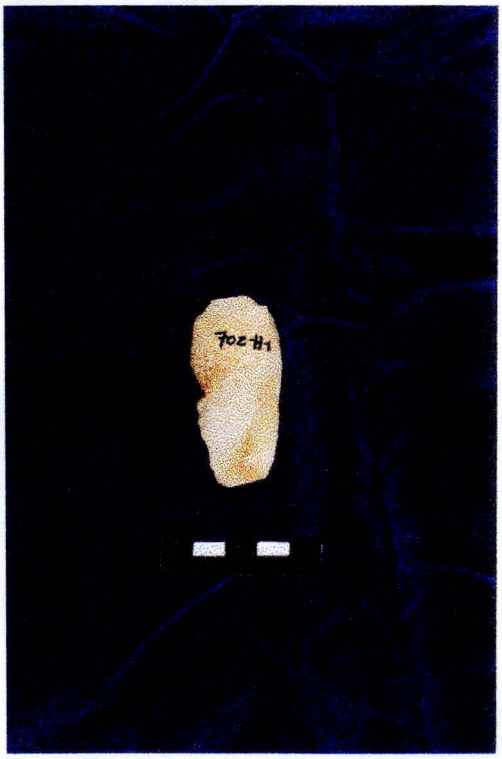


Figure 25.1: **Documentary photograph: Experimental tool F02-H1**

Figure 25.2.1:
SEM micrograph:
F02-H1: x 15 mag. after 10 min. use

Figure 25.2.2:
SEM micrograph:
F02-H1: x 30 mag. after 10 min. use

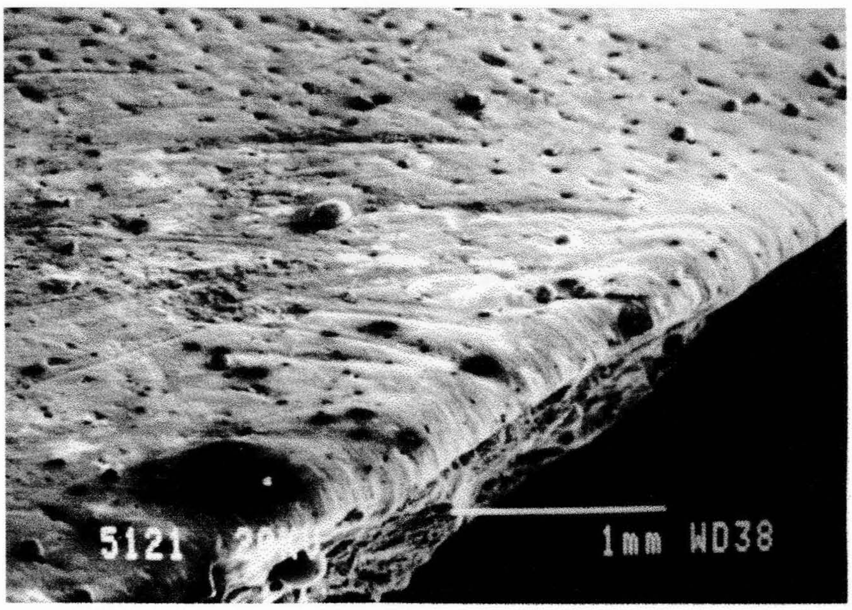


Figure 25.3.1:
SEM micrograph:
F02-H1: x 15 mag. after 30 min. use

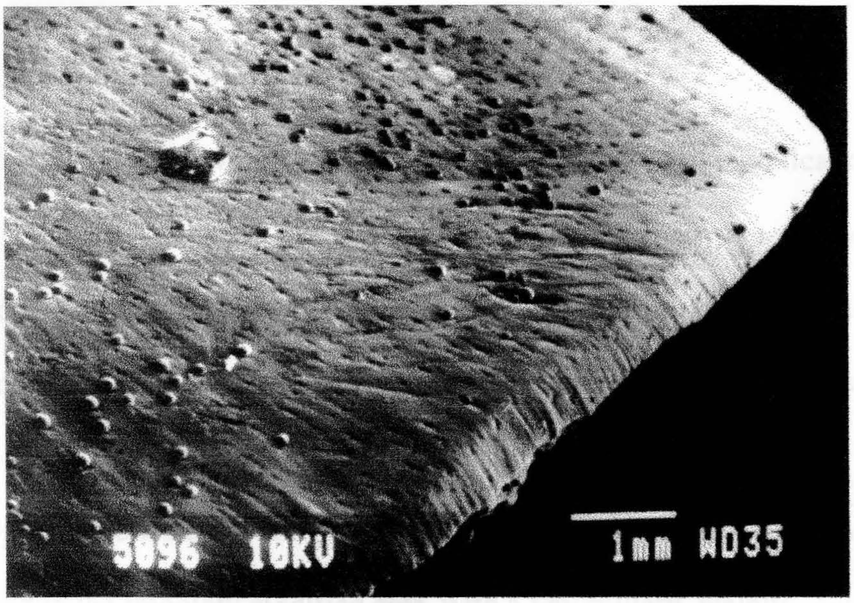
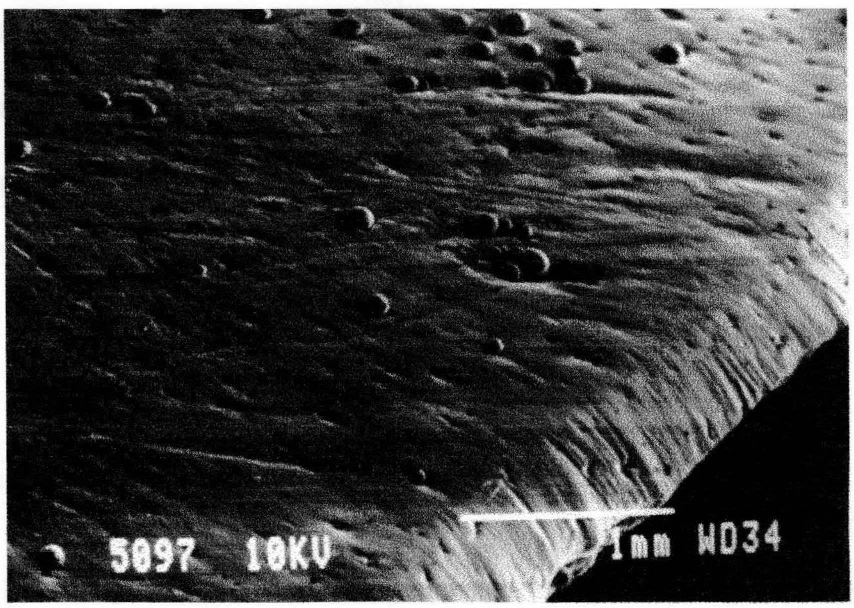


Figure 25.3.2:
SEM micrograph:
F02-H1: x 30 mag. after 30 min. use



3.3.5) The H1 tools: Processing the inner side (burnishing) of a *Bos taurus* (cattle) hide

3.3.5.1) The H1 tools – a short discussion

W01-H1: After the 1st working period only a slight amount of modification was observed on the tip of the tool (Fig. 21.2.1). This modified area was too small to display any recognisable striation composition. No striations were observed on the body of the tool (Fig. 21.2.2). The 30 min. specimen showed a remarkable increase in modification of the tool tip (Fig. 21.3.1). Striations observed displayed a clearly defined acutely angled criss-cross composition (Fig. 21.3.2). Visible striations were largely restricted to the smoothly modified area, with a few solitary, mainly diagonally oriented striations situated on the tool tip surface. A polish was observed on the tool tip. This polish was clearly visible up to 20 mm away from the tool tip.

W02-H1: The 10 min. specimen displayed virtually no modification in terms of both rounding and smoothing to the tool tip or striation marks on the tip or surface of the tool (Fig. 22.2.2). After 30 min. of employment a radical increase in the smoothing and rounding of the tool tip could be noted (Fig. 22.3.1). This smoothed area displayed a multitude of clearly visible longitudinally orientated striations interrupted by a few diagonal striae (Fig. 22.3.2). An area of polish was visible on the tool tip. This polish was restricted to the very tip of the tool.

W03-H1: A slight degree of rounding and smoothing of the broad tool tip together with longitudinally oriented striation marks on the very tip of the tool was visible on the 10 min. specimen (Fig. 23.2.2). After the final working period the tip of the tool was much more rounded (Fig. 23.3.1) with a multitude of longitudinally oriented striation marks situated on this smoothed rounding (Fig. 23.3.2). No prominent striation marks were observed on the body of the tool on either the 10 min. or the 30 min. specimen. A very limited polish, restricted to the tip of the tool, was visible after 30 min. of employment.

F01-H1: The tip of the 10 min. specimen was minimally modified by means of rounding and smoothing without any visible striation marks (Fig. 24.2.2). After 30 min. of employment a slight degree of smoothing and rounding occurred on one side of the broad, notched tool tip. This smoothed area displayed some longitudinally oriented striation marks. A few longitudinally and diagonally oriented striation marks were visible on the body of the tool (Fig. 24.3.3). These were too few and too randomly dispersed to ascribe them to any defined composition. No noticeable polish was observed on the tool tip.

F02-H1: After 10 min. of employment only a slight degree of rounding was visible on this relatively broad, flat tip (Fig. 25.2.1). Longitudinally oriented striation marks were visible on the modified rounding, while a few randomly dispersed, primarily diagonally oriented striae were visible on the surface of the tool tip (Fig 25.2.2). The 30 min. specimen attested to an increase in modification to the tool tip (Fig. 25.3.1). Longitudinally oriented striations were visible on the enlarged rounded area, while an increase was detected in the amount of mostly diagonal striations forming acutely angled criss-crosses on the surface of the tool tip (Fig. 25.3.2). No polish was noted on the tool tip.

3.3.5.2) Summary of the H1 tools

While very little modification (both rounding and smoothing) to the tool tips was visible after the 1st working period, the H1 tool tips were noticeably modified after the final working period. Modification to the tool tips extended to a limited polish observed on the tips of the weathered tools. No definite polish was visible on the tips of the fresh tools. A clear demarcation could be observed between the working tips and the surfaces of the tools. This demarcation was enhanced after prolonged use.

Modification marks observed can be described as generally longitudinal in orientation. This predominantly longitudinal orientation sometimes alternated with noticeable diagonal and acutely angled criss-cross oriented striations. The striation composition remained restricted to the smoothly modified areas of the tool tips and was therefore largely observed on the 30 min. specimens. The surfaces of the tool tips displayed some striae. Surface striations were, however, too few and too widely dispersed to ascribe them to any readily recognisable composition. Both tool tip and surface striations were more intense on the fresh than on the weathered tools.

A medium sized tool proved to be the most functional. Tools that were either too large or too small hampered the scraping method used.

Striations observed on the H1 tools are probably the result of sediment particles, though no sediment was intentionally used in the processing of the hides. Striations are therefore ascribed to the natural environment in which the hide was processed. No striation marks are thus expected on tools used in a laboratory controlled environment.

3.3.6) The H2 tools: Processing the inner side (burnishing) of a *Bos taurus* (cattle) hide with the aid of sediment

W01-H2

Description	A long, relatively slender tool in appearance, which tapers to a point at both ends. The working tip is steeply shaped, rendering this tool extremely functional and easy to work with. The length of the tool was also a good feature regarding its functionality. The inner side of a *Bos taurus* (cattle) hide was processed, with the aid of sediment.
Faunal association	Shaft fragment of an *Equus ferus* (horse) radius.
Length	225 mm
Cortical thickness	6 mm
Weathering stage	1

Figure 26.1: **Documentary photograph: Experimental tool W01-H2**

Figure 26.2.1:
SEM micrograph:
W01-H2: x 15 mag. after 10 min. use

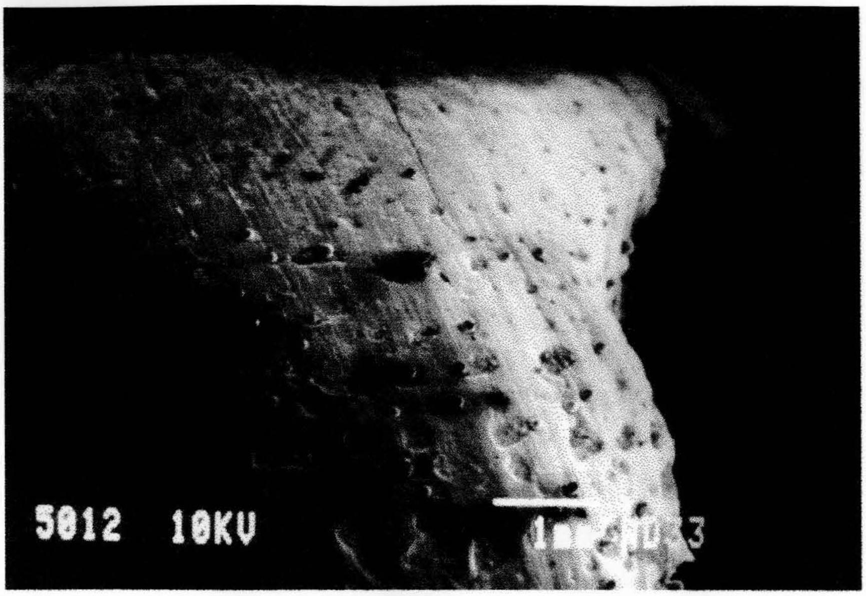


Figure 26.2.2:
SEM micrograph:
W01-H2: x 30 mag. after 10 min. use

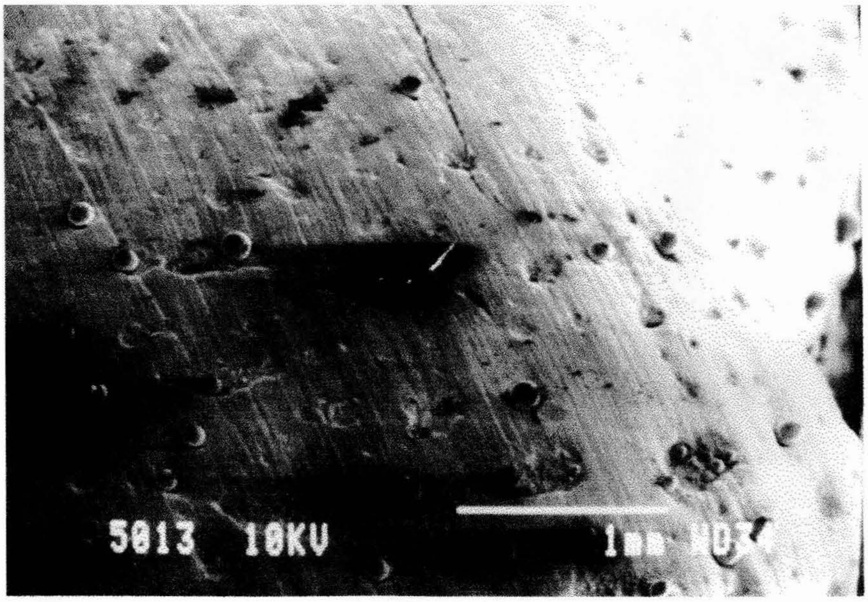


Figure 26.3.1:
SEM micrograph:
W01-H2: x 15 mag. after 30 min. use

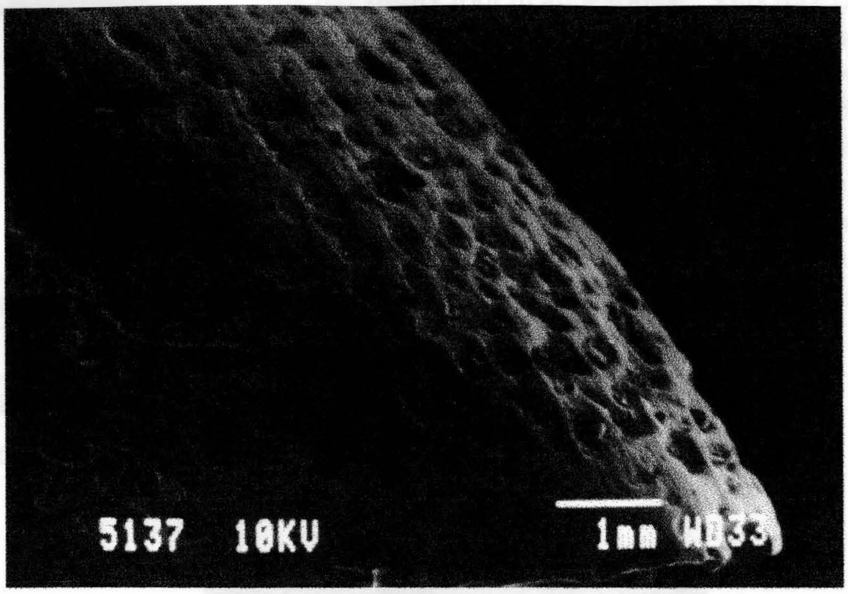
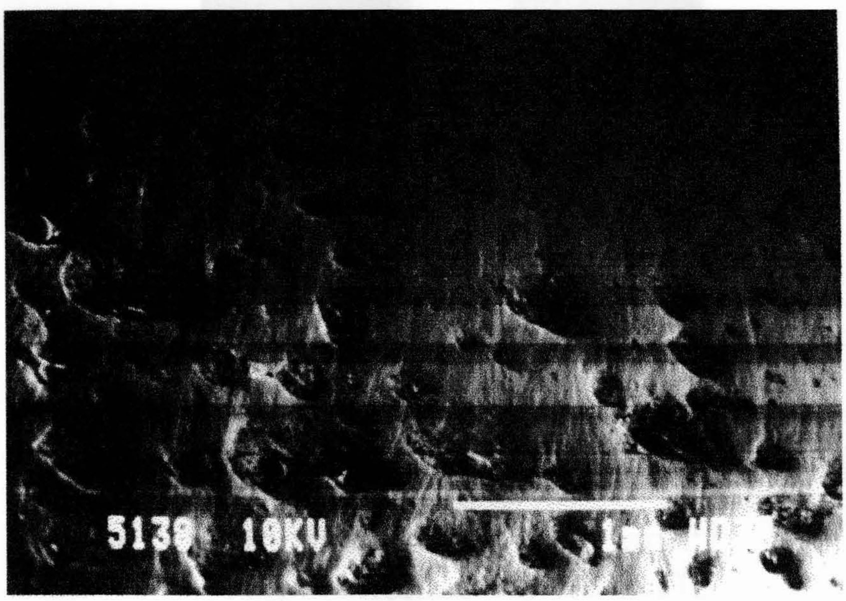


Figure 26.3.2:
SEM micrograph:
W01-H2: x 30 mag. after 30 min. use



W02-H2

Description	A big sturdy tool in appearance. This tool has one flat end with the other end tapering into a flat, rounded, gently sloping end. This end proved to go blunt very early during the experiments, and the tool was therefore not very functional in processing the inner side of the hide of a *Bos taurus* (cattle) with the aid of sediment. A polish on the blunt end was observed within the first 6 min. of experiments.
Faunal association	Shaft fragment of a *Tragelaphus oryx* (eland) femur.
Length	180 mm
Cortical thickness	9 mm
Weathering stage	1

Figure 27.1: **Documentary photograph: Experimental tool W02-H2**

Figure 27.2.1:
SEM micrograph:
W02-H2: x 15 mag. after 10 min. use

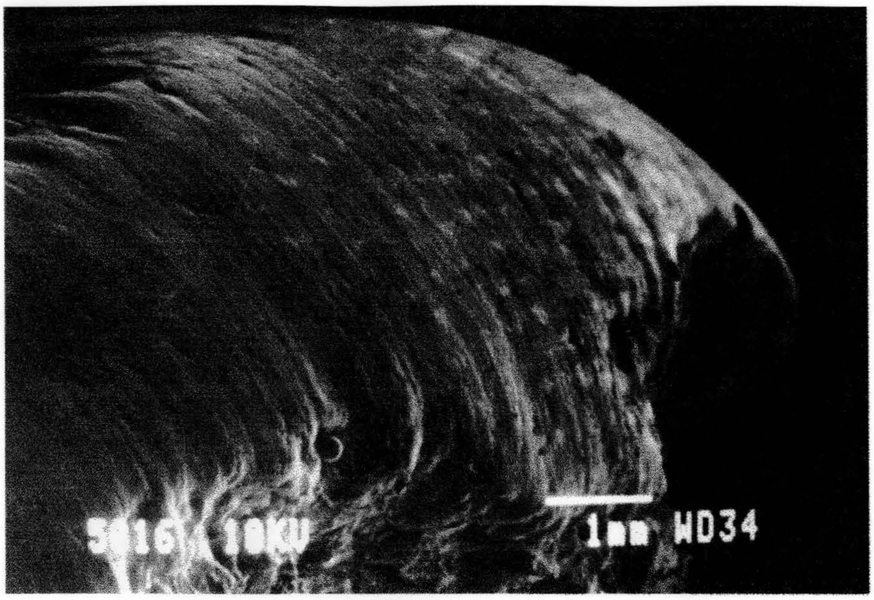


Figure 27.2.2:
SEM micrograph:
W02-H2: x 30 mag. after 10 min. use

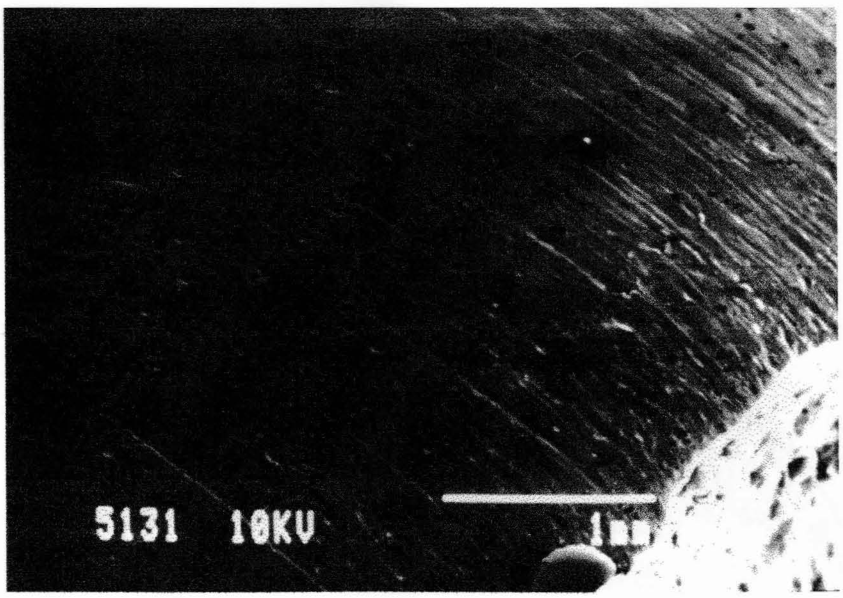


Figure 27.3.1:
SEM micrograph:
W02-H2: x 15 mag. after 30 min. use

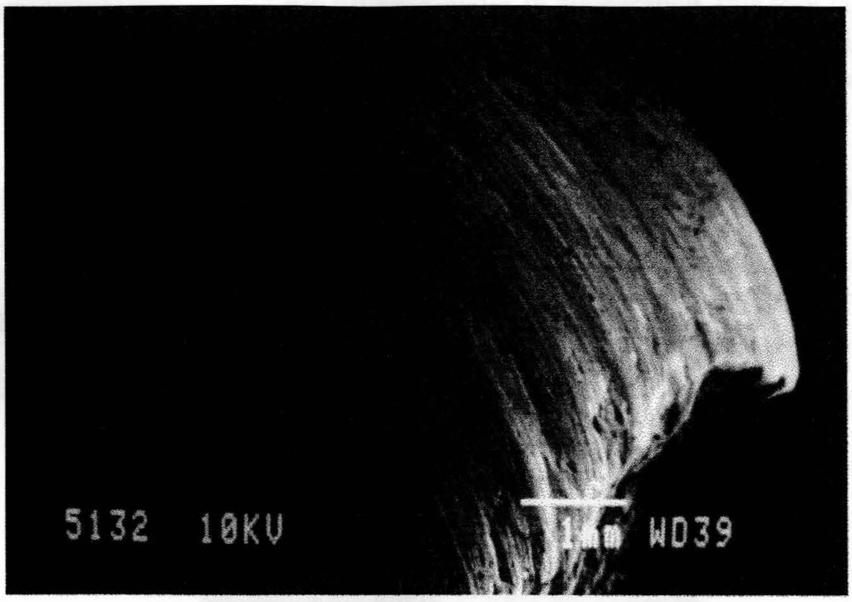
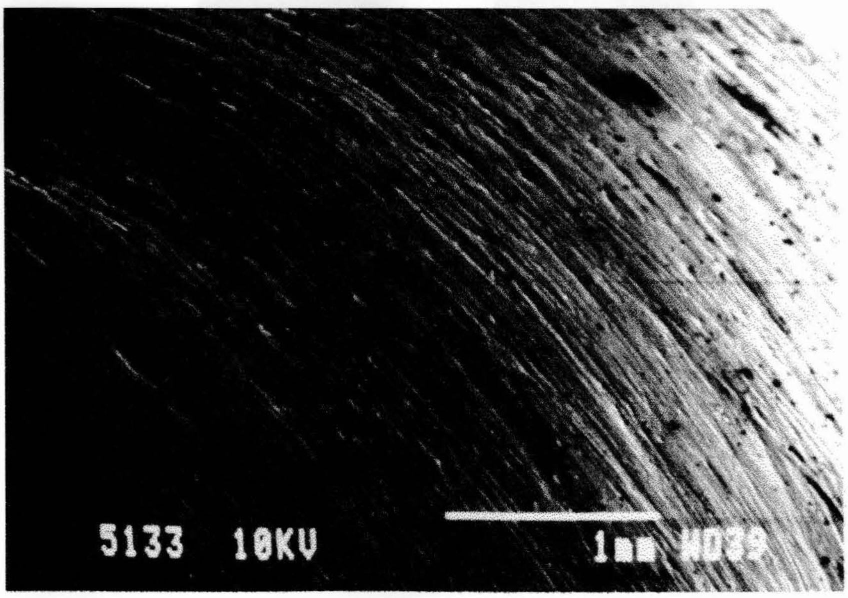


Figure 27.3.2:
SEM micrograph:
W02-H2: x 30 mag. after 30 min. use



W03-H2

Description	Relatively slender in appearance, this tool tapers to a point at both ends. The working tip is steeply shaped which rendered the tool very functional in processing the inner side of a *Bos taurus* (cattle) hide with the aid of sediment.
Faunal association	Shaft fragment of a *Hippotigris grevi* (Grevy zebra) femur.
Length	139 mm
Cortical thickness	9 mm
Weathering stage	2

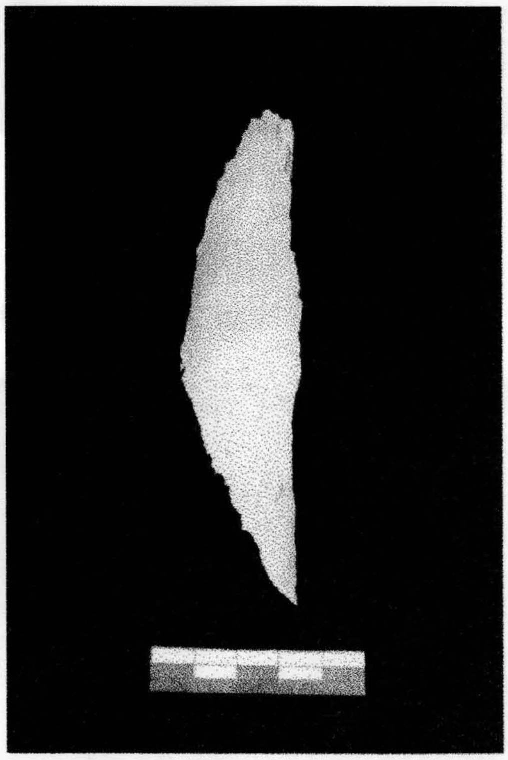


Figure 28.1: **Documentary photograph: Experimental tool W03-H2**

Figure 28.2.1:
SEM micrograph:
W03-H2: x 15 mag. after 10 min. use

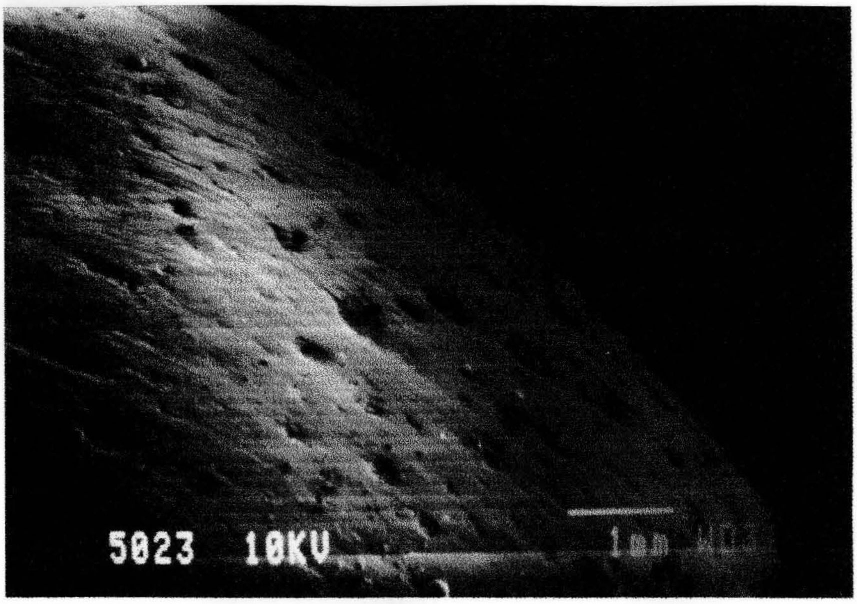


Figure 28.2.2:
SEM micrograph:
W03-H2: x 30 mag. after 10 min. use

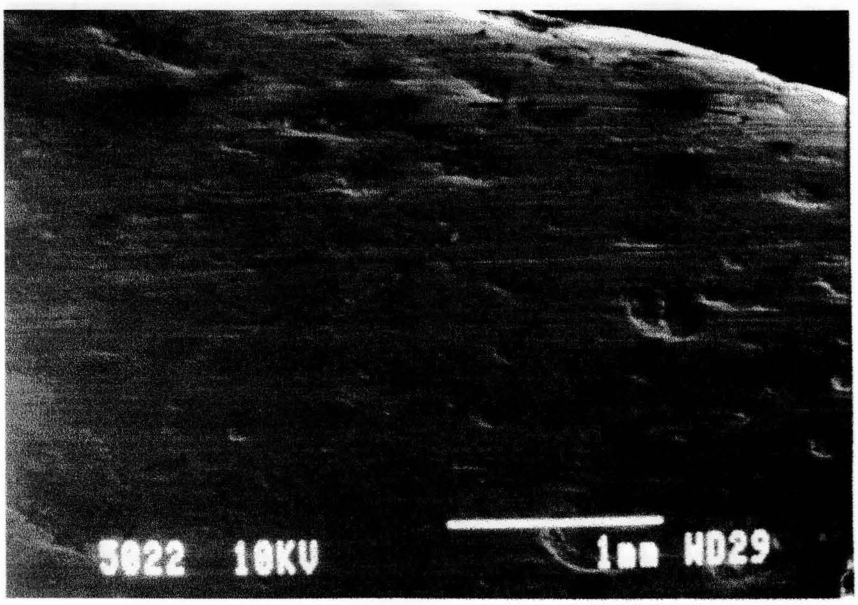


Figure 28.3.1:

SEM micrograph:
W03-H2: x 15 mag. after 30 min. use

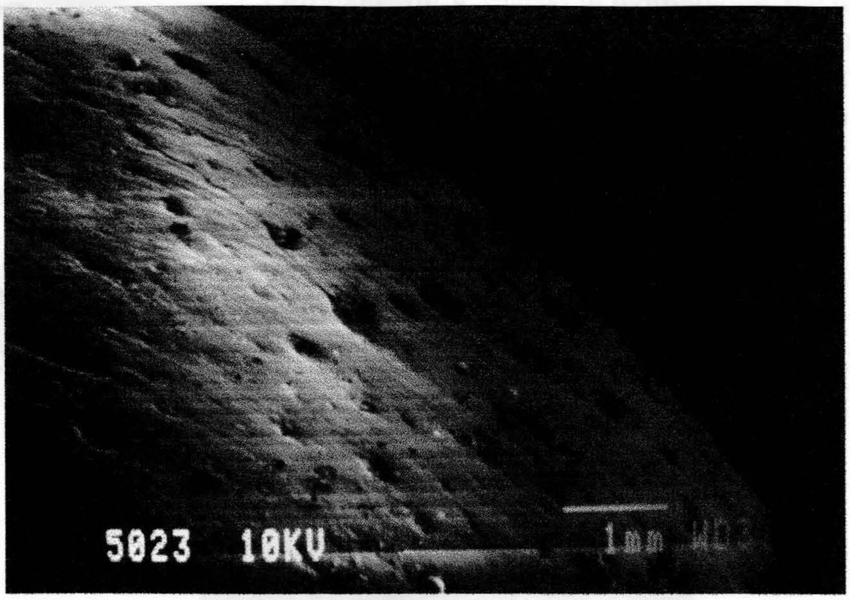
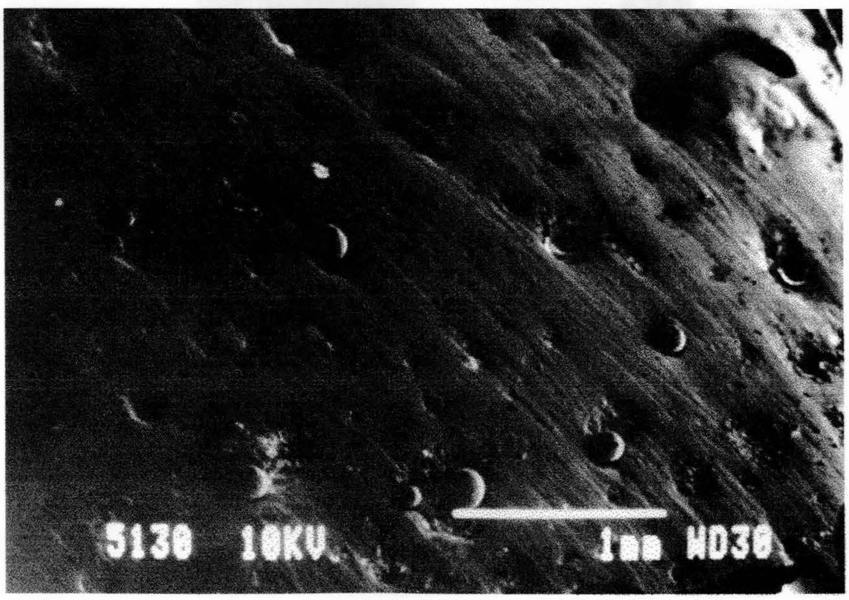


Figure 28.3.2:

SEM micrograph:
W03-H2: x 30 mag. after 30 min. use



F01-H2

Description	Prominently V-shaped in morphology, the working tip of this tool split during fracture. The relative short tool proved functional during use, processing the inner side of a *Bos taurus* (cattle) hide, aided by the use of sediment.
Faunal association	Shaft fragment of a *Bos taurus* (cattle) tibia.
Length	44 mm
Cortical thickness	3 mm
Weathering stage	Fresh/Green

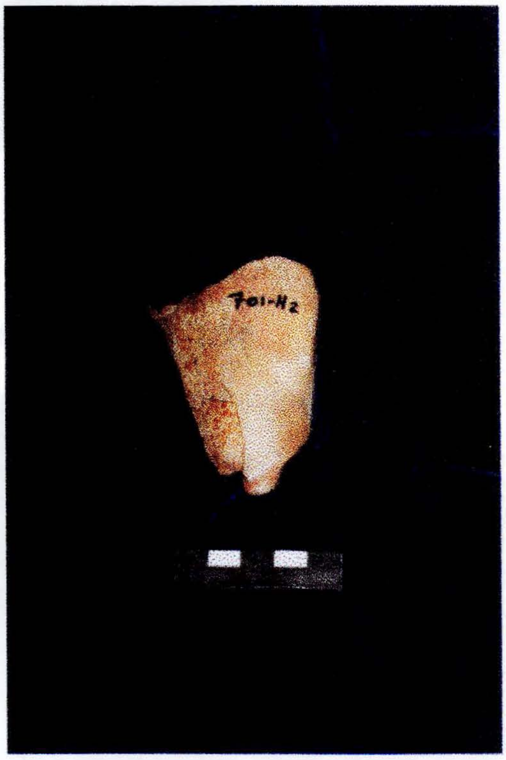


Figure 29.1: **Documentary photograph: Experimental tool F01-H2**

Figure 29.2.1:

SEM micrograph:
F01-H2: x 15 mag. after 10 min. use

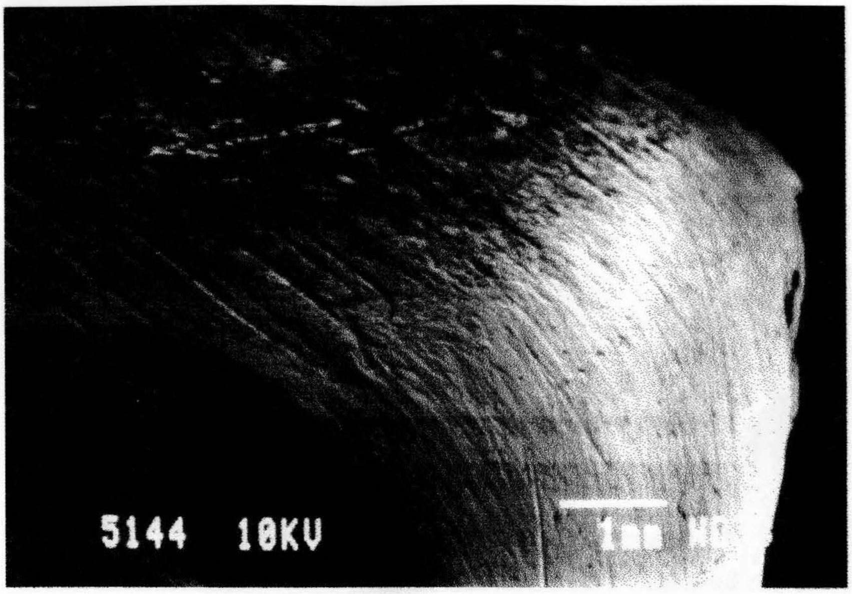


Figure 29.2.2:

SEM micrograph:
F01-H2: x 30 mag. after 10 min. use

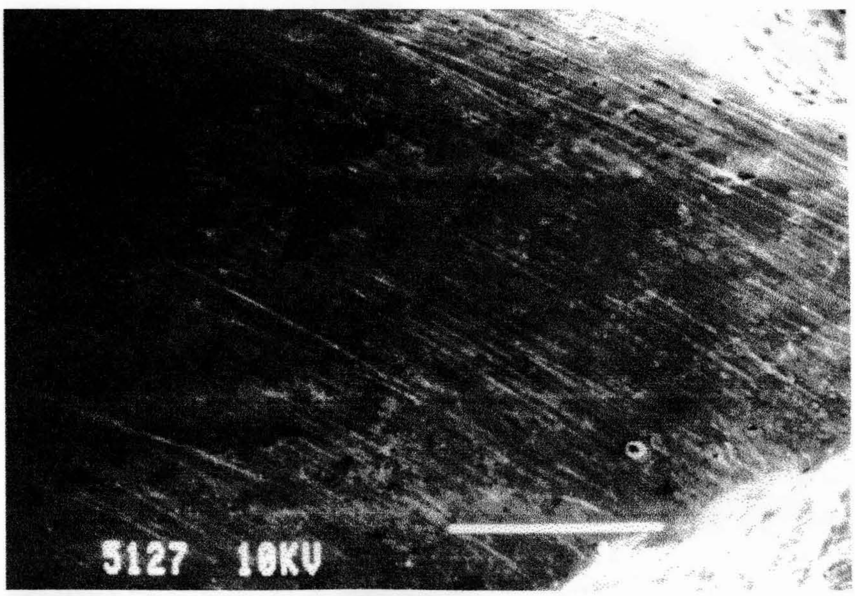


Figure 29.3.1:
SEM micrograph:
F01-H2: x 15 mag. after 30 min. use

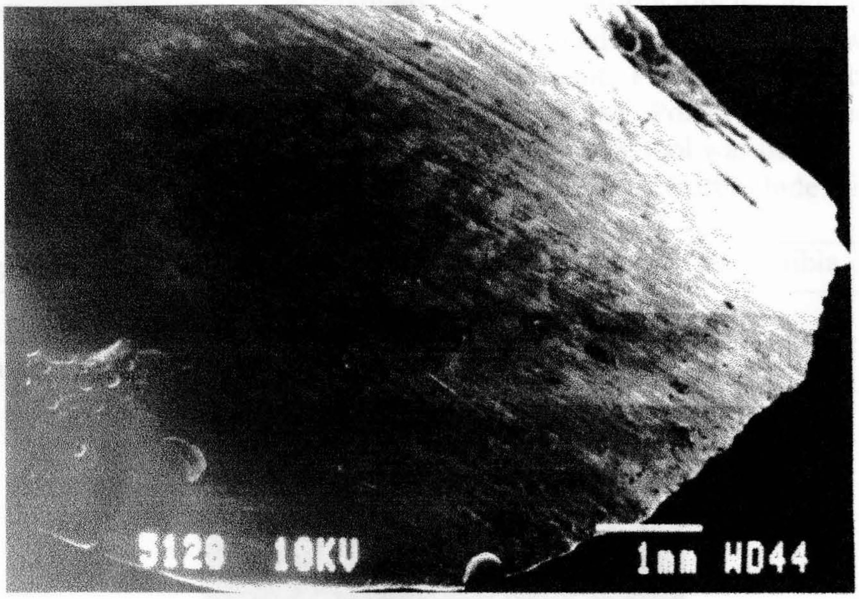
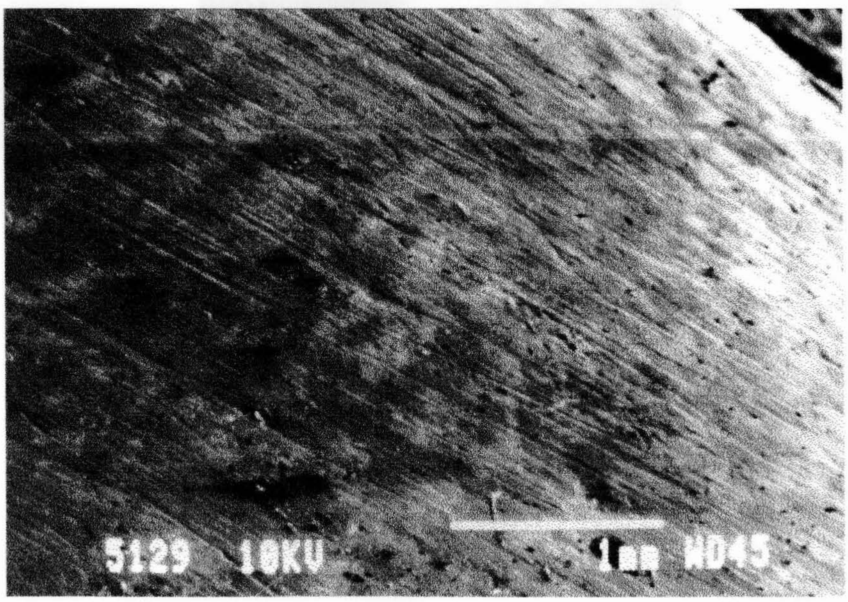


Figure 29.3.2:
SEM micrograph:
F01-H2: x 30 mag. after 30 min. use



F02-H2

Description	A relatively big, broad, sturdy looking tool, with ragged edges on both ends of the tool. The working tip formed a double point. Part of the outer cortex splintered away during use. Polish was observed on the tip after 7 min. use. The tool was used to work the inner side of a *Bos taurus* (cattle) hide with the aid of sediment.
Faunal association	Shaft fragment of a *Bos taurus* (cattle) tibia.
Length	56 mm
Cortical thickness	6 mm
Weathering stage	Fresh/Green

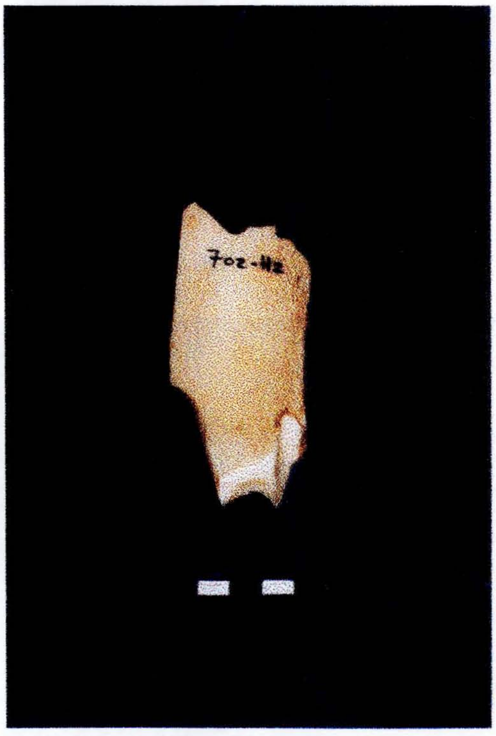


Figure 30.1: **Documentary photograph: Experimental tool F02-H2**

Figure 30.2.1:
SEM micrograph:
F02-H2: x 15 mag. after 10 min. use

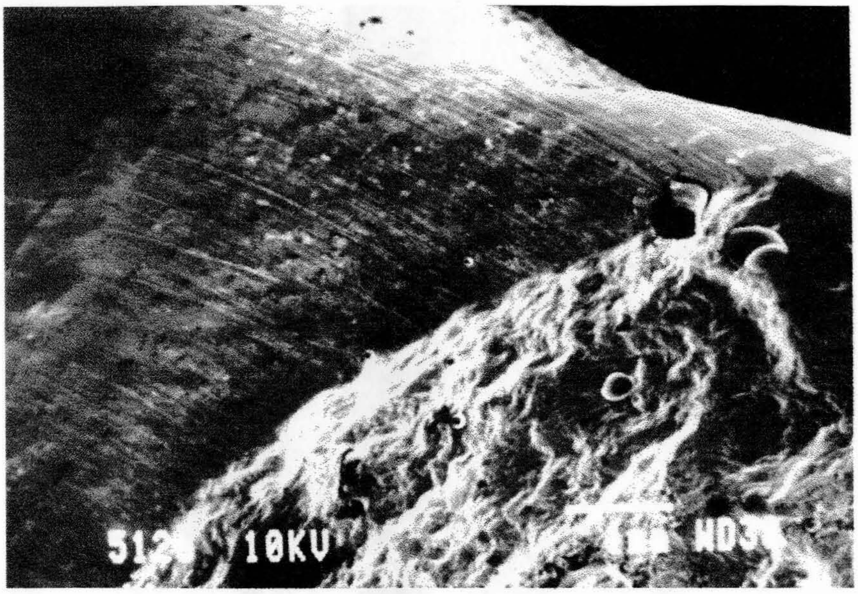


Figure 30.2.2:
SEM micrograph:
F02-H2: x 30 mag. after 10 min. use

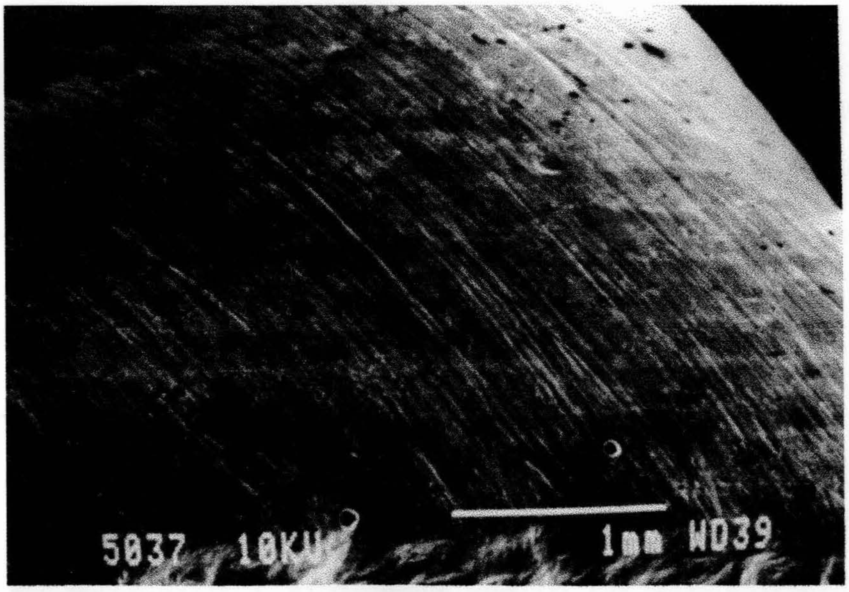


Figure 30.3.1:
**SEM micrograph:
F02-H2: x 15 mag. after 30 min. use**

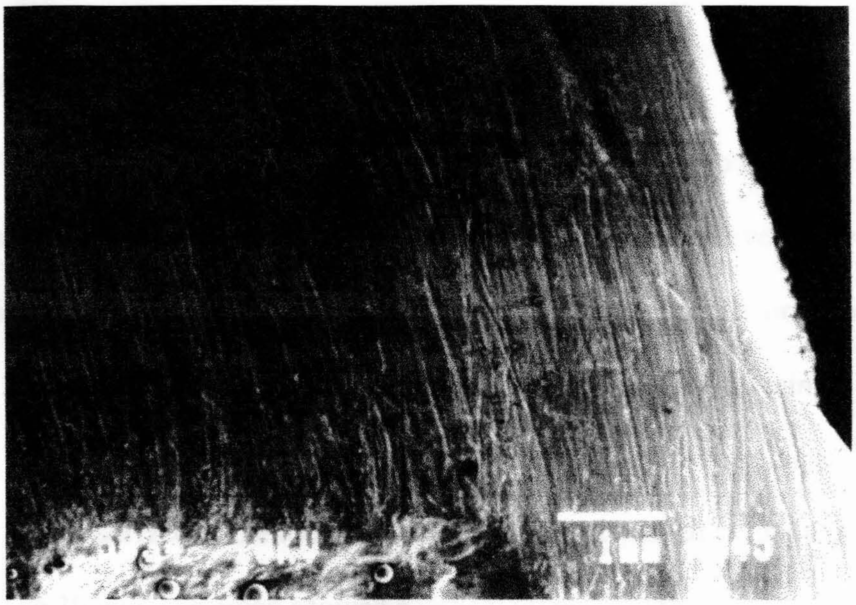
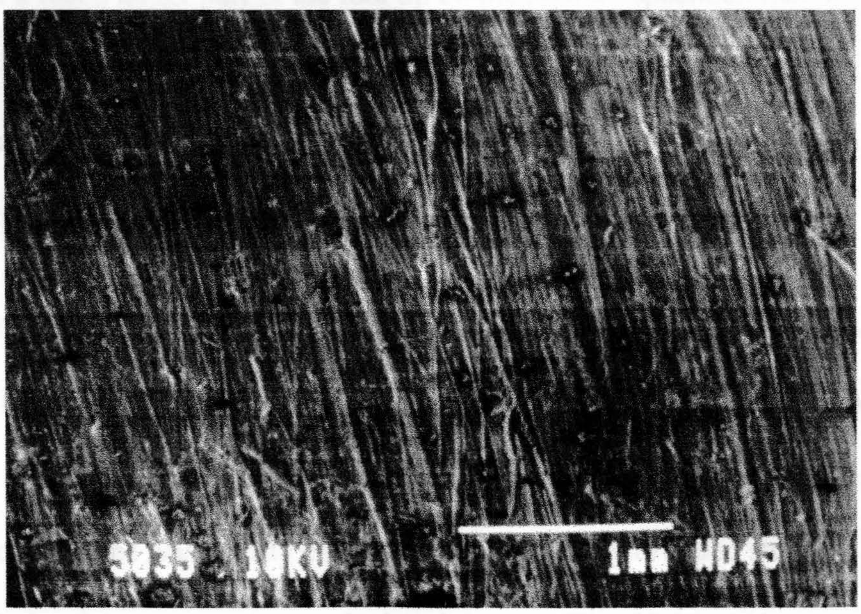


Figure 30.3.2:
**SEM micrograph:
F02-H2: x 30 mag. after 30 min. use**



3.3.6) The H2 tools: Processing the inner side (burnishing) of a *Bos taurus* (cattle) hide with the aid of sediment

3.3.6.1) The H2 tools – a short discussion

W01-H2: While a definite degree of smoothing and rounding to the tool tip was observed after 10 min. of employment, this smoothed tool tip displayed many primarily longitudinally oriented striations together with some diagonally oriented striae (Fig. 26.2.1). Pitting also occurred as a noticeable feature of the 10 min. specimen (Fig. 26.2.2). A few small longitudinal, diagonal and transverse striations were observed on the surface of the tool. Surface striations displayed no definable composition. The 30 min. specimen showed a radical increase in the rounding and smoothing of the tool tip. This tool tip displayed a vast increase in the amount of longitudinally oriented striations interrupted by an occasional diagonal striation mark. Pitting covered a much larger part of the tool tip on the 30 min. specimen than it did on the 10 min. specimen (Fig. 26.2.2). Surface striations of the 30 min. specimen displayed the same features as observed on the 10 min. specimen. The very steeply pointed tool tip proved to be very functional.

W02-H2: The 10 min. specimen displayed a marked degree of rounding and smoothing to the broad, flat tool tip. Primarily longitudinally oriented striations were restricted to this smoothed tool tip area (Fig. 27.2.2). After 30 min. of employment the modified tool tip area was greatly enlarged. Longitudinally oriented striae covered the whole of this enlarged smoothed tool tip area (Fig. 27.3.2). No modification marks were observed on the surface of either the 10 min. or the 30 min. specimen. The broad tool tip proved to be dysfunctional and not much of the hide was being processed as the tool tip quickly became blunt.

W03-H2: After the 1st working period some rounding and smoothing to the tool tip was observed. This tip displayed a multitude of primarily longitudinally oriented striations interrupted by diagonal striae on occasion. Pitting was also clearly visible (Fig. 28.2.2). The 30 min. specimen displayed a radical increase in modification to the tool tip morphology. The enlarged smoothed area was covered in primarily longitudinally oriented striations. Pitting covered a larger part of the tool tip (Fig.28.3.2). Some clear longitudinal and diagonal striations were visible on the surfaces of both the 10 min. and the 30 min. specimen. On both specimens surface striations were too few and too widely dispersed to ascribe them to any readily recognisable composition.

F01-H2: After the 1st working period the tip of the tool was markedly rounded and smoothed. Primarily longitudinally oriented striations, interrupted on occasion by a few diagonal striations forming acutely angled criss-crosses, were observed (Fig. 29.2.1 & 29.2.2). The 30 min. specimen displayed a greatly enlarged smoothed area on the tool tip. Longitudinally oriented striations covered the entire smoothed tip area (Fig. 29.3.2). Reworking erased many of the diagonal striations observed on the 10 min. specimen. No striations were observed on the bodies of either the 10 min. or 30 min. specimen.

F02-H2: On the edges of the broad, notched tool tip a narrow area of smoothing was visible after 10 min. of employment. Longitudinally oriented striations, alternating with a few diagonal striations, covered the whole of this smoothed tip area (Fig 30.2.2). After 30 min. the smoothed tip area was greatly enlarged. Primarily longitudinally oriented striations, interrupted by some diagonal striations forming acutely angled criss-cross formations, covered the enlarged smoothed tip area (Fig. 30.3.1 & 30.3.2). No striae were observed on the body of either the 10 min. or the 30 min. specimens. Pitting remained absent on both specimens. The broad, notched morphology of the tool tip rendered this tool relatively hard to work with.

3.3.6.2) Summary of the H2 tools

A high degree of tool tip modification (both rounding and smoothing) was observed on both the 10 and 30 min. specimens. Modification extended to only a slight polish on the tips of both the fresh and weathered tools. A demarcation could be observed between the working tips and the surfaces of the tool tips. This demarcation was less prominent on the H2 than on the H1 tools where no sediment was used. Prolonged use of the H2 tools resulted in even smoother overall tool tip shapes.

Striation compositions were largely restricted to the modified areas of the tool tips. Primarily longitudinally oriented striations alternating with a few diagonal striations forming acutely angled criss-cross compositions, together with pitting, occurring on the very tip of the tool as the characteristic use-wear pattern. This wear pattern remained constant, appearing very similar on the 10 min. and 30 min. specimens. However both striations and pitting were more prominent after the 2nd working period. The bodies of the tools displayed some striations. These striations were too few and too widely dispersed to ascribe them to any identifiable composition. Striations were overall more intense on the fresh tools, while pitting was more prominent on the weathered tools.

A medium sized tool was found to be the most functional. The morphology of the tool tip proved to be an important factor of functionality. Neither the flat nor the notched tip proved to be functional, and a pointed tip was preferred.

3.3.7) The T1 tools:
Extraction of termites from their mounds

W01-T1

Description	This large tool has its articular end still partially intact at one end while the other end tapers into a steeply shaped point. This working edge proved to be very functional in breaking through the hard outer crust of the termite nests. The partially intact articular end also proved to serve as a handle to the tool, rendering this tool extremely easy to handle.
Faunal association	Fragment of an *Equus ferus* (horse) ulna with the distal articular end still partially intact.
Length	291 mm
Cortical thickness	7 mm
Weathering stage	1

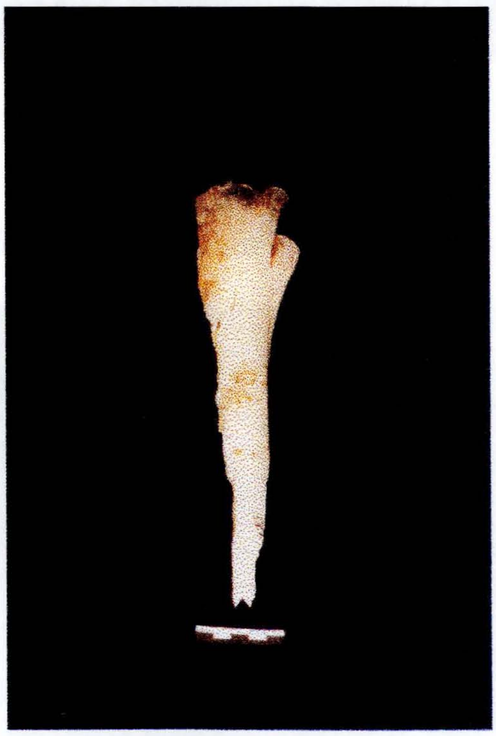


Figure 31.1: **Documentary photograph: Experimental tool W01-T1**

Figure 31.2.1:

SEM micrograph:
W01-T1: x 15 mag. after 10 min. use

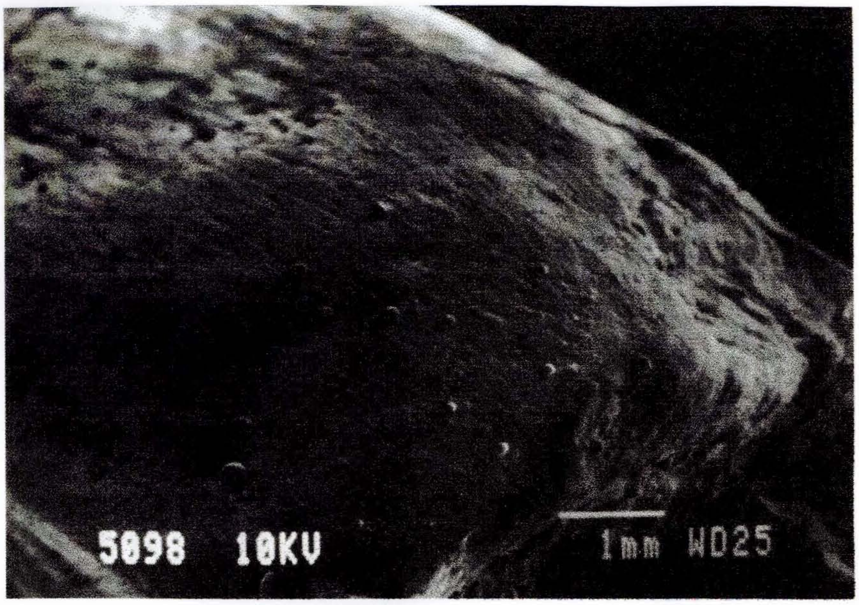


Figure 31.2.2:

SEM micrograph:
W01-T1: x 30 mag. after 10 min. use

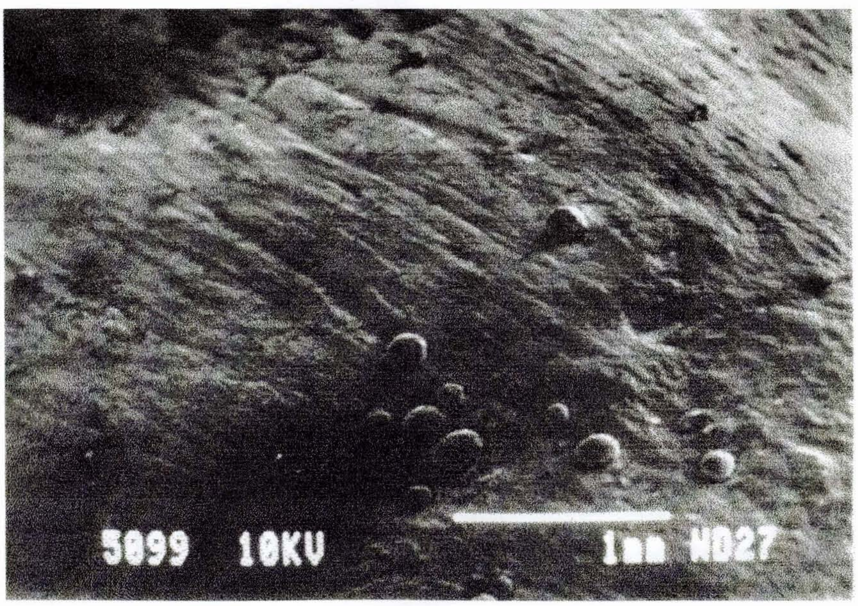


Figure 31.3.1:
SEM micrograph:
W01-T1: x 15 mag. after 30 min. use

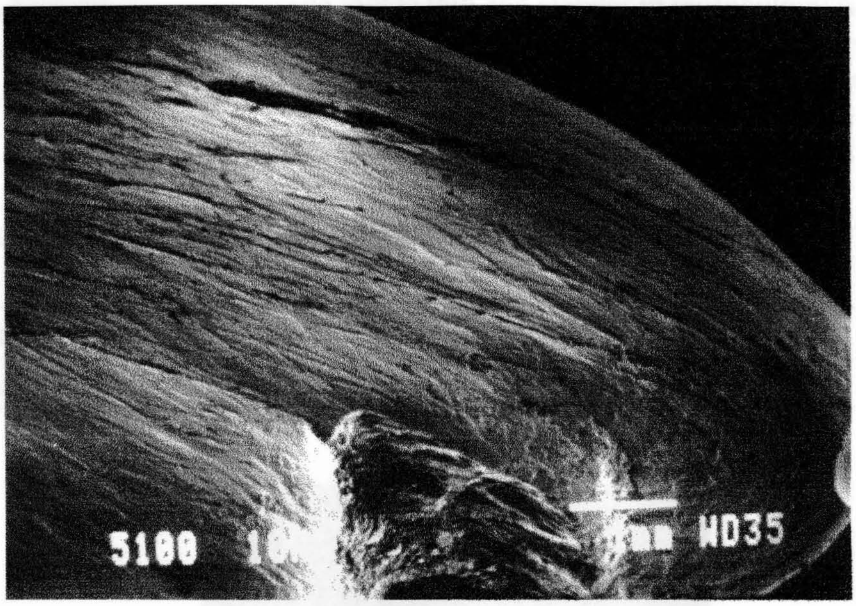
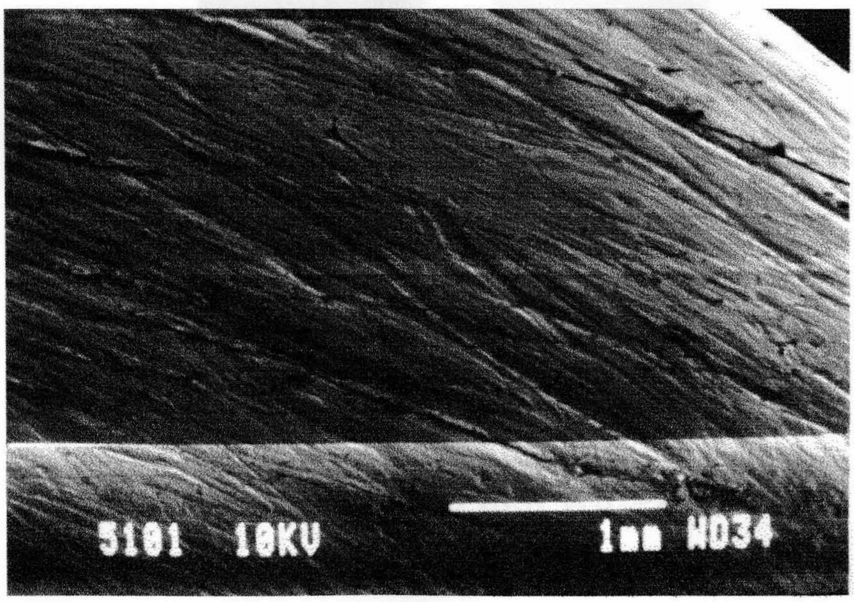


Figure 31.3.2:
SEM micrograph:
W01-T1: x 30 mag. after 30 min. use



W02-T1

Description	The tool is thin and slender in morphology with a rugged pointy edge on the one end and tapers to a point at the other end. This working edge forms a relatively steep V-shape, which proved to be very functional in breaking through the hard outer crust of the termite nests.
Faunal association	Shaft fragment of an *Equus ferus* (horse) humerus.
Length	156 mm
Cortical thickness	7 mm
Weathering stage	1

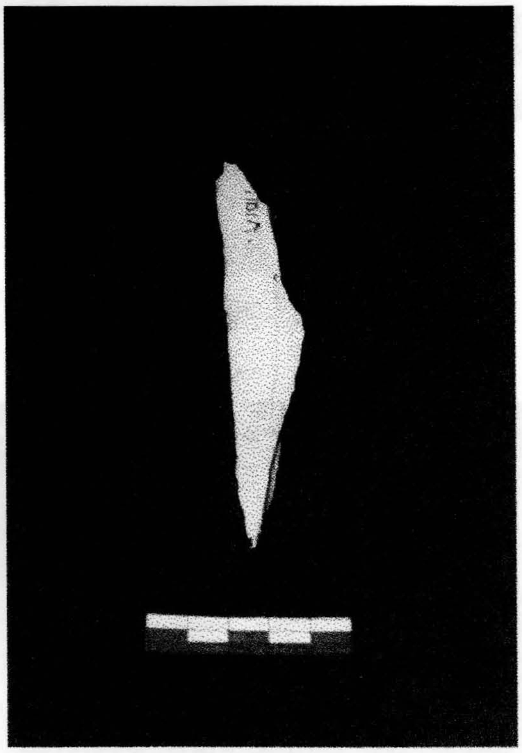


Figure 32.1: **Documentary photograph: Experimental tool W02-T1**

Figure 32.2.1:
SEM micrograph:
W02-T1: x 15 mag. after 10 min. use

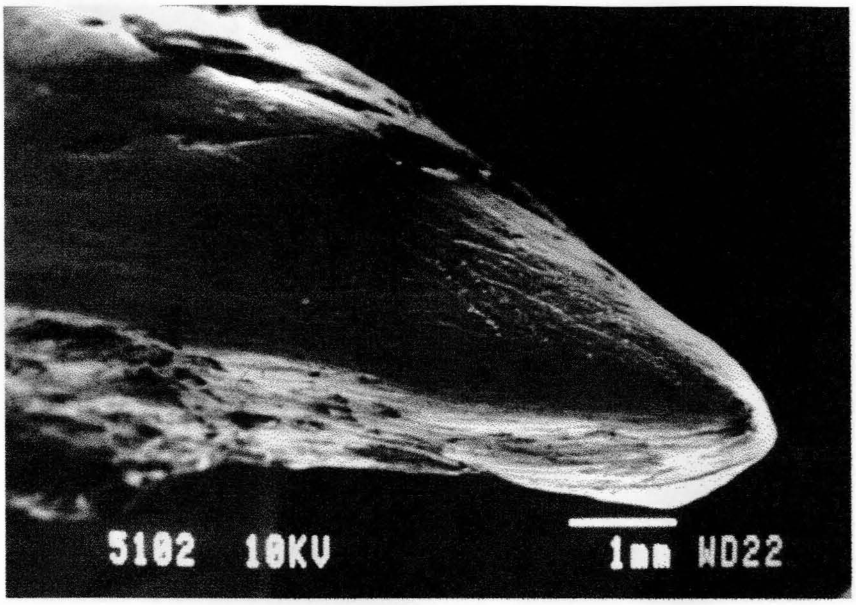


Figure 32.2.2:
SEM micrograph:
W02-T1: x 30 mag. after 10 min. use

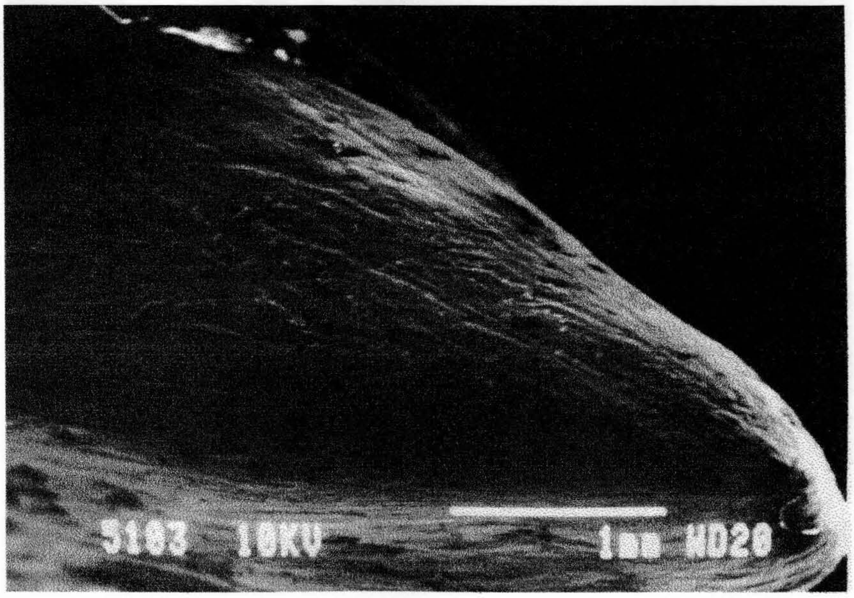


Figure 32.3.1:
SEM micrograph:
W02-T1: x 15 mag. after 30 min. use

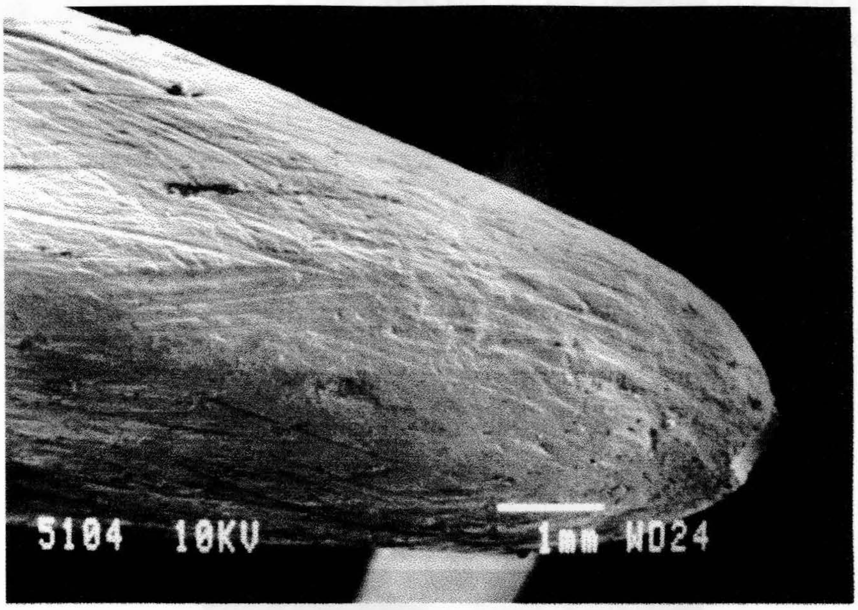
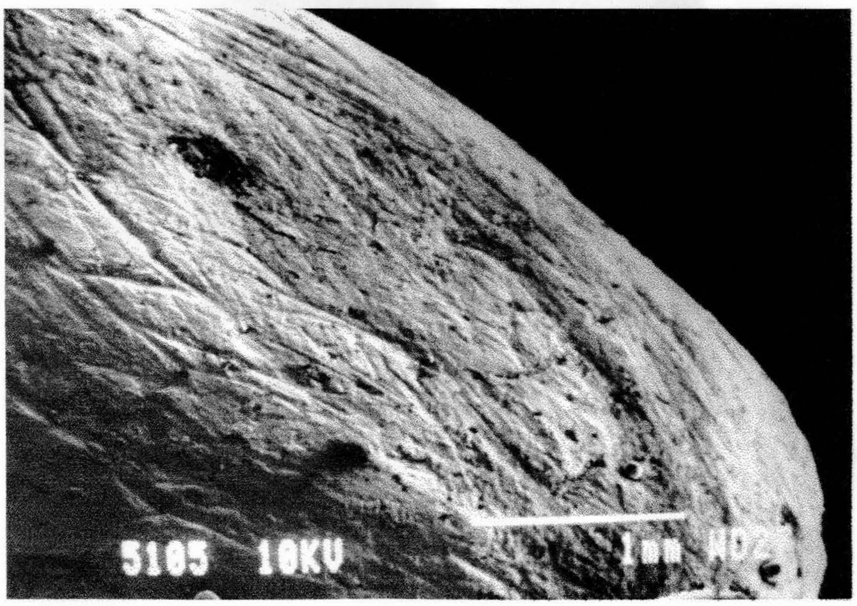


Figure 32.3.2:
SEM micrograph:
W02-T1: x 30 mag. after 30 min. use



W03-T1

Description	A thin, very slender tool tapering to a point at both ends. The working tip is steeply shaped which provided a very functional working edge in breaking through the hard outer crust of the termite nests.
Faunal association	Shaft fragment of an *Equus ferus* (horse) tibia.
Length	130 mm
Cortical thickness	6 mm
Weathering stage	2

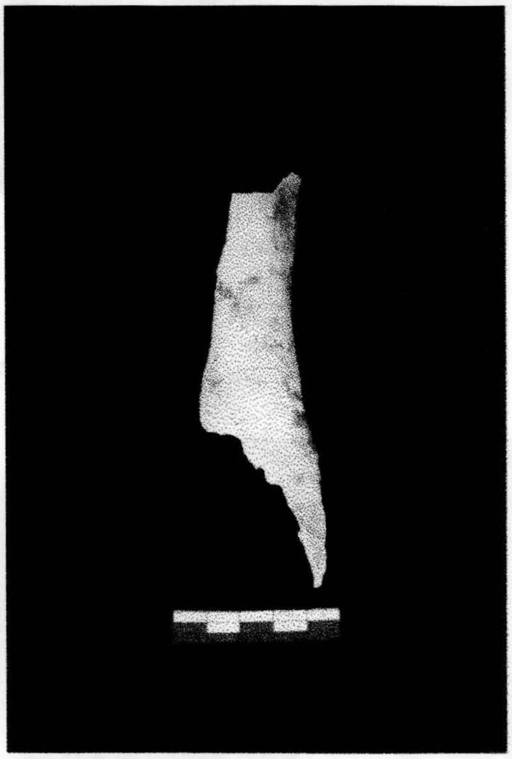


Figure 33.1: **Documentary photograph: Experimental tool W03-T1**

Figure 33.2.1:
SEM micrograph:
W03-T1: x 15 mag. after 10 min. use

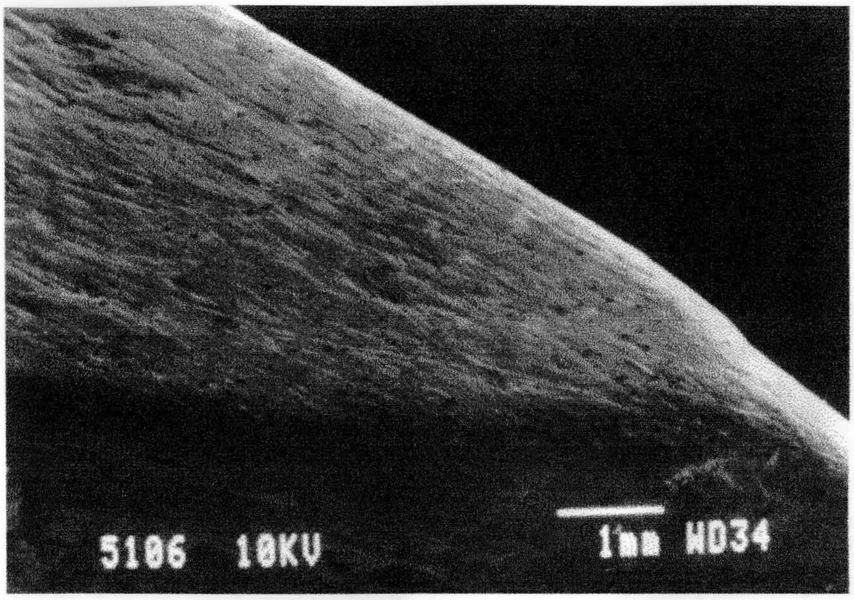


Figure 33.2.2:
SEM micrograph:
W03-T1: x 30 mag. after 10 min. use

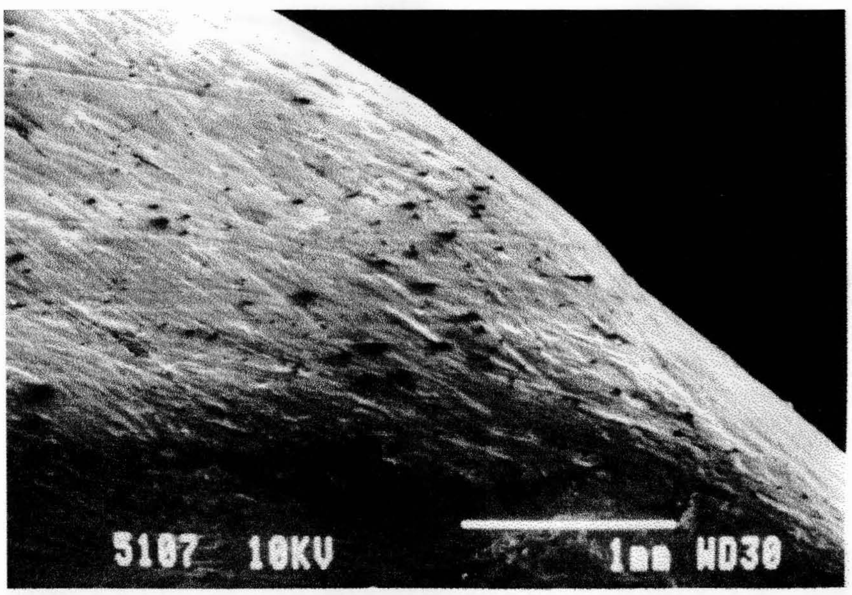


Figure 33.3.1:
SEM micrograph:
W03-T1: x 15 mag. after 30 min. use

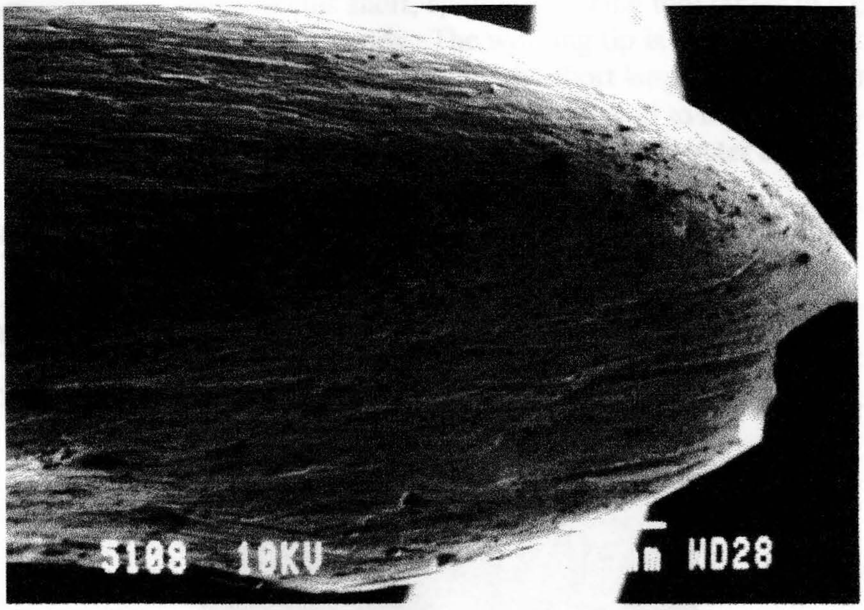
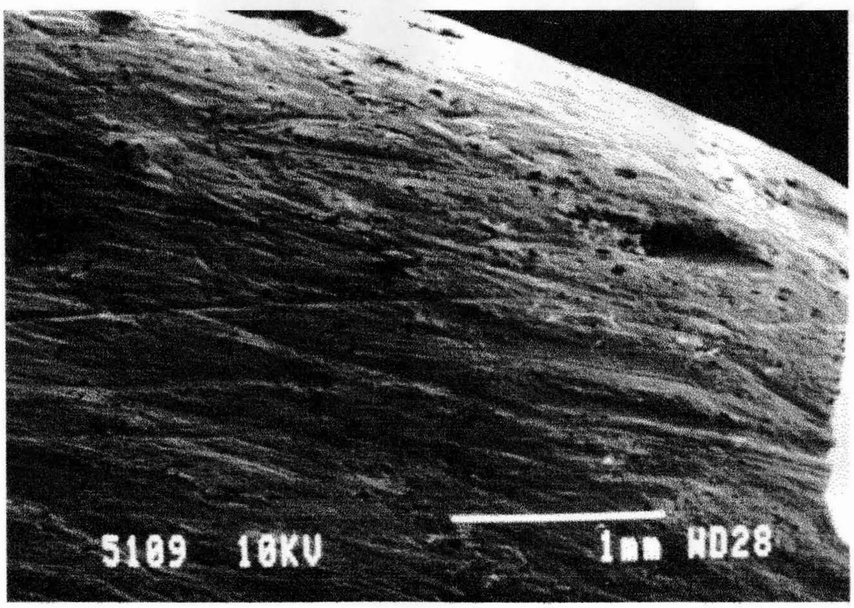


Figure 33.3.2:
SEM micrograph:
W03-T1: x 30 mag. after 30 min. use



F01-T1

Description	This short, splintery looking tool tapers to a point at both ends. The working tip is very steep and slender. Despite the short length of this tool the morphology of the tip proved to be extremely functional in breaking the hard outer crust of the termite nests.
Faunal association	Shaft fragment of a *Bos taurus* (cattle) tibia.
Length	58 mm
Cortical thickness	5 mm
Weathering stage	Fresh/Green

Figure 34.1: **Documentary photograph: Experimental tool F01-T1**

Figure 34.2.1:
SEM micrograph:
F01-T1: x 15 mag. after 10 min. use

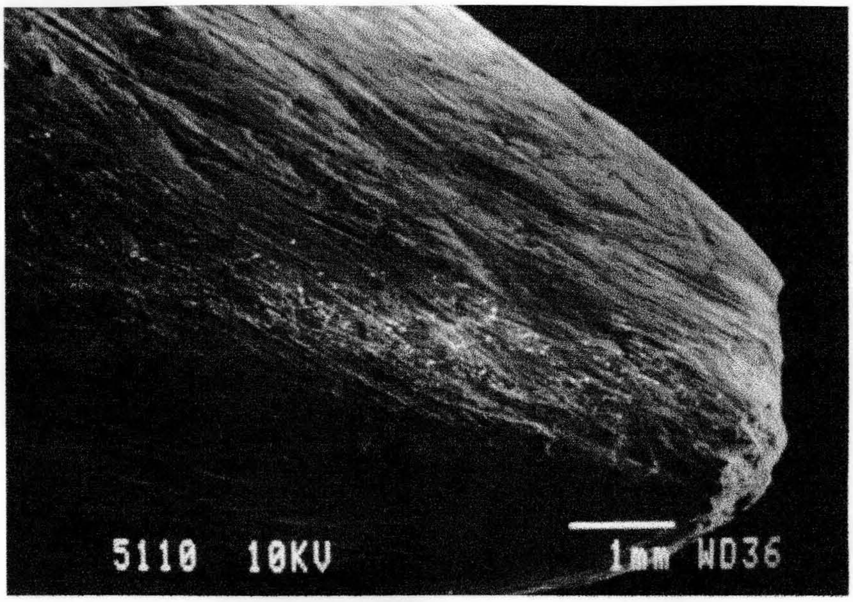


Figure 34.2.2:
SEM micrograph:
F01-T1: x 30 mag. after 10 min. use

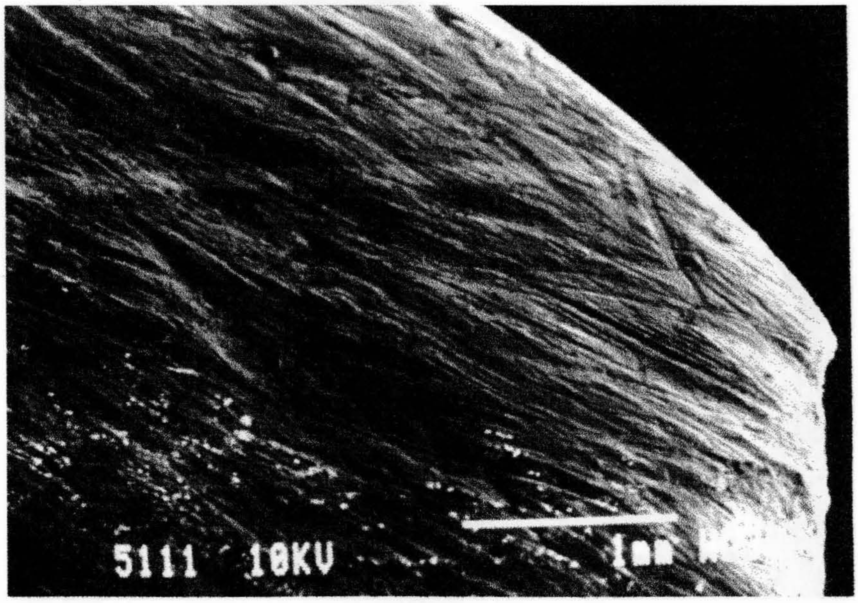


Figure 34.3.1:

SEM micrograph:

F01-T1: x 15 mag. after 30 min. use

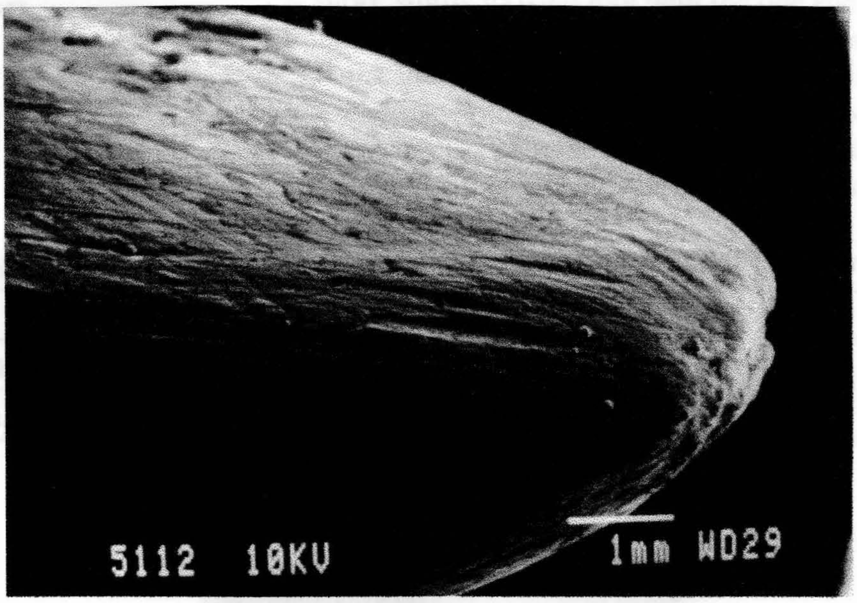
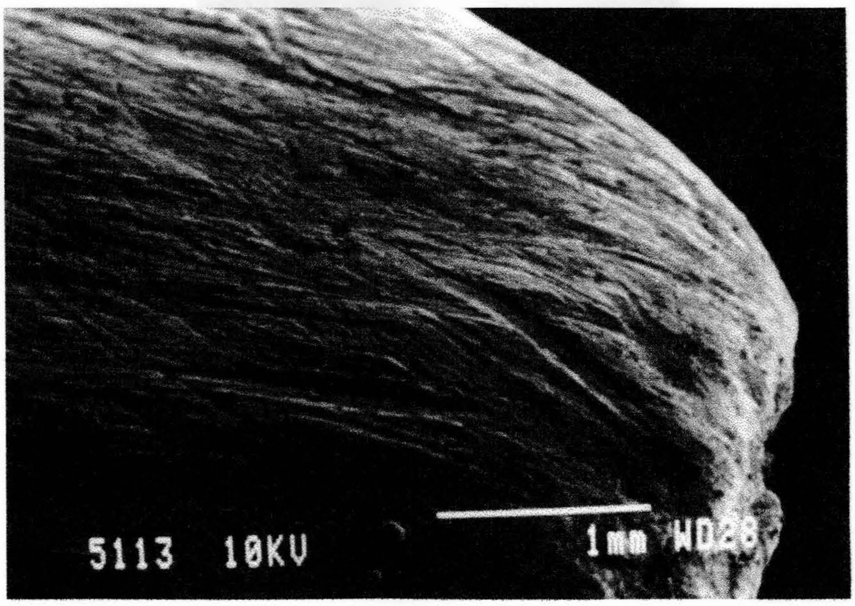


Figure 34.3.2:

SEM micrograph:

F01-T1: x 30 mag. after 30 min. use



F02-T1

Description	A short, sturdy looking tool with the one end fractured in a rugged manner and the other end tapering into a gently sloping point. This relatively flat working edge proved to be difficult to work with when trying to break the hard outer crust of the termite nests, though once the crust was broken the tool was relatively functional.
Faunal association	Shaft fragment of a *Bos taurus* (cattle) femur.
Length	49 mm
Cortical thickness	6 mm
Weathering stage	Fresh/Green

Figure 35.1: **Documentary photograph: Experimental tool F02-T1**

Figure 35.2.1:
SEM micrograph:
F02-T1: x 15 mag. after 10 min. use

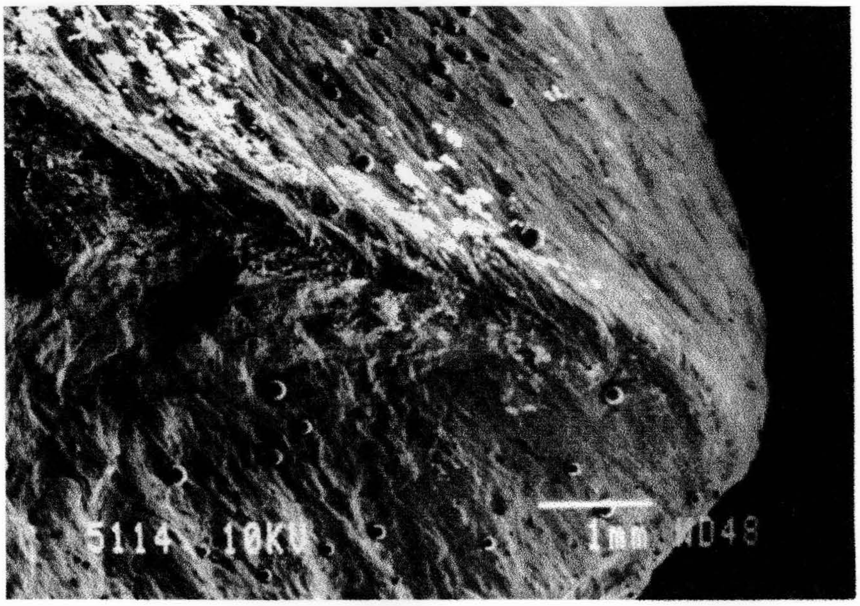


Figure 35.2.2:
SEM micrograph:
F02-T1: x 30 mag. after 10 min. use

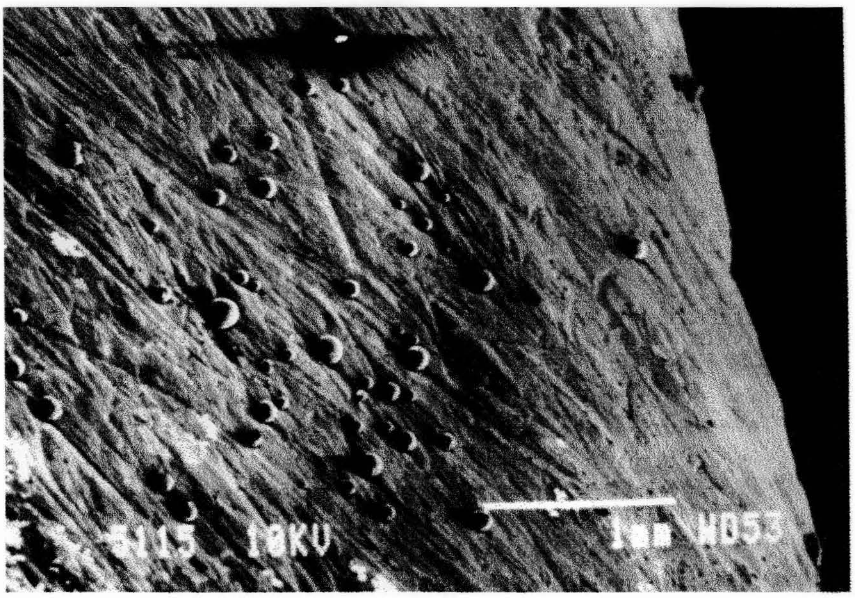


Figure 35.3.1:
SEM micrograph:
F02-T1: x 15 mag. after 30 min. use

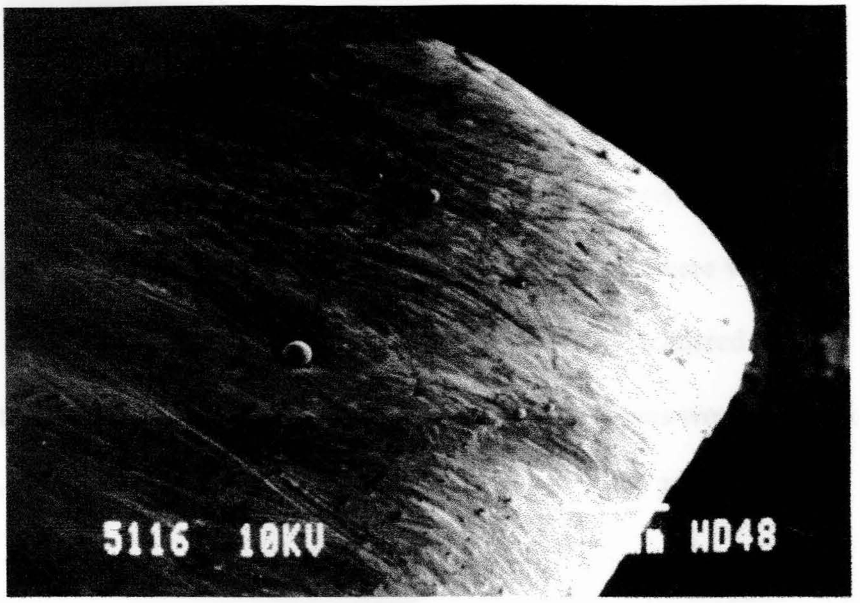
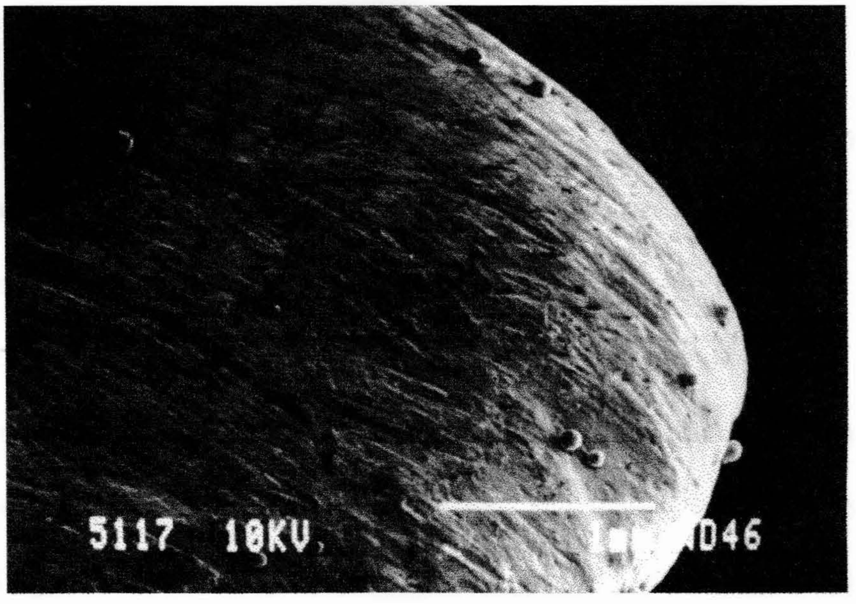


Figure 35.3.2:
SEM micrograph:
F02-T1: x 30 mag. after 30 min. use



3.3.7) The T1 tools: Extraction of termites from their mounds

3.3.7.1) The T1 tools – a short discussion

W01-T1: The 10 min. specimen showed a slight degree of rounding and smoothing to the tool tip. Mainly longitudinally oriented striations together with diagonal striations forming acutely angled criss-cross formations were visible on the very tip of the tool. The same overall composition of striations occurred on the surface of the tool behind the tip (Fig. 31.2.2). These compositions were composed of less striae than compositions restricted to the very tool tip. After 30 min. of employment the tip was more rounded and smoothed, with a combination of longitudinally oriented and acutely angled criss-cross striae covering both the tip (Fig. 31.3.2) and the body of the tool (Fig. 31.3.1). A noticeable polish was visible on the tool tip. After 30 min. of employment this polish extended back up to 60 mm from the tool tip.

W02-T1: After the 1st working period the slightly rounded tool tip displayed a multitude of longitudinally oriented and acutely angled criss-cross striae on the surface of the tool tip (Fig. 32.2.2). The 30 min. specimen attested to a marked increase in the rounding and smoothing of the tool tip. With no clear division between the smoothed working tip and the surface of the tool, modification observed can be described as longitudinally oriented and acutely angled criss-cross striation compositions (Fig. 32.3.1 & 32.3.2). After the 30 min. working period an easily observable polish stretched up to 45 mm from the working tip.

W03-T1: After 10 min. of employment the slightly smoothed tool tip displayed primarily diagonal striations forming acutely angled criss-crosses on the surface of the tool (Fig. 33.2.2). No clear division existed between the tool tip and the surface of the tool. The 30 min. specimen displayed much more smoothing of the tool tip. All sides of the tool tip were gradually smoothed to a gently rounded tip. A multitude of acutely angled criss-cross striations was observed all around the surface of the tool tip (Fig. 33.3.2). The tool displayed some polish, restricted to the 10-15 mm area of the tool tip.

F01-T1: The slightly rounded tip of the 10 min. specimen blended in with the surface of the tool. Mainly longitudinally and diagonally oriented striations were observed forming a patterned composition of acutely angled criss-crosses on the surface of the tool (Fig. 34.2.2). This striation composition was observed on all sides of the tool. A slight increase in the rounding of the tool tip was observed on the 30 min. specimen. Longitudinally and diagonally oriented striations formed a readily recognisable composition of acutely angled criss-crosses covering the surface of the tool tip (Fig. 34.3.1 & 34.3.2). This striation composition was observed on all sides of the 30 min. specimen. A slight degree of polish restricted to the very tool tip was observed.

F02-T1: Some rounding and smoothing of the tool tip was visible after 10 min. of employment. Striations observed on the rounded tip of the tool were mainly longitudinal. Many of these striations continued to the body of the tool. Surface striations can be described as longitudinally and diagonally oriented forming clearly identifiable acutely angled criss-cross compositions. From time to time the criss-cross composition was interrupted by transverse striations (Fig. 35.2.2). A slight increase in rounding to the broad, flat tool tip was observed on the 30 min. specimen. The specimen also chipped during the 2nd working period (1 medium chip). Primarily longitudinally oriented striations, dominant on the very tool tip smoothing, continued to the surface of the tool behind the tip. Surface modification can be described as primarily longitudinally and diagonally oriented striations together with a few widely dispersed transverse striations. A readily identifiable composition of longitudinally oriented striations together with acutely angled criss-crosses was obvious (Fig. 35.3.2). This patterned composition of striations was visible on both sides of the tool. A slight polish, restricted to a 10-15 mm area from the tool tip, was visible.

3.3.7.2) Summary of the T1 tools

While the 1st working period showed only a slight modification (both rounding and smoothing) of the tool tips, tool tip modification increased markedly after the 30 min. working period. Modification extended to a high degree of polish on the weathered tools. Fresh tools displayed a very limited degree of polish, restricted to the tool tips only. Employment caused tips to form gradually tapering points where the tips of the tools gently blended with the surfaces of the tools behind the points.

Longitudinally oriented and diagonal striations forming acutely angled criss-cross formations were prominent on the tool tips. This striation composition decreased in intensity away from the tips of the tools. The striation composition remained constant, with both the 10 and 30 min. specimens displaying the same basic composition. Transverse striations generally occurred further away from the tool tips. Modification occurred all around the tool tips and was not necessarily restricted to a working planes, although patterns were sometimes concentrated at a specific side of high contact with the substance. No intensity difference was observed between striations on the weathered or fresh tools.

A medium to a large sized tool proved to be the most functional.

3.4) Summary of experimental findings

3.4.1) Experimental tool morphology:

3.4.1.1) Rounding and smoothing

In overall tool tip morphology all the experiments showed an increase in rounding and smoothing to the tool tips. With increased use tools used to dig for subterranean food sources in both a hill/hillslope (G1 tools) and riverbank environments (G2 tools), and tools used to extract termites from their mounds (T1 tools) showed a general rounding and smoothing of the tool tips to approach gradually tapering points. Prolonged working increased the smooth transition from tool surface to tool tip.

A demarcated area of use wear formed on the tips of tools used to debark both hard (B1 tools) and softwood (B2 tools) trees, as well as on tools used to burnish hide with and without the aid of sediment (H2 & H1 tools respectively). Re-employment of the tools used to debark the hard and softwood trees and those used to burnish hide enhanced the demarcation between tool surface and the actual working edge.

Tools used to burnish hide with the aid of sediment (H2 tools), showed a tendency towards gradually tapering points after the 2nd working period.

3.4.1.2) Polish

A degree of polish was displayed on all the tools. Polish was most characteristic of the tool tips when tools were used to dig for subterranean food sources in both hill/hillslope and riverbank environments (G1 & G2 tools), when they were used to burnish hide with and without sediment (H2 & H1 tools respectively) and when they were used to extract termites from their mounds (T1 tools).

On the tools used to dig for subterranean food sources on a hill/hillslope (G1 tools) and in a riverbank environment (G2 tools), and to extract termites from their mounds (T1 tools), striation compositions were largely restricted to the polished areas, which in general were more pronounced on the weathered than on the fresh tools.

Tools used to burnish hides (H1 tools) displayed a polish on the working tips of the weathered tools, while polish was also associated with the increasingly enlarged areas and less restricted working tips of the tools used with sediment (H2 tools) to burnish the hides. Once again polish was more pronounced on the weathered than on the fresh tools.

3.4.2) Location and composition of striations

Modification marks were largely restricted to the working tips or contact surfaces of the tools used to debark hard (B1 tools) and softwood (B2 tools) trees (B2 tools) and those used to process hides, both with and without the aid of sediment (H2 & H1 tools respectively).

Modification marks on tools used to dig for subterranean food sources on a hill/hillslope (G1 tools), in a riverbank environment (G2 tools) and tools used to extract termites from their mounds (T1 tools) tended to occur all around the tool tips, although areas of high contact with the substance being worked could be identified.

Modification marks on all the tools were consistent: A patterned composition of striations observed after the 1st working period would appear very similar to the composition observed on the same tool after the final working period. Different tools employed in a specific experiment also displayed similar striation compositions.

In summary the tools used to dig for subterranean plant foods (bulbs) on a hill/hillslope (G1 tools) displayed a perpendicular angled criss-cross composition of striae on the tool tips. They were also the only experimental tools readily displaying striae, especially transverse striae, on the bodies of the tools.

Tools used to dig for subterranean food sources (rootlets, worms and insects) in a riverbank environment (G2 tools) displayed widely dispersed random striations consisting of longitudinal, diagonal and transverse striations. Prolonged working easily erased the striations.

Weathered tools used to debark the *Maytenus undata* (hardwood) (B1 tools) and *Celtis africana* (softwood) (B2 tools) trees, displayed primarily longitudinally oriented and acutely angled criss-cross formations. Quantitatively more striations were observed on the tips of tools used to debark the *Celtis africana* tree (B2 tools) than on the tips of tools used to debark the *Maytenus undata* tree (B1 tools). This is probably the result of the formation of larger working areas on the tool tips of the tools used to debark the *Celtis africana* tree (B2 tools), due to the softer bark of the of this tree. Striation marks on the fresh tools used to debark the *Maytenus undata* tree (B1 tools) were easily erased by prolonged working. Fresh tools used to debark the *Celtis africana* tree (B2 tools) displayed a more prominent acutely angled criss-cross composition of striae – probably the result of slippage of the fresh bone against the bark.

Tools used to process the inner side of a *Bos taurus* (cattle) hide (H1 tools) displayed a tool tip striation composition of longitudinally and diagonally oriented striations forming acutely angled criss-crosses. The same striation composition was observed on the tools used to burnish hide while making use of sediment (H2 tools), though striations on these tools were much more intense than when no sediment was used (H1 tools). Pitting recurred as a characteristic feature of the weathered tools used to burnish hides with the aid of sediment (H2 tools).

The tips of tools used to extract termites from their mounds (T1 tools) displayed a readily identifiable composition of longitudinally oriented and acutely angled criss-cross striation compositions.

In all the experiments modification marks were primarily restricted to the tool tips. However, tools used to dig for subterranean food sources on a hill/hillslope (G1 tools), in a riverbank environment (G2 tools) and tools used to extract termites from their nests (T1 tools) displayed modification marks further away from the tool tips. This characteristic was most prominent on the tools used to dig for subterranean food sources on a hill/hillslope (G1 tools). Compositions of these marks were similar to the marks observed on the tool tips though they decreased in intensity away from the tips. Where modification marks occurred on tool surfaces striations were too few and too widely dispersed to ascribe them to any readily identifiable composition.

Chapter 4
Conclusion – discussion and interpretation

4.1) Overall tool morphology and visual characteristics

Concerning the morphology of the tools all the experimental tools showed an increase in rounding and smoothing to the tool tips with prolonged working periods. This modification was most prominent on tools used to dig for subterranean food sources in both the hill/hillslope (G1 tools) and riverbank (G2 tools) environments, on tools used to extract termites from their nests (T1 tools), and to a lesser degree on tools used to burnish hide with the aid of sediment (H2 tools). After the second working period, the tips of tools used to burnish hide with the aid of sediment tended to acquire a general rounding and smoothing that approached gradually tapering points more or less similar to that of the archaeological specimens (see Fig. 36a). Hence the rounding and smoothing of these sets of tools must result from the abrasive substances with which they came into contact.

A clear demarcation between the functional area of the tool and the overall tool surface was characteristic of tools used to debark both hard (B1 tools) and softwood (B2 tools) trees, as well as tools used to burnish hides (H1 tools). This must be due to the fact that the area of contact between the tools and the substances against which they were worked was more restricted.

A polish was observed on the tapering points of the tools used to dig for subterranean food sources in both the hill/hillslope (G1 tools) and riverbank (G2 tools) environments, on tools used to burnish hides with the aid of sediment (H2 tools), and on tools used to extract termites from their nests (T1 tools). Once again, this appears to be due to the abrasive property of the sediments with which they came into contact.

Polish varied in degree from experiment to experiment but was in general more prominent on the weathered than on the fresh tools. Polish on the tools used to debark both hard (B1 tools) and softwood (B2 tools) trees and those used to burnish hides (H1 tools) remained restricted to the demarcated working planes of the tool tips.

Use-wear patterns or striation compositions were largely restricted to the smoothly modified tool tip areas, regardless of whether they were gradually tapering or demarcated in morphology. On tools used to dig for subterranean plant foods in both the hill/hillslope (G1 tools) and riverbank (G2 tools) environments and to extract termites from their nests (T1 tools), use-wear patterns were observed all around the tool tips, because of the broader area of contact. However, patterned compositions on the tools used to debark both types of trees (B1 & B2 tools) and on tools used to burnish hides both with and without the aid of sediment (H2 & H1 tools) were limited to the tools' demarcated working plane that actually came into contact with the substance being worked.

Tools used to dig for subterranean food sources in the two environments (G1 & G2 tools) and tools used to extract termites from their nests (T1 tools) tended to be morphologically similar to the fossil specimens (see Fig. 36a). According to Backwell (1999) and Backwell & d'Errico's (2001) description the fossil specimens exhibit "a single rounded end with smoothing/polish confined to an area of between 5 and 50 mm from the tip". The experimental tools also displayed use-wear patterns all around the tips, typical of the patterns displayed on the archaeological material (see Fig. 39a,b & 40a,b). Patterned compositions of striations observed on these experimental tools also decreased in intensity away from the tip, another characteristic of the archaeological material.

While striation marks were overall more intense on the fresh than on the weathered experimental tools, I do not believe that this characteristic is useful in determining whether the early hominids used their tools in a fresh or weathered state. Inquiry should instead be directed towards the breakage patterns of bone. Experimental studies conducted by Bunn (1989) breaking fresh animal long bones with a hammerstone and anvil technique often yielded "only one large shaft fragment or several smaller fragments". Fractures were concoidal and produced relatively robust shaft fragments (see Fig. 41). My experimental breaking of fresh bones produced the same robust shaft pieces, in morphology very different from the bone tools from the Gauteng sites. While breaking long bones to produce experimental tools, I found that the more weathered the bone the higher the tendency to fracture in a more splintered fashion. This observation corresponded to Behrensmeyer's (1978) observation on the natural weathering of bone and the associated natural breakage patterns.

Concerning the breakage patterns of fresh vs. weathered bones, Backwell's (1999) taphonomic analysis of stratigraphically associated bones is of importance. D'Errico *et al.* (2001a) conclude that "almost all the bone tools from long bone shafts (97%) showed longitudinal fractures typical of weathered bone and some specimens have use-wear overlying carnivore damage". Wear patterns characteristic of the bone tools furthermore "occurred on larger, wider and more robust bone fragments" (Backwell & d'Errico 2001). Bones used as tools were therefore larger, wider and more robust than the other stratigraphically associated bones, but in morphology and breakage pattern they were not made from fresh bone. I agree with Backwell & d'Errico's (2001) statement that "early hominid users selected heavily weathered bone fragments of a particular size range and shape (long, straight bone flakes and horn cores)" from the landscape. I am of the opinion that the bones selected fell within the range of Behrensmeyer's (1978) weathering stage 4, where bones naturally tend to break in a splintered fashion. Weathering of stage 4 or approaching stage 4 must have characterised most of the bone surface.

Backwell & d'Errico (2001) suggest that selected bones ranged in size between 130-190 mm. My experimental studies showed that medium to larger sized tools proved to be the most functional. The size range proposed by Backwell & d'Errico (2001) and d'Errico *et al.* (2001a) easily approximates my medium to large range.

My experimental studies also proved that shaft pieces with an articular end still intact and useful as a handle were the most successful. Bone pieces that were fractured at both ends often cut through the gloves I used while conducting experiments. Early hominids therefore may have selected for weathered bones (ranging between 130-190 mm in size) with one articular end still intact, of which only the broken tips have been recovered or identified through excavation and microwear analysis.

While both Backwell and d'Errico's and my experimental tools were used for periods of up to 30 min., Brain (Brain & Shipman 1993) used his experimental tools for a much longer period. The bones were fresh when collected, although their state when used was not described. Brain used tool A for a total of eight hours and tool B for a total of four hours in digging for subterranean bulbs. He found that a "noticeable smoothing of the sharp edges of the flakes was apparent after one hour of digging, while rounding of the digging tip was well developed after four hours of use. This rounding did not appear to be much accentuated in the subsequent four hours of digging to which tool A was subjected". This observation indicates that tool tip morphology stabilises to a degree after a certain amount of employment time while the tool remains functional. Bone tools therefore had the capacity to be used for relatively long periods of time, a characteristic that would easily have assigned them a semi-permanent to permanent place in the toolkits of the early hominids. These tools should therefore not be regarded as instant, impromptu or expedient.

It is significant that I did not observe wear patterns in any of the recessed areas where small flakes chipped away during experimental employment of my tools. Wear within such recessed areas is a feature characteristic of the fossil tools (Backwell 1999; Backwell & d'Errico 2001). The absence of wear patterns in recessed areas on my experimental tools can be a further result of the short employment time vs. the possibly much longer employment periods of the fossil specimens.

4.2) Wear characteristics and interpretations

4.2.1) The G1 experiments: Digging for subterranean plant foods (bulbs) on a hill/hillslope

Modification marks observed on tools used to dig for subterranean plant foods on a hill/hillslope can in short be described as primarily perpendicularly angled criss-cross formations with solitary diagonal and longitudinal striae interrupting this composition. This striation composition corresponds to wear patterns observed on the SEM micrographs of both Brain's and Backwell's experimental tools employed in the digging for subterranean plant food sources (see Fig 42b & c).

In order to obtain bulbous plant foods, the experimenter is required to scratch and scrape out the soil around the bulbs and angular dolomite and chert blocks. Such activity involves actions of poking, wiggling, scratching and scraping to remove the soil and prise out the bulb. Motions perpendicular or oblique to the bone tool's main axis are used, leaving scratches that are both longitudinal and at an angle to the bones long axis. Transverse scratches result especially from contact with dolomite and chert stones as one is trying to loosen the bulb in the soil (Brain & Shipman 1993; Backwell & d'Errico 2001; d'Errico *et al.* 2001a). Brain & Shipman (1993) explain that soil can be scratched out with a narrow, pointed instrument such as a bone flake. In less rocky situations more robust tools such as horn cores are effective.

Vrba (1989) supports Brain & Shipman's (1993) theory of the early bone tools being employed as digging implements. She is of the opinion that global climatic change produced habitat changes, which resulted in biologically and culturally evolutionary responses. Referring specifically to global cooling and aridification around 2.5-2 Mya, she explains that a "high below ground biomass is characteristic of xeric, open areas and that digging out of such foods must have been an important feeding strategy of hominids in the open savanna. If true then the earliest digging tools may well reflect cooling, aridification and the spread of grassland in Africa".

Brain & Shipman's (1993) theory is opposed by Backwell & d'Errico (2001) and d'Errico *et al.* (2001a), who based their argument primarily on striation compositions observed on the tips of experimental tools. Backwell & d'Errico (2001) are of the opinion that the wear pattern observed on tools used to dig for subterranean plant foods is rather different from the use-wear patterns observed on the archaeological material (see Fig. 42a,b & c), which are described by Backwell (1999) as "running parallel or sub-parallel to the long axis of the bone".

Backwell & d'Errico (2001) support their opinion with evidence from the ethnographic record. They claim that the early hominid bone tools "appear inefficient for digging activities compared with the long, stout and often heavy digging sticks used by modern hunter-gatherers to extract tubers, larvae and small game".

I strongly oppose this supporting argument. Digging sticks of modern hunter-gatherers form part of a sophisticated tool kit comprised of specialised tools used by communities where the division of tasks and task specialisation is the order of the day (Deacon & Deacon 1999). The early hominid bone tools from the Gauteng sites are associated with the Developed Oldowan/Early Acheulean stone tool industries (Clark 1993; Kuman 1994a,b; Kuman *et al.* 1997). These stone tools are generally believed to have been multipurpose tools (Volman 1984; Kuman 1998; Klein 2000). As the digging stick fulfills the role of a specialised tool within the modern day hunter-gatherer's toolkit, I am of the opinion that the early hominid bone tools fulfilled a multipurpose role in an early hominid toolkit consisting mostly of multipurpose stone tools. I therefore reject Backwell & d'Errico (2001) and d'Errico *et al.*'s (2001a) one-to-one comparison from a specialised to a multipurpose toolkit. Tasks performed by hominids over the Stone Age period remained very basic in character (such as the cutting of meat), while the morphological appearance of their stone tools underwent radical change.

Striation patterns achieved by Backwell and d'Errico, Brain and myself on experimental tools used to dig for subterranean plant foods on a hill/hillslope all exhibit a very similar use wear pattern. When this pattern is compared with the archaeological material (see Fig. 41a,b & c) it appears to be quite different. However SEM micrographs of some of the archaeological specimens display a relatively identifiable perpendicular angled criss-cross composition of striations (see Fig. 44a & b), very similar to that of the experimental tools. I therefore suggest that as many sets of striation compositions as possible should be carefully identified from the archaeological record in order to determine the variety of uses for which these tools were employed.

Based on similarities of striation compositions observed on some of the fossil specimens, as well as on Backwell and d'Errico's, Brain's and my experimental tools, I am of the opinion that the excavation of subterranean plant food sources was one of the activities for which the early hominids employed their bone tools.

4.2.2) The G2 experiments: Digging for subterranean food sources (rootlets, worms and insects) in a riverbank environment

A random striation pattern, composed of longitudinally, transverse and diagonally oriented striations was identified on experimental tools used to dig for subterranean food sources in a riverbank environment. Overprinting was visibly the most characteristic feature of use-wear on these tools.

The randomly positioned striations would make identification with any patterned composition of striae difficult to identify, although randomly situated striations can denote a composition in itself. Despite the fact that some of the archaeological specimens display a slight percentage of randomly situated striations (Backwell 1999), some of my tools used in other experiments displayed this feature as well. Randomly situated striations are therefore not exclusively a characteristic of tools used in the digging for subterranean food sources in a riverbank environment.

Smoothing and overprinting also proved to be a characteristic of the tools I used in all my categories of experiments. Despite the polished, smoothed surfaces underlying the striations on the fossil specimens (Backwell 1999; Backwell & d'Errico 2001), polish cannot be exclusively ascribed to digging in a riverbank environment. A degree of polish was found on most of my experimental tools, while the characteristic concentration of striations overlying the polish on the fossil tools is absent from experimental tools used to dig for subterranean food sources in a riverbank environment.

However, when the high degree of polish and randomly situated striation observed on my experimental tools are compared with those observed on the fossil specimens the possibility that two or more processes were involved in modification to the fossil specimens cannot be excluded.

Based on the fact that my experimental tools did not display the characteristic concentration of striations overlying the polish on the tool tips, so typical of the fossil specimens, both the high degree of polish and randomly situated striations on my experimental tools lead me to conclude that digging for subterranean food sources in a riverbank environment was definitely not the only, or perhaps even the primary function of the early hominid bone tools.

4.2.3) The B1 & B2 experiments: Debarking of the *Maytenus undata* (Koko) and *Celtis africana* (White Stinkwood) trees

Longitudinally oriented and acutely angled criss-cross striations were identified on the weathered tools used to debark both the *Maytenus undata*, an indigenous hardwood tree, and the *Celtis africana*, an indigenous softwood tree. Overprinting was the most characteristic feature of the fresh tools used to debark the hardwood tree (B1 tools). Fresh tools used to debark the softwood tree (B2 tools) displayed much less overprinting with predominantly longitudinally oriented striae and acutely angled criss-crosses, similar to the pattern observed on the weathered tools.

Experimental debarking of the hardwood tree made only a slight impact on the very outer surface of the bark. Striations observed (B1 tools) are therefore ascribed to the harsh contact between the experimental tools and the hard bark of the tree due to the poking action. The experimental debarking of the stinkwood tree proved that debarking was much easier on a tree with a softer bark.

Acutely angled criss-cross striation marks on the weathered tools used to debark the hardwood tree (B1 tools) can be ascribed to slippage of tools against the bark during an activity that was primarily pecking in a near longitudinal motion. Despite the readily identifiable longitudinally oriented and acutely angled criss-cross striation pattern on these tools, I am not convinced that that the early bone tools were used in debarking activities of hardwood by the hominids. Despite the fact that striation compositions closely resembled the archaeological specimens, the experiment was very unproductive, producing only a few wood shavings and exposing virtually no wood, despite the cumulative employment time that these tools were used for.

Once the experimental tools broke through the bark of the softwood tree (B2 tools), a continued hard scraping action produced primarily wood shavings, exposing the wood of the tree. Potentially this activity could have provided the hominids with an additional raw material to produce new objects from. Despite the fact that wooden objects associated with the ESA are scant in the archaeological record, clear evidence for woodworking exists at Kalambo Falls, Zambia (Clark 1975) and Amanzi Springs, South Africa (Deacon 1970). I believe that debarking activities of softwood trees can be included in the employment activities of the bone tools by the early hominids.

4.2.4) The H2 & H1 experiments: Processing the inner side (burnishing) of a *Bos taurus* (cattle) hide with and without the aid of sediment

Despite the general assumption that the processing of the inner side of hides would produce a smoothed, polished modification on tools (Brain & Shipman 1993; Shipman 1989), Runnings *et al.* (1989) observed striations overlying the polish on bone tools used to burnish hide.

Striations on the tools I used to burnish hide both with and without the aid of sediment can be summarised as primarily longitudinal in orientation. The intensity of striations markedly increased on the tools where sediment was used (H2 tools). I ascribe the occurrence of more prominent striation patterns on the H2 tools solely to the use of sediment during the burnishing process. The sparse presence of striation marks on tools used to burnish hide without the aid of sediment (H1 tools) is ascribed to the chance inclusion of sediment particles, a result of the natural environment in which experiments were conducted. No striation marks are expected on tools used in similar experiments conducted under laboratory-controlled conditions.

Brain & Shipman (1993) raise the question of how early hominids managed to keep bone and stone atrefacts for days or weeks at a time without losing them in the course of their daily food seeking activities. They propose the use of carry bags to transport their tools and gathered foods. Simple bags would serve as an explanation for the apparent use of the same tools over successive days or weeks. Despite the fact that bone is a less useful raw material than stone, Shipman (1989) explains that bone is very useful in particular tasks, "especially in various aspects of hide working such as separating, cleaning and burnishing."

I believe that the primarily longitudinally oriented striae on bone tools used in the experimental burnishing of hide may suggest that early hominids employed bone tools in a similar activity. The formation of clearly defined working planes on the tools used to process hide is ascribed to the initial general morphology of the experimental tools. Slender, pointed tools more similar to those from the archaeological record proved to be the most functional in both sets of burnishing experiments, which suggests this was a shape the early hominids would have selected from the landscape.

Making use of sediment as an aid in burnishing hide in the H2 experiments created tools that approached the morphology of the archaeological specimens. Their primarily longitudinal striations also are most characteristic of the archaeological wear pattern (Backwell 1999; Backwell & d'Errico 2001) (see Fig. 36b & 37).

I suggest that further experiments should be conducted on various activities and methods involved in hide processing, including separating, cleaning and burnishing. Experiments should also be conducted with tools that are morphologically more similar to those from the archaeological record. Such experiments could solve the issue of the demarcated tips, while more tapered points might also serve to produce wear patterns all around the tips of the tools.

Pitting observed on the weathered H2 tools used to burnish hide with the aid of sediment is ascribed to the contact with sediment. Sediment was used dry in the experiments. Experiments where moistened sediment or mud is used as an aid in the burnishing process are suggested.

Further experiments may also address different methods of stretching the hide and the impact this has on the wear patterns produced.

4.2.5) The T1 experiments: Extraction of termites from their mounds

Tools used to extract termites from their mounds displayed a recognisable longitudinally oriented and acutely angled criss-cross striation composition. This corresponds well to compositions observed on Backwell's experimental tools (see Fig. 42d), and when compared with some of the archaeological specimens the similarities are obvious (see Fig. 36b, 37 & 42a).

From their experiments to excavate termite mounds, Backwell & d'Errico (2001) found that "striations radiating from the tip were finer (5-30 μm) and ran parallel or sub-parallel to the long axis of the bone". They ascribed this striation pattern to the repeated abrasion against the tools caused by angular fine-grained sediments found in the hard outer crust of the termite mounds. A motion parallel to the main axis of the tool was found to be the most efficient way to perforate and flake off the crusts of the mounds. I agree with this observation after experimental termite foraging.

Based on the similarities of micro-striations observed on both the experimental tools and the fossil specimens, Backwell & d'Errico are convinced that a bone tool-assisted termite extraction tradition was a persistent component of the subsistence behaviours of early hominids (Backwell & d'Errico 2001; d'Errico *et al.*2001a). Their observation carries further weight in that it, for the first time, demonstrates the often predicted link between living chimpanzee and early hominid social and cultural adaptations (Boesch & Tomasello 1998).

Backwell & d'Errico (2001) used a Mann-Whitney *U* test to establish values for striation width, which detected a difference between the Swartkrans fossil tools and their tools used to extract termites from their mounds. They state that striation widths on all of the experimental tools, including tools used to excavate subterranean bulbs, were significantly different from each other, but that the "closest similarity" was recorded between the Swartkrans and termite digging tools. This difference they ascribe to a known variability in the sedimentological composition of termite mounds located in different areas and belonging to different species, stating that it therefore does not affect their interpretation. However they do not address the issue of different termite species in the present or the past in the Cradle of Humankind World Heritage

Site area.

An unpaired *F* test to establish the variance of striation orientation showed the "orientation of striations on the Swartkrans and termite digging tools to be most similar, and significantly different from other experimental tools" (Backwell & d'Errico 2001), referring specifically to tools used to dig for subterranean plant foods (bulbs).

Neither in terms of striation width nor orientation is there thus an exact correlation between the fossil specimens and experimental tools used to extract termites. The striation widths and orientations on the experimental termite foraging tools are, however, closer to that of the fossil specimens than striation widths and orientations on the experimental digging tools. Backwell & d'Errico (2001) and d'Errico *et al.*'s (2001a) method of a cumulative averaging of all striation widths and orientations in their analysis of the fossil specimens might account for the non-matching results.

To a degree I support the theory proposed by Backwell & d'Errico for termite extraction. Corresponding longitudinally oriented striation compositions on SEM micrograph images of experimental and some fossil tools are quite similar (see Fig 36b, 37, 42a,d & 45a,b). However, Backwell & d'Errico's (2001) statement that "alternative explanations seem unlikely" is perhaps very premature, especially in light of the small database on experimentally employed bone tools available at the time. My study showed that the extraction of termites from their mounds is not the only process causing the characteristic longitudinally oriented and acutely angled criss-cross striation composition on the tips of tools.

My study did not allow time enough to take measurements of all the striations observed on tools used in different experiments, but these specimens can be studied in future for this purpose.

4.3) Conclusion

As a result of the experimental project undertaken a few concluding remarks will be highlighted regarding the manufacture and use of the early hominid bone tools. Suggestions for further study are also made.

My experiments showed that if the early hominids did indeed use bone for tools, the implements were probably highly selected for in the landscape. Weathered bone flakes (of Behrensmeyer's stage 4), with preferably one articular end intact, and ranging in size from 130-190 mm, is proposed as the most useful pieces to have been selected.

Breakage patterns observed on fresh bone fractured by the hammerstone and anvil technique produced robust bone pieces. The working tips of these fresh tools were either flat or broad and V-shaped, making them difficult to work with. In morphology they are also very different from the tips of the fossil tools. A Behrensmeyer's stage 4 weathering would have caused the bone to flake naturally, or very easily with a hammerstone and anvil technique, into pieces with more slender, tapering tips, more similar to the morphology of the tips of the fossil specimens. The selection of weathered bone pieces also serves to explain striation marks overlying carnivore damage (Backwell & d'Errico 2001), while they would have also been cleaner to use.

Brain, Backwell, d'Errico and I all conducted experimental studies in an attempt to answer questions regarding the use of the early hominid bone tools.
Brain & Shipman (1993) proposed that the tools were used to dig for subterranean plant food sources, particularly the bulbs of the *Scilla marginata* and *Hypoxis costata*.

Experimental tools used by Brain, Backwell and myself (G1 tools) to excavate bulbs from a dolomitic habitat all displayed a very similar striation composition of primarily perpendicular angled criss-cross formations on the tips of the tools with frequent wider, transverse striations situated further away on the bodies of the tools.

My experimental digging for riverbank food sources, the G2 experiments, led to a characteristic polish formation on the tips of the tools. Prolonged working easily erased random striations observed on the tool tips. Both these characteristics of polish formation and overprinting were to a degree visible on tools used in different experimental categories, while striations overlying polish typical of the fossil tools were absent from the experimental tools. However, both the high degree of polish and the randomly situated striations on the experimental tools are also found to a degree on the fossil specimens, highlighting the possibility that the fossil tools could have been employed in more than one activity. I am therefore of the opinion that the bone tools were definitely not exclusively used for digging activities in a riverbank environment. Such digging activities were probably also not a primary function of the bone tools. Continued studies on polish formation might serve to shed more light on this activity.

The experimental debarking of the *Maytenus undata* (hardwood) and *Celtis africana* (softwood) trees displayed primarily longitudinally oriented and acutely angled criss-cross compositions on the tips of the tools. The unproductivity of debarking a hardwood tree (B1 tools) convinced me that the early hominids did not employ their bone tools in debarking activities of hardwood trees. However, debarking of a softwood tree (B2 tools) much easier exposed the wood of the tree while striation compositions observed on the tool tips matched that observed on the fossil specimens.

Experimental burnishing of hide produced a patterned composition of primarily longitudinal striae on the tool tips (H1 tools). Experiments where sediment was used in the burnishing process produced the same striation composition on tool tips (H2 tools), although it was much more intense. Striations observed therefore probably result from contact between the bone tool and sediment particles. I ascribe striations observed on tools used directly on the hide (H1 tools) to chance inclusions of sediment particles due to the natural environment in which I conducted my experiments. Striation patterns observed on tools used in both these sets of experiments are very similar to that of the fossil specimens.

Backwell & d'Errico (2001) and d'Errico *et al.* (2001a) are convinced that the early hominid bone tools were employed to extract termites from their mounds. Experimental tools used in this activity by Backwell, d'Errico and by myself (T1 tools) produced a very similar, more longitudinally oriented striation composition. Often sub-parallel or diagonal striations formed acutely angled criss-cross compositions on the tips of the tools.

In short, I am not of the opinion that the early hominid bone tools were employed in debarking activities equivalent to that of the debarking of the *Maytenus undata* or hardwood trees.

The digging for subterranean food sources in a riverbank environment is also highly unlikely to have been a primary function of the tools.

Based on the overall striation compositions observed on my experimental tools and to a lesser degree on the morphology of the tool tips and the productivity of the activities involved, I conclude that the hominids could have employed their bone tools to excavate subterranean plant foods (bulbs) on a hill/hillslope, to debark softwood trees, to process hides with and without the aid of sediment, and to extract termites from their mounds.

Poking, scraping and scratching out of soil and wiggling actions necessary to prise out subterranean bulbs from dolomitic hill/hillslope environments cause perpendicular angled criss-cross striae on the tips of the tools, while the sharp edges of angular chert and dolomite blocks are responsible for the often much broader transverse striations situated on the bodies and tips of these tools. This striation composition is comparable to striations found on some of the Swartkrans specimens (see Fig. 39a,b & 44a,b).

Both the poking action used in termite foraging, and the scraping action used in the debarking of softwood trees and the burnishing of hides produced more longitudinally oriented and acutely angled criss-crosses on the tips of the tools. This striation composition is comparable to, and most characteristic of the fossil tools (See Fig. 36b, 37, & 45a,b).

From my experimental study it is clear that different actions and experiments may cause similar striation patterns on tool tips. The scraping action used in the debarking of the *Celtis africana* (softwood) tree and in the burnishing of the *Bos taurus* (cattle) hides, and the poking action used in the extraction of termites from their nests, all caused longitudinally oriented and acutely angled criss-cross striae on the tool tips. It is furthermore worthy to note that the low powered microscopic approach has never been precise enough to determine the kinds of substances or materials on which stone tools were used. This approach emphasises the action of a tool and the relative density of the material being worked (Odell 1977, 1979; Shea 1992). These observations from wear patterns on stone tools probably also apply to bone tools when examined by the low powered microscopic approach. I therefore propose the expansion of the existing database of experimentally modified bone to determine how many different processes, of both anthropic and natural origin, will produce similar wear patterns comparable to patterns identified on the fossil tools.

This brings me to my second proposition, namely that more accurate interpretations will result if the variety of striation compositions on the fossil specimens are identified and described. This is preferable to a cumulative description in which all striation widths and orientations form the basis of an average description, as done by Backwell & d'Errico (2001) and d'Errico *et al.* (2001a).

It is clear from SEM micrographs of the fossil tools that striation compositions vary from longitudinally oriented and acutely angled criss-cross compositions (see Fig 36b, 37 & 45a,b) to more perpendicularly angled criss-cross striations with noticeable transverse striations (see Fig 39a,b & 44a,b). I found that patterns observed on tools used in different experiments corresponded to these different wear patterns on the fossil tools. Perpendicularly angled criss-cross striation patterns on tools used to dig for subterranean plant foods closely resemble the perpendicularly angled striation patterns on some of the fossil tools (see Fig. 39a,b & 44a,b). In turn longitudinally oriented and acutely angled criss-crosses on tools used to debark softwood trees, tools used to burnish hide and tools used to extract termites from their mounds are more similar to longitudinally oriented and acutely angled striation compositions on other fossil specimens (see Fig. 36b, 37 & 45a,b).

The variety of striation compositions on the fossil tools should serve as the basis for determining the variety of functions of the early hominid bone tools. It is noteworthy that different striation compositions are sometimes present on individual tools - see Fig. 40a & b, where the outer side of the tool tip shows a composition of almost perpendicularly angled criss-cross striations, while the inner side of the tip is characterised by more longitudinally oriented striations.

I believe that both the variety of striation compositions on the different fossil specimens and the presence of different compositions on individual tools should be interpreted as patterns potentially produced by different processes. This variety of patterns reflects the variety of activities for which the tools were employed establishing their role as multifunctional tools within the early hominid toolkits.

MICROWARE image analysis software, with the capacity to establish exact widths, lengths and orientations of striations, might serve as the ideal tool in defining different striation compositions. The creation of "abstract" categories of widths, lengths and orientations to establish hypothetical striation compositions will enable the scientist to test experimental results that produced different wear patterns on the tips of the tools but most importantly also to test experimental data sets that produced quantitatively and qualitatively similar striation patterns, which can in turn be tested against the fossil specimens. The creation of such categories of striation compositions should not, however, be seen as a straightjacket into which the interpretation of fossil tools must be forced. Composition categories should rather serve as an aid against which certain hypotheses could be closely tested.

Thirdly and lastly I am of the opinion that both microwear and residue analysis as complementary sciences should form the basis of any functional inquiry. Residue analysis can guide the experimental archaeologist towards substances that could have been worked, though it needs to be remembered that depositional contexts may not always be favourable for the preservation of residues. Microwear on the other hand might shed more light on how a substance was worked, for example in a slicing, cutting or scraping action.

Establishing the function of the early hominid bone tools as part of the earliest hominid toolkits can only serve to broaden our understanding of the vaguely understood, remote past cultural processes.

Appendix 1

Photographs and micrographs of Backwell and Brain's experimental studies and of the fossil tools

Figure 36a: **SKX 38830**

Figure 36b: **SKX 38830: x 40 mag.**

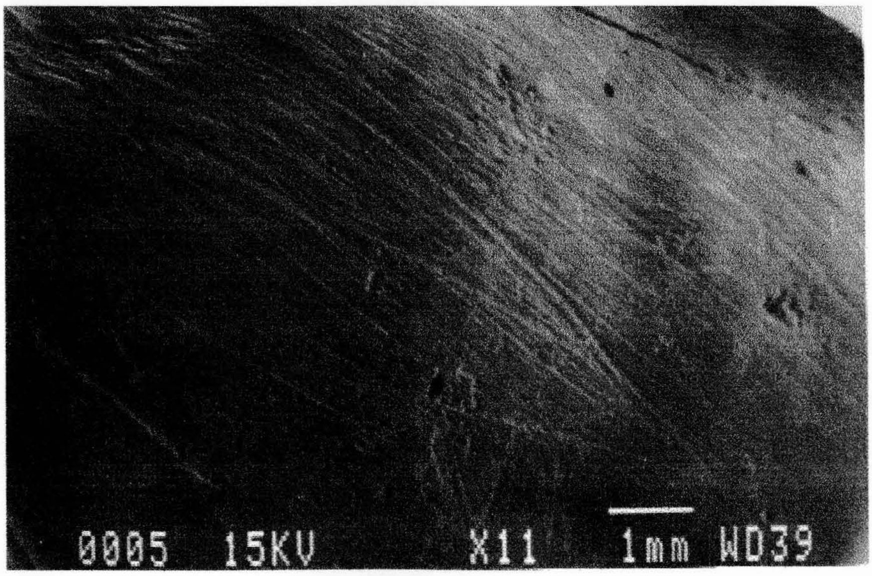


Figure 37: **SKX 35196: x 10 mag.**

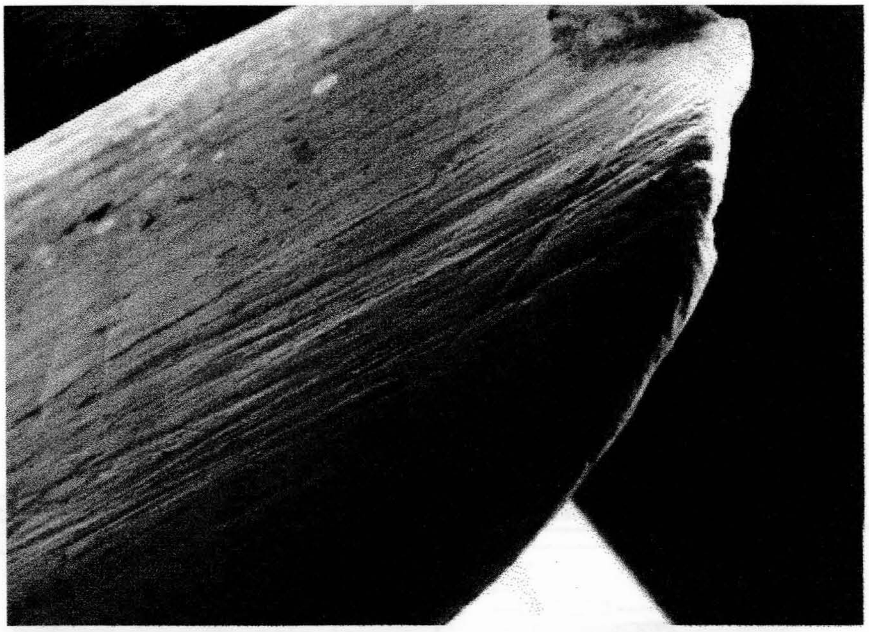


Figure 38: **Image analysis of microwear patterns**

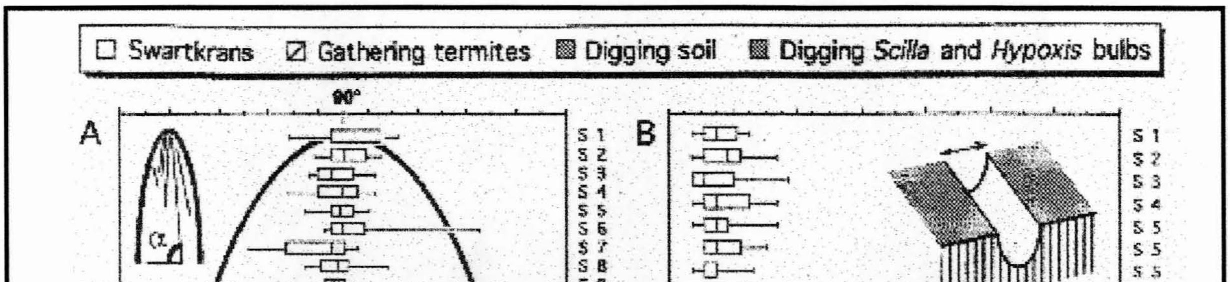


Image analysis of the wear patterns on the Swartkrans fossils and on experimental bone tools. (A)Variability (Upper) and mean (Lower) in the orientation of the striations on the Swartkrans tools (S) and on the experimental tools used to dig termite mounds (T), to excavate the ground in search of tubers and larvae (G), and to extract bulbs (B) [Brain's experimental tools (7)]. An unpaired *t* test has shown the orientation of the striations on the Swartkrans and termite digging tools to be most similar, and significantly different from the other experimental tools. (B) Striation width as measured at x 40 magnification on all of the striations visible. A nonparametrical statistical test has shown the striation widths on all of the experimental tools to be significantly different from each other, but with the closest similarity recorded between the Swartkrans and termite digging tools.

Figure 39a: **SKX 47046: x 10 mag.**

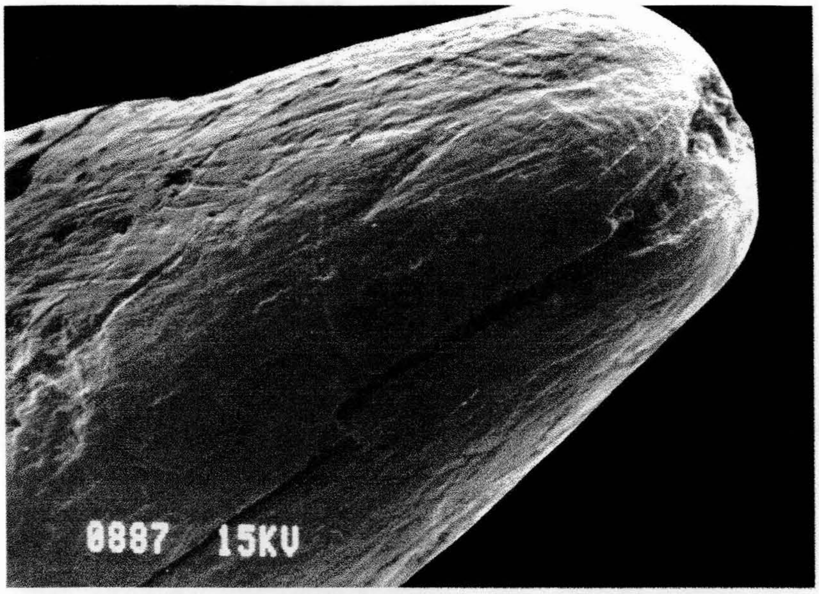


Figure 39b: **SKX 47046: x 10 mag.**

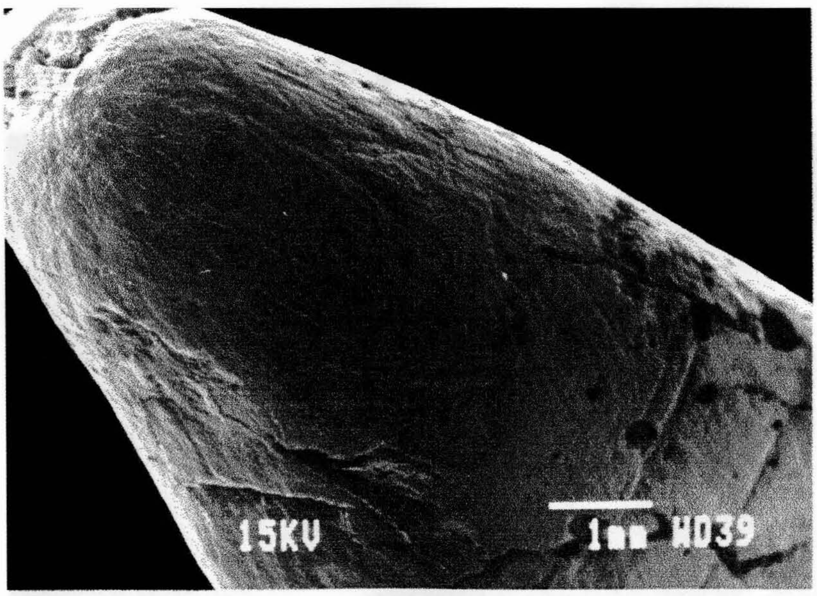


Figure 40a: **SKX 19845: x 40 mag.**

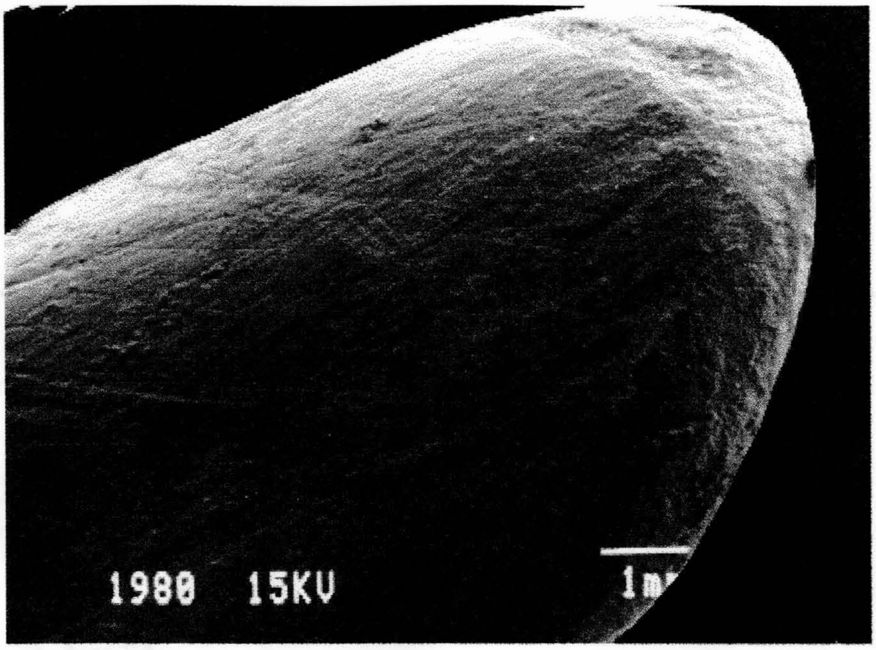


Figure 40b: **SKX 19845: x 40 mag.**

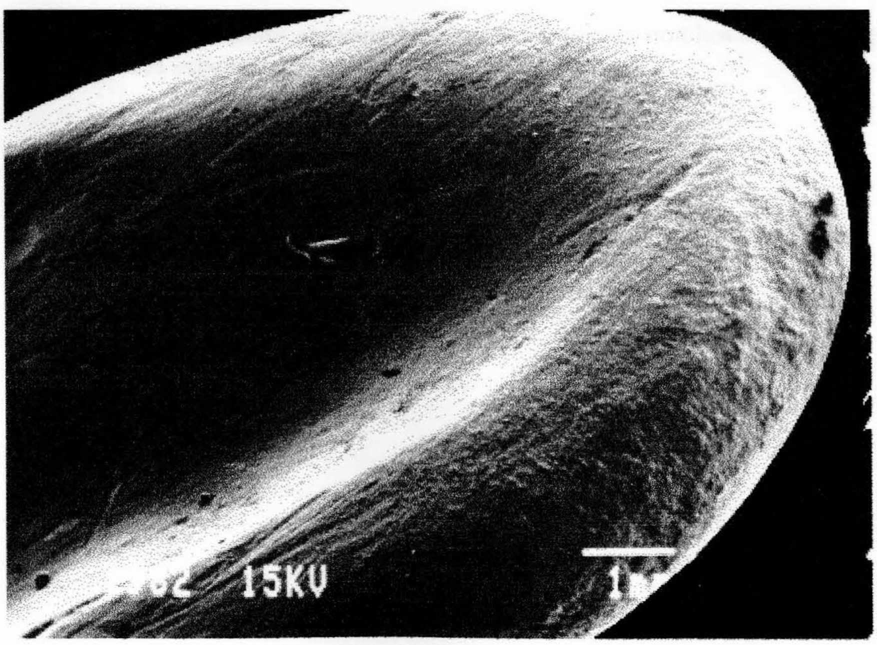
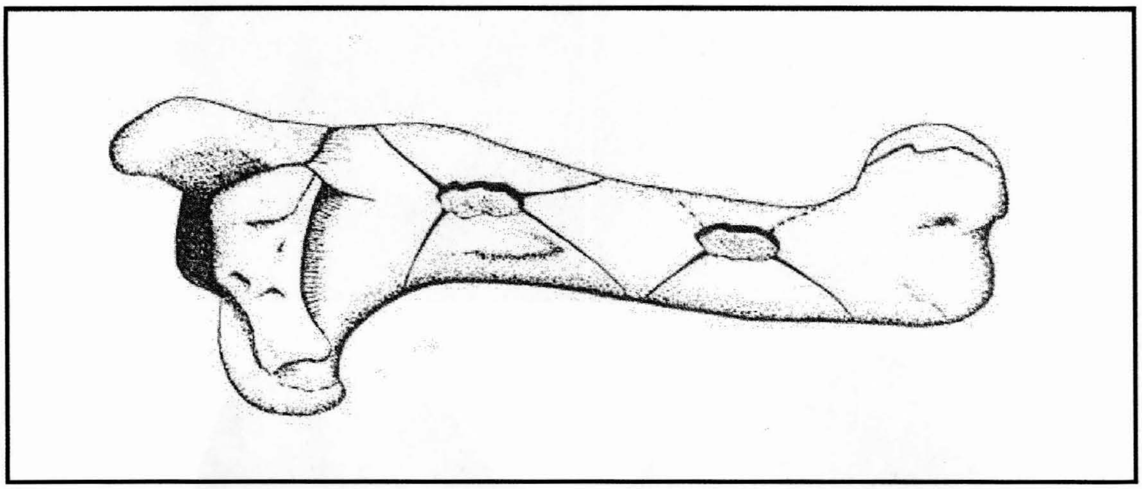
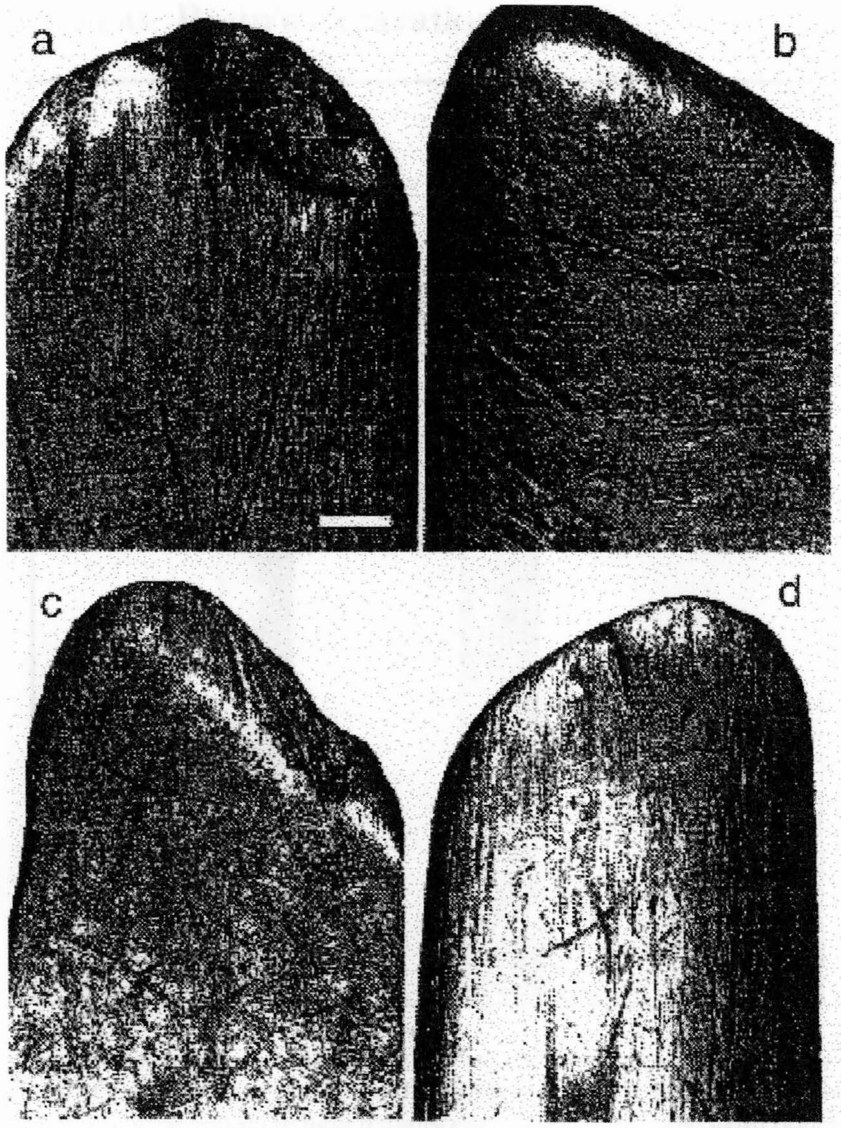


Figure 41: **Bone breakage patterns**



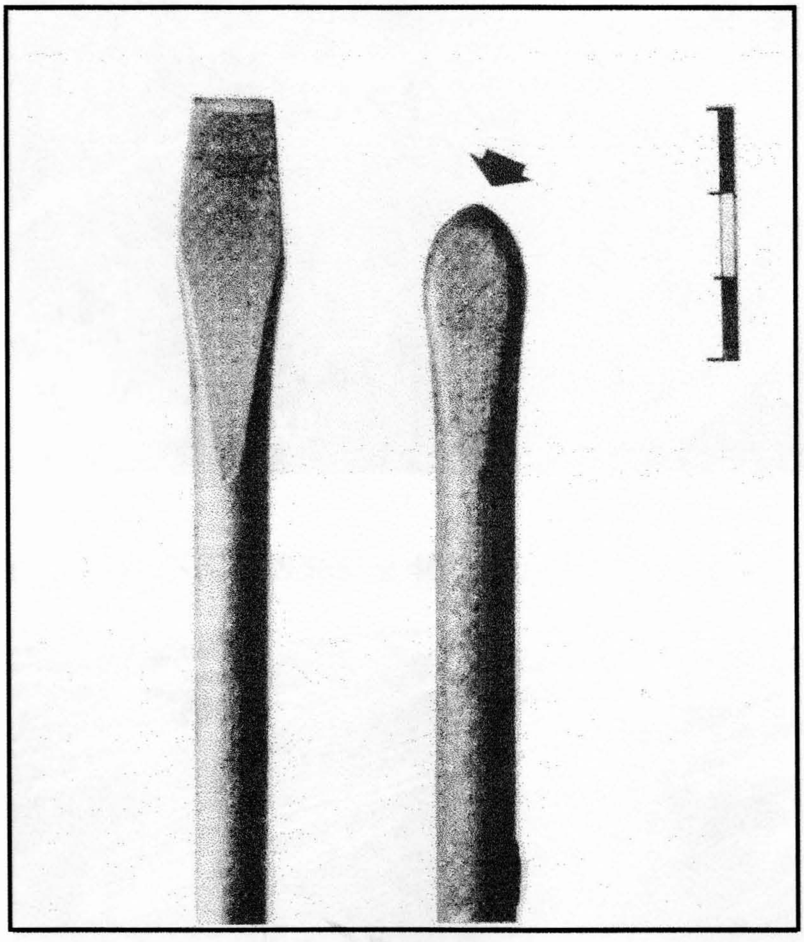
Schematic drawing of large bovid humerus showing hammer stone impact notches and characteristic fracture patterns resulting from experimental breakage techniques.

Figure 42: **Wear patterns on experimental and fossil tools**



Wear patterns on Swartkrans and experimental bone tool tips photographed in transmitted light from transparent resin replicas. (a) Bone tool from Swartkrans Member 3 (SKX 38830). (b) Tip of a tool used in Brain's experiment to dig up *Scilla marginata* bulbs. (c) Blackwell's experimental bone tool used to dig the ground in search of tubers and larvae. (d) Backwell's experimental bone tool used to dig a termite mound.

Figure 43: **Brain's excavation tools**



The effect of digging on the appearance of metal tools – in this case screwdrivers used as digging tools in the course of the Swartkrans excavation. The tool on the left is, as yet, unused, while the other show characteristic wear and scratching reminiscent of that seen on the worn bones from Swartkrans.

Figure 44a: **SKX 29365: x 10 mag.**

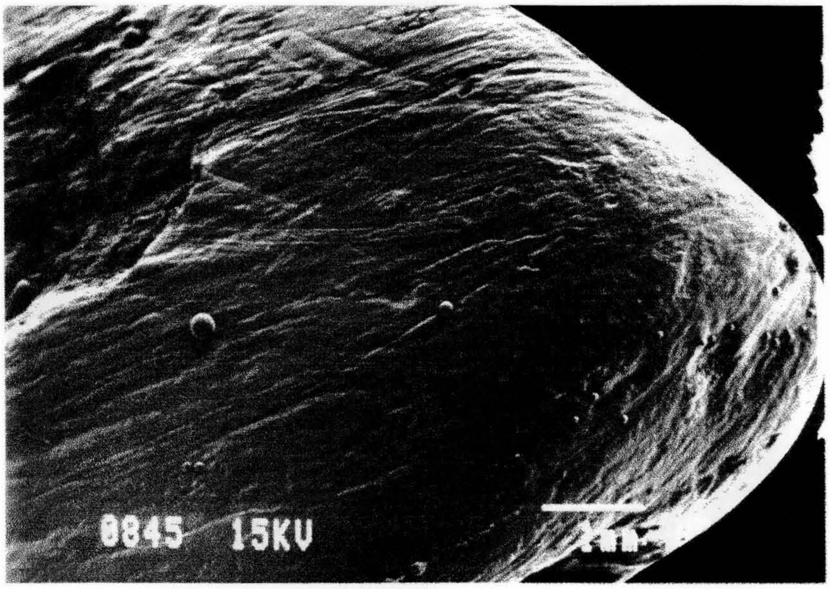


Figure 44b: **SKX 29365: x 40 mag.**

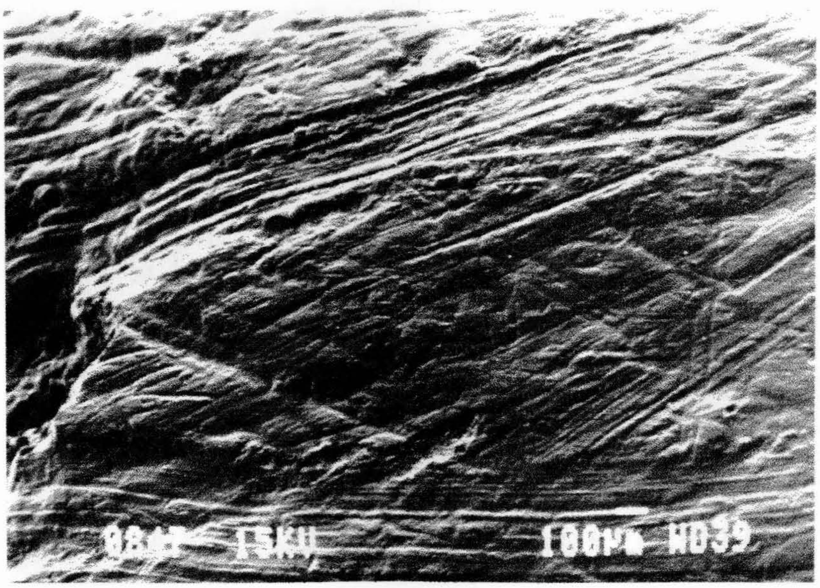


Figure 45a: **SKX 9123: x 10 mag.**

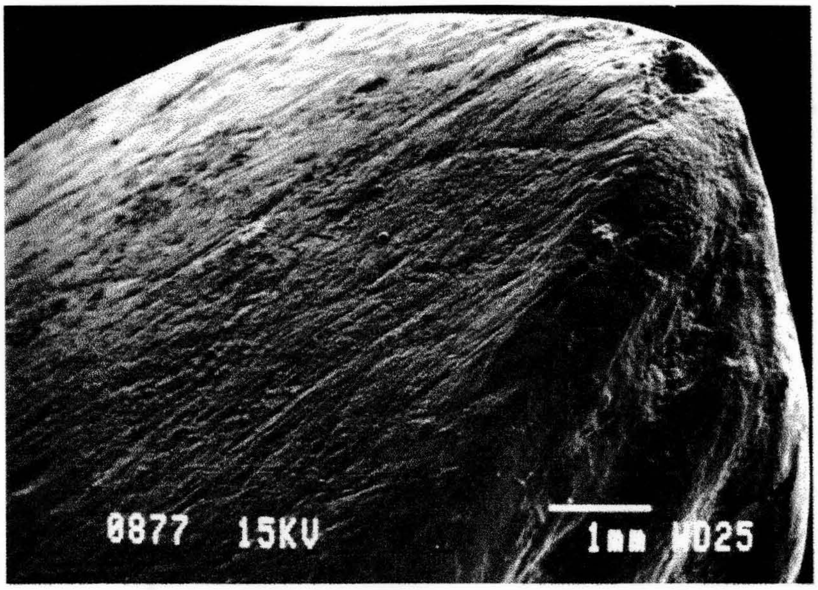
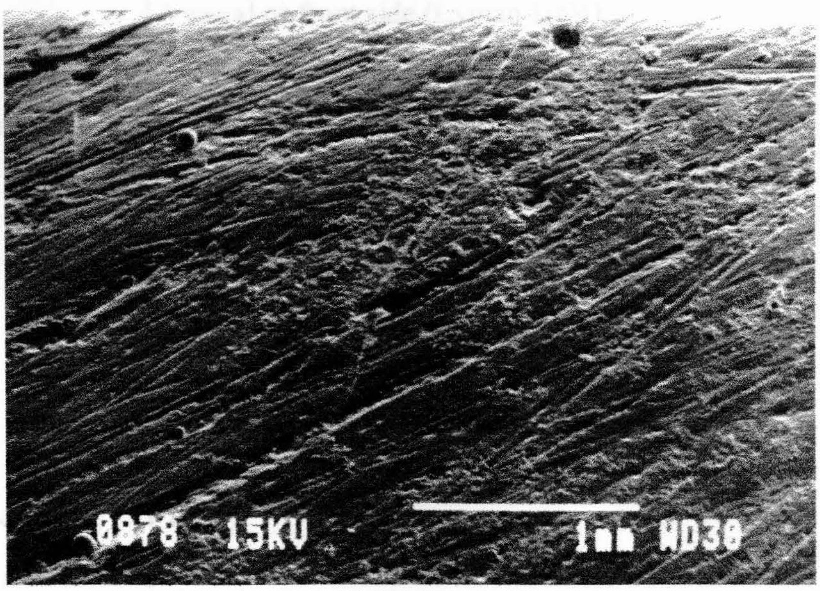


Figure 45b: **SKX 9123: x 40 mag.**



Appendix 2

Terms used

• **Abiotic**	Any non-biological process with the capacity to modify bone (Lyman 1994).
• **Acute**	At sharp/high angles.
• **Agent**	The immediate physical cause (such as biological, geological or hominid) of modification to a bone surface (Marshall 1989).
• **Anterior**	Ventral or front side (Lyman 1994).
• **Assemblage**	Collection of fossil material (bone or artefactual) in a single stratigraphic unit representing the basic analytic unit of studies (Irving *et al.* 1989).
• **Biotic**	Any biological process (micro- or macroscopic living organisms) capable of modifying a bone surface (Lyman 1994).
• **Bioturbation**	The churning and stirring of a sediment by organisms (Irving *et al.* 1989).

- **Carnassials** — Scissor-like molars (Bunn 1989).
- **Crenulated edges** — (Ragged edge chewing.) Irregular jagged edges that result from intense, sustained chewing (Backwell 1999).
- **Composition** — An organisation or arrangement imposed upon the component elements within an individual micrograph/photograph or observable on the surface or tip of a tool.
- **Criss-cross** — A compositional formation resulting from diagonal (sub-parallel) striations situated in opposing directions and crossing one another at an angle.
- **Cryoturbation** — A collective term to describe the stirring, churning modification, and all other disturbances of soil resulting from frost action (Irving *et al.* 1989).
- **Diagenesis** — All the chemical, physical and biological changes undergone by a sediment after its initial deposition, and during and after its lithification, exclusive of surficial alteration (weathering) and metamorphism. It embraces processes such as compaction, cementation, reworking, replacement, crystallisation, leaching, hydration, bacterial action and formations of concretions (Marshall 1989).
- **Diaphysis** — A long bone shaft (Lyman 1994).

• **Digging**	To turn up soil with an implement with the main purpose of bringing a buried object up or out. To make way into another substance (Dr. T Loy: Pers. comm).
• **Distal**	The part furthest away from the point of attachment to the trunk (Lyman 1994).
• **Dorsal**	Posterior or back side (Lyman 1994).
• **Epiphysis**	The growth end of a long bone (Lyman 1994).
• **Flake scars**	(Impact scars, conchoidal flake scars.) Scars occurring on the internal surfaces of bone as a result of impact or percussion. Flake scars caused by hammerstone blows are similar to those produced by carnivores, though generally slightly bigger in size. Flake scars are characterised by a general conchoidal overall shape, with a negative bulb of percussion (Backwell 1999).
• **Force**	A push or pull that can be dynamic (causing change) or static (balanced) (Marshall 1989).
• **Fracture**	A localised mechanical failure to a bone (Lyman 1994).
• **Grinding**	To sharpen, smooth, polish or prepare a tool by intentional friction, by continuously rubbing it against another substance (Dr. T. Loy: Pers. comm).

• **Hide processing**	An encapsulating term for the three processes of separating, cleaning and burnishing: **Separating:** A cutting or slicing action is used to separate the hide from the flesh. **Cleaning:** With a scraping action the hair on the outer side of the hide is removed. **Burnishing:** A scraping action is used to remove all blood, fat etc. from the inner side of the hide. Continuous scraping will serve to tan the skin providing a soft, smooth, workable hide. This step in the burnishing process can be done on the inner and/or outer side of the hide (Oliver 1989; Shipman 1989).
• **Hominid**	Hominid refers to members of the family Hominidae, which includes the genera *Australopithecus* and *Homo*. Human is restricted to archaic and modern *Homo sapiens* (Marshall 1989).
• ***In Situ***	Primary context or original position (Backwell 1999).
• **Intensity**	Heightened level of both the quality and quantity of striations (Dr. T. Loy: Pers. comm).
• **Lateral**	Away from the middle or mid-line (Backwell 1999).
• **Loading**	The application of force creating a stress-strain situation. Loading can be dynamic or static in nature. Dynamic loading

	is a "concentrated and sudden impact to a bone", while static loading is a "distributed, constant pressure applied overall" (Marshall 1989).
• **Longitudinal**	Parallel to the long axis of a bone (Gifford-Gonzalez 1989).
• **Medial**	Towards the middle or mid-line (Backwell 1999).
• **Medullary surface**	Inner surface of an animal long bone or shaft piece (Bunn 1989).
• **Mimics**	Mimics result when different processes or agents produce the same or qualitatively similar patterns (Oliver 1989).
• **Modification**	Any alteration in size, structure or texture of bone by an external agent (Marshall 1989).
• **Modification background**	This includes all non-hominid produced modifications which can be identified by studying assemblages not subject to hominid activity, and contemporary processes that produce analogous patterns (Gifford-Gonzalez 1989).
• **Pecking**	To use a tool in a repeated hard thrusting action (Dr. T. Loy: Pers. comm).
• **Percussion notches**	Semicircular to arcuate shaped indentations on the outer cortex due to hammerstone breakage. Percussion notches are

generally found in association with negative flake scars on the inner surface of the bone. Although similar in appearance, percussion notches are characteristically more frequent and in cortical view broader and shallower than tooth notches (Backwell 1999).

- **Perpendicular** At a right angle to the long axis of a bone (Gifford-Gonzalez 1989), or crossing at right angles.

- **Poking** To use a tool in a repeated gentle thrusting action (Dr. T. Loy. Pers. comm).

- **Polish** A glassy sheen or lustre observed around the worn extremity of a specimen (Backwell 1999).

- **Proximal** The part situated closest to the point of attachment to the trunk (Lyman 1994).

- **Rounding** A rounded shape observed at an extremity (Backwell 1999).

- **Scraping** To repeatedly draw the hard or pointed edge of a tool over another substance (Dr. T. Loy: Pers. comm).

- **Smoothing** The loss of natural angularity that occur on edges, protrusions, and flat surfaces of bone. As the result of an act of abrasion, smoothing does not need to result in a significant loss of bone mass or exhibit a sheen or lustre on the bone surface

(Backwell 1999).

- **Spiral** — Curved in a helical, partially helical or completely helical pattern around the circumference of a shaft (Gifford-Gonzalez 1989).

- **Striation** — A general term used to describe various forms of linear damage to a bone surface. Here striations refer to the relatively fine linear markings in the vicinity of the worn tip. Striations do not include the fine fissuring of bone fibres caused by natural processes (Backwell 1999).

- **Substance** — That upon which a bone tool was used. Soft, hard and mixed soft and hard substances are recognised. Soft substances include hides, meat and soft vegetables. Mixed and hard substances are encountered in tasks such as digging (categorised as hard in very rocky areas and mixed where there is soft soil with some rocks or pebbles), bark-working, grinding hard grains, or butchery, where both soft meat and hard bone is encountered (Shipman 1989).

- **Tahonomic overprinting** — Also called differential modification, overprinting denotes a process by which a pattern produced by one process is added to or obscured (even destroyed) by a pattern produced by another process (Marshall 1989).

• **Tip**	The use oriented pointed or rounded end of a piece of bone, tool or experimental tool (Marshall 1989).
• **Tooth crushes**	(Punctuate depressions.) Roughly circular depressions of cortical bone nested in underlying cancellous bone (Backwell 1999).
• **Tooth notches**	(Lunate fractures.) Semicircular to arcuate shaped indentations usually occurring along the fractured or longitudinally split edges of a bone. Each notch usually displays two inflection points on the outer cortex and negative flake scars on the inner surface. Although similar in appearance tooth notches occur less frequently than percussion notches. In cortical view tooth notches are narrower, deeper and smaller than percussion notches (Backwell 1999).
• **Tooth pits**	Roughly circular markings scarring the bone surface without any inward crushing of the bone cortex (Backwell 1999).
• **Tooth punctures**	Roughly circular holes which travels through the entire thickness of a bone's cortex, resulting in a bone with a depressed, roughly circular outline with inward crushing (Backwell 1999).

- **Tooth scores** — (Scores, striation/gouge marks or tooth scratches.) These are relatively shallow furrows with smooth internal grooves, with either a V-shape or U-shape in cross-section depending on the morphology of the tooth cusp that produced the score (Backwell 1999).

- **Unique patterns** — (Diagnostic or definite criteria, signatures or unique signature patterns.) These are patterns produced by a specific agent or process (Shipman 1989).

- **Whittling** — A repeated slicing action in an away or downward direction (Dr. T. Loy: Pers. comm).

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