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1 INTRODUCTION

It is said that the history of mankind is like a novel with most of its pages torn or lost. The few pages of information we have, are based upon fossil evidence leading to scientific facts as well as educated guesses.

Fossilized bones have been excavated worldwide from sites, caves and shelters where ecological factors permitted such preservation. South African caves in particular have yielded essential specimens, helping to reconstruct the past. A few examples include the famous Sterkfontein caves [5,6,7], Kromdraai [8,9], Swartkrans [10,11], Makapansgat [12,13] and Florisbad [14,15]. These sites date back several million years, shedding light on early man and its descendants. There are, however, little information on the origin of Anatomically Modern Humans. Only a few sites present chronologies dating back to upper Pleistocene, the era believed to be fundamental in the evolution of anatomical modern *Homo sapiens*. Sites and caves falling within this expected time period include Rose Cottage cave [16,17,18,19], Sehonghong [20, 21], Border Cave [22,23], Klasies River Mouth [24,25] and Kemp's Caves [1,26].

Kemp's Caves are situated in the Krugersdorp area in the Ngonyama Game Reserve. It was accidentally discovered in 1991 and has yielded a large quantity of fossilized and modern faunal material during ongoing excavations. Electron spin resonance (ESR) dating revealed dates as young as Holocene (6.1 ± 0.4 ka) to Upper Pleistocene (140 ± 8 ka)[1]. Southern African caves, however, do not contain volcanic material which accommodate the accurate geological dating of sites [27]. This presents difficulty in acquiring absolute dates. Therefore, to confirm the ESR dates, other methods of dating are required. One of these methods is comparative faunal analysis, which provides relative dates. Identification of an extinct faunal species is of especially great importance, for it may enhance the accuracy of the cave date, and give an indication of how the climate and environment may have changed during this crucial era in human evolution [3,4].

Faunal identification does not only give insight into the cave's elapsed time, but also supplies data on the taphonomy of the cave. Taphonomy is the study of how bones came to be buried at a specific location [27]. Animals collect bones for various purposes, but the majority of assemblages are collected by predators for sustenance [2]. Identification of the predator (man or animal) responsible for the accumulation of the cave's assemblage reflects the diet and behaviour of that species. Modification, such as gnawing and cut marks, of the faunal specimens also gives an indication as to which species were responsible for the collection of bones [3,28]. The different species identified in the faunal assemblage may also reflect the climatological conditions and the ecology present during the different periods of influx into the cave by knowing the general diets of these animals [29,30,31].

Faunal analysis is a crucial tool in the investigation into the complexity of caves. How, and under which circumstances they developed, as well as the mysteries they contain yield important information of the cave's inhabitants. Kemp's Caves in particular may yield invaluable information pertaining to our existence, as this site falls within the critical period for the origin of Anatomically Modern Humans.

Faunal analysis is, however, a time consuming and tedious task. A single specimen is identified to part and side of the skeleton and if possible to the species it belongs to. This is done by an expert comparing morphological characteristics of the

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excavated piece to its modern counterpart [3,4]. However, osteological measurements often constitute the only method of accurate identification. This, for example, is the case when sheep and goat specimens are analysed within the same faunal assemblage [32]. Since identification of skeletal specimens is thus possible by using metrical data, it may be possible to use a database of measurements to identify faunal specimens of an excavation site. Therefore, an investigation into possible computerized identification utilizing absolute osteometric values may yield a method which can be useful when a preliminary faunal list of a site is needed. This method may not be as accurate as the eye of an expert, but will certainly give a good idea of the faunal species present in an excavation.

The two aims of this study were to firstly analyse the faunal remains of Kemp's Caves with regard to the ESR dating, climatic changes in the area and the taphonomy of the cave. Secondly, it was to investigate the possibility of computerized identification of bones. These aims could only be achieved by conducting the study in three different stages:

Stage I: *The analysis of the faunal remains of Kemp's Caves.*

This stage of the study entailed the morphological identification and analysis of the macrofaunal remains of Kemp's Caves. The interpretation of this data included climatological, ecological and taphonomic aspects, as well as possible confirmation of the ESR dates. This may give an idea of the conditions and environment during the evolution of Anatomically Modern Humans.

Stage 2: The collection of skeletal measurements and the development of a computerized programme for possible identification of bones.

During this stage of the study it was attempted to ascertain whether bones could be identified exclusively according to measurement values. Because this is a new method, only the hind limb long bones of Southern African bovids were measured as a pilot study. Measurements to significantly differentiate between hind limb long bones of Southern African Bovidae were determined. Modern specimens of several South African museum collections were then measured and values were entered into a database. This data was used in the development of a computer programme for osteometric identification using the abovementioned measurements. Statistical analysis was done on all osteometric data obtained.

Stage 3: Testing the computerized identification of bones.

The computerized programme developed in Stage 2 was tested for accuracy and reliability on a few of the bones of Kemp's Caves by comparing the computerized results with the results obtained by the conventional methods in Stage 1. As only a few measurements were available for the Kemp's Caves specimens, it was decided to use modern specimens of known identification (of which all measurements could be taken) to also be compared to the computerized results.

2 LITERATURE

1. INTRODUCTION TO KEMP'S CAVES

Kemp's Caves are situated approximately 2 km west of Krugersdorp (26°04'51" S, 27°42'20" E) in the Ngonyama Game Reserve (see Figure 2.1). The caves were accidentally discovered through a series of events during 1991. A game ranger of the reserve stumbled upon a modern human skeleton in an area situated across the lion camp. As part of the police investigation to identify the remains, the expertise of Dr VD Kemp (coroner of the University of the Witwatersrand) was required. Dr Kemp visited the site and immediately realized the abundance of fossil material present in the area. This was reported to Prof M Henneberg at the University of the Witwatersrand, who started excavations in 1992. After Prof Henneberg left the country in 1996 research at the caves has been continued by the Department of Anatomy of the University of Pretoria [1].

The dolomitic ridge revealed a series of complex open caves, which was named after Dr Kemp. The caves are typical of the dolomitic caves formed in this area and run approximately from NW to SE [33]. Analysis by Keyser indicates a young cave age, due to the caves' position above water level [26]. This is based on the geological theory that the higher the cave (closer to the water table) the younger it is. It is thus assumed that the Kemp's caves are relatively young due to the fact that the Rietfontein stream is almost at the same level as entrance of the cave.

The caves contain fossiliferous breccia in various stages of calcification and decalcification in its walls, roof and floor [1]. Breccia often falls from the roof to the floor creating difficulty to analyze the date of the specimens according to layers in which it was first deposited.

Figure 2.1 is a simplified illustration of some of the important cave sites of South Africa and includes some older fossil sites as well. It clearly shows the close proximity of Kemp's Caves to the "Cradle of Mankind" sites in the Gauteng province.

FIGURE 2.1: Cave and excavation sites in South Africa

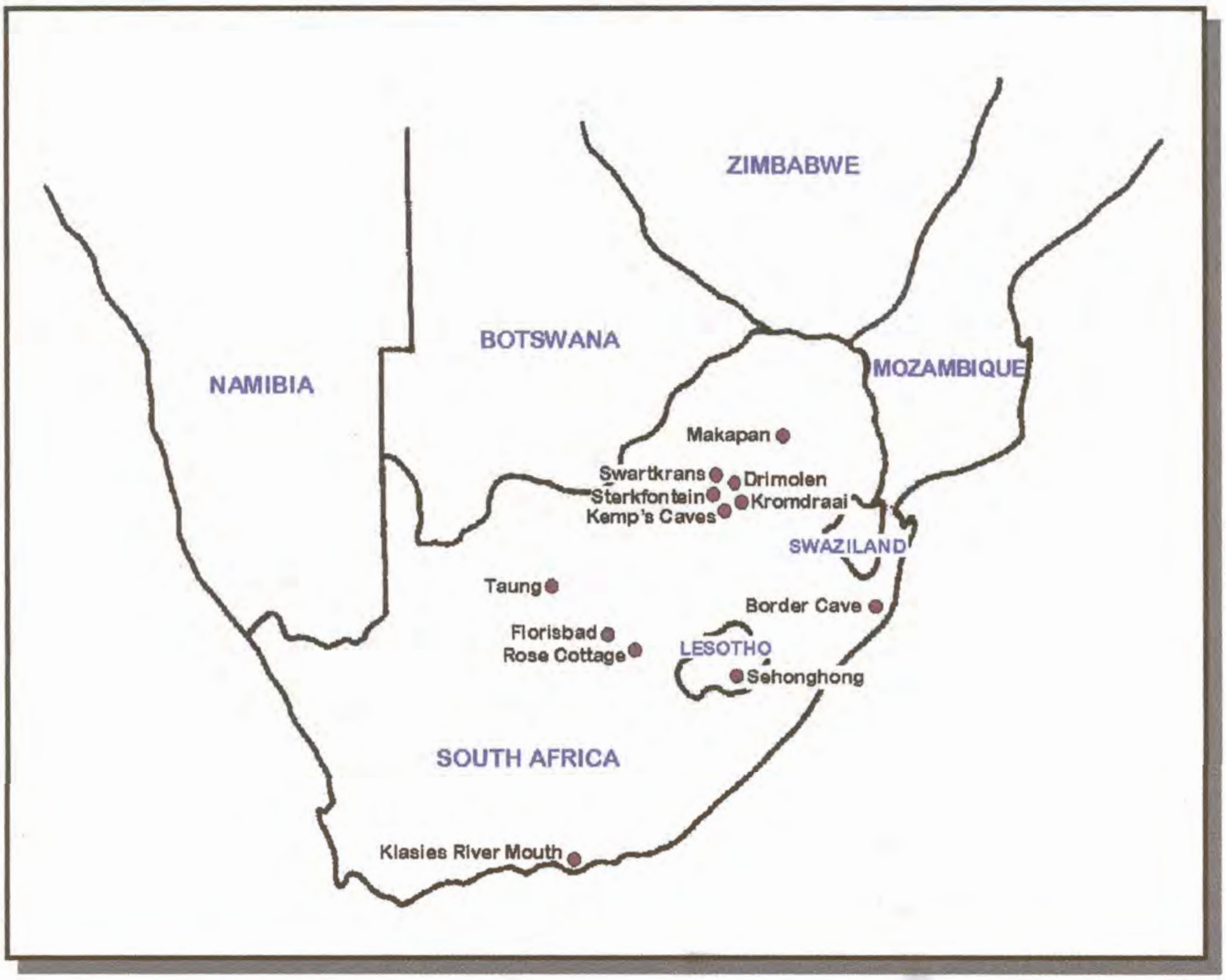

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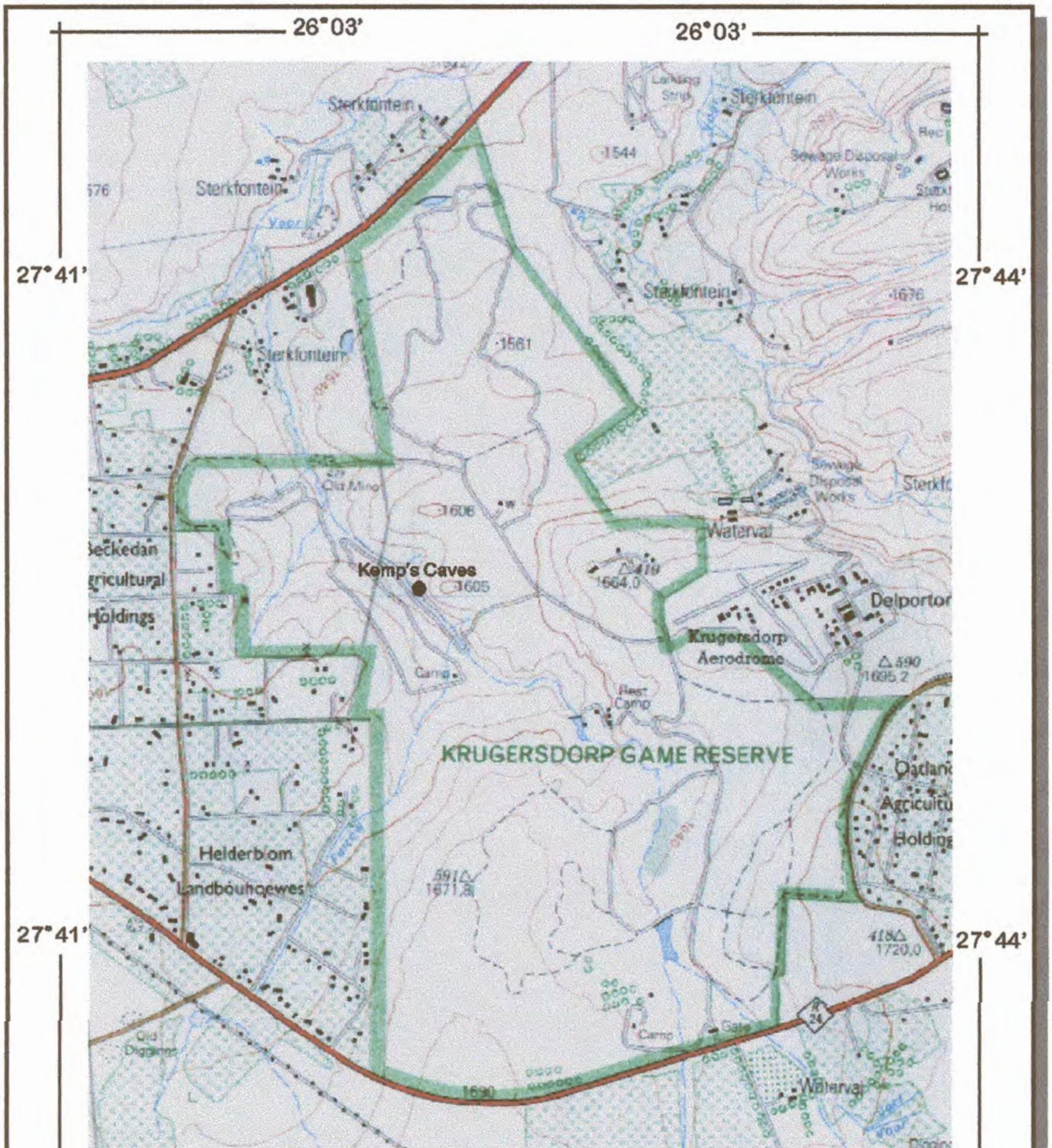
Figure 2.2 shows the Ngonyama Game Reserve (former Krugersdorp Game Reserve) 2 km west of Krugersdorp, with the location of Kemp's Caves.

FIGURE 2.2: Ngonyama Game Reserve (Copyright State 1997)



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Kemp's Caves is comprised of three separate caves:

❖ Upper Kemp's Cave (UKC)

UKC was initially identified as a rock shelter [1]. It is mostly filled with collapsed rock and extends at least 7m into the ridge [33].

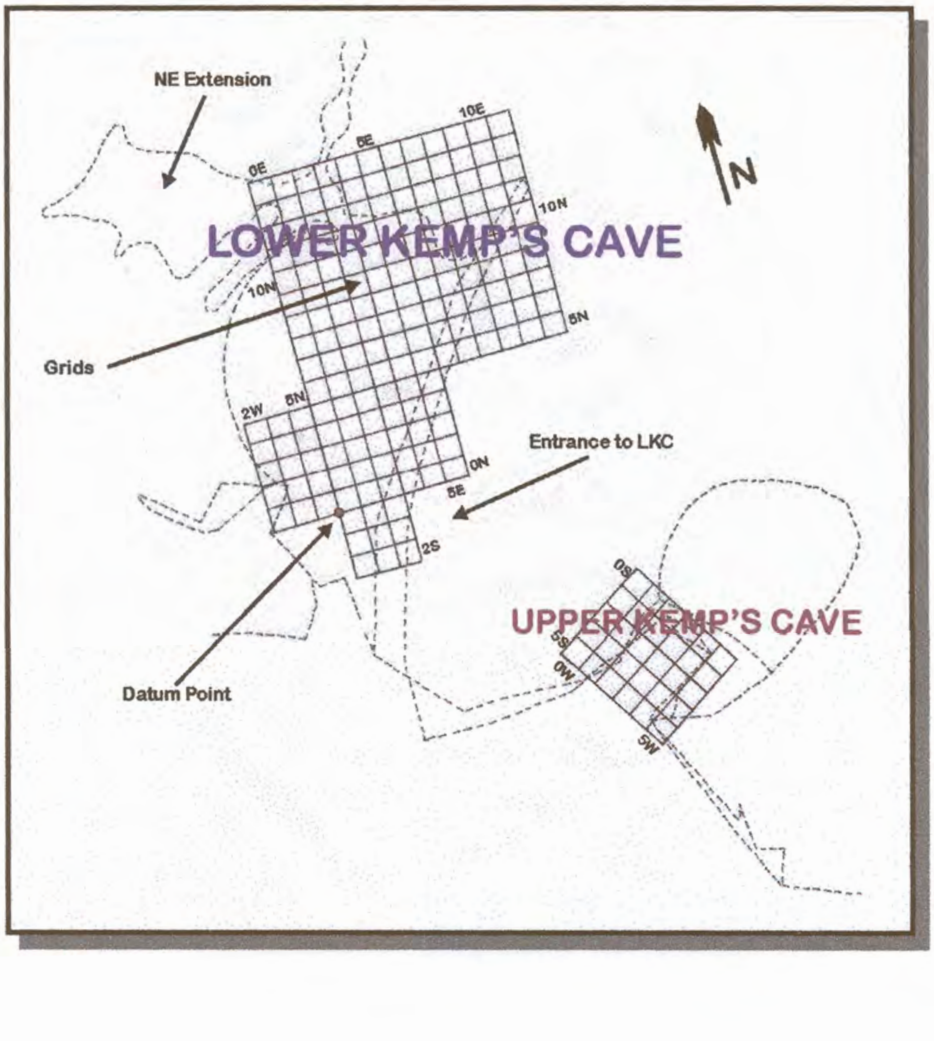
❖ Little Western Cave (LWC)

LWC is situated to the south of the entrance of UKC. It is approximately 2m long, 1m high and 1m wide [33].

❖ Lower Kemp's Cave (LKC)

This is the largest cave, situated 20m south west of UKC [1]. It is approximately 15m long and 10m wide. The height differs at separate locations in the cave and ranges between 0.1 - 5m [33]. Material retrieved from LKC was used for this study.

FIGURE 2.3: Upper and Lower Kemp's Caves



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Initially a grid system was built using a datum point (designated as "0") established near the middle of the entrance of LKC. In this system, for example, a square lying 6m to the North and 2m to the East from this datum point is labeled 6N2E [33].

Problems such as the irregularity of the cave and the theft of the wires contributed to the fact that there is no permanent grid at LKC [26]. The assemblage was excavated using archaeological methods, and all material was screened through rough and fine mesh. Breccia blocks were assigned to provenance and prepared in the laboratory by using mechanical and chemical preparation techniques [1]. Only parts of LKC have been excavated, thus there are still abundant breccia to be recovered.

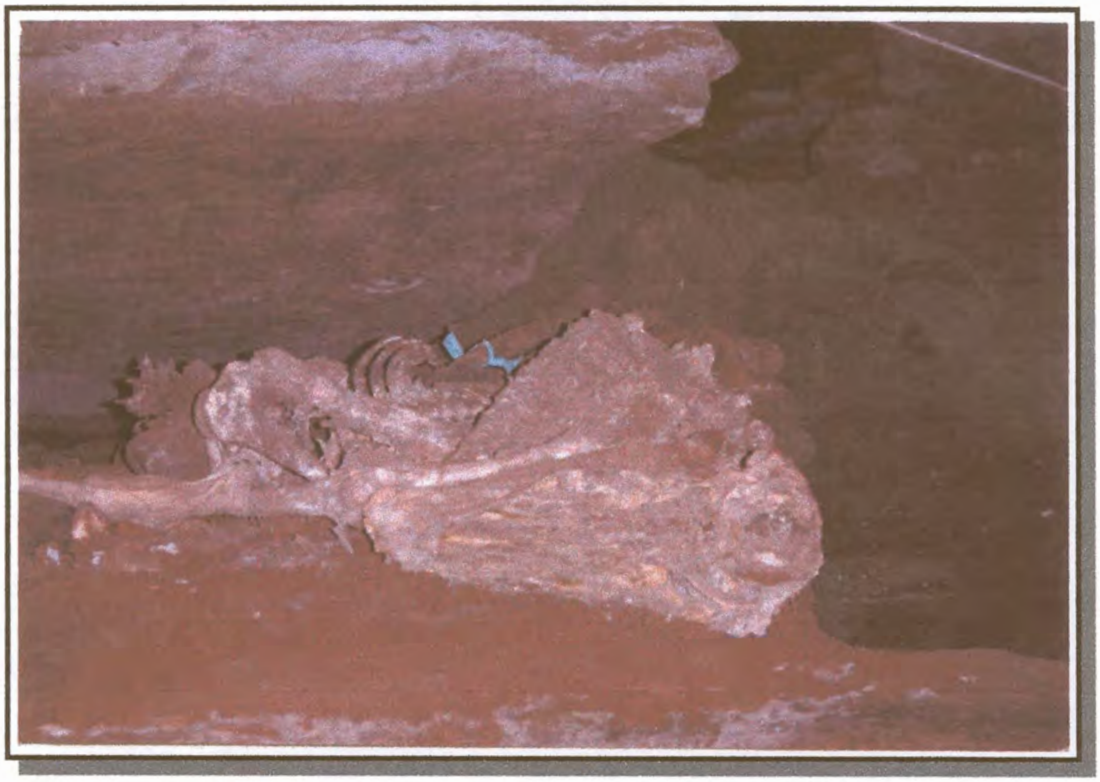
Figures 2.4, 2.5 and 2.6 are photographic representations of the entrances of UKC, LWC and LKC respectively. Figure 2.7 shows a juvenile Eland skeleton located deep within LKC, a more recent attribution to the cave's contents.

FIGURE 2.4: Entrance to Upper Kemp's Cave (Copyright University of Pretoria)

FIGURE 2.5: Entrance to Little Western Cave (Copyright University of Pretoria)

FIGURE 2.6: Entrance to Lower Kemp's Cave (Copyright University of Pretoria)

FIGURE 2.7: Juvenile Eland skeleton in Lower Kemp's Cave (Copyright University of Pretoria)



The modern human skull discovered at the site exhibits physical features resembling the San people. It is that of a young adult male aged 22-27 years. The fractured skull has porcupine gnaw marks on the frontal, zygomatic, temporal and maxillary bones. A clay bowl, corresponding to pottery usually attributed to the Sotho-Tswana people, was found in close proximity to the skull [1,26].

Artifacts such as animal bones, pottery, charcoal, glass, metal wire, as well as a Late Stone Age chert scraper (52mm X 26mm), were unearthed at the entrance of the cave. There were also a few fragments of the skull found at the cave, near these artifacts. Reconstruction of some of the glass fragments yielded a 'marble stopper' type bottle, commonly used earlier this century. Other human remains excavated at the site include carpals, tarsals and phalanges of both hands and feet, ribs and several teeth of a young adult of uncertain sex. These modern human remains were

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excavated by the University of the Witwatersrand and is still part of their collection. A rusted nail, broken earthenware pot and a complete Middle Stone Age spear point was also found in the vicinity of these human skeletal remains. A lower third molar belonging to an adult aged 25-35 years originated from a small ash-filled crevice in the rock in LKC. The molar was worn to the second degree, and quite large in size [26].

Presently the Department of Anatomy at the University of Pretoria is excavating in Lower Kemp's Cave which exhibits the most fossil material. Although no ancient hominid bones have as yet been discovered, Kemp's Caves fall within the expected time period for the origin of anatomical modern humans and may still yield specimens which could shed light on the evolution of anatomical modern humans [1].

Little is known about this era in human evolution. A large number of fossiliferous caves and shelters have been identified and investigated in Southern Africa, but only a few have chronologies dating back to Upper Pleistocene [34]. Aspects such as Upper Pleistocene environmental changes [35], MSA assemblages and interpretation of human behaviour [36], as well as origin, locality and demographic shifts [37] are still being debated because of the insufficient representation of this era in the fossil record.

Klein describes palaeoanthropology as a historical science, which interprets and reconstructs the life of extinct humans from their preserved skeletal anatomy. It then also assumes their behavior and the processes that shaped them but, in comparison with other evolutionary disciplines, the data is always meager [38]. Therefore, compared to the evolution of animals, the history of man is still poorly represented in the fossil record but every discovery sheds new light on old theories.

A number of contradicting theories regarding the geographical origin of

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modern humans exists. One theory is "multiregional evolution" which states that modern humans evolved semi-independently in Europe, Asia and Africa [39]. Another theory is known as the "Out of Africa" hypothesis that argues that modern humans evolved in Africa, migrated to Eurasia later and replaced the people living there [40]. Walter et al [41] argued that not only did early modern humans originate in Africa but evidence at the Red Sea coast suggests that the first modern humans occupied mostly coastal areas. Kemp's caves contain fossils from the time period in which anatomical modern humans evolved. If hominid remains are found at Kemp's Caves it may yield important information in this respect, being an inland site with dates of this era. The lack of significant human and natural disturbance of the fossil bearing deposits may, on the other hand, also be important to substantiate the theory of Walter et al [41].

2. ECOLOGY OF KEMP'S CAVES

Ecology is described as the scientific study of living things in relation to each other and to their environment [42]. The close interrelationship between fauna, flora, climate and geology, therefore assists the scientist in the understanding of the environment and time in which cave deposits occurred.

McKee [43] remarks that any environmental changes, apparently associated with hominid evolution, are revealed in part by the animals that changed, or did not change, within the same local context. Faunal analysis can therefore, either corroborate or challenge ecological hypothesis. This provides an important context for the appearance of the genus *Homo* and associated artefacts within a biotic community. Climatological [29,30,31] and geological [61] studies will therefore shed some

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light on the origin of anatomical modern humans. Thackeray [30], however, reminds that although fossil remains may facilitate environmental reconstruction, the fossil record represents only a portion of the animals that lived at the time of the deposition.

Consequently, the ecological significance of the fauna is subject to varied interpretations. It is therefore essential to corroborate evidence of all faunal elements from a site [43].

The regional ecology is thus of great importance to have a clear understanding of the faunal assemblage, taphonomy and the processes that have been busy changing and creating Kemp's Caves and the immediate area surrounding the cave. Geology, the climate, as well as the fauna and flora (veld types - past and present) give the essential background required for analysis.

2.1 Geology

Approximately 3500 - 2500 million years ago, the oldest rock formations in South Africa developed. They belong to the Archaean time period (Table 2.1). These formations constitute the basement or floor on which the younger sediments were deposited. Large masses of granite, called greenstone belts, intruded into older belts of volcanic and sedimentary rocks. These formations form an ancient greenstone terrain which underlies a large part of the country.

The granite-greenstone basement, together with it's younger cover rocks, form the Kaapvaal Craton. This ancient core of continental crust has remained relatively undisturbed since Archaean times [44].

TABLE 2.1: Geological time scale adapted from Viljoen & Reimold [44].

EON	ERA	PERIOD	EPOCH	MYA
PHANEROZOIC	CENOZOIC	QUATERNARY	HOLOCENE	Recent
			PLEISTOCENE	1.6
		TERTIARY	PLIOCENE	5
			MIOCENE	23
			OLIGOCENE	35
			EOCENE	56
			PALAEOCENE	65
	MESOZOIC	CRETACEOUS		145
		JURASSIC		208
		TRIASSIC		245
	PALAEOZOIC	PERMIAN		290
		CARBONIFEROUS		365
		DEVONIAN		405
		SILURION		440
		ORDIVICIAN		520
		CAMBRIAN		570
PRECAMBRIAN	PROTEROZOIC	LATE		900
		MIDDLE		1600
		EARLY		2500
	ARCHAEAN	LATE		3000
		MIDDLE		3400
		EARLY		

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Between 2600 and 2250 million years ago, during the Proterozoic (Table 2.1), a large part of the Kaapvaal Craton was submerged by an inland sea. Older formations like the Ventersdorp lavas (huge volumes of lava flowed with interlayered sediments) were covered by a widespread sequence of sediments, known as the Transvaal Supergroup. Kemp's Caves fall within this geological group. These rocks were deposited in a large sedimentary basin [44]. This probably happened during the first major marine transgression over the continental mass in the Late Archaean [45]. It extends roughly between Mafikeng in the west, Nelspruit in the east, Pietersburg in the north and Vredefort in the South [44].

The lowest rocks of the Transvaal Supergroup consist mainly of quartzite. In many places it contains a narrow, dark-coloured quartz-pebble conglomerate known as the Black Reef. It is this conglomerate that carries gold [44].

Carbonate sediments, Malmani dolomite, accumulated in a shallow sea after deposition of the Black Reef. These distinctive carbonate rocks (dolomite and limestone) contain stromatolites, which were formed by ancient organisms similar to present-day algal colonies. The Malmani dolomites contain numerous caves. The caves have formed recently in geological time as a result of dissolution of the carbonate by penetrating groundwater. Dissolution occurred particularly along fractures in the rock. Sterkfontein, Swartkrans and Kromdraai are well-known caves found within these sediments. Although these dolomite cave formations have made these areas of South Africa the famous "Cradle of Mankind", it also poses a problem in certain parts of the country where the surface collapses as a result of dissolution, causing sinkholes [44]. Lead, zinc, vanadium and fluorite mineralization occur within the Malmani dolomite, making it economically favourable for mining [45].

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2.2 Climate

The climate of any place on earth is controlled by three important factors [46]

❶ Latitude.

❷ Position relative to the distribution of land and sea.

❸ Height above sea level.

Other factors such as general circulation of the atmosphere, ocean currents, the nature of underlying soil, vegetation cover and orientation relative to hills or mountains influence the climate and each other [46].

Kemp's Caves fall within the Northeastern corner of the Highveld climatic region. It is in close proximity to the Northern Transvaal region. The average precipitation of this region currently varies from 900mm on its eastern border to 650mm in the west. The rainfall is almost exclusively due to showers and thunderstorms which is characterized by short periods of considerable rainfall. These storms are often violent with strong, gusty south-westerly winds. The winter months are normally dry and about 85% of the annual rainfall occurs in the summer months from October to March. Rain is sometimes accompanied by hail [46].

The average daily temperatures range from 27°C in January to 17°C in July. In extreme cases it may rise to 38°C and sink to -10°C respectively. For an average of 120 days during may to September, frost is likely to occur. On average winds are light except when accompanied by thunderstorms. The sunshine duration in summer is about 60% and in winter 80% of the possible. Average sunshine hours per day are between 8 and 9 hours [46].

2.3 Flora

Vegetation is made up of individual plants, few or many, according to their habitat, which belongs to a number of different species. A balance is maintained at a level of development determined by the locality or environment of living together, competing with and assisting each other. A unit of vegetation whose range of variation is small enough to permit the whole of it to have the same farming possibilities is defined as a *veld type*. Acocks developed the classification of 70 veld types, plus 75 variations for South Africa [47].

A survey conducted in 1950 classified the area around Kemp's Caves as being part of sour grassveld vegetation. Vegetation changes according to the way it is treated, and Acocks is of opinion that little or no vegetation in South Africa is in its original condition. Several theories on the vegetation during past and future eras, place Kemp's Caves on the border of different vegetation patterns. Around A.D. 1400 Kemp's Caves were probably situated on the border between bushveld and sour grassveld. Future probability (approximately 2050), positions Kemp's Caves on the junction of three veld types namely bushveld, sour grassveld and mixed grassveld. If vegetation in South Africa is under constant scientific management Kemp's Caves should be pure sour grassveld [47]. Sourveld is defined as being veld where the forage plants become unacceptable and less nutritious on reaching maturity, thus allowing the veld to be utilized for only a portion of each year [48].

Kemp's Caves fall specifically into Acocks veld type 61, called bankenveld. Bankenveld is classified as a false grassveld type [47]. Low and Rebelo edited a revised vegetation description of South Africa in 1996. According to the new edition, Kemp's cave fall within the Grassland Biome, which is dominated by a single layer of

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grasses, specifically veld type 34, Rocky Highveld Grassland. Bankenveld and Rocky Highveld Grassland is synonymous [49]. It is possible that this veld type was an open savanna of *Acacia caffra* (Common hook-thorn). In certain parts along its northern margin it is still open savanna, and sour bushveld regularly occurs on the rocky outcrops and hills.

Three variations of Bankenveld are recognized [47]:

➊ Western variation (sandy plains)

➋ Central variation (Witwatersrand area, high lying, largely rocky country)

➌ Eastern variation (sandy plains, but wetter than Western variation)

Kemp's Caves fall within the central variation. The rocks are mainly quartzite, shale, dolomite, chert and granite. The soils are poor and acid, and either stony or sandy. The winters are severely frosty. With regular burning the veld is particularly sour and virtually ungrazable in winter. On the rocky hills and ridges the vegetation is bushveld dominated by *Protea caffra* (Common sugarbush), *Acacia caffra* (Common hook-thorn), *Celtis africana* (White Stinkwood) and a large number of south bushveld shrubs. *Xerophyta retnervis* is a typical plant of the hills but in the sheltered valleys and sinkholes there are temperate transitional forests. Species such as *Kiggelaria africana* (Wild peach), *Halleria lucida* (Tree fuchsia) and *Leucosidea sericea* (Old wood) can be found in these forest areas [47].

Principal grass genera include *Schizachyrium* (Autumn grass), *Eragrostis* (Love grass), *Digitaria* (Finger grass), *Panicum* (Buffalo grass) and *Setaria* (Bristle grass). This veld type has a wealth of forbs and bushy plants and is closely related to the more mountainous parts of Lowveld Sour Bushveld, but it is drier and less hot [47].

Table 2.2 shows a detailed list of the characteristic species of this veld type. Kemp's Caves are situated next to the small Rietfontein river, in a rocky mountainous, forest area at an altitude of approximately 1550m.

TABLE 2.2: Kemp's Cave area plant species as listed by Bredenkamp & van Rooyen [49]

NATIONAL NO.	SPECIES	
	A. GRASSES	
	Trachypogon spicatus	Giant speargrass
	Diheteropogon amplectens	Broadleaf bluestem
	Schizachyrium sanguineum	Red autumngrass
	Andropogon schirensis	Stab grass
	Loudentia simplex	Common russet grass
	Tristachya leucothrix	Hairy trident grass
	Panicum natalense	Natal panicum
	Bewsia biflora	False love grass
	Digitaria tricholaenoides	Purple finger grass
	Digitaria monodactyla	One-finger grass
	Sporobolus pectinates	Fringed dropseed
	Harpochloa falx	Caterpillar grass
	Ctenium concinnum	Sickle grass
	Rendila altera	Toothbrush grass
	Alloteropsis semialata	Black-seed grass
	Monocymbium ceresiiforme	Boat grass
	B. DICOTYLEDONOUS FORBS	
	Sphenostylis angustifola	Wild sweetpea
	Acrotome hispida	Rough-hair sage
	Senecio venosus	Broom ragwort
	Senecio coronatus	Ragwort / Canary weed
	Justicia anagalloides	
	Pentanisia angustifola	
	Pearsonia cajanifola	
	Indigofera comosa	
	Xerophyta retinervis	
	Alcalypha angustata	
	Vernonia oligocephala	
	Cheilanthes hirta	Parsley fern

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TABLE 2.2: Continue

	C. NON-GRASSY FORBS	
	Scilla nervosa	Wild squill
	Rhus rehmanniana	Bluntleaf current
	Rhus discolor	Gwarrie
	Vernonia natalensis	
	Berkeya setifera	Disseldoring
	Helichrysum oreophilum	Sewejaartjie
	D. WOODY VEGETATION	
162	*Acacia caffra*	Common Hook thorn
387	*Rhus leptodictya*	Mountain karee
392	*Rhus pyroides*	Common Wild current
396.1	*Rhus zeyheri*	Blue taaibos
657	*Ehretia rigida*	Puzzle bush
399	*Maytenus heterophylla*	Common spike-thorn
594	*Euclea crispa*	Blue guarri
253	*Zanthoxylum capense*	Small knobwood
471	*Dombeya rotundifolia*	Wild pear
87	*Protea caffra*	Highveld protea
39	*Celtis africana*	White stinkwood
447	*Ziziphus mucronata*	Buffalo-thorn
703	*Tapiphyllum parvifolium*	Small velvet leaf
702	*Vangueria infausta*	Wild medlar
710	*Canthium gilfillani*	Rock alder
537	*Combretum molle*	Velvet bushwillow
617	*Olea europaea*	Wild olive
463	*Grewia occidentalis*	Cross-berry

This Bankenveld veld type is transitional between typical grassland and bushveld. The distribution of woody elements is mostly influenced by the frosts during winter. Bankenveld was interpreted by Acocks as a fire-maintained grassland, therefore developing into savanna if fire was excluded [49].

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2.4 Fauna

The habitat of an animal is closely associated with the flora which occupies the area. The frequency of a specific species is therefore dictated by its feeding type which in turn is based on the flora available.

The Ngonyama Game Reserve has been surrounding the Kemp's Cave area since 1963. Certain species have been introduced to the area which may not have been naturally present before the recent habitat changes. A typical example is *Antidorcas marsupialis* (Springbok). This fact may complicate conclusions made from faunal material during climatological change and interpretation.

Earlier upper Pleistocene faunal remains which accompany MSA artifacts in Southern Africa are all reported to be overwhelmingly modern. Extinct species include three extinct genera, namely the giant Buffalo, *Pelorovis*, the giant Hartebeest *Megalotragus*, and the giant warthog *Stylochoerus*. Extinct species in surviving genera include *Equus capensis* (Giant cape horse/zebra), *Antidorcas australis* and *Antidorcas bondi* (springboks), *Hipparion* (three-toed horse), *Sivatherium* (short-necked giraffes), *Megantereon* (sabre-tooth cats) and *Theropithecus* (giant baboon) [37].

A species list combining information on animals which may have been present in the area in the past (du Plessis [50]), animals which normally occur naturally in this type of habitat (Smithers [51]), as well as the actual species found on the reserve are represented in Table 2.3. Only larger mammal species are shown. Most of the species in the list that occupied the Kemp's Caves area are still present in the Ngonyama Game Reserve.

TABLE 2.3: Species list of past and present larger mammals within the Kemp's Caves area

PRIMATES	
Homo sapiens	Human
Papio cynocephalus ursinus	Chacma baboon
Cercopithecus aethiops	Vervet monkey
CARNIVORA	
Proteles cristatus	Aardwolf
Hyaena brunnea	Brown Hyaena
Crocuta crocuta	Spotted Hyaena
Panthera pardus	Leopard
Panthera leo	Lion
Felis caracal	Caracal
Felis lybica	African wildcat
Felis serval	Serval
Vulpes chama	Cape fox
Canis mesomelas	Black-backed jackal
Aonyx capensis	Cape clawless otter
Melivora capensis	Honey badger
Poecilogale albinucha	Striped weasel
Ictonyx striatus	Striped polecat
Civetictis civetta	African civet
Genetta	Genet
Suricata suricatta	Suricate
Herpestinae	Mongoose
PERISSODACTYLA	
Equus burcelli ♦	Burchell's zebra
ARTIODACTYLA	
Phacochoerus aethiopicus ♦	Warthog
Potamochoerus porcus	Bushpig
Hippopotamus amphibus ♦	Hippopotamus
Giraffa camelopardalus ♦	Giraffe
Sylvicapra grimmia ♦	Grey Duiker
Raphicerus campestris ♦	Steenbok
Ourebia ourebia ♦	Oribi
Oreotragus oreatragus ♦	Klipspringer
Tragelaphus scriptus	Bushbuck

TABLE 2.3: Continue

Pelea capreolus ◆	Grey Rhebuck
Redunca fulvorufula ◆	Mountain Reedbuck
Redunca arundinum ◆	Reedbuck
Aepycyros melampus ◆	Impala
Antidorcas marsupialis ◆	Springbok
Hippotragus equines ◆	Roan
Damaliscus dorcas phillipsii ◆	Blesbok
Alcelaphus buselaphus	Red Hartebeest
Hippotragus niger	Sable
Connochaetes gnou ◆	Black Wildebeeast
Tragelaphus strepsiceros ◆	Kudu
Connochaetes taurinus ◆	Blue Wildebeest
Syncerus caffer	African buffalo
Taurotragus oryx	Eland
RODENTIA	
Xerus inourus	Ground squirrel
Paraxerus cepapi	Tree squirrel
Cryptomys hottetotus	Common molerat
Hystrix africeaustralis	Porcupine
Pedetes capensis	Springhare
LAGOMORHPA	
Lepus saxatalis	Scrub Hare
HYRACOIDEA	
Procavia capensis	Rock dassie
TUBULINDENTATA	
Orycteropus afer	Aardvark
PHOLIDOTA	
Manis temminickii	Pangolin

◆ Animals that occurred here in the past [50]

3. SITE DATING

Six heavily fossilized teeth prepared from breccia blocks from three different localities in LKC, as well as a seventh from *in situ* deposits were selected in 1996 for ESR (Electron Spin Resonance) dating [1]. Sample preparations and measurements

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followed conventional ESR laboratory procedures [52]. Fragments of enamel were mechanically removed from different locations on the teeth. The preparation of several sub-samples tested the uniformity as well as the possibility of contamination of the specimens. The result was dates ranging from 11 ± 0,6 ka to 140 ± 8 ka classifying it as Upper Pleistocene. The youngest date is Holocene in age and dates to about 6,1 ± 0,4 ka [1].

The ESR dates of the site should be confirmed with other methods of dating. It may be difficult considering the problems associated with the dating of Southern African sites, as the development and formation of these caves do not easily accommodate geological dating for absolute results [27].

Scientists use two kinds of dating methods:

❶ Chronometric / Absolute dating

→ gives a date of actual number of years [27].

❷ Relative dating

→ gives an idea whether something is older or younger than the other [27].

Faunal dating is a method of relative dating, thus giving no definite date in years. The rock matrix from which the bone was excavated can, however, be chronometrically dated if necessary. Faunal analysis can therefore be very informative when an extinct species is discovered. Knowing the approximate era in which this animal roamed the earth, gives an idea of the date of that particular section of the site [27]. Therefore comparative faunal analysis might aid in confirming the dating of Kemp's Caves.

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4. OTHER SOUTHERN AFRICAN CAVES AND SITES WITH SIMILAR DATES

Other sites in Southern Africa such as Rose Cottage Cave, Melikane and Sehonghong fall in the same time period as Kemp's Caves [34].

4.1 Rose Cottage Cave

Rose Cottage Cave is situated on the Platberg, a few kilometers away from Ladybrand in the eastern Free State (29°13' S, 27°28' E). Cave dates range from 5970 ± 70 to 28 000 ± 80 BP. The cave is about 20m long and 10m wide and is protected by a great boulder that encloses the front of the cave, leaving a skylight. The aims of the excavations are the dating of the cultural sequence and reconstructing environments through time. A grid of 38m^2 was excavated and later reduced to 26m^2. Charcoal from the cave's occupants has been particularly useful in providing evidence of vegetation and climatic change in the eastern Free State during the Pleistocene and Holocene. A high species diversity of micro and macro mammals has been identified from this site [16]. Rose Cottage Cave also has a long detailed sequence from early Middle Stone Age through to the Later Stone Age [19].

4.2 Sehonghong

Sehonghong rock shelter is situated in the Thaba Tseka district of eastern Lesotho (29°46' S, 28°47' E). It lies on a west-flowing tributary of the Orange River. Recently, new radiocarbon dates were established as being between1400 BP and 70 000 BP. Its long sequence of Middle and Later Stone Age deposits makes it an important site for understanding the prehistory of Lesotho. It also has potential for key issues in Southern Africa as a whole, for instance the transition from the MSA to

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LSA, as well as the hunter-gatherer adaptations [53]. Sehonghong is known from historical sources to have been occupied by hunter-gatherers until AD 1872 [54]. Excavations started in 1971 under the direction of Carter, who demonstrated that the deposit is made up of a series of major occupation horizons. Non-occupation periods have led to the confirmation of extreme cold periods during some parts of the Pleistocene [55].

4.3 Border Cave

Border Cave is close to the international border between South Africa and Swaziland. It is situated on the western escarpment of the Lebombo mountains in the north of Kwazulu-Natal, approximately 2km from the Ngwavuma river gorge [22]. The dates of Border Cave have been fairly well researched, and range between 49 000 BP and130 000 BP [23]. The cave is about 50m wide and 30m deep. At an elevation of 600m just below the escarpment the height ranges between two and seven meters. The bedrock consists of rhyolites and basalts, which relate to the Stormberg series in the Karoo. The cave is accessible only from a narrow ledge, which may have been ideal for defense and security [22]. Fifteen sedimentary units have been described [23]. The first hominid remains found by Horten in 1940, included a skull as well as tibial and femoral fragments. After this several other hominid remains were found by Cooke, Jones and Malan [22]. An infant skeleton was recovered from a shallow grave. Beaumont recovered an Iron-Age burial and a mandible during the seventies. Middle Stone Age stone tools of the Levallois type, made from local trachytic lavas and quartzite, are associated with these remains [22].

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4.4 Klasies River Mouth

Klasies River Mouth is situated near the town of Humansdorp on the southern coast of South Africa in the Cape Province (34°06' S, 24°24' E) [56]. The Klasies River descends in a series of falls and is never dry. The area has a combination between Mediterranean and Subtropical climates [25]. More or less five caves with several chambers were first excavated on a large scale by Singer and Wymer from 1967 to 1968. Smaller excavations, particularly at the main site, was conducted by Deacon during 1984 with the main goal being dating. The main deposits contain artifacts and associated faunal remains that are clearly beyond the 40 000 - 30 000 year range of conventional radio-carbon dating [56].

There are still problems associated with the dating, but global sequences of late Pleistocene sea level and climate changes firmly place the MSA layers between 60 000 BP and 128 000 BP. The main site has provided fragmentary human skull bones that appear to be anatomically modern [25]. Twenty-four MSA dated and two LSA dated fragmentary human specimens were recovered [56].

The artifacts from the main site closely resemble MSA artifacts from other sub-Saharan sites. Bone implements are mostly absent and stone tools dominate.

The faunal remains include mammals, birds, occasional fish and numerous shellfish. Fifteen different bovid species were identified at the main site.
The mortality profiles of the bovids are dominated by very young and post-prime individuals which suggest that these species were hunted. Human hunters obviously found it easier and less dangerous to hunt very young and very old individuals [56].

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5. FAUNAL ANALYSIS

Voigt [28] defines faunal remains as the physical remnants of animals which died on a particular spot. She also describes the initial purpose of faunal analysis as merely producing a "laundry list" of identified species from faunal remains. Quantative data can also disclose the antiquity of the animal and what relation it might have had to man [57]. Swartkrans, Sterkfontein, Kromdraai and Makapansgat are well known sites where many archaezoologists have done research on the faunal assemblages of ancient times.

5.1 History

The first major contribution of archaeofaunal remains by means of a faunal analysis was in providing proof of the antiquity of man [57]. Lartet and Christie [28] undertook probably the first faunal analysis during their investigation of Palaeolithic cave sites in France in the 1860's. Bones were recovered side by side with stone implements and were used for interpretation of the diet of the occupants [28]. The first proper archaeozoological interpretation is linked to two Swiss workers named Rutimeyer and Duerst. In 1862 Rutimeyer described the mammal bones from neolithic lakeside dwellings in Switzerland. He was presumably the first to distinguish between wild and domestic animals. Thus domestication studies were underway [57].

Bate was the first to use quantative data to deduce climatic changes during the Upper Pleistocene. In 1930 she plotted frequencies of two species in different strata of the Mount Carmel caves, each of a different habitat, thus interpreting the Pleistocene environment [57].

The study of animal bone in South Africa grew out of research on the early hominid accumulations by Dart in the 1950's. During the 1960's Brain began to do

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research on the mechanisms at work in bone accumulations in general. The results of his faunal analysis was published in 1981. This publication was the corner stone of faunal analysis in Southern Africa. Since then, Brain has done extensive research on caves such as Swartkrans, Sterkfontein and Kromdraai. Today, publications such as "The hunter or the hunted?" [2] and "Swartkrans: A cave's chronicle of early man" [58] are used as benchmarks for methods in faunal analysis. To our knowledge, the only publication predating this, is work done on the Gamtoos valley by Hendey and Singer in 1965 [28].

5.2 General approach

Traditionally many faunal studies focused on zoogeographical relationships, environmental evolution, and the impact of humans on the landscape from the perspective of animals [58,59]. Recently topics such as nutrition, resource use, economics and other aspects of human behaviour have also been studied [58,59,60].

There have been numerous investigations and analyses on faunal remains in archaeology and palaeoanthropology for the purposes of:

- Taphonomic studies [2,58,61,]
- Domestication investigations [62,63]
- Study of human communities, including culture, diet and behavior [59,60,64]
- Species identification for special purposes, including behaviour, extinct species morphology and morphological differences between and within species [64,65,66,67]
- Climatological indications and interpretations [17,29,30,31]
- Dating [21,29,31]

Brain characterizes the faunal analysis of an African cave as a detective story where the clues are the bones, and the aim of the investigation is to establish causes

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of death. However, in this investigation the evidence is ancient and no witnesses survived to relate their stories [2].

Analysis of macrofaunal remains is a time consuming and tedious process if accurate results are required. Experts in this field have used reliable conventional methods for decades. These methods rely heavily on the expertise of the analyst.

Reitz and Wing [68] describes an archaeozoological study as consisting of three parts: identification, analysis and interpretation. Clason's definitions on primary and secondary data distinguished between identification and analysis [69]. The identification stage is part of collecting the primary data, which includes element representation and taxonomic identification [2,65,66,67,70]. All these facts can be replicated by subsequent analysts if necessary [68].

During faunal analysis information on the following aspects are captured, if possible:

❶ Identification and classification

Each specimen is analyzed separately by comparing the fragment with modern animal material. This is done by identifying the part of the skeleton and then classifying the fragment to the possible species by means of visual morphological characteristic comparison [4,57].

❷ Measurements

Measurements of complete bones are done and the fragments are weighed [4, 28].

❸ Age determination

This is done using several methods depending on which part of the skeleton the fragment originates from. Tooth eruption and tooth wear, as well as epiphyseal fusion, are the methods most frequently used to determine age [4, 28].

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❹ Condition

The condition of the bones, whether fossilized, modern, burnt, broken, containing tooth or claw marks, reveal much about the possible history of the animal [4,28,57].

❺ Modification

Human modification is when bones were sharpened or modified for use in hunting, food preparation, making of clothes, ornaments and accessories [4,28].

Secondary data are derived from primary data by means of several quantification techniques. Secondary data is therefore the basis of analysis. Age classes, sex ratios, butchering patterns and relative frequencies of taxa, are only a few elements of this process [68].

The Southern African experts are extremely few in relation to the abundance of faunal material that has to be analyzed. The time factor presents a problem to the archaeologist and anthropologist waiting in line for a faunal analysis of their site, which may result in unwanted research interruption and suspension.

6. Taphonomy

Lyman defines taphonomy as the study of the transition, in all details, of organics from the biosphere into the lithosphere or geological record. In short it is the science of the laws of embedding or burial [71].

6.1 History

Even before taphonomy had been given a place in scientific studies, many researchers were concerned with the forces and agents responsible for marks on bones recovered from various prehistoric contexts. In 1823, Buckland, for example,

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observed a hyaena at Oxford University and was amazed by the mode of destruction of bones. Tournal (1833) took Buckland's observations on hyaenas a bit further by not just looking at the gnaw marks on prey-bones, but also at the locations of the bones as well as the association with the remains and traces of their predators [71].

In 1940 a Russian palaeontologist, I A Efremov, created the term *taphonomy* by combining the Greek words *taphos* (burial) and *nomos* (laws). However, quite a few terms have been used in publications describing taphonomy [71]:

- Weigelt's publication on taphonomy in 1927 is seen as the first major work on vertebrate taphonomy. He suggested the term *biostratinomy* meaning the study of the environmental factors that affect organic remains between a organism's death and the final burial of the remains.
- Richter described *aktuo-palatologie* as the science of the origin and present-day mode of formation of future fossils.
- In 1963 Muller used the term *fossildiagenese*, which translates to fossilization events that take place after the final burial of organic remains.

6.2 General approach

Since the first descriptions of bone assemblages, taphonomy became important not only to palaeontologists but also to archaeologists and archaeozoologists. The book published by CK Brain, "The Hunters or the Hunted?", in 1981 specifically incorporated taphonomy of South African caves [2].

The primary accumulating agent of the cave is deducted from the faunal analysis. It can therefore indicate, for example, the type of animal (human or non-human) or environmental agent that was responsible for the accumulation of the deposits, and the reason for the specific location. Taphonomy is thus part of the

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faunal analysis and reflects the holistic approach of archaeologists trying to understand and explain the totality of history [71].

As bone passes from being part of a living animal, to part of a diet of either man or animal, to human or animal refuse, to part of a sediment, to part of an archaeological sample, a lot of information about the living animal is lost. Hence, much information about human activities is also lost [4].

In 1967 Clark and Kietzke identified seven formal categories of processes which have an impact on bone assemblages during the taphonomic trajectory. Each of the processes may distort or reduce information on the assemblage. These seven processes are [4]:

❶ Biotic processes

Natural environment and human culture that influence the presence and numbers of animals at a specific site.

❷ Thanatic processes

Processes that bring about death and deposition of animals.

❸ Perthotaxic processes

Processes which result in the movement and destruction of bone before they are finally formed into a deposit.

❹ Taphic processes

The impact of physical and chemical agents which act upon bones after burial.

❺ Anataxic processes

The recycling processes by which buried bones are re-exposed to fluvial action, weathering, trampling etc.

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⑮ Sullegic processes

Archaeological activities that result in selective recovery or non-recovery of bones.

⑯ Trephic processes

The research decisions related to sorting, recording and publication.

Davis [57] describes by way of a practical example how intricate taphonomy may be. The Masaai are primarily dependant upon cows for their milk and may sometimes use the blood too. Examination of the faunal debris may, however, not reveal any trace of cattle remains (the mainstay of their economy), for cattle may only rarely have been slaughtered [57].

The processes of taphonomy remind us to consider how little we understand animal taphonomy and how well we interpret the samples in a faunal analysis [4].

7. OSTEOMETRY

Metrical data gives an indication of the size and shape of a bone. Measurements are normally taken with a calliper, measuring tape and osteometric box. Whatever the equipment, the data should be comparable to other studies to be significant. Von den Driesch published a widely used set of measurements in 1976 [72]. This included illustrations and definitions of measurements for several mammalian and avian taxa.

Osteometrical data has a wide variety of applications:

❶ Separation of skeletally similar species

➘ Payne [4] as well as Badenhorst and Plug [32] have used measurements to distinguish between sheep and goat species.

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➘ Peters and Plug [73] studied the osteomorphological differences of *Antidorcas marsupialis* and *Antidorcas bondi*.

➘ Peters [74] compared the osteometry of *Syncerus caffer* and *Bos taurus*.

➘ Perry and Brink [75] did comparative postcranial osteometry of *Antidorcas marsupialis* and *Pelea capreolus*.

❷ Domestication

➘ Domestication has induced morphological change, specifically size reduction [4].

➘ Higham [76] specifically showed size reduction from wild to domesticated animals.

➘ Davis [77] compared Late Pleistocene and Holocene animals and also found a reduction in size, and suggested that it was due to climatic change.

❸ Examination of size variation through time and space

➘ On making use of metrical data of a large geographical area, studies have already demonstrated size variation through time in specific species [4].

➘Audoin-Rouzeau [78] did extensive research on particularly the differences in bone measurements of cattle and sheep from prehistoric to medieval sites.

❹ Phylogeny and affinities

➘ The phylogeny and close relationship between two different species may be enhanced by the differences as well as similarities of their measurement values. An example is the distinction between wolf and domestic dog which has been researched extensively. In some parts of the world there are, for example, no wild canids which suggests that domestic dogs had spread in

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association with people [4].

➘ Watson and Plug [79] also studied *Oreotragus major wells* and *Oreotragus oreatragus*.

Metrical data can be both more sensitive and more objective than human judgement when attributing a taxon. However, some skeletal traits will be better presented by measurements, and others equally well, or even better by morphological description. For instance, a measurement of a skeletal part can just as easily be visually assessed.

7.1 Manipulation of metric data

If osteometric information is used to distinguish between or classify species, measurement values may be referred to by manually searching for the appropriate information. Science has benefitted from technology as it has developed over time, and accelerated the search for viable information when needed.

Data captured by scientists are normally organized in such a way that they have additional value beyond the value of the facts alone. This concept is defined as information [80].

Computerized technology makes use of information systems, characterized as a set of interrelated components that collect, manipulate, and disseminate data and information. It provides a feedback mechanism to meet an objective. This feedback may lead to an awareness and understanding of a set of information and how that information can be made useful to support a specific task [80]. Performing this procedure manually may demand unlimited time. A computer programme may achieve several objectives in an instant with the same procedure. It can manipulate

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and disseminate osteometric values to do a specific task, for example, use the database to calculate the percentage probability of a species by evaluating a set of data.

The analysis of metrical data [81,82,83] and morphological characteristics [84,85,86] of bones through complex mathematical techniques is commonly used in the analysis of human remains, but have seldom been used on faunal remains.