CHAPTER 2

Materials and Methods:
The Goldsmith's Fossil Fauna Assemblage

2.1 Materials

The faunal assemblage available for study consists of 2981 specimens. These were extracted from limeminers' dumps, which consist of loose earth and breccia blocks excavated by the limeminers from the adjacent caverns. This dump collection will provide a good preliminary indication of what is represented in the intact cavern deposit. 74% (N=2210) of the assemblage was unidentifiable while 26% (N=771) was identified at least to skeletal part and taxon. Analysis of the faunal assemblage was conducted as outlined in the methods sub-section below.

2.2 Methods

Data on the specimens was recorded as:

- Specimen number
- Skeletal element
- Element portion
- Side
- Taxon
- Size Class, for bovids

- The age of the individual where possible
- Bone surface modifications and
- Weathering stage (following Behrensmeyer 1978)

2.2i. Taxonomic Identification

Modern osteological collections and fossil comparative samples from the Bernard Price Institute of Palaeontology and the Department of Anatomy at the University of the Witwatersrand, and the Transvaal Museum were used as a reference collection for taxonomic analysis. Literature on taxonomic identifications based on teeth and fauna was also consulted (e.g. Hillson 1986, 1996). This offered a foundation for classification of the bone remains according to a broad classification (Order) initially, with refining to Family, Genus and Species identification for bone with preserved diagnostic features. Carnivores were assigned to, small (≤ 30kg), medium (30- ≤ 100kg) and large sizes (≥ 100kg), while bovid size classes were allocated according to Brain's (1974, 1981) principle:

Size Class 1, 0-23kg: upper limit, large female duiker

Size Class 2, 23-84kg: upper limit, large male blesbok

Size Class 3, 84-296kg: upper limit, large wildebeest or roan antelope

Size Class 4, more than 296kg: eland or buffalo

I consulted Job Kibii and R.J. Clarke for confirmation of the taxonomic identifications while R.J. Clarke verified bone surface modifications.

2.2ii. Identification of Bone Surface Modifications

Taphonomy, a term coined by Efremov (1940), has become a significant branch of most studies in faunal analysis. Definition of the term incorporates all forces that had an impact on bones between death of an animal and the recovery of its remains. Raymond Dart initiated a taphonomic study of fossil assemblages in South African cave sites, initially with his observations of damage to fossils from Taung, and then classifying and interpreting modified fossil bones from Makapansgat (Dart 1926, 1929, 1957, 1960). C.K. Brain (1981) later undertook a comprehensive taphonomic investigation of southern African cave sites. Other researchers have contributed to this field (e.g., Simons 1966; Behrensmeyer 1978; Binford 1984; Klein & Cruz-Uribe 1984; Blumenschine & Selvaggio 1988, 1991; Selvaggio 1994 and Pickering 1999, 2001). The study presented in this report is a continuation of such investigations. The results presented here are a culmination of an in depth taxonomic and taphonomic analysis of the Goldsmith's faunal assemblage.

Taphonomic studies such as that of Pickering (1999) have demonstrated that accumulation of bone in South African Plio-Pleistocene sites occurs as a result of three agents: hominids, non-hominid animals and physical agents (such as forces of gravity, sedimentation and other geological processes). All these factors impart modification marks on bone. Bone surfaces were studied under a microscope at 6x magnification in order to identify any stone tool modification, mammalian feeding and gnawing, burning, trampling, sediment abrasion and preparation damage. Bone surface modifications were studied on all the identified specimens with the exception of small mammalian faunal specimens and dental remains.

a. Stone tool modification

Hominid involvement with palaeontological assemblages is best indicated by the presence of stone tool-related modification. These modifications occur in the form of percussion fracture inflicted on bone during marrow extraction, cutmarks, scrape marks, slicing marks and chopping marks inflicted during butchery (Binford 1981; Potts & Shipman 1981; Shipman 1981; Blumenschine & Selvaggio 1988; Selvaggio 1994).

Percussion marks usually occur on mid-shaft bone fragments, notched bone and flakes (Blumenschine & Selvaggio 1991). They tend to occur more frequently on larger animal bones than on smaller animal bones, since the large bones require more force and repeated blows in a single location to produce fracture (*ibid.*). Extensive percussion renders bone into 'flake' pieces (i.e. comminuted). Percussion marks are characteristically different from those produced by cutting action; they are associated with patches of microstriations only visible microscopically, they are usually shallower, narrower, shorter and occur in dense unidirectional patches (Blumenschine & Selvaggio 1988). *Cutmarks* are the best indicator of direct hominid involvement with bone assemblages. They are characterised by short, oblique, fine parallel striae that vary in length within a groove produced by the tool (Binford 1981; Bunn 1981; Shipman 1981; Domínguez-Rodrigo & Pickering 2003). They do not occur in a random fashion. Microscopically they are V-shaped in cross-section and some may be flattened at the bottom indicating the bluntness of the tool used (Bunn 1981; Potts & Shipman 1981). The parallel cutmarks are produced because in most butchery cases it is necessary to attempt to cut flesh off the bone more than once for its removal.

Defleshing of bone using a stone tool also results in *scrape marks* (Potts & Shipman 1981). These marks are formed by 'drawing an edge across a bone surface in a direction roughly perpendicular to the long axis of the edge' resulting in fine, parallel, multiple striations resembling cutmarks but more faint and located on a broad area of the bone surface (Potts & Shipman 1981: 577).

Slicing marks are produced by positioning the tool edge across the bone in a constant motion in relation to the long axis of the artefact, creating numerous fine parallel striations within each main groove (Potts & Shipman 1981). In most cases these do not bear signs of the sharpness or bluntness of the tool, as the slicing tool is not positioned perpendicular to the bone. Striking a bone perpendicular to the long alignment of the edge creates *chopping marks,* resulting in V-shaped cross sections and small splinters of bone compressed inwards at the base of the main groove.

b. Mammalian related damage

Mammals such as carnivores, porcupines and other rodents can leave characteristic modification marks on bone (Maguire *et al.* 1980; Brain 1981; Binford 1984; Pickering & Wallis 1997). No signs of porcupine or other rodent feeding damage were evident on the Goldsmith's assemblage fauna, therefore emphasis with be placed on carnivore related damage.

Carnivores

Among carnivores, spotted hyaenas, once believed by earlier researchers to be incapable of accumulating bone (e.g. Dart 1956), are responsible for the most obvious carnivore modification of bone. This is because their dentition is specialised for bone crunching. However, other carnivores may leave distinctive marks on bone (Simons 1966; Brain 1981). Carnivore modification marks include punctures, scores, pits, furrows, ragged edge chewing, chipping back, and acid-related digestion marks (Breuil 1938; Binford 1981; Hill 1989; Marshall 1989).

Punctures occur as a result of bone collapsing under pressure from a tooth (Shipman & Phillips 1976; Binford 1981). A puncture does not usually break through the bone to form a perforation but the bone rather caves inwardly into a depression. A *score* results when a tooth is dragged along compact bone (Binford 1981). Scoring marks resemble cutmarks in that they are short parallel striations occurring close together. However, they differ in the manner in which they follow the bone's curvature and are U-shaped in cross section (Bunn 1981). In contrast to cutmarks, scores usually trace the bone contour (Binford 1981).

Pits, unlike punctures, perforate the bone such that it appears to have been bored through (Binford 1981). Generally found on cancellous bone, *furrows*, or what other authors refer to as scooping or hollowing out (e.g. Bonnichsen 1973; Maguire *et al.* 1980; Brain 1981), occur as a result of removal of soft tissue against the tougher compact bone. Carnivores, especially hyaena, chewing on bone with incisors and canines produce what Brain (1981) refers to as *ragged edge chewing*. *Chipping back*, like pressure flaking, is flaking off of bone cortex on the surface, resulting in a 'retouched' appearance (Binford 1981). *Digestion marks* are characterised by pitting and smoothing of the bone surface. However, not all swallowed bone may suffer from acid etching. Carnivores sometimes swallow bones encased in skin, which protects them from stomach acids (Pickering 2002).

c) Mimicry

Mimicry of patterns created by different agents can cause errors in the identification of the accumulating agent and/or the bone modifier. Mimics result when two or more different processes of modification produce similar patterns (Marshall 1989). Spiral fractures, scratch marks, cutmarks and flakes constitute some of the patterns, which can be produced by trampling, rockfall, processing by hominids, excavation damage and carnivore gnawing on bone (*ibid.*). Therefore modification patterns should be treated with caution and not in isolation of other distinguishing patterns.

d) Post depositional modification

1. Weathering

After an animal's death and decay of tissues, bones are exposed to the effects of temperature, humidity and soil chemistry (Behrensmeyer 1978). These factors, in turn, manifest themselves on the bone and modify not only the bone surface but the structure as well. Alteration of the bone structure due to abiotic factors is referred to as weathering.

Behrensmeyer (1978: 153) defines weathering as “the process by which the original microscopic organic and inorganic components of bone are separated from each other and destroyed by physical and chemical agents operating on the bone *in situ*, either on the surface or on the soil zone”. The extent of bone weathering is not only a factor of external forces, but also of bone macrostructure and microstructure, specific bone element, age, size or weight. Other factors that influence the extent of bone weathering include time since death and exposure to the surface or burial (Behrensmeyer 1978; Brain 1981; Gifford 1981; Gifford-Gonzalez 1989; Lyman 1994). Behrensmeyer’s (1978) model of identifying and classifying bone weathering stages is widely used and is therefore applied in this study due to absence of other equally suitable studies. Behrensmeyer (1978) identified five stages of weathering, which are only relevant to animals weighing more than 5kg:

Stage 0: Bone is not cracked and no flaking is observed. Fat, skin and tissue are still present.

Stage 1: Cracking is present. Fat, skin and tissue may still adhere to the bone.

Stage 2: Outermost layers of bone display flaking, sometimes with cracks. Ligaments, skin and cartilage might still be present.

Stage 3: The bone exterior consists of patches of rough bone with a fibrous consistency.

Stage 4: A rough and fibrous texture dominates the bone surface, if not the entire surface. Cracks are open, with splinters.

Stage 5: The splinters have enlarged, rendering bone fragile and easy to break. During this stage the bone might have lost its shape.

2. Abrasion

Brain (1967) observed what he termed abrasion on animal bones that were trampled by humans and animals in sediments near a waterhole. He reported that the effects of trampling on bone can result in smoothing and polishing of the surface. Bones abraded by sediments may take on the appearance of carnivore tooth scratch marks and, when exposed to aeolian abrasion for a significant period of time, broken ends acquire a rounded form (Shipman & Rose 1983, 1988). Geological processes are known to alter bone surface. These include erosional wear caused by aeolian or fluvial action (Brain 1967; Olsen & Shipman 1988). One of the processes most commonly studied is sedimentary abrasion, which is created by pressure from the sediment causing the deposit to glide across the bone and thus abrade the bone surface (Olsen & Shipman 1988).

3. Trampling

When bones are stepped on, or trampled upon, physical changes are observed. Trampling usually exhibits characteristic surface polishing and shallow thin scratch marks, which are randomly positioned and found on bone shafts (Behrensmeyer *et al.* 1986; Olsen & Shipman 1988; Shipman & Rose 1988). Trample marks are usually oriented transverse to the long axis of the shaft (Villa *et al.* 2005). They have the tendency of mimicking 'human-made' cutmarks but do not possess multiple internal striations common in cutmarks (Andrews 1995; Marean & Ehrhardt 1995).

4. Insect action

Insect modification on bones is characterised by smooth, rounded, concave pits on the bone surface (Andrews 1995). Modification by insects has also been described as producing shallow meandering furrows (Behrensmeyer 1978).

5. Sediment compaction

Sediment compaction results in plastic deformation of bone. Sedimentary modification is distinguished from other cultural alterations by its widespread occurrence over the shafts of long bones, irrespective of muscle origins and insertions or other attachments of soft tissue of the bone (Olsen & Shipman 1988).

6. Burning

Indication of fire (burning) is a significant topic in human evolution studies. The presence of burnt bone in an early hominid context could carry implications about hominid behaviour. Burnt bone, however, is not limited to hominid activities. It can occur as the result of veldt fires. Surface colour alteration, cracks and loss of microstructure and carbon deposits are key to differentiating between bone burnt through human intention and otherwise (Brain 1993; Bennet 1999; Hanson 2005). Bone remains from the hominid site of Swartkrans demonstrate different phases of burning and their various effects on the bone. Buff coloured bones are suggestive of brief, low intensity heating, while additional heating at higher intensity levels may cause bone to carbonise (indicated by a dark brown colour) and ultimately calcine, acquiring a whitish colour (Klein & Cruz-Uribe 1984; Brain 1993). Loss of bone microstructure is recognised as a factor of heating at very high temperatures. Cracking, another histological and macroscopic indicator of burning, is treated with caution because it is not solely associated with burning; it can be the result of post-depositional processes such as sediment compaction (Brain 1993; Shipman *et al.* 1984). According to a study conducted on the nature of burnt bone, all bone identified as burnt possessed visible accumulations of carbon (Hanson 2005). Therefore carbon accumulations are the best individual indicator of burning. Other factors such as matrix colour and cracking need to be considered in conjunction with carbon accumulations (*ibid*.).

7. Staining

Fossil bones usually lose their original cream colour. A taphonomic project conducted on bones in exposed conditions without vegetation demonstrated that the bones tend to be bleached white (Andrews 1995). Other colours result when bone is preserved in varied sediments. Manganese oxides are associated with rocks formed in shallow marine depositional environments (i.e. dolomites and limestone). When such rocks decay, bones in associated deposits acquire a black (or dark brown) colour (*ibid.*). Colour change has sometimes been misinterpreted as an indication of burning (Ogola 2003). However, the high carbon content of burnt bone distinguishes it from manganese-stained bone, which would be manganese rich, rather than carbon loaded (Sillen & Hoering 1993).

e) Adhering matrix

The nature of Goldsmith's site, a cave breccia site, makes it logical for one to take note of the presence or absence of breccia on the bone assemblage. This could provide an indication of whether the bones (and the stone tools) originate from just one infill or from various deposits. All bones were inspected for the presence of adhering breccia.

f) Excavation and preparation damage

Excavation and preparation can damage specimens and potentially erase critical information, which can also result in reduction of identifiable specimens. Post-fossilization damage has, in some cases, been erroneously interpreted as hominid induced damage (White & Toth 1989). A detailed study of the damage, the context of the find and associated bone alterations are factors to be considered before any conclusions can be drawn regarding the origin and nature of the modification. Bone remains from Goldsmith's site and many similar excavated cave sites in the Witwatersrand area have been exposed to two human-induced post-depositional damage processes: lime mining operations in the early 1900s, and excavation and/or preparation damage. Limeminers' methods of extracting the mineral (lime) from the caves involve drilling holes and subsequent blasting of dolomite, lime and breccia with explosives, which resulted in damage to some of the fossils. Researchers often must conduct excavation with picks, spades and jack hammers, which also produce damage to some bone surfaces. These types of damage however, are clear as they leave fresh marks or breaks, which are whiter in appearance, as compared to pre-fossilisation modification. A portion of Goldsmith's fossils has been developed from solid breccia with air scribes or small chisels for identification purposes. The bones were prepared with care by experienced technicians, but even under the hands of skilled preparators, damage, especially to bones encased in breccia, is possible. Bone modification caused by lime-mining excavation and preparation damage varies from complete fragmentation, particularly of small and fragile bone to cracking and/or fracturing of bone and minor scratch marks on bone surfaces.

2.2iii. Measures of Skeletal Element and Individual Abundance

Skeletal element measures used in the process of cataloguing specimens provide the basis for understanding the relative abundance of faunal parts in the sample. Various quantification methods were used: Number of Identified Specimens (NISP), Minimum Number of Elements (MNE), Minimum Number of Individuals (MNI), comprehensive Minimum Number of Individuals (cMNI), Minimum Animal Units (MAU) and percentage Minimum Animal Units (%MAU), as described below.

1) A specimen refers to an individual bone piece in the sample. Specimen is a term applied here to define 'a bone, tooth or fragment thereof' (Grayson 1984: 16). For example, eight pieces of identifiable bone represent eight *NISP*. The *Number of Identified Specimens* (*NISP*) is therefore determined by the value of identifiable bone fragments. Appendix 1 provides the list of identified specimens with diagnostic morphological features for the Goldsmith's assemblage. Single tooth specimens were recorded as tooth enamel fragments or attributed to tooth type when a significant portion of the tooth was present.

2) The *Minimum Number of Elements* (*MNE*) was calculated with methods proposed by Bunn (1982; 1986) and Bunn & Kroll (1986). Grayson (1984: 16) defines element as 'a single complete bone or tooth in a skeleton'. The MNE was derived by counting specimens that are comparable in relation to taxon, bone portion, size and side. Bone specimens matching, in terms of these factors, were identified as single elements. Calculating the MNE is an essential step in determining skeletal elements and individual abundance as most measurements are derived from the minimum number of elements observed.

3) The *Minimum Number of Individuals* (*MNI*) represented by the elements in an assemblage is determined by establishing the least number of the individual animal/s represented by the bone specimens (Klein & Cruz-Uribe 1984; Grayson 1989). For example, eight complete femora (four left and four right) represent a minimum of four individuals as a complete skeleton consists of two femurs, a left and a right. MNI estimates do not necessarily have to match elements to a single animal. They are calculated to establish the minimum number of animal individuals represented in the assemblage.

4) *comprehensive Minimum Number of Individuals* (*cMNI*) has been applied by other researchers (e.g. Pickering 1999) as a derivative of the MNI. Elements corresponding in terms of taxon, side, size and age are more likely to represent the same or different individuals. Therefore cMNI is a further match of bone elements to determine if they belong to single or different individuals. Pickering (1999: 16-17) provides an example of the concept:

> "If nine cervical vertebrae of *Papio* were represented in a faunal assemblage, then the MNE for *Papio* cervical vertebrae would equal nine.

> The “traditional MNI” for baboon cervical vertebrae would then be calculated to two, because an individual baboon possesses only seven cervical vertebrae so at least two individuals must have contributed to an assemblage with nine cervical vertebrae. But if, side-by-side comparison of the specimens showed that three of the pieces were juvenile, another was much larger than the other preserved specimens and the remainder were from a medium-sized adult, the MNI could (should) be raised to three to accommodate those differences”.

5) *Minimum Animal Units* (*MAU*) *and percentage Minimum Animal Units (%MAU).* The *Minimum Animal Unit (MAU)* is a measure of skeletal part abundance presented by Binford (1984) in an attempt to determine if carcass portions were dismembered and preferentially transported by humans. For example, a living animal possesses two proximal humeri, therefore the MNE count is divided by two so that ‘the frequency of animal units is expressed’ (Binford 1984: 51). MAU, therefore, is a measure of the minimum number of animal body parts necessary to account for elements observed (Binford & Bertram 1977). To arrive at an MAU, the MNE is divided by the number of times the bone element occurs in a skeleton. To calculate the %MAU, a 100 percentage is assigned to the highest MAU and the rest of the MAU values are adjusted against the 100 percentile, as per taxon or size category

2.2iv. Bone Shaft Fragments and Bone Fracture Attribute Analysis

1a) Bone fragments

Refitting of bone fragments has proved useful in measuring skeletal elements and in improving the accuracy of calculating the Minimum Number of Elements (MNE) (Bunn 1982, 1986; Bunn & Kroll 1986). Refitting bone pieces reduces the Number of Identified Specimens (NISP) while potentially increasing the Minimum Number of Elements (MNE), as has been apparent in most research employing these measures of skeletal elements (e.g. Pickering 1999; Kibii 2000; Ogola 2003). Refitting of fragments is a very time-consuming task, as every piece that corresponds to a single element has to be matched with others. Only eight bone fragments have been re-fitted in the Goldsmith's faunal assemblage. Eight other pieces correspond as elements belonging to the same individual.

Bones processed from breccia blocks are complete, and most did not display damage from excavation (neither by lime mining nor by the recent excavation for this project). However, most bones from the loose infill indicated the opposite. All of the unidentifiable fragments (i.e. fractured bone) were from the loose earth. Most of the unidentifiable specimens are long bone shaft fragments, which have no defining morphology. Complete bones of the hands and feet were, however, recovered from the loose deposit.

1b) Long bone shaft fragments

Long bone shaft fragments are long bone diaphyses greater than or equal to 4cm, with no preserved articular ends (Brain 1974, 1981; Villa & Mahieu 1991; Pickering 1999). These include portions of skeletal elements such as the humerus, femur, radius, tibia and fibula of macro-mammalia and equid and bovid metapodials (Pickering 1999). Unidentifiable long bone shaft fragments were classified with other unidentified specimens as unidentifiable bone fragments.

2) Bone Fracture Attribute Analysis

A bone fracture attribute refers to the morphology, impact scars and marks associated with bone breakage (Villa & Mahieu 1991). For this study, I utilized Villa and Mahieu's (1991) model of bone fracture analysis in archaeological assemblages in France. It is important to note that their study was conducted on human long bones whereas the Goldsmith's long bones sub-assemblage consists of various macro-fauna. Pickering (1999) points out that human long bones are relatively longer and straighter than artiodactyls, perissodactyls, non-human primates and carnivores. Pickering (1999) also notes that the differences in bone architecture may affect bone breakage patterns differently between humans and other taxa. Therefore this model is applied with caution to non-human long bone fracture patterns due to absence of other detailed studies on long bone fracture attributes in other taxa.

Villa & Mahieu (1991) studied three Upper Paleolithic archaeological sites to determine the effects of processes that led to bone breakage in the three locations. Their analysis was conducted on materials from archaeological sites in Southern France: Sarrians, Fontbrégoua and Bezouce. A brief explanation of the three sites is important here as a means of comparison between the three sites and Goldsmith's:

1) Sarrians, a collective burial with bones broken *in situ* by pressure from the deposit.
2) Fontbrégoua, a cave site with bones displaying 20% frequency of human impact notches and 30% stone tool cutmarks; a site argued to represent cannibalism.
3) Bezouce, a collective burial with 22 individuals. The site possesses a large proportion of breaks caused by a pick and shovel of an amateur archaeologist and the landowner.

Villa & Mahieu (1991) developed five criteria with which to assess whether bone was broken when fresh/green or dry.

a) *Fracture outline* attributes can occur as one of the following three states

1. a *transverse* fracture is a straight break in line with the width. Transverse fractures are associated with dry bone breakage.

2. a *curved* fracture pattern is spiral, and sometimes occurs in combination with V-shaped or pointed breaks. Spiral fractures occur when bone is broken in a green or fresh condition.
3. *intermediate* fractures do not fit 'neatly into the transverse, curved or V-shaped classes' (Villa & Mahieu 1991: 36).

b) *Fracture angle* refers to the angle formed by the fracture surface and the cortex surface. Three angle states have been recorded:

1. *oblique* (obtuse or acute) angles, which are associated with fresh or green bone break.
2. *right* angles, which occur when dry bone fractures.
3. *oblique and right angle* which are assigned to breaks with variable angles (i.e. those which do not fall solely into oblique or right angle categories)

c) *Fracture edge* is the consistency of the fracture fringe. Smooth fracture outlines are associated with green bone while dry bone produces jagged edges when it breaks.

d) *Shaft circumference,* a concept developed by Bunn (1983), is divided into three attribute states. The shaft circumference principle excludes complete long bone shafts. Only bones with incomplete shaft portions are accommodated in this criterion. The three states are as follows:

1. The preserved shaft circumference is less than half the original circumference (< 50%)
2. Shaft circumference is more than half (> 50%) in a portion of the bone length
3. 100% of bone shaft circumference is present in a section of the bone length

An assemblage with high frequencies of complete diameters is indicative of an accumulation of post-depositionally broken bones. This conclusion is however reached in consideration of other attributes mentioned in this section. Hyaenas, as mentioned, crunch on bone, hominids also break open bone for marrow processing; therefore an assemblage accumulated by these agents would render shaft fragments incomplete.

e) *Length/breath* ratios of bones with a length of ≥ 4cm and a breadth of < 100% of the shaft diameter were calculated. Elongate splinters (i.e. fragments that are longer than they are wide) can be the result of percussion on green bone. Sub-fossil bone breaks in short splinters. It is important to note that larger bones (humeri and femora) produce larger length/breadth ratios than thinner bones such as radii and ulnae. Thus high length/breadth ratios can be the effect of bone type and not necessarily the consequence of perimortem or postmortem effects. Therefore, for bone fracture attribute analysis in the Goldsmith's assemblage, larger bones such as tibiae and femora were measured separately from narrower bones (e.g. fibulae and radii).

A bone specimen may possess more than one fracture attribute (criteria numbers a-d) and therefore the number of attributes noted will not be representative of the number of specimens but of the attribute states observed. Only long bone shaft fragments 4cm and more were included in the analysis of bone fracture attributes. Bone shaft fragments with complete circumferences were excluded from the analysis. While most of the specimens displayed pre-fossilized fractures, some of the fractures observed were recent and were therefore not considered for bone fracture attribute analysis.

Table 1. Absolute values of Bone Fracture Attribute Analysis for Villa & Mahieu's (1991) sample.

Attribute states	Sarrians	Bezouce	Fontbrégoua
Fracture angle			
Oblique	22	27	114
Right	176	174	47
Right & oblique	71	52	13
Total	**269**	**253**	**174**
Fracture outline			
Transverse	193	144	92
Curved & V-shaped	74+32	59+23	42+92
Intermediate	59	61	35
Total	**358**	**287**	**261**
Fracture edge			
Smooth	111	158	163
Jagged	247	129	98
Total	**358**	**287**	**261**
Shaft circumference			
1) <50%	16	33	115
2) >50%	10	0	23
3) 100%	200	60	13
Total	**226**	**93**	**151**