Working
and Guiding
in the Cradle
of Humankind

Working and Guiding

in the Cradle of Humankind

BY

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Reader in Human Evolution and the Public Understanding of Science

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CONTENTS

WORKING AND GUIDING IN THE CRADLE OF HUMANKIND

INTRODUCTION

OBJECTIVES OF THIS BOOK

This book and series of modules was developed with the objective of creating a comprehensive manual to working and guiding in the Cradle of Humankind region. It has been specifically designed for two primary types of users: students of palaeoanthropology and individuals wishing to take tourists through the region. It aims to provide the reader with a more comprehensive and compact guide to the region and its pre-history than is currently available. Students of the specialist field guide training course on the Cradle of Humankind (COH) should use the book in conjunction with the *Field Guide to the Cradle of Humankind (2nd edition)* and the *Handling of Emergencies in the Cradle of Humankind (1st edition).*

Working and Guiding in the Cradle of Humankind is divided into five modules designed to impart a detailed knowledge of the Cradle of Humankind. Please note that many sections of the text, particularly those concerning legal issues related to the South African Heritage Agency, UNESCO and general government legislation have been derived from government documents and official websites. The user should note that these are often edited by the author and should not be used for legal purposes or specific citation. Anyone wishing to consult the original legislation or legal documents should consult the original sources as given. References to these sources may be found in the appendices.

HOW TO USE THIS BOOK

This guide refers to a number of documents dealing with subjects such as World Heritage Site status and South African heritage law. Please note that the author has added numerous comments and notes on interpretation and it is critical for the reader who requires greater detail or clarification to refer to the original referenced material. The comments and notes are those of the author and are not meant to represent the opinions of either the original cited authors or any other interested parties.

The language of palaeontology can be a complex and specialised one. The guide or student who is new to the field should try not be intimidated by the large number of unfamiliar terms they may encounter in the book. As you progress through the text you will find that these words will become increasingly recognizable. To help the reader I have attempted to define each of these more technical terms in the body of the text where the word or phrase first appears and through the use of explanatory footnotes.

To get a good background to the subject students should read the *Field Guide to the Cradle of Humankind (2nd edition)* before commencing with these modules. This will give you an understanding of such subjects as how fossils are formed and under which conditions, what the significance of fossils are to human history and what exactly palaeontology is and what the science hopes to achieve. It should also help to familiarise you with some of the terminology.

australopithecine /
australopithecine /
ape-man - literally
"Southern Ape"

For more on Mrs. Ples
see Pg. 70 of the *Field
Guide to the Cradle of
Humankind* (2nd edition)

*Examples of
explanation and
reference boxes*

A NOTE TO CRADLE OF HUMANKIND GUIDES

The Cradle of Humankind area is one of the most remarkable places on the planet, and I hope that you will enjoy being able to tell your guests about the magic of the region. There is nowhere else in the world where more evidence of human evolution may be found in such a small area. Our earliest ape ancestors, the first members of the genus *Homo*, some of the earliest stone tools: the Cradle of Humankind has it all. The brief visit by your guests to the site or area is your one opportunity to tell them of these wonders and you would do well to make the most of it..

South Africa has produced one of the richest records of human evolution in the world, and by far the greatest part this record has come from the fossils that have been recovered from the Cradle of Humankind UNESCO World Heritage Site, which includes the Sterkfontein, Swartkrans and Kromdraai sites in Gauteng. Within this region are dozens of fossil bearing caves ranging in age from approximately 3 million years to just a few hundred years in age. What makes the area even more exciting to those interested in our pre-history is that only a relatively few sites have actually been explored or excavated to any great extent. Little work has been conducted on the regional geology or even the cave geology of the sites themselves. Chances are therefore that the Cradle of Humankind will still have a lot more to teach us about our pre-history.

INTRODUCTION

Fortunately, scientific and public interest in the Cradle of Humankind has increased due to recent important fossil discoveries and UNESCO recognition. The academic, private and governmental sectors are increasing their activities in the area and plans are afoot to develop its infrastructure so that more people and tourists can visit its sites. These plans include the development of a series of small site museums plus a R250 million educational centre at Moghale's Gate in the north-western corner of the Cradle of Humankind..

A Cradle of Humankind area has been proclaimed by UNESCO and the South African authorities. This is made up of two separate parts. The so-called "core area" includes the fossil bearing caves and largely consists of dolomitic limestone. It comprises some 47,000 hectares. The "buffer zone" comprises an additional approximately 80,000 hectares of land without fossil sites. This area has been included to develop in the interest of the core area. In recent years the two areas have been treated as a single "World Heritage Site" and thus the entire region may be considered a single 127,000-hectare site. The Cradle of Humankind is almost unique among World Heritage sites in that the critical areas (the core area and fossil sites themselves) are largely held in private hands.

This book is designed to give you detailed information about this special region and the necessary knowledge and skills to be able to guide both first time and repeat visitors to the Cradle of Humankind. The course will also familiarise you with the general rules and regulations about guiding visitors in this very special, protected area.

The guide should always keep in mind that visitors will not be able to see the fossils in the rock at the sites and many people do not understand the significance of the region. It is therefore up to you, the guide, to give them an experience that they will both enjoy and find educational. To achieve this you need a good knowledge of the area and its importance, and enjoy telling visitors what you know. Fortunately the story of the Cradle of Humankind (COH) is also the story of where we humans came from - a story that most people find fascinating. Tell the story well and with accuracy and you will find the rewards are great for both you and your visitors. It is important to note that this book primarily deals with the earlier pre-history of the region.

This book is broken into five modules as follows:

General Information, History and World Heritage Site Status

The Sites

Research Methods used in the Cradle of Humankind

Conservation, Classification and Identification

The Living and Ancient World

You will be examined on each module separately and once you have passed all five modules and been practically assessed you will be certified as a Specialist Guide in the Cradle of Humankind.

HOW TO STAY UP TO DATE WITH DEVELOPMENTS IN THE FIELD

It can often be frustrating for a guide in an active research area such as the Cradle of Humankind (COH) because new evidence is constantly being found and our knowledge of human evolution advances at such a rapid rate. What is considered 'fact' one month may be shown to be incorrect the following month. It is critical for you as a guide to understand that this is the nature of Science. Hypotheses, which are effectively educated guesses, are based upon the available information and data. When new data arises scientists re-evaluate their hypothesis. Thus science is dynamic and changing and while this can add to the challenges of your work it is also exciting. This idea of an advancing, evolving science and human history should be conveyed to your guests, as it is an integral part of the experience of being in the COH.

It is particularly important that you keep up to date with these changes, as human evolution is a very popular subject and our newspapers, television and other media often report new findings and research. Some of your guests are therefore sure to ask you about topical issues. If you don't know about them, it may be embarrassing for you or worse yet, the visitor may lose trust in you.

But how do you keep up with these changes? One way is to make a habit of watching the media for any reports on human evolution. Do not just look out for information on the COH though. Keeping up to date with what is happening in the field around the world will give you a much better understanding of human evolution and make you a more interesting guide.

Another suggestion is to keep in close contact with the researchers working in the field. Most graduate students and academics will be happy to help you and can alert you to new discoveries, possibly even in advance of their announcement to the public. But remember that some academics might tell you about a find or some other information in confidentiality. In other words they may not want you to tell the public about it until they themselves are ready. In such situations find out from the person exactly what you can tell to your guests. This will help you to maintain a trustworthy relationship with these individuals!

Given the dynamism of the science of human evolution it is more than likely that by the time this book is published some of the dates, names and information contained within the Modules will have changed. Nevertheless, the course should act as a good starting point for anyone wanting to gain specific and a fairly comprehensive knowledge of the Cradle of Humankind. Please also note that sections such as those on *The Living and Ancient World* are intended as a general guide only.

Prof. Lee R. Berger

Johannesburg, 2005

MODULE 1

General Information, History and World Heritage Site Status

OVERVIEW OF THE REGION

The dolomitic cave deposits of South Africa have yielded arguably the richest record of both hominin and mammalian evolution in Africa. Fossils were first recognized in these deposits in the early 20th century, but it was the discovery of the Taung child skull from the Buxton limeworks in 1924 that led to the recognition of the importance of these cave sites. Two critical discoveries followed shortly thereafter: the discovery of the first adult **australopithecine** remains from Sterkfontein in 1936, and the discovery in 1938 of another type of 'ape-man' at Kromdraai. The two finds demonstrated, for the first time, the possibility that not all hominins were the ancestors of living humans and that there may have been a number of other branches of ape-men who died out.

> **australopithecine /** australopithecine / ape-man - literally "Southern Ape"

While hominins have often been the focus of research since 1924, the remains of large numbers of other **vertebrates** have also been recovered from these sites. Unlike in **lacustrian** and **terrestrial** deposits such as those in East Africa, the dolomitic caves of South Africa provide an ideal protected environment for fossilization. Therefore the fossil vertebrate material, when recovered, is generally in very good condition. The vertebrate animal fossils from South African caves are of particular interest because of their completeness and variety, and because of the differences in composition from East African sites, that is, the record in South Africa is often better preserved and in better condition than the very well known fossils from sites such as those in Ethiopia, Kenya and Tanzania. **Invertebrate** remains, **coprolites**, **ova**, fossilized hair and fossil plant material are also commonly preserved and provide a rich record of life in the geological

> **vertebrates /** vertebrates / animals with backbones
>
> **lacustrian /** lacustrian / lake
>
> **terrestrial /** terrestrial / land dwelling
>
> **Invertebrate /** Invertebrate / animals with no backbone
>
> **coprolites /** coprolites / fossil dung
>
> **ova/** ova / eggs

past, or palaeo-environments, as we call these environments long past. Even invertebrate and vertebrate trackways have been preserved in mudstones.

articulated /
articulated / still connected and in "life" position

carnivores /
carnivores / meat eating animals

bovids / bovids /
antelopes, buffalo and their relatives

taphonomic /
taphonomic /
burial

calcium carbonate
/ calcium carbonate /
lime

riverine / riririne /
related to rivers
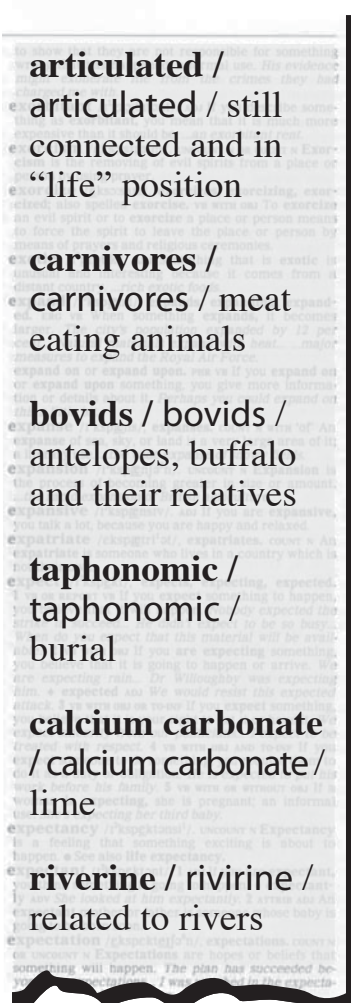
Possibly the most remarkable aspects of the South African caves are the sheer numbers and densities of fossils that are found in some localities, with quite literally hundreds of thousands of bones packed into relatively small areas, and the completeness of many **articulated** skeletons of various vertebrate species. These articulated remains, including those of hominins, **carnivores** and **bovids** offer a valuable record of individual species morphologies as well as insight into **taphonomic** processes. Because of the quality of preservation in the **calcium carbonate** based breccias and flowstones, the bone and tooth surfaces are also in extremely good condition and offer researchers a glimpse at bony detail not available on bones and teeth recovered from terrestrial, lacustrian and **riverine** deposits.

Dating of the deposits and individual fossils has however proved to be challenging. The first efforts to date the sites in the COH involved comparing them with European and East African sites, but recent advances in geological understanding, and geophysical and radiometric methods have shown promise in accurately dating South African fossils and breccias (see Module 2).

Hominins are represented in the South African cave sites by over 1000 catalogued specimens from more than 11 different cave deposits. Hominin remains include adults and juveniles as young as several months in age, complete skulls, **ossicles**, and postcranial remains that cover every aspect of the skeleton. At least four and possibly more species of early hominin are found in the South African cave sites.
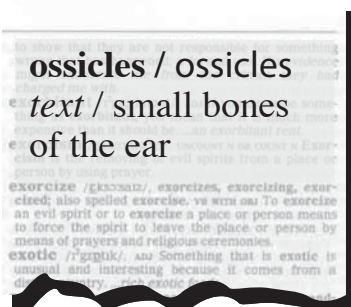
ossicles / ossicles
text / small bones
of the ear

While the hominin fossils from South Africa are not nearly as old as the oldest hominin sites in East Africa (East African

fossil hominins may date back over six million years while those in South Africa are probably all less than three million years in age), the South African examples are important because they are almost always more complete and are found in the presence of a much greater range of vertebrates. They are therefore able to tell us a lot about the period in which they lived. In addition the high concentrations of fossils in the South African caves have offered **taphonomists** and **palaeo-ecologists** the opportunity to access and study them much more easily than sites in East Africa and elsewhere. Also, the period of time which the South African hominins cover represent some of the most critical periods in human evolution, where some of the most important changes have taken place.

taphonomists and palaeo-ecologists / taphonomists and palaeo-ecologists / scientists who study ancient environments and ecologies

For more on this see Pg. 119 of the *Field Guide to the Cradle of Humankind* (2nd Edition)

We now recognize that the fossil bearing breccias of the South African caves

palaeo / palaeo / ancient

accumulated over a long period of time, in fact many hundreds of thousands if not million of years, and in a wide variety of **palaeo**-environments. In fact bone accumulations are still being made in the area and undergoing fossilization even today. Nevertheless, it is clear from the vertebrate fossil record that most of the early hominin-bearing breccias accumulated under very different environmental conditions than those present in the dolomitic regions today. Some experts suggest that the area was a riverine forest environment while others believe it was more of a savannah grassland, in fact it is probable that environments changed over time in the COH. So why were these fossils preserved so well?

Accumulation of bone in the Cradle of Humankind caves has occurred in a variety of ways. In many cases animals simply fell into the caves and were killed or trapped, while in others, scavengers or predators dragged their corpses in. Some animals actually lived and then died in the caves.

Bones may be preserved in a wide variety of conditions, but at the COH they were mainly preserved by calcium carbonate. Precipitation on the roofs of the limestone caves caused droplets of calcium carbonate to drip down and effectively 'cement' sediments and bone together. We call rock that has been welded together in this way, "breccia". The COH breccias are interlaced with flowstones, stalactites and stalagmites comprised of purer calcium carbonates than the breccias which are contaminated by other debris often giving them distinctive colours. Fossils occur in almost every situation within the cave and the quality of preservation is highly dependant on immediate local conditions.

stalactites / stalactites / downward hanging cave features
stalagmites / stalagmites / upward growing cave features

GEOGRAPHICAL SITUATION OF THE EARLY HOMININ-BEARING CAVES IN SOUTH AFRICA

The caves of South Africa where hominin fossils are found, or "hominin bearing" caves as we call them, are all confined to regions of dolomitic exposure. Dolomites resemble limestone but differ in that they are composed of calcium magnesium carbonate and were formed on the floor of ancient seas that once covered the area more than 2.5 billion years ago. The sites are found in three areas: Makapansgat, in the Limpopo Province; Taung in the North West Province and the UNESCO World Heritage Site area known as the Cradle of Humankind, which is situated north and west of the greater metropolitan area of Johannesburg in the Gauteng Province. The Taung site is found in tufaceous cave deposits formed on the edge of the Kalahari dolomitic escarpment, while the Makapansgat limeworks site and the sites within the Cradle of Humankind are situated within caves in **karstic** terrain.
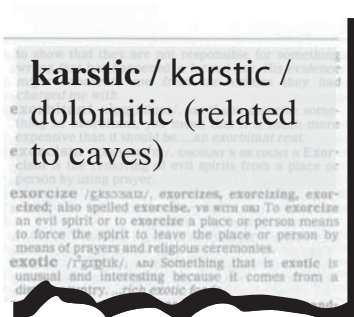
> **karstic** / karstic / dolomitic (related to caves)
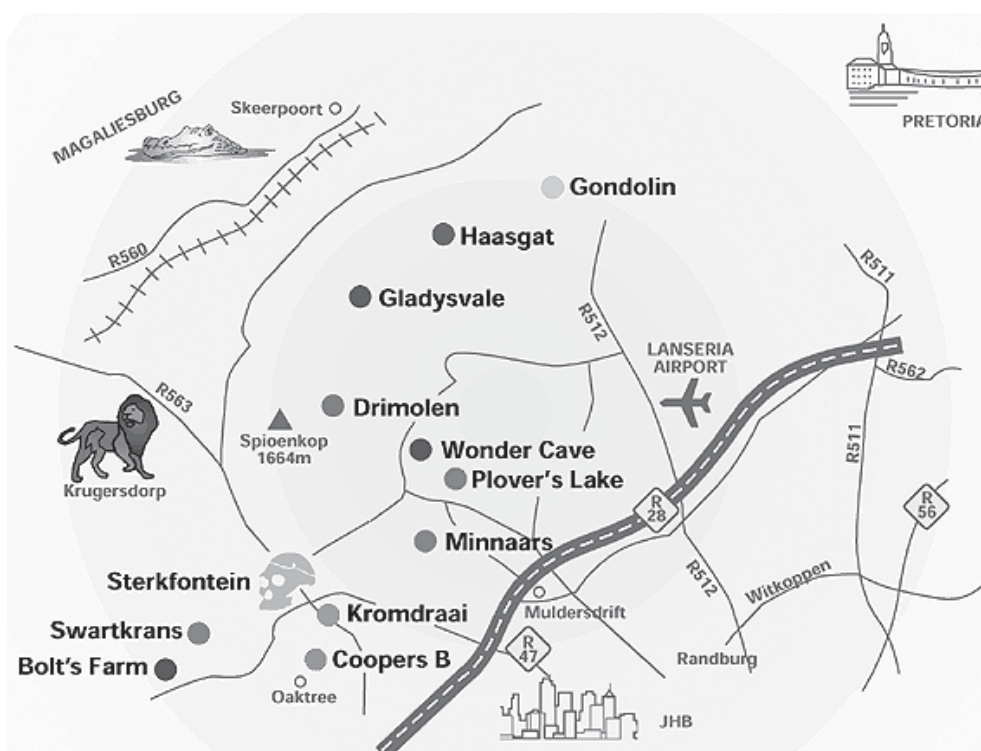
A base map of the Cradle of Humankind area. The dark lines outline the core area of the Cradle of Humankind (www.cradleofhumankind.co.za).

HISTORY

South Africa provided the earliest African fossil evidence relating to hominin evolution. The first of this evidence was provided by the exciting recovery of the Taung child skull in 1924. Shortly thereafter, Robert Broom recovered adult specimens of early African hominins at Sterkfontein in 1936, which would lead to the recovery of numerous hominin specimen from this site. In 1938, Broom discovered at Kromdraai a hominin that was more robust and had a

For more on Broom see Pg.'s 62 – 63 of the *Field Guide to the Cradle of Humankind* (2nd Edition)

more specialised tooth arrangement than the Sterkfontein ape-men. These characteristics lead him to believe that the newly found bipedal or upright walking ape was not an ancestor to us humans. This led to a new concept of evolution that held that not all bipedal apes were directly ancestral to humankind and that at least one other branch of hominin had existed. One branch of hominin evolved into humans or *Homo sapiens*, while another led to the more robust form of ape-man, which eventually became extinct.

Two other South African hominin bearing sites, Makapansgat in what is now known as the Limpopo Province, and Swartkrans near Sterkfontein, were found just after the Second World War which ended in 1945.

As well known South African palaeontologist Phillip Tobias has pointed out "South Africa was the region within which grounds emerged for the first serious claims that this continent, rather than Asia, had cradled humanity". By the late fifties, East African finds began to add support to the South African hominin fossil record. However, the discoveries first at Olduvai Gorge Tanzania dating to

For more on Tobias see Pg. 74 of the *Field Guide to the Cradle of Humankind* (2nd Edition)

just after two million years ago, and then Laetoli in Tanzania, Koobi Fora in Kenya, and Omo and Hadar in Ethiopia as well as other sites, shifted both scientific and public interest away from the collections and sites in South Africa.

Despite this lack of international interest, working in a hostile political environment since 1948 until the transition to a democratic government in 1994, and being under an academic boycott for much of the latter part of this period, several significant research projects were undertaken in South Africa, primarily by three principal groups of scientists and technicians.

At the then Transvaal Museum, now incorporated within the Northern Flagship Institute, was a team led by J.T. Robinson and later by C.K. 'Bob' Brain. This team focused on both caring for and studying the Museum's large collection of hominins that had been collected by Broom from Sterkfontein, Kromdraai and Swartkrans. Brain also pioneered research into cave formation processes and studies of taphonomy. Elizabeth Vrba, alongside Brain, continued this work through the 1970s and early 1980s, analysing animal or faunal remains and excavating at Kromdraai and Gondolin. By the late 1980s the work at the Transvaal Museum was being taken forward by Francis Thackeray and Virginia Watson who undertook excavations at Plover's Lake and then at Kromdraai in the early 1990s. The Kromdraai work was done in conjunction with the author and members of the Palaeo-Anthropology Research Unit (PARU) at the University of the Witwatersrand.

Another important research group was that of Raymond Dart, Alun Hughes and James Kitching. Dart was by then at the Bernard Price Institute for Palaeontology at the University of the Witwatersrand, and he and his group focused on analysing the results of work carried out at the site of Makapansgat.

The third important research group was the University of the Witwatersrand's Palaeo-Anthropology Research Unit (PARU) and its predecessors. Under the direction of Phillip Tobias between 1966 and 1996, PARU initially focused on field activities at Sterkfontein. However, the unit was also involved at other sites as well as in laboratory activities related to research into human origins.

During most of this time a field team under the direction of the late Alun Hughes conducted PARU field operations, and when he became terminally ill, Lee Berger briefly assumed the role between 1990 and 1991. Ron Clarke was finally appointed to head up the field work at Sterkfontein in 1992, a position that he still holds.

Early in the 1980s, PARU began to extend activities to the Buxton Limeworks near Taung, work that was continued into the early 1990s by Jeff McKee of the then Department of Anatomy at the University of the Witwatersrand. McKee also restarted excavations at the site of Makapansgat and nearby Buffalo Cave in the early 1990s.

PARU also became involved in excavations at the site of Gladysvale under the direction of the author early in 1991. This team worked together with Andre Keyser who was then with the Geological Survey of South Africa, but later joined PARU. Gladysvale was the first new early hominin site to be discovered in southern Africa since 1948. Keyser had also conducted survey and sampling of several sites in the area including Haasgat. In 1993, Keyser's explorations resulted in the discovery of hominin remains at the site of Drimolen.

A significant re-organisation took place in South African palaeoanthropological sciences after 1996. Following the retirement of Phillip Tobias, the University of the Witwatersrand closed PARU and its activities were taken over by a new research group named the Palaeoanthropology Research Group (PARG) under the direction of the author.

PARG's research activities extended beyond Sterkfontein, Drimolen and Gladysvale and the collaborative work at Kromdraai to include new work at Swartkrans and other lesser known sites including Coopers, Motsetsi, Bolt's farm, Schurverberg and Plover's Lake. Significant international collaborations were formed for the purposes of fieldwork, including work with the University of Zurich at Gladysvale, French teams at Drimolen, Duke University researchers at Coopers and Plover's Lake and the University of Arkansas at Swartkrans, Plover's Lake and in regional Geographic Information System (GIS) surveys.

In 2000 the University of the Witwatersrand formed two new units to handle the increase in work. The Sterkfontein Research Unit (SRU) was formed to undertake specialized work at Sterkfontein under the direction of Phillip Tobias while the Palaeoanthropology Unit for Research and Exploration (PURE) was set up under the author in the Bernard Price Institute for Palaeontology to continue the research activities at the other COH sites.

Palaeoecology /
palaeoecology /
ancient ecology
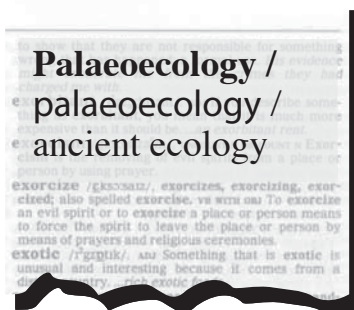
Kevin Kuykendall of the Department of Anatomical Sciences at the University took over from McKee the excavations at Makapansgat and Buffalo Cave. He worked with a number of American and British colleagues and later, conducted seasonal fieldwork at Gondolin with members of PARG and Washington University. Kuykendall later set up a project known as the Makapansgat Area **Palaeoecology** and Palaeoanthropology Research Project (MAPP).

The restructuring of museums in South Africa, meanwhile, resulted in a name change for the Transvaal Museum which became known as the Northern Flagship Institute. Francis Thackeray of the Institute worked with PARG/PURE and Harvard University at Kromdraai and later at Coopers and Swartkrans. In the late 1990s Thackeray and French colleagues started work at a site in the Bolt's Farm area.

The University of the Witwatersrand recently brought together all of the different groups at the University into a single entity, which was given the working name of the Human Evolutionary Institute for Research (HEIR) in 2004 under the leadership of Trefor Jenkins.

The research efforts of the past decade have resulted in the discovery of hominin and archaeological remains at all sites in the Cradle of Humankind area with the exception of the more limited excavations at Bolt's farm, Haasgat and Motsetsi.

1.	Swartkrans	7.	Wonder Cave
2.	Sterkfontein	8.	Drimolen
3.	Kromdraai	9.	Motsetsi
4.	Bolt's Farm	10.	Gladysvale
5.	Minaars	11.	Haasgat
6.	Plovers Lake	12.	Gondolin

The location of sites in the Cradle of Humankind, 2004 (from Hall et al. 2004)

A number of other researchers have also conducted important work in the COH. This has included analyses of the stratigraphic sequences of the Plio-Pleistocene deposits, the study of non-hominin animal fossils and fossil plant and pollen material, the dating the sites and the morphology of the hominins. Some of this work is reviewed later.

WHAT IS A WORLD HERITAGE SITE?

The COH was proclaimed a World Heritage site by UNESCO in December of 1999. There is often a great deal of misunderstanding concerning just what exactly a World Heritage site is. In simple terms, it is a site, location, historical place or other area that has been recognized by the United Nations as a site of critical heritage importance to the people of the World. This special status grants the site the permanent protection of the United Nations, at least in theory. It therefore indicates to the world that the United Nations will act as the permanent protector or 'watch-dog' over the site.

For additional information on UNESCO policy and individual world heritage sites visit the web site at www.unesco.org.

The following summarises the main aspects of the UNESCO charter.

UNESCO's World Heritage mission is to:

- Encourage countries to sign the 1972 World Heritage Convention and to ensure the protection of their natural and cultural heritages;

- Encourage countries to be represented at the Convention and to nominate sites within their national territory for inclusion on the World Heritage List;

- Encourage countries to set up reporting systems on the state of conservation of World Heritage sites;

- Help countries safeguard World Heritage sites by providing technical assistance and professional training;

- Provide emergency assistance for World Heritage sites in immediate danger;

- Support public awareness-building activities for World Heritage conservation;

- Encourage participation of local populations in the preservation of their cultural and natural heritages;

- Encourage international cooperation in the conservation of cultural and natural heritage.

WHAT IS THE UNESCO WORLD HERITAGE CENTRE?

The UNESCO World Heritage Centre is the Secretariat to the World Heritage Committee. It was established in 1992 to develop a cooperative approach to the conservation of both cultural and natural heritage considered to be of outstanding value to the world.

The Centre works to encourage states to adhere to, and implement the Convention concerning the Protection of the World Cultural and Natural Heritage. There are currently 162 Member States of the Convention. As at January 2001, 690 sites – 529 cultural, 138 natural and 23 mixed properties in 122 countries, are on the World Heritage List. The World Heritage Centre works closely with the 162 States Parties, as the member representative groups are called, and advisory bodies to the Committee. The Centre coordinates its work with UNESCO field offices around the world as well as relevant international environmental and cultural conventions and programmes.

What is UNESCO's "Global Strategy"?

Obviously not all heritage sites can be protected by the UN, which has limited resources. Sites applying for World Heritage status must therefore be judged to have an importance to the world community and fulfil a number of criteria before they can be included on the list. UNESCO has a "Global Strategy" that facilitates the inclusion of sites on the World Heritage list. The UNESCO Global Strategy was adopted by the World Heritage Committee in 1994. It seeks to achieve a fair, balanced and representative World Heritage List or, in other words, to ensure that the List reflects the World's cultural and natural diversity of that is of universal value.

Countries are encouraged to become "States Parties" to the Convention, and to identify and nominate regions and sites that they believe have importance to the world. UNESCO believes that it must support and build the capacities of countries and regions if they are to effectively protect the sites included on the List. The Organisation monitors all World Heritage sites to ensure that they are being properly protected and conserved.

In order to implement the vision of a World Heritage site, UNESCO has put forward a strategy for monitoring and intervention in World Heritage sites. The strategy is outlined as follows from the UNESCO website:

Through proactive and innovative international cooperation activities, States Parties of the developing world will be supported in the elaboration of national laws and regulations for the identification, protection and conservation of cultural and natural properties of potential outstanding universal value for nomination to the World Heritage List so as to achieve a more balanced and equitable List. Moreover, in accordance with the Global Strategy all States Parties will be requested to review their national tentative list to identify categories of properties within their territory which are under-represented on the World Heritage List. The Centre will carry out analyses of the World Heritage List and national tentative lists in cooperation with the Advisory Bodies. The need for further thematic and comparative studies required to guide the States Parties in their endeavour to revise their tentative list and to select properties for World Heritage nomination will be identified.

Special efforts will be made to build capacities for local authorities in the context of urban conservation of world heritage historic cities. Training and technical cooperation will be provided for the strengthening of legislative, policy planning and institutional support for the conservation of world heritage sites, adapted to the particular type of a site (e.g. multi-use and multi-tenure cultural landscape, forest reserve, historic urban centre, etc.); promotion of adherence to conservation legislation, regulations, policies and plans at the regional and local levels; integration of sustainable conservation actions into development programmes; and development of local and regional skills, competencies and infrastructure for on-site protection and interpretation through the organization of national and regional training courses, seminars and curriculum development. Advice will be provided to States Parties to develop fiscal policies to help finance conservation activities. A reform of the World Heritage Committee will be initiated so as to enhance the decision-making processes and to improve the implementation of the Convention. This will include provision of clearer guidance to States Parties concerning all aspects of implementation of

the Convention, increased representation of under-represented regions and categories of heritage on the World Heritage List, greater participation of States Parties in the work of the World Heritage Committee and establishment of priorities and criteria for provision of international assistance for world heritage projects. Efforts will be undertaken to ensure effective legal protection to increase international cooperation and to sensitize public opinion and commitment in favour of the protection and sustainable management of World Heritage properties.

Notes

MODULE 2

The Cradle Of Humankind Sites

A REGIONAL PERSPECTIVE

The early hominin bearing deposits in South Africa occur in solution caves and cracks in the earth, or fissures, in the Chuniespoort Group, Malmani Subgroup of the 2.7 to 2.1 billion year old Transvaal Supergroup, that today forms an undulating karstic landscape in which numerous soil filled depressions have developed. Apart from Makapansgat, which occurs in the Limpopo Province, and Taung, which occurs on the Ghaap Escarpment of the Griqualand West Supergroup in the North-West Province, all the other sites discussed occur in the Cradle of Humankind in Gauteng. The base of the Malmani Subgroup has been dated to 2.5 billion years ago, and the top of the Penge Formation, which overlies the Malmani Subgroup at 2.4 billion years

old (*Walraven and Martini, 1995*). Within the Malmani Subgroup, five sub-units (the Oaktree, Monte Christo, Lyttelton, Eccles and Frisco formations) are recognised in the dolomite, based on their chert content and the types of stromatolites that occur, as well as on the presence of interbedded mudstone and rare quartzite (*Button, 1973*).

Fracture patterns (like fault lines) have been noted to be a major influence on the form a particular cave takes (e.g. Brain, 1958). Such fracture patterns are controlled by the makeup of the regional geology as a whole, and recent large scale geological work on the Cradle of Humankind has helped us to understand why caves are positioned and formed as they are.

HISTORY OF GEOLOGICAL INVESTIGATIONS

Although much work has been undertaken on various aspects of the fauna and flora that have been found in the cave fills, surprisingly the sediments themselves have not been studied as closely.

The earliest geological work on the fill of the fossil hominin bearing caves was undertaken by Basil Cooke in 1938, but after this initial work, little geological work was undertaken on the cave sites until Brain began a detailed study in 1958. His efforts were the first attempt at a systematic description of the sites, and the age or generation of some of the first stratigraphic schemes. Subsequent to this, works by Partridge (1978), Brain (1981, 1993a,b,c), Partridge and Watt (1991) and Clarke (1994) and Pickering (2004) significantly improved our understanding of the stratigraphy of the cave fills. But prior to the work of Hancox *et. al.* (2002), Lacruz (2002), Pickering et. al. (2003) and Pickering (2004), most studies were of a purely **lithostratigraphic** nature. Fortunately major advances in studying the **chronostratigraphy** of Pleistocene cave fills have been made in the past five years (e.g. Moriaty et al., 2000) and much of the work being done now follows this latter, more advanced method. Many computer related techniques that were not available in the past (see Lacruz, 2002; Schmid, 2002; Nigro et al., 2003; Lacruz et al., in press) are now also being used to help us understand the stratigraphy of the cave fills. These new methods mean that most of the cave fills now need to be restudied.

lithostratigraphic / lithostratigraphic / based on the appearance, position and form of rocks in a sequence

chronostratigraphy / chronostratigraphy/ age-based approach
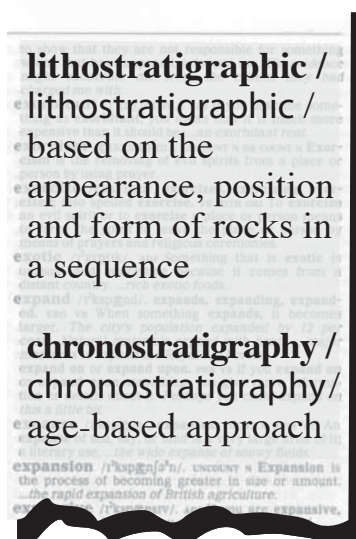
HOW A CAVE FORMS AND FILLS

Our understanding of the structural control of the caves in the Cradle of Humankind World Heritage Site has been radically improved by computer aided examination of remotely gathered data, the enhancement of air photos, and satellite and thermal (heat) images. This work may be even further improved upon in the near future through the use of high-resolution hyperspectral scans (multiple spectrum) that can help us identify groundwater concentrations and rock types. It is hoped that the scans may also help us to identify new cave sites in the future.

Before the recent work of various researchers and geologists on the Middle Pleistocene sequences at Gladysvale (i.e. Hancox et al.., 2002; Lacruz, 2002; Lacruz et al., 2002; Pickering, 2002 and Pickering et al., 2003), the fills of the caves in South Africa had been described and interpreted using lithostratigraphic principles, with little or no effort having been made to apply modern chrono- and sequence stratigraphic concepts.

Over the past several years a number of advances have also been made with regard to the mapping of cave fills, and in our understanding of their stratigraphy, and, to a more limited extent, the processes that create cave fills. One of the major advances in the work being undertaken in the caves of the Cradle of Humankind, is the introduction of laser theodolite mapping (see Module 3 for more on this), and the development of a Geographic Information System (GIS) for recording three dimensional data in cave systems. The use of a laser theodolite allows for the cave structure to be accurately mapped, as well as improve precision of provenience information of fossils, artifacts and even rocks and parts of rocks. If correctly used, this technique can also record bone orientations, which in turn provides information on what forces put the bone

See Lacruz, 2002; Schmid, 2002; Nigro et al., 2003 and Module 3

in the position that we find it. A number of other geological and palaeontological parameters may also be recorded and later analyzed to determine such important information about cave fills as the path the sediment or fossil was transported along (also known as the "transport path"), the location of the original cave openings, and fan and cave floor **topography** at any given time in their existence.

topography /
topography /
surface features
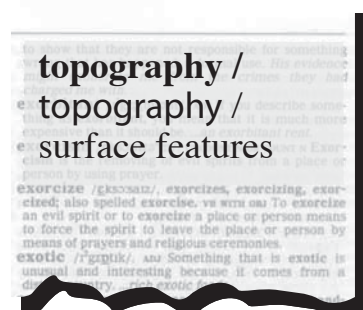
In the past, conventional GIS systems (Geographical Information Systems) were not suitable for use in cave systems. But advances in computer software and the machines themselves mean that the use of GIS therefore allows for large a digital archive of the cave fill to be generated and manipulated. The creation of such an archive of the cave fill allows the user to visualise and analyse the spatial and temporal contexts of all geological data, as well as to interpret the fossil and artifact materials in their temporal and spatial contexts. This allows researchers who were not originally involved in the excavations to virtually re-excavate sites.

To date such techniques have only been used by Lee Berger's students at Swartkrans (Nigro et al., 2003), Gladysvale (Lacruz, 2002; Lacruz et al., in press; Pickering, 2002,2003), Plover's Lake internal deposits and Coopers D, but they are showing great promise in the study of all cave fills, and would also be useful for other sites in the region.

For a good example of the practical use of these methods go to the website www.cast.uark.edu/cast/cradle.

The detailed geological mapping means that for the first time one may link bone accumulations to specific areas on the actual cave floor. Experience has shown that the **distal** parts of

distal / distal / back or the furthest from the front

winnowing / winnowing / seperation by water

fans, particularly where they join against a side or back wall, are sites of high densities of bone. Partridge's early work at Makapansgat led him to suggest that the positioning of these high densities of bones was probably as a result of flood waters carrying carcasses to the back of the cave, or that they floated there in standing bodies of water like underground lakes or pools. An alternative explanation is that other taphonomic agents including bone **winnowing** on the fan surface, and carnivore activity (i.e. they dragged their kills into certain areas of the cave to eat or store), were the cause. We now know that sedimentological accumulations may be distinguished from other taphonomic accumulations by the positions or orientations of long bone shafts and clasts.

A CLOSER LOOK AT THE SITES

Sterkfontein

The cave site at Sterkfontein is situated about 10km to the north-northwest of the town of Krugersdorp on the southern side of the Bloukrans River Valley, on the farm Swartkrans. The history of the caves goes back to 1894 when G Martignalia, a Rand pioneer who was looking for lime to mine, discovered the site.

cranio-dental /
cranio-dental /
head and teeth
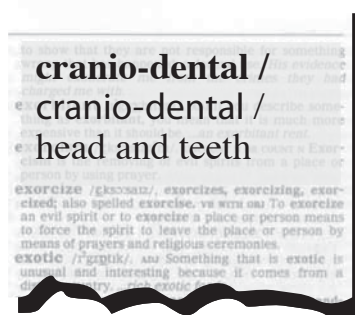
Fossiliferous breccias were discovered there in 1896 and since this time the caves have been best known for the vast wealth of fossils that they contain. Scientific collecting began in 1936 following a find the previous year of a fossilized baboon skull. The first adult australopithecine skull was discovered shortly thereafter and described by Broom in 1937. A number of additional fossils, including both **cranio-dental** and post-cranial remains, were recovered soon after.

In 1947 the important hominin cranium of "Sts 5", which is more commonly known as "**Mrs. Ples**", was discovered. In 1956 C.K. Brain discovered stone tools in breccia dumps in an area west of the Type Site. Because of the perceived difference in age, the area was named the "Extension Site" and excavations by Revel Mason and Brain in 1957, and later

Mrs. Ples / Mrs. Pleas / short for Plesianthropus transvaalensis, the original scientific name given to the species of ape man Broom was finding at Sterkfontein

For more on *Mrs. Ples* see Pg. 70 of the *Field Guide to the Cradle of Humankind* (2nd edition)

For more on Brain's contributions see Pg. 73 of the *Field Guide to the Cradle of Humankind* (2nd edition)

that year by John Robinson, resulted in the recovery of many more tools. Robinson also discovered several hominin teeth with the tools. Excavations of the fossil bearing cave areas were renewed in late 1966 under the direction of P.V. Tobias and A.R. Hughes and they continue to this day, the longest running palaeontological excavations in Africa. A near-complete hominin skeleton, StW 573, was recently uncovered from an area of the cave known as the Silberberg Grotto (Clarke, 1998).

Basil Cooke (1938) wrote the first study dealing with the geology of the site, and since this time the stratigraphy of the deposits have been the focus of several studies. The first of these after Cooke were broad descriptive classifications (e.g. Haughton, 1947; King, 1951; Robinson, 1952). C.K. "Bob" Brain (1958) gives the first detailed description of the stratigraphy and sedimentology of the site in a **geomorphological** study of the cave system. These works together provided the standard lithostratigraphic subdivision of the site prior to Partridge's (1978) critical study which forms the basis of our understanding of the site today.

> **geomorphological** /geomorphological / study of the geological form or structure

Because earlier stratigraphic studies did not examine the full extent of the cave system, and were based on only limited areas that were visible due to mining or excavation, in 1978 Partridge re-appraised the stratigraphy of the sequence at Sterkfontein. He documented six Members (or related geological units), and designated the fills process of formation. Based on work on the internal morphology of the Sterkfontein caves, in the middle 1980's Wilkinson suggested that the fossiliferous deposits at Sterkfontein were up to 50m in depth or more. This contradicted Partridge's earlier findings and so to resolve this difference of opinion, a drilling programme began in 1989. The programme, which took oriented drill cores through the site in several areas, helped to clarify the issue of the thickness of the deposits, and of the stratigraphic relationships of the various members.. Clarke used the information from up-to-date excavations in 1994 to propose some modifications to the existing geological understanding and focused largely on Members 4 and 5. Kuman (1994a,b; Kuman and Clarke, 2000) further subdivided the Member 5 deposit (formerly known as the Extension Site) into three discrete infills, terming them the Oldowan Infill, the StW 53 Infill, and the Sterkfontein Member 5 West Infill.

The sedimentological nature of the Sterkfontein formation were finally summarized by Partridge in 2000. According to Partridge the formation is composed of six members and averages 20m in thickness, reaching a maximum thickness of 30m in places. Member 1 forms the **basal** subdivision and may reach a thickness of over 12m. Member 1 is thought to represent an early period of cave enlargement according to Partridge, and is composed mainly of dark

> **basal** / basal / bottom most
>
> **manganiferous** / manganiferous / manganese rich

brown **manganiferous** cave earth and roof collapse blocks. The absence of bone and surface material indicates that openings to the outside were either very small or absent. In the upper part of the Member a number of thin flowstone layers occur.

speleotherms / speleotherms / stalagtites and stalagmites

debris cone / debris cone / A pyramid of sediments that accumulated from above

Lenses / Lenses / Thin Lines

Member 2 is exposed in the underground cave system in the Silberberg Grotto which was first reported by Tobias (1978), and consists of up to 8m of pale brown to red, sandy silt matrix, in which numerous broken **speleothems** are stuck. An abundance of bone occurs near the base including the nearly complete "Little Foot" skeleton (StW 573). Partridge (2000), notes that in places Member 2 is separated from Member 1 by a flowstone layer, and attributes the nature of the fill to deposition on a **debris cone** when the cave had a deep shaft-like opening.

Member 3 **unconformably** overlies Member 2, being separated from it by up to 1.2 m of flowstone in places. In terms of volume it is the most

unconformably / unconformably / there was time and/or erosional break between the deposition of the younger deposit Member 3

extensive member and its maximum thickness of 9m (Partridge, 2000). Above the basal flowstone the remainder of the unit is composed of up to 8m of reddish, matrix-supported breccia, with locally abundant bone. **Lenses** of flowstone up to 4m thick are recorded from this Member (Partridge, 2000).

Member 4 overlies Member 3 and comprises a succession of debris cones that become shorter and flatter as you get higher in the deposit. The various units of the Member are preserved at the Type Site area where Broom undertook his early excavations, and from where specimens such as Sts 5 were found. In fact most of the early hominid specimens from Sterkfontein were recovered from Member 4. The majority of these hominin specimens have

See Module 5 for more on these species of ape men

been classified as *Australopithecus africanus*, though Clarke (1989) has suggested that a second species ancestral to *Paranthropus* might also be present. This Member has also yielded more than 300 fragments of fossil wood. Unit A (a sub unit of the Member) consists of a fill up to 5m thick, comprising angular chert and dolomite clasts that are cemented by massive flowstone. Pockets of reddish brown silty sand also occur. Unit B comprises the bulk of the Member and consists of up to 6m of crudely stratified, mixed breccia, consisting of

small chert and dolomite blocks in a matrix of silty, reddish brown sand. This unit contains a high percentage of soil and other externally derived material washed in from the overlying hillslopes. Unit C occurs as a series of less clast rich pockets around the outside edges of unit B, the top of which is formed by flowstones attributed to Unit D.

Member 5 (A-C) is separated from Member 4 by a period of no deposition of sediments. The base of Member 5 breccia occurs in a number of solution features in the underlying Member 4 (in other words, member 5 has cut into Member 4 in many places). Unit A (the StW 53 Infill) is formed by up to 5m of dolomite and chert clasts in a calcite veined matrix consisting of reddish brown sand. No stone artifacts can be attributed to this unit. Unit B (Oldowan Infill) breccias contain abundant chert and dolomite clasts set in a dark reddish brown, poorly calcified clayey sand, as well as Oldowan stone artifacts. Unit C (Sterkfontein Member 5 West) contains less abundant chert and dolomite clasts, set in a matrix of yellowish red, well calcified silty sand. It is thought to contain Early Acheulean stone tools (Partridge, 2000).
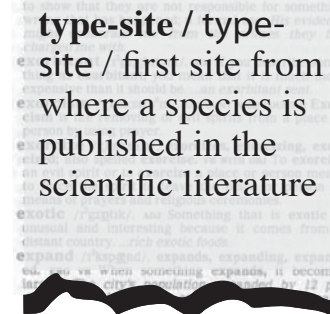
Member 6 (A and B) is found in solution pockets in the upper parts of Member 5. Unit A comprises up to 25 cm of flowstone, which is overlain by up to several meters of dark reddish brown, breccia.

Member 2 of Sterkfontein has come to prominence as a result of the discovery of a near-complete hominin skeleton (Clarke, 1998). Initially the search for the skeleton was prompted by the discovery of well preserved hominin foot bones, referred to as StW 573, in Member 2 breccia (Clarke and Tobias, 1995). Discussing the age of StW 573, it was suggested by Clarke and Tobias (1995) that based on the position of Member 2 several meters below Member 4, the foot bones were likely to be older than 3.0 Mya, and perhaps as old as 3.5 Mya. However, McKee (1996) argued that this was not consistent with the evidence of the faunal record and the deposit was probably similar in age to Member 4 of Sterkfontein, between 2.6 and 2.4 Mya. McKee was supported by the palaeomagnetic stratigraphy recorded at the site (Partridge et al., 1999; Partridge et al., 2000) after the discovery of the rest of the StW 573 skeleton. The author and his team (2002) examined the faunal evidence from Sterkfontein Member 2, and also concluded that the deposit was likely to be younger than 3.0 Mya, and might be better estimated at between 2.0 and 3.0 Mya, or perhaps even younger. Most recently, Partridge and his colleagues (2003) suggested the surprising age of between 4 and 4.5 Mya, almost a million years older than their original estimations, although these dates are hotly contested. The most recent studies by independent geochronologists have supported an age for the skeleton younger than 3.0 Mya.

Kromdraai (A,B,C)

The site of Kromdraai is situated some 1.5 km to the East of Sterkfontein, adjacent to the Cooper's deposits. Along with Taung, Sterkfontein and Swartkrans, Kromdraai was one of the first sites found to contain hominin material. It is also the **type-site** of Paranthropus robustus.

type-site / type-site / first site from where a species is published in the scientific literature

The first fossils from Kromdraai were discovered by Broom in 1938, including a fragmented skull and some associated post-cranial remains. Two main sites are recognised at Kromdraai: Kromdraai A (the faunal site) and Kromdraai B (the hominin site). A third excavation trench is known as Kromdraai C. Although originally subdivided into these three different units (A-C), recent excavations have shown that Kromdraai B and C are actually a continuation of Kromdraai A.

In early 1941, Broom undertook limited excavations near the block from which the original *Paranthropus robustus* type specimen had been recovered at Kromdraai B (Broom, 1946). He then commenced work at Kromdraai A in 1947, in the hope of associating the abundant fauna recovered from the breccias of Kromdraai A, with the material from Kromdraai B as this second deposit contained a much richer and more complete fossil assemblage (Broom, 1958, Broom and Schepers, 1946). Broom's blasting with dynamite of the breccias at Kromdraai A succeeded in revealing an abundant fauna. Subsequent excavations by Brain in 1955, Vrba in 1977 and most recently by Thackeray and the author have expanded the fauna known from both localities and have added stone tools to the Kromdraai A assemblage.

The Kromdraai deposits occur in an East-West striking fissure. Prior to 1980, only limited surface areas were exposed and could be studied, and the accounts of the stratigraphy of Brain (1958, 1975, 1981) only deal with these. In 1980, Elizabeth Vrba supervised the drilling of two borehole cores that were then utilised by Partridge for stratigraphic and sedimentological studies (Partridge, 1982). Partridge (2000) recognises a Kromdraai and Kromdraai West Formation in what was previously referred to only as Kromdraai B. He subdivides the two formations into five members, all of which are believed to have formed under a debris cone situated near the eastern end of the depository, at least 12m above the present land surface.

Member 1 at Kromdraai is the most extensive unit and is composed of a succession up to 13m thick of roof block clasts (chert and dolomite) and rare bone, set in a matrix of reddish brown sandy silt. Crude stratification is present parallel to the sides of the cone. Member 2

overlies Member 1 but the contact indicates that a period of time separates the two Members (Partridge, 2000). Member 2 is similar to Member 1 in general composition, but is only a 1m to 2m thick deposit around the flanks of the central debris cone. Bone fragments are rare. Member 3 overlies Member 2 and is preserved only on the western flank of the debris cone. It forms a breccia sequence up to 4m thick of deeply weathered chert and dolomite clasts and abundant bone, set in a matrix of pale reddish brown sandy silt. The weathered nature of the clasts suggests that the roof cover may have been fairly thin during the deposition of Member 3, and that deroofing (the period where the roof of the cave eroded away) was already underway. Stratification is evident in the lower part of the sequence. Nearly all the fossil material recovered from Kromdraai has come from the lower part of Member 3. Stalagmites have also grown from near the base of this sequence in places.

Member 4 unconformably overlies Member 3 with an abrupt and wavy contact (Partridge, 2000) and consists of up to 3m of chert and dolomite clasts and rare bone in a matrix of reddish yellow silty sand. Member 5 shows an increasing silt content over Member 4 (Partridge, 2000), but is otherwise similar to Member 4, comprising a sequence of around 1m of weathered chert and dolomite clasts and rare bone in a reddish brown silty matrix.

Partridge (2000) believes that when viewed as a whole, the Kromdraai (B) Formation represents a fairly dry climatic period. Only patches of vegetational cover were present and surface material and soil were fairly rapidly flushed into the cave during storms.

Coopers

As presently excavated Coopers is a collection of three distinct sites (termed A, B and D) with different depositional histories and fill dynamics. The sites are situated between Sterkfontein and Kromdraai on the south flank of the Bloukrans Valley and all occur in dolomites of the Monte Christo Formation. Although the site has been known since 1938 (Shaw, 1939, 1940; Brain, 1958), and other faunal remains have been previously reported there (Shaw, 1939; Broom and Schepers 1946; Berger et al., 1995; Steininger and Berger, 2000), it has received little attention until very recently when quite a number of fossil hominins have been discovered.

Cercopithecid monkeys (see Module 5) have been found at Coopers A, but the geology has not been studied in any great detail. In 1954, Brain excavated Coopers B, but concluded that the main deposits were poorly fossiliferous. Excavations on a new site (Coopers D) were initiated in June 2001 by the author and colleagues. The area of current excavation extends along an east-west trending, 3m wide by 20m long deroofed cave. An area of some 60m2

has been cleared to a depth of between 1m and 1.5 m. This has revealed a new cave fill deposit that as presently exposed consists of two geologically discrete sequences. These two fills are termed Coopers D West and Coopers D East deposits (Berger et al. in press).

Studies of the relationships between the two deposits show the Coopers D west deposit to be the older of the two fills and that the sequence rests on a dolomitic floor that preserves flowstones of various types and forms. Two entrances probably fed sediment to the cave at about the same time, one to the northeast and a second to the southwest creating stratified sequences. This stratified sequence contains an abundant **micromammalian fauna**, and forms the bulk of the lower unit. At places this sequence has filled the chamber to the roof, but in other areas it is separated by a thin flowstone from a slightly coarser top unit. The lack of any evidence of roof collapse, coupled with the presence of flowstones that bound the various units, suggests that the entire series was deposited while the cave still had a fairly complete roof.

micromammalian fauna / micromammalian fauna / small animals such as rats and mice
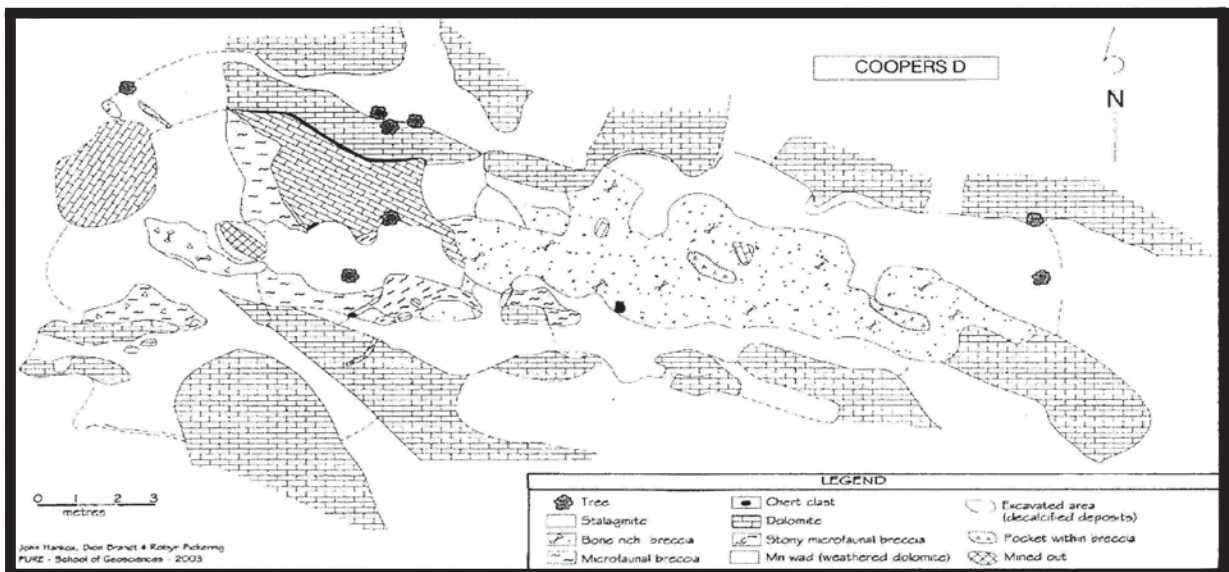
Coopers D in plan from Hall et al. (2005).

The Coopers D East deposit is far coarser and contains roof block clasts of chert and dolomite up to 50cm in diameter. The whole deposit is almost identical to that observed by Partridge at nearby Kromdraai (discussed in the previous section). This was deposited as a cone beneath a vertical to subvertical roof opening. The shape of the deposit is to a large extent controlled by the three-dimensional confines of the cave. The presence of numerous roof block clasts may be evidence of the initial stages of the deroofing of the cave.

Coopers A and B have produced collections of small fossil, the exact provenience of which is uncertain. As a result, this book focuses on Coopers D, which has produced a large hominin-bearing sample.

Bolt's Farm

The Bolt's Farm site is a series of isolated cave infills located 3km southwest of Sterkfontein that have been historically (and erroneously) referred to as a single site or area. A survey of solution cavities and pits associated with fossils in the Bolt's Farm area was undertaken by Peabody in 1947 and 1948 as part of the University of California African Expedition under the leadership of Camp. Faunal material collected during this fieldwork was subsequently studied by a number of palaeontologists. Frank Senegas and Francis Thadering (Senegas et al, 2002) briefly reviewed research related to Bolt's Farm and assigned GPS coordinates and waypoints to the pits identified by earlier teams. Non-hominin primates from Pits 6 and 23 were described by Freedman (1957, 1976). Cooke (1985) described a new mustelid, *Ictonyx bolti*, from Pit 10. He also described cranial material of a sabre-tooth cat *Dinofelis barlowi*, from Pit 23 (Cooke, 1991). Proboscidean (elephant) fossils from Pit 7 were examined by Cooke (1993a), suids (pigs) from Pits 3 and 14 (Cooke, 1993b) and specimens of *Antidorcas recki* (an extinct springbok) from Pit 3 (Cooke, 1996). Fauna from Waypoint 160 (Senegas. et. al., 2002) has been used to suggest that this site is one of the oldest Plio-Pleistocene sites in the Sterkfontein area, possibly over 4.0 Mya (Senegas and Avery, 1998; Senegas and Michaux, 2000).

See the photograph of the Dinofelis skull on Pg. 127 of the *Field Guide to the Cradle of Humankind* (2nd edition)

biochronological / biochronological / faunal dating
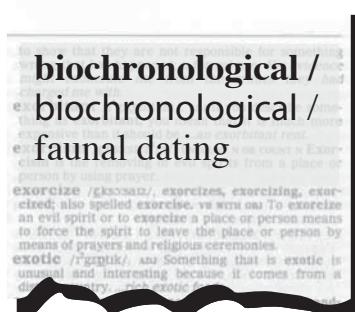
Extensive mining activities at the Bolt's Farm sites have removed much of the contextual information from the various deposits, and the geology of the area is virtually unknown. Fossils obtained from the numerous pits identified by the University of California African Expedition are almost certainly of different ages, making **biochronological** analysis particularly difficult.

27

Swartkrans

Swartkrans is situated approximately 1km to the west-northwest of Sterkfontein on the north side of the Bloubank Valley. The cave site occurs on the intersection of two fault lines that trend roughly east-west and north-south (Brain and Watson, 1992). Most of the original roof of the cave has been removed by erosion.

The earliest palaeontological work at Swartkrans dates to 1948 when Broom began collecting fossils at the request of the University of California African Expedition discussed in the previous section on Bolt's Farm. Broom worked at the site until his death in 1951, and he, and later John Robinson, recovered a large amount of hominin material. This material included the first recorded occurrence of more than one hominin species in a single deposit: *Paranthropus robustus* alongside a type of early *Homo* (Broom and Robinson, 1950, 1952). Robinson continued his work at Swartkrans until 1953, when the site was abandoned.

In 1965, C.K. Brain of the Transvaal Museum resumed work at the site, work that continued for the next 21 years. Brain's excavations involved sampling mining displaced breccia blocks, as well as the first **in situ** excavations at the site. The meticulous nature of the provenience data that he recorded (a level far beyond what was generally accepted as the norm at the time) allowed a workable Geographical Information

in situ / in situ / in place or undisturbed

System (GIS) based 3-D map of *in situ* deposits to later be reconstructed (Nigro et al., 2003). The faunal assemblage that Brain was able to extract from this site was instrumental in his re-interpretation of the way bones accumulate in the fossil caves, detailed in his (1981) book, aptly titled The Hunters or the Hunted? Other notable discoveries at Swartkrans included evidence of the earliest controlled use of fire (Brain and Sillen, 1988), as well a number of bone tools that are thought to be termite mound digging implements (Backwell and D'Errico, 2001).

Early work at Swartkrans, however, centered on lime mining and the collection of fossil material around this mining activity, and the early accounts of the geology are thus purely descriptive (e.g. King, 1951). Quoting work by Brain, Oakley (1954a,b) discusses some aspects of the breccia types at Swartkrans. Brain (1958) however provided the first comprehensive geological study and developed the first model for the stratigraphy of the site. Work continued at Swartkrans for the following two decades (Brain, 1976) and in the mid 1970s Butzer (1976) advanced
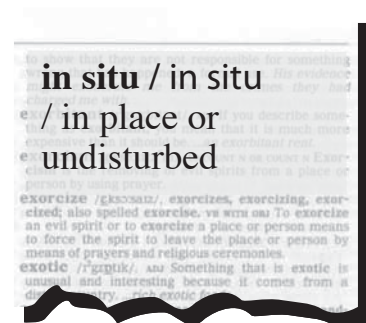
on Brain's earlier work and formally defined the Swartkrans Formation, with two component members. But it was not until 1979, when Brain began *in situ* excavations of the sedimentary strata of Members 1, 2 and 3, that meaningful geological data was generated. His efforts provided a number of insights into the complexity and nature of the fill, and led to the development of a five-member stratigraphy for the site, with each member separated from its older counterpart by an erosional **discontinuity** (Brain, 1993a).
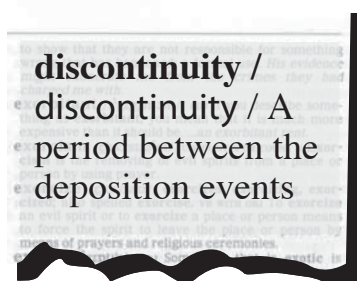
> **discontinuity / discontinuity / A period between the deposition events**

In detail, Member 1 (A-C) represents the early stage of fill, with unit 1A being formed by a basal 2m thick clean flowstone that represents chemical sedimentation while the cave was still mostly closed. Unit B consists of a poorly sorted angular breccia, containing numerous chert and dolomite roof blocks set in a matrix of yellowish red, poorly calcified clayey sand. This deposit is interpreted as a large debris cone, that was supplied sediment via a vertical shaft (Partridge, 2000), and nearly filled the chamber within a very short period, possibly only 20 000 years according to Brain (1993a). A new shaft entrance near the north wall of the cave allowed for the accumulation of Unit C, which comprises a series of steeply dipping breccia fans, separated by pale reddish brown, highly calcified silty-sand and flowstones.

Member 2 is believed to be separated from Member 1 by a period of erosion, during which time a receptacle was formed between the lower bank and hanging remnant of Member 1. Renewed deposition down a shaft near the center of the cave led to the infilling of this feature by reddish brown clayey silty sand and clasts of dolomite and speleothems. Flowstone lenses bound the individual subunits, and the matrix is highly calcified. These Member 2 sediments are highly fossiliferous, and yield a diverse mammalian fauna including hominins. This unit has also yielded artifacts of a Developed Oldowan or Early Acheulean industry, as well as bone tools .

> **For a more detailed description of the bone tools see Pg. 122 of the *Field Guide to the Cradle of Humankind* (2nd edition)**

> **For more information on this subject see Pg. 78 of the Field Guide to the Cradle of Humankind (2nd edition)**

Member 3 was excavated between 1982 and 1986. This infill was formed in a 6m deep gully eroded into Member 1 and 2 deposits. It is mostly noted for the fact that it contains burnt bone, the spatial and temporal distribution of which is suggestive of the controlled use of fire in the cave entrance (Brain and Sillen, 1988), and this therefore marks the earliest evidence of the controlled use of fire on the planet.

Member 4 is a largely uncalcified deposit that occupies the northeast corner of the cave, and was deposited under an overhanging roof remnant according to Partridge (2000). It contains abundant Middle Stone Age artifacts but has not yet been excavated. Member 5 is much younger than Member 4, from which it is separated by an erosional disconformity. It forms a 4m thick, lightly calcified deposit on the northwest side of the cave, and has yielded abundant remains of the extinct springbok *Antidorcas bondi*, from which a radiocarbon age of 11 thousand years (Kya) has been obtained (Brain, 1993).

The cave fill at Swartkrans documents a history of repeated cycles of erosion and deposition, which Brain and Watson (1992) attribute to alternating **glacial** and **interglacial** climatic cycles. They based this idea on the fact that Member 5 formed during the peak of the current interglacial period. Brain and Watson (1992) suggested that other depositional phases may have been interglacial as well. Although Partridge has suggested that this may not hold true at other sites, Brain (2000) still favours the original interpretation and notes that each of the fossiliferous deposits at Swartkrans represents a brief interglacial accumulation. This would imply, however, that numerous glacial-interglacial cycles are not preserved in the cave fill history an important point about how representative the cave deposits are of the whole of the external environment.

glacial / glacial / during ice ages

interglacial / interglacial / between ice ages

Gladysvale

The Gladysvale site is some 13km north-northeast of Sterkfontein on the John Nash Nature Reserve and occurs in the Eccles Formation. Mining for bat guano and lime took place in the caves there between 1902 and 1928. The first fossil discoveries were made in the mid-1930s. Camp and Peabody excavated large numbers of fossils from the site in 1948 as part of the California expedition. The results of their work were not published, but they did keep a record of their fieldwork, and of the stratigraphic sections they excavated. These records are found in Peabody's notebooks, which are archived at the University of California Museum of Paleontology in Berkley.

See the sections on Bolt's Farm and Swartkrans for more information about this expedition
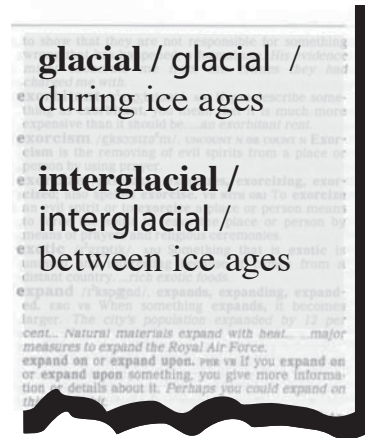
For the next four decades Gladysvale was largely forgotten until 1992 when early hominin fossils were discovered there. Gladysvale was the first new early hominin site to be discovered in South Africa in nearly half a century (Berger et al., 1993). Finds included teeth from *Australopithecus africanus* from *ex situ* mine dumps (Berger, 1992; Berger et al., 1993). Following these discoveries, Gladysvale became the focus of much new research (Hancox et al. 2002; Lacruz 2002; Lacruz et al. 2002, in press; Schmid 2002; Pickering, 2002; Pickering et al., 2003), and is now one of the better documented and understood of the COH cave sites.

Gladysvale is a large system of caves consisting of several underground chambers reaching to a depth of 65m below the surface (Martini and Keyser, 1989). The cave system is structurally controlled and Digital Terrain Modeling of the interior cave at Gladysvale has shown that the cave walls are highly parallel, being controlled by vertical fractures and faults in the dolomite (Schmid 2002). The roofed section consists of an upper chamber and at least two lower depositories, in which a number of different aged fills are preserved. These are collectively known as the Gladysvale Internal Deposits (known in short as GVID). The outer de-roofed section is known as the Gladysvale External Deposit or GVED (Lacruz 2002; Lacruz et al. 2002).

To date at least five episodes of cave fill have been documented, which, based on the fauna and provisional ESR dates (short for Electron Spin Resonance), seem to have occurred from around 2 Mya, and at 1.4 to1.2 Mya, 800 to 600 Kya, and 250 to 200 Kya (unpublished ESR dates and Schmid, 2000).

Most of the work so far has focused on the 800 to 600 Kya aged fill. Here the GVED and back wall of the upper internal cave fill (GVID), known as the Peabody Chamber, provide the keys to understanding the nature of the depositional system and cave fill. This deposit is unique among the South African cave sites in that it has an extensive stratified succession' first noted by the author and Tobias in 1994, that is amenable to modern stratigraphic analysis. These two researchers (1994) divided the exposed section into a Lower Stony Breccia and an Upper Pink Breccia. Since then excavations have opened up a large area of the GVED and have shown that the deposit is far more extensive and laterally continuous than originally thought.

Studies of the GVED and GVID deposits have shown the nature of the Pleistocene fill to be highly episodic; being composed of numerous cyclic flowstone bound units or FBUs (following the terminology of Moriaty et al. 2000). Packages of FBUs stack into flowstone bound intervals (FBIs) that in turn are capped by thicker accumulations of fairly uncontaminated flowstone

(flowstones that do not contain debris from the outside). As such FBU's and FBI's represent chronostratigraphic sequences that can be correlated throughout the deposit.

The stratigraphy of the GVED deposit comprises eleven individual flowstone bound units (Lacruz et al., 2002), each of which can be defined on the basis of clast and matrix composition, petrology, sedimentary structure and the presence or absence of micro- and macro faunal remains. These have been grouped into three FBIs (Lacruz et al. 2002) that are traceable into the Peabody Chamber (Pickering, 2002; Pickering et al., 2003).

Due to the stratified nature of the deposit and its lateral continuity, the 800 to 600 Kya sequence at Gladysvale has the potential to be an excellent record of terrestrial palaeoclimate information for the interior of South Africa during the Middle Pleistocene.

Drimolen

The site of Drimolen occurs some 7km to the north of Sterkfontein. First investigated in 1992, the site has subsequently produced a large hominin fossil assemblage, and a moderate sized non-hominin assemblage. The site contains numerous remains of *Paranthropus robustus*, as well as several specimens belonging to a form of early *Homo* (Keyser et al., 2000). Keyser (Keyser et al, 2000) provides a block diagram showing the stratigraphic relationships of the fills. Like Swartkrans and Sterkfontein, the cave at Drimolen is placed stratigraphically within the Monte Christo Formation. These authors subdivide the fossiliferous sediments at the site into two groups that they term the "*in situ*" deposits and the "Collapsed Fill". Within the *in situ* deposits two fossil bearing horizons are recognised, a "Blocky Breccia" and a "Cave Siltstone". The authors note that these two units are contemporaneous and represent the **proximal** and **distal** deposits of the debris cone. The Blocky Breccia is composed of dolomite and chert clasts set in a pinkish brown sandy matrix. It is richly fossiliferous and all the hominin material come from this unit. The Cave Siltstone is a finely laminated reddish brown siltstone that is internally structured by ripple cross-stratification, and preserves significant numbers of micromammalian remains. The Collapsed Fill occurs only in the main quarry and comprises an oversize clast breccia with dolomite roof blocks up to 5m in diameter. The matrix of this unit is a dark brown manganiferous dolomitic soil derived from the hillslope to the west of the site (Keyser et al. 2000). The very fine female robust australopithecine skull is considered one of the finest fossil hominid skulls yet found in the COH.
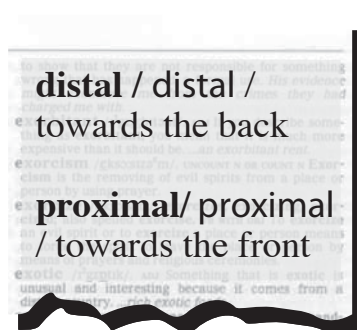
distal / distal / towards the back

proximal/ proximal / towards the front

Pictured on the cover of the Field Guide to the Cradle of Humankind (2nd edition) and on Pg. 128

Gondolin

The site of Gondolin occurs in an abandoned limeworks 4km southwest of the town of Broederstroom in the North West Province. Like Gladysvale, Haasgat and Motsetse, the cave occurs in dolomites of the Eccles Formation. The site was first excavated in 1979 by E.S. Vrba, producing a moderate sized faunal assemblage (Watson, 1993b). Renewed work at the site in 1997 revealed two isolated hominin teeth (Menter et al., 1999), one of which belongs to *Paranthropus*, while the other remains unidentified.

The geology of the site is briefly described by Menter (Menter et al., 1999), who provides a cross-sectional schematic of the fill. These researchers essentially recognise three phases of fill based on the succession preserved on the north and western walls of the cave. The base of the sequence is formed by a flowstone cemented, oversize clast, roof collapse breccia, with clasts up to 5m in diameter (Menter *et al.* 1999). This basal collapse material forms the nucleus for debris cone sedimentation. Sediment was fed through an opening in the northeastern corner of the main chamber. In this part of the cave the basal unit, termed the "Conglomerate Unit" by Menter and colleagues is formed by a breccia layer with an average clast size of 10cm, and a minimum thickness of 2.8m. According to the authors, this unit fines upward into the overlying "Finer Clastic Unit". This part of the fill comprises finer sediment, and is highly fossiliferous. The entire sequence is capped by a unit of flowstone. From the description, this sequence suggests a fairly rapid infill, followed by a choking of the cave entrance, and flowstone precipitation.

Haasgat

The cave site of Haasgat is a simple east-west trending cavern that occurs on the farm Leeuwenkloof 48 JQ in the Brits district. Like Gladysvale and Gondolin it was formed in the dolomites of the Eccles Formation. Fossiliferous breccias were first recognised there in 1980 by J. Martini, and excavations at the site were initiated by Andre Keyser in 1988. A moderate sized, diverse faunal assemblage has been recorded from Haasgat, including a well-preserved primate component (McKee and Keyser, 1994; von Mayer, 1988). No hominins have been recovered from Haasgat, and no excavations are currently being undertaken at this site.

As at Coopers, Kromdraai, Drimolen and Gondolin, the fill of the cave is fairly simple, being restricted to two main events. It preserves a similar sequence to a number of the sites in the area, with a basal sequence composed of oversized dolomite and chert roof blocks, cemented by massive flowstone, overlain by fossiliferous laminated silts and breccia. The geology of the site has been described by *Keyser (1991).*

The main part of the preserved fill is composed of reddish brown silts that sporadically preserve chert and dolomite clasts, and are thought to have been deposited on the distal slopes of a debris cone (Keyser, 1991). These silts contain abundant bone, ranging in size and nature from complete bovid long bones, to microscopic bone fragments. That deposition of these silty deposits was not constant is evident by the presence of a 15cm thick flowstone that separates the silt sequence into two flowstone bound units. Following the deroofing of the cave, numerous solution hollows formed, that preserved a typical dolomite chert breccia, and fossil bone with a staining of manganese.

Plover's Lake

Initial excavations at the Plover's Lake external deposits began in 1991, but no stratigraphy has yet been proposed. Only a brief account of the geology is given by Thackeray and Watson (1994), who identify two "channels" of deposits separated from each other by a chert partition. According to these researchers, the breccia reaches a maximum thickness of 3.5m in the southern channel. Thackeray and Watson (1994) retrieved a moderate sized faunal assemblage from an area of hard breccia containing clasts of dolomite and chert. Several primate fossils were recorded, but no hominins have yet been found in the hard breccia deposit.

A second fossiliferous deposit was recently recognised in an elongated cave approximately 50 m from the hard breccia deposit. This second fossiliferous unit consists of primarily decalcified sediments, and is referred to as the Plover's Lake Internal deposit; consequently, the hard breccia deposit sampled by Thackeray and Watson (1994) is now referred to as the Plover's Lake External deposit. The relative association of these two deposits is unknown at this time. Three hominin teeth and other remains of humans have been recovered from the Internal Deposit which fit together via interproximal contact. These teeth are indistinguishable from modern human teeth, and are associated with a diverse Middle Stone Age (MSA) stone tool assemblage (Berger et al., 2003).

Motsetse

Motsetse is located approximately 16km north-east of Sterkfontein in the Eccles Formation. Excavations were first undertaken at the site by the author in 1999, and a diverse faunal assemblage has been collected. Three main calcified breccia deposits were recognised at the site, while three smaller fossiliferous areas were also identified during an initial exploration of the area (Berger and Lacruz, 2004). The main areas have been designated the Upper, Middle and Lower deposits, with cemented breccias that vary from dark brown in the upper

deposit, to a lighter pinkish colour in the middle and lower deposits. Clasts consist of chert, dolomite and quartz, with extensive areas of decalcified sediments immediately surrounding the hard breccias.

Minnaars

No formal excavations have been undertaken at Minnaars and fossils recovered from this locality have been derived from occasional samples. Virtually nothing is known of the geology of the deposit, and only a handful of fossil material has been collected.

DATING SITES IN THE CRADLE OF HUMANKIND

How Old Are They?

Miocene - c24 Mya – c5 Mya

Pliocene - c5 Mya – c1.6 Mya

Pleistocene – c1.6 Mya – c10,000 Years before present (Ybp)

Holocene – c10,000 Ybp – present

One of the primary goals of palaeontological or archaeological work is to determine exactly how old a find is. There are two basic types of dating methods - relative dating, where we attempt to establish whether something is older or younger than something else, and absolute or chronometric dating, where we attempt to establish the number of years before the present the age of an object, fossil or sediments layer is. Since the discovery of the Taung child in 1924, determining the age of the deposits in which the South African fossils are located has been an important focus. This is because we wish to reach an understanding of our fossils' position in human and animal evolution.

The following section reviews the history of attempts to date the South African sites. It is however important to note that attempts to "date" sites prior to the 1960s were based almost entirely on attempts to correlate them with fauna from Europe and from limited excavations in other African countries. In other words, scientists tried to understand their the age of the South African fossil sites from what they had learned from other sites around the world. Furthermore

the terms that they used to try and describe certain periods in the Earth's history such as "Miocene", "Pliocene"* and "Pleistocene" lacked absolute meaning until the widespread use of radiometric dating techniques at the East African sites. It is therefore important for the reader to recognise the limitations of the terminologies used by these earlier researchers and understand that the dates assigned to the epoch's at the beginning of this chapter and elsewhere are relatively modern in origin.

The first hominin fossil discovered in Africa was the "Taung Child" and although Raymond Dart (1925) did not initially provide an estimate of the age of the Taung deposit when he first described the Taung Child, he was soon asked to do so by British scientists given the importance of the find (Smith, 1925). Dart (1926, 1929, 1933) responded to this request by suggesting that the Taung deposit was most likely Pliocene in age. Although Robert Broom was one of the few scientists of the time that supported Dart's suggestion that the Taung Child was hominin, he was less certain about Dart's suggestion for the age of the Taung deposit,. Based on the fauna recovered from the site, he thought that it could be either Pleistocene or Pliocene, though he clearly preferred the younger Pleistocene option (Broom, 1925a, 1925b, 1930, 1934).

The first geologist to examine the Taung locality was also able to conclude only that the deposit was either Pliocene or Pleistocene in age (Young, 1925). Based on an examination of some of the baboon skulls that had been recovered from Taung at the time, or just before the recovery of the Taung child, Haughton (1925) had earlier suggested that the site might correlate with the pre-Pleistocene of Europe. Sir Arthur Keith (1931), although critical of the hominin status of the Taung skull, suggested it could not be older than the beginning of the Pleistocene.

Robert Broom then recovered the first adult australopithecine specimen from the site of Sterkfontein in 1936. As a result of his investigation of the fauna from the site, Broom (1936, 1937, 1938, 1941a,b, 1943) suggested a Pleistocene age for the locality; though he later raised the possibility that Sterkfontein could be Pliocene (Broom and Schepers, 1946). He based this on the presence of an extinct hyena, Lycyaena (now referred to Chasmaporthetes), and a fossil cat called Megantereon in the deposit. Cooke (1938) tentatively correlated the Sterkfontein deposits with a series of alternating wet-dry phases of sediment deposition in the Vaal River basin, suggesting an upper Pleistocene age for the hominin-bearing locality (in this context "upper" means younger and "lower" would mean older, thus "upper Pleistocene" is

the most recent part of the Pleistocene). Middleton Shaw (1938) correlated the teeth of a fossil pig from Sterkfontein to remains recovered from the Plio-Pleistocene aged Vaal River gravels (Broom, 1928).

As discussed in the previous section, Kromdraai was discovered to be an australopithecine-bearing locality in 1938 by Robert Broom who initially considered the site to be middle Pleistocene in age (Broom, 1938, 1941a,b, 1943, 1950; Broom and Schepers, 1946). Broom believed Kromdraai was more-or-less contemporaneous with Sterkfontein, though of a younger age within the middle Pleistocene as the faunal remains from the two sites had some notable differences. Dart (1940b) agreed with Broom that the Sterkfontein and Kromdraai fossils were likely to be younger than Taung. He placed Sterkfontein and Kromdraai in the Pleistocene because he believed they were more advanced forms of the (Pliocene-aged) Taung child, suggesting that, "their place in the Pleistocene is thus natural" (Dart, 1940b).

The earliest fossils recovered from Makapansgat were sent to Raymond Dart in 1925, though it was not until 1945 that he sent a group of students to the site to examine the deposit in more detail. The first australopithecine specimens were recovered from the site in 1947 (Dart, 1948a,b). The first age estimate of Makapansgat was produced by Bosazza and his colleagues (Bosazza et al., 1946). They believed that the site was accumulated early in the first of four invasions of the Kalahari desert, the base of which was placed in the early Pliocene, about 6 Mya. It was later demonstrated (Brain, 1958; Brain, et al., 1955) that the deposits were not from such an invasion. Based on his study of the cyclical erosion of the cave's surfaces, Barbour (1949a,b) suggested that Makapansgat was somewhat older than the lower Pleistocene. Broom felt that the faunal remains from Makapansgat were so different from anything that had been recovered from the other known fossil localities in South Africa that they were probably Pliocene in age, certainly older than Sterkfontein, and perhaps even older than Taung (Broom, 1950).

As discussed in the previous sections, the first hominin remains were recovered from Swartkrans in 1948 by Broom in association with the University of California, Berkeley African expedition (Broom 1949). Not long after beginning operations at the site, a well preserved mandible (jaw bone) that Broom assigned to a new species - *Telanthropus capensis* (now referred to early *Homo*) was found in association with the *Paranthropus* materials that were also being recovered form the site (Broom and Robinson, 1949). Initially Broom believed the *Telanthropus* mandible (SK 15) to belong to a considerably later date than other fossils from Swartkrans as it was found in a pocket of different coloured breccia within the main deposit (Broom and Robinson, 1949). It was thought that the main deposit was upper Pliocene, while the SK 15 mandible was lower Pleistocene. The subsequent discovery of further *Telanthropus* material

(SK 45) in the same, main deposit as the *Paranthropus* material caused Broom and Robinson (1950) to reconsider their estimated age for the more human-like material, indicating that the two species were contemporaneous, and thus perhaps the whole assemblage was of Pliocene age.

In 1947 Haughton suggested that since all of the South African fossil localities known at the time exhibited a similar, limited pattern of climatic fluctuations in their sedimentation (i.e. they were all deposited under similar arid conditions), that they were most probably all of the same geological age. Haughton (1947) believed that the differences in the fauna between the localities represented ecological differences, not temporal (time), caces were separated by large geographical distances, in particular Taung and Makapansgat. King (1951) recognised a similar depositional sequence at all of the South African cave sites, and he agreed with Haughton that they had all been deposited under the same arid (dry) conditions. As a result, he also concluded that all of the sites were broadly contemporaneous, and most likely Pliocene in age. Broom and Robinson (1950; Robinson, 1952) challenged this interpretation on both stratigraphic and faunal grounds. Since the three sites in the COH are all within a few kilometres of each other, yet their identified faunal components were considered to be so different, they were regarded as having accumulated at considerably different ages (Broom and Robinson, 1950; Robinson, 1952). They concluded instead that the sites were probably upper Pliocene, with a possible lower Pleistocene date for Kromdraai.

Cooke (1952) then provided the first detailed chronological correlation of the fossil caves of South Africa using fauna, and suggested that Makapansgat was of a broadly similar age to Sterkfontein, which he proposed was approximately in the lower to middle Pleistocene, revising his earlier (1938) opinion of the age of the sites. He also suggested that Taung correlated well with Sterkfontein and Makapansgat, and that they could all be referred to the lower Pleistocene. Dart (1952) correlated the fauna from the grey breccia (later known as Member 3) of Makapansgat with that of Omo in east Africa, and suggested that the site was lower Pleistocene; he also correlated the overlying reddish-brown breccia (later known as Member 4) with Kromdraai and Olduvai Gorge, which indicated to him that this deposit was also lower Pleistocene, though younger than the grey breccia.

Oakley (1954a,b) supported Robinson's (1952) view that the Sterkfontein valley sites represented a successive sequence of deposits of Pliocene or, more likely, Pleistocene age. He initially suggested that Taung was the oldest of the sites, followed by Makapansgat, though he later altered this view and indicated that Sterkfontein might be older than Makapansgat (Oakley, 1957). He therefore finally suggested that the sites were deposited in the following sequence: Taung – Sterkfontein – Makapansgat – Swartkrans – Kromdraai (Oakley, 1957).

He also provided a correlation of the South African faunal assemblages with those from sites in East Africa, suggesting that Taung, Sterkfontein and Makapansgat compared well with Omo and Kanam, and that Swartkrans and Kromdraai could be related to Beds I and II of Olduvai Gorge (Oakley, 1957). It is important to note here that to this point in the history of dating the South African sites, all of these geologists and geochronologists supported the idea that the sites had their infill laid down at roughly a single moment in time, an idea that would eventually be replaced with the concept of multiple fills in a single site. This advanced view of the nature of cave infills, however, was still many years in the future, over the next decade (through the 1950's) there would be a focus on examining the fauna from the South African sites in order to determine their age.

Based on a new comparative study of the fauna from the South African sites, in the mid-nineteen fifties Howell (1954; 1955) agreed with Oakley's succession of sites, suggesting a lower Pleistocene age for all of the South African localities. He considered that Makapansgat was likely to be younger than Sterkfontein. He also noted that Taung could be either older or younger than Sterkfontein, since the majority of the fauna identified by Broom were extinct. Peabody (1954) concluded that geologically there was no reason to assign Taung to the Pliocene, but that it should rather be referred to the lower Pleistocene.

Brain *et al.* (1955) further examined the geology of the fossil caves, and interpreted the climatic fluctuations in deposition to indicate that Makapansgat was younger than Sterkfontein, and in fact likely overlapped Swartkrans in age; this conclusion was also supported by the faunal evidence (Brain et al., 1955). In the most detailed geological and **climatological** examination of the fossil sites to that point, Brain (1957, 1958) concluded that the sites were lower Pleistocene, and that Sterkfontein was slightly older than Makapansgat, while Swartkrans and Kromdraai were younger.

climatological /
climatological /
Study of the
climate
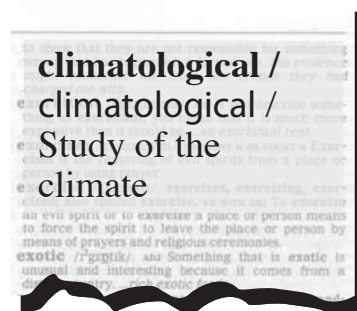
Ewer (1956, 1957) undertook the most detailed study of the fauna from the hominin-bearing cave sites of South Africa to date, and concluded that they were most likely all lower Pleistocene. She suggested that Sterkfontein was slightly older than Makapansgat, making it probably the oldest of the South African sites, as the exact position of Taung in the sequence was not certain. The fauna of Kromdraai suggested to Ewer (1956, 1957) that this was the youngest of the hominin-bearing caves of South Africa, and probably of a lower Pleistocene age. She also indicated that Swartkrans was likely to be considerably younger than Sterkfontein and Makapansgat.

Kurtén (1957, 1960, 1962) then correlated the faunal materials from the South African caves with deposits in Europe and Java, suggesting that the australopithecine sites were middle Pleistocene in age, and contemporaneous with *Pithecanthropus* (*Homo erectus*) in Asia. By placing the South African site younger than those that contained *Homo erectus* in Asia, Kurten had concluded that the australopithecines could not be ancestral to later humans!

The relationships between terminology being used in Europe and Asia and that of Africa was becoming increasingly confusing due to the differences between the faunas of these continents. Therefore, in an attempt to clarify some of the confusion surrounding the geochronological terminology of southern Africa relative to east Africa, Asia and Europe, several authors proposed a system of faunal stages (or faunal spans) (Cooke, 1963, 1967; 1968; Ewer and Cooke, 1964; Vrba, 1974; Wells, 1962, 1967, 1969a). They suggested that four faunal spans be recognised in southern Africa: the Sterkfontein span (including Sterkfontein and Makapansgat), the Swartkrans span (including Swartkrans and Kromdraai), the Cornelia span (including the Vaal River gravels) and the Florisbad span (including Vlakkraal). These authors were all in general agreement that the sites were deposited in the following sequence: Sterkfontein Member 4 (type site) – Makapansgat – Sterkfontein Member 5 (extension site) – Swartkrans – Kromdraai. Wells (1969a) however did suggest that the Sterkfontein Member 4 (type site) could be older than Makapansgat. The position of Taung was uncertain, though it was thought to be broadly equivalent in age to Sterkfontein and Makapansgat. Cooke (1968) suggested that the Sterkfontein faunal span could be correlated with Olduvai Bed I, Laetoli and Omo, while the Swartkrans faunal span compared well with Olduvai Bed II and the Peninj Beds. Hendey (1974a) generally agreed with this outline, though he grouped the hominin cave sites together into an early Makapanian age (Makapansgat and Sterkfontein) and a late Makapanian age (Swartkrans and Kromdraai). Several later studies seriated the fossil localities in an attempt to provide greater resolution of the chronological succession of the sites (McKee, 1995; McKee et al., 1995).

Compared with the larger faunal assemblages extracted from Sterkfontein, Swartkrans and Kromdraai, other sites in the Sterkfontein area, including Gladysvale, Bolt's Farm and Coopers, produced smaller collections. It was originally estimated (Cooke, 1952, 1963, 1967; Wells, 1967, 1969a) that Bolt's Farm was lower Pleistocene, while Gladysvale was early middle Pleistocene, and that both sites overlapped Swartkrans, Kromdraai and Member 5 of Sterkfontein. A fossil suid from Bolt's Farm correlated the site with Koobi Fora, though it was noted that the Bolt's Farm workings represented several discrete localities that overlapped with both Swartkrans and Sterkfontein deposits (Cooke, 1974, 1978a,b). The absolute age of the Bolt's Farm was estimated to be approximately 2.0 Mya (Cooke, 1991). The later discovery of a well-preserved elephant tooth suggested that part of the Bolt's Farm complex might be as old as 2.9 to 3.4 Mya (Cooke, 1993b). Too few fossils had been recovered from Coopers prior to the 1970s to estimate the age of the deposits.

Radiometric and Faunal Dating

With the use of radiometric dating techniques in palaeoanthropology in the 1960's (Leakey, et al., 1961), researchers for the first time were able to absolutely date the fossil sites they were excavating. Prior to this and the development of an accurate radiometric scale, many scientists held that the Pleistocene began approximately 200 Kya, while the Pliocene was thought to extend to about 900 Kya (Keith, 1931), though there was no consensus as to where the Plio-Pleistocene boundary should be placed (Cooke, 1973; Howell, 1972; King, 1955; Oakley, 1964). As a result, earlier attempts to date the South African caves (Pliocene versus Pleistocene, etc.) cannot be directly compared with later discussions, as prior to the development of absolute dating techniques, researchers discussed in the previous section were using entirely different timescales and terminology. The potassium-argon (K/Ar) dates achieved at Olduvai Gorge in the early 1960s at last provided a framework for the accurate dating of hominin fossil localities.

When the first K/Ar dates were produced for Olduvai Gorge (Leakey et al., 1961; see also Leakey, 1967:86), the age estimate of 1.8 Mya significantly extended the timescale over which scientists believed human evolution had occurred. Several other absolute dating techniques were used at the hominin-bearing sites in Africa soon after (Bishop and Miller, 1972) though none of them proved workable in the South African context (Tobias and Hughes, 1969) due to the absence of any accurate way to "set" a radioactive clock – but more about that later. As a result of the use of these radiometric techniques in East Africa, however, an absolute timescale could finally be applied to the question of hominin evolution. The position of the Plio-Pleistocene boundary was accepted at approximately 1.8 Mya (Cooke, 1973, 1977; Berggren et al., 1980), and the use of absolute dates became accepted practice in palaeoanthropology. Although the radiometric dating techniques could not initially be applied to the cave sediments in South Africa, correlations between the faunas of South Africa and those of the accurately dated East African sites were possible. Although indirect, such comparisons still allowed for the development of a more accurate time scale for the South African hominin caves deposits than had previously been possible.

suids / suids / pigs
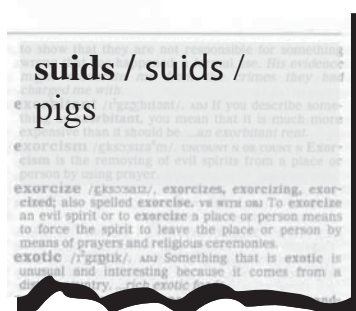
Several attempts to correlate the South African and East African fossil localities have concentrated on the fossil **suids** of Africa. Although researchers tended to disagree on some points of taxonomy and phylogeny, most of these studies agreed on the overall correlations of the South African and east African materials (Cooke, 1974, 1978a, 1983, 1985; Cooke and Maglio, 1972; Harris and White, 1979; White and Harris,

1977). The general consensus was that Makapansgat correlated to Shungura B and C, and thus was approximately 2.5 – 3.0 Mya. The pigs of Sterkfontein were undiagnostic (for dating purposes), but it was thought that Member 4 was probably around 3.0 Mya, and Member 5 was about 1.5 Mya (Cooke, 1983; Cooke and Maglio, 1972). The Swartkrans pigs were correlated to the upper portion of the Koobi Fora sequence in Kenya, as well as Bed II of Olduvai and Shungura H and J, which put the site at approximately 1.7 Mya (Cooke, 1983). Kromdraai's pigs were compared to Bed II of Olduvai, and estimated at about 1.5 Mya (Cooke, 1983). A small number of pig specimens from Bolt's Farm suggested that it overlapped with Shungura B – E and H (Harris and White, 1979), indicating a probable age of between 1.74 and 3.36 Mya for this mixed assemblage site. Pig specimens from Coopers correlated with the KBS tuff at Koobi Fora (Harris and White, 1979), suggesting an age of between 1.64 and 1.88 Mya.

One of the more important points of disagreement between Cooke (1978a) and White and Harris (1977) revolved around the identification of pigs at Makapansgat. White and Harris (1977) held that *Metridiochoerus andrewsi* was represented at Makapansgat, while Cooke (1978a) held that the specimens referred to *Metridiochoerus andrewsi* were actually *Potamochoeroides shawi*. *Metridiochoerus andrewsi*, which is common in Plio-Pleistocene fossil localities in Africa, while *Potamochoeroides shawi* is only known from to South Africa. Cooke (1978a) maintained that if it was *Potamochoeroides shawi* that was represented at Makapansgat, the species was of little value for age correlations. White and Harris (1977) held that the *Metridiochoerus andrewsi* found at Swartkrans was at a more advanced evolutionary stage than those from Makapansgat, therefore Swartkrans correlated with younger fossil sites than Makapansgat.

proboscidean / proboscidean / elephants and their close relatives
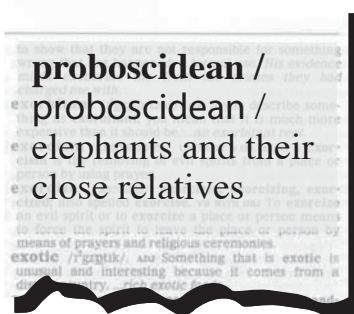
Although fossil **proboscidean** remains are very rare in the South African cave breccias, they have been tentatively used for correlations (Cooke, 1993; Cooke and Maglio, 1972; Maglio, 1973). *Elephas recki* has been identified at Sterkfontein, Makapansgat and Bolt's Farm, suggesting to Cooke (1993b) an age of 3.0 – 3.5 Mya. A more advanced type of *Elephas* that was recovered from Member 3 of Swartkrans, referred to either *Elephas recki*, or more likely *Elephas iolensis*, a Middle to Late Pleistocene form known from the Vaal River gravels of South Africa (Cooke, 1993).

As we moved into the late 1980's the attempt to date the South African caves became even more important as abundant hominin finds were being made in East Africa and these needed to be correlated with the many finds from South Africa if we were really to understand the

mode and tempo of human evolution across Africa. To this end, Delson (1984, 1988) attempted to correlate the East and South African faunal assemblages using the abundant primate material recovered from the various sites. He criticised **biostratigraphical** approaches that relied upon stages of evolution to determine chronological affinity because such studies employed circular reasoning in linking time to evolution, and vice versa, and because they depend on a **gradualist** model (slow and steady change) of species evolution (Delson, 1984; see also Vrba 1977, 1982). Delson constructed instead a series of **biozones** based on the longer, stratigraphically controlled sequences of East Africa, and then compared the South African materials to the geochronologically dated East African fossils. He concluded that Makapansgat was probably the oldest site at roughly 3.0 Mya; Sterkfontein Member 4, Taung and Pit 23 of Bolt's Farm fell somewhere between 2.0

biostratigraphical / biostratigraphical / bio- biological and stratigraphical- stratigraphy

gradulist / gradulist / slow and steady change

biozones / biozones / zones based on the presence or absence of certain animals

and 2.5 Mya; Swartkrans, Kromdraai, Coopers A and Pit 6 of Bolt's Farm were approximately 1.65 to 1.9 Mya (Delson, 1984, 1988). It is important to note that by this time, discrete deposits within the cave sites were being recognized as independent infills.

bovids / bovids / antelopes and their relatives

Going back in time, however, Vrba (1975) first correlated the **bovids** from South Africa with Olduvai Gorge in Tanzania and East Rudolf in Kenya. She estimated that Sterkfontein Member 5 and Kromdraai B were approximately 0.5 Mya, Kromdraai A was 1.0 Mya, Swartkrans Member 1 was 1.5 Mya, Sterkfontein Member 4 was 1.5 to 2.0 Mya, and Makapansgat was just over 2.0 Mya. Her later work (Vrba, 1976, 1977) reiterated these dates, but suggested that Sterkfontein Member 4 was roughly between 2.0 and 2.5 Mya, and Makapansgat was probably closer to 2.5 to 3.0 Mya. In her most comprehensive study of the age of the South African hominin sites, Vrba (1982) again revised her estimates, indicating the following ages: Makapansgat 3.0 Mya, Sterkfontein Member 4 2.3 to 2.8 Mya, Taung 1.0 to 2.5 Mya, Kromdraai B 1.0 to 2.5 Mya (but probably around 2.0 Mya), Swartkrans 1 1.5 to 1.8 Mya, Sterkfontein Member 5 1.5 and Swartkrans 2 1.0 million years in age. She stayed with these dates subsequently (Vrba, 1985a,b), again stressing the close correspondence between the faunas of Sterkfontein Member 4 and Makapansgat Member 3, and the Pliocene age of Makapansgat Member 3 (Vrba, 1987a,b).

Partridge had by then utilised a study of cyclic erosion and nick-point migration to estimate the dates of openings of the fossiliferous caves (Partridge, 1973). The study produced age estimates of the sites that were significantly different from estimates previously derived from faunal studies. The study suggested that Makapansgat began to fill at 3.7 Mya, Sterkfontein at 3.3 Mya, Swartkrans at 2.6 Mya, and Taung at 0.9 Mya. These dates were unexpectedly young for Taung, prompting Tobias (1973, 1975, 1978) to re-evaluate the **phylogeny** of hominins in South Africa, and to suggest that the Taung Child may represent *Paranthropus robustus* rather than *Australopithecus africanus*. However, several authors indicated that such a geomorphological approach was unlikely to be reliable (Bishop, 1978; Butzer, 1974; de Swardt, 1974; Howell, 1978; White et al., 1981), and it appears to have been abandoned.

phylogeny /
phylogeny /
evolutionary
relationship
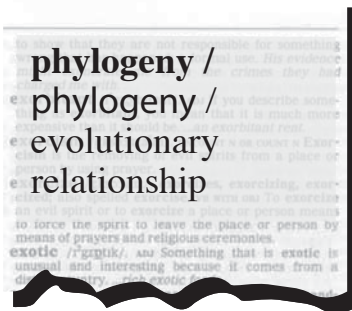
Several other more recent studies have attempted to date the Taung Child skull, producing mixed results. Based on the environmental and stratigraphic context of the Taung Child, Butzer (1974) suggested that it was contemporaneous with Swartkrans and Kromdraai, not Sterkfontein and Makapansgat as had been previously supposed. Examination of the uranium content of the tufas in which the Taung child was probably encased, produced age estimates of between 0.76 and 0.94 Mya (Vogel, 1985; Vogel and Partridge, 1984), dates that were supported by a plating technique called thermoluminescence (Vogel, 1985). These lines of evidence were also used by Tobias (1973, 1975, 1978) in his re-evaluation of hominin phylogeny in South Africa, and Partridge (1985) suggested that the entire primate fauna of Taung represented a relict population in southern Africa, meaning that it had still existed while the remainder of the species went extinct elsewhere in Africa. However, these young dates were ultimately shown to be flawed (Tobias et al., 1993), and dates of 2.4 to 2.6 Mya for the non-hominin deposit, and 2.6 to 2.8 Mya for the probable hominin deposit, were realised based on the faunal material from the site (McKee, 1993a; Cooke, 1990).

Several attempts to date the South African cave sites using palaeomagnetism (looking at the orientation of magnetic particles in the sediment) have produced mixed results. Although Member 3 of Makapansgat (the main hominin-bearing Member) could not be sampled due to the poor mechanical qualities of the rock (Brock et al., 1977), an age estimate of 2.9 to 3.3 Mya was generated for Makapansgat, with the most likely age 3.06 to 3.32 Mya (Brock et al., 1977; McFadden et al., 1979; McFadden, 1980; Partridge, 1979, 1982); this estimate was later altered according to the revised geomagnetic polarity timescale of Cande and Kent (1995) to 3.11 – 3.58 Mya (Partridge et al., 2000). White et al. (1981) criticised the palaeomagnetic dates from Makapansgat, and suggested instead that the minimum

age of the site could be 2.4 Mya, rather than 2.9 Mya. Maguire (1985) questioned the validity of the assumption that Makapansgat represented a sedimentary succession, raising the possibility that more than one of the Members at Makapansgat could have accumulated contemporaneously.

Palaeomagnetic studies at Sterkfontein, Swartkrans, Kromdraai and Taung together originally produced inconsistent results (Brock et al., 1977; McFadden, 1980; McFadden et al., 1979; Partridge, 1982; Partridge, Latham and Heslop, 2000), though Kromdraai was tentatively associated with the Matuyama reversed epoch (0.73 – 2.58 Mya), and Sterkfontein Members 2, 3 and 4 with the Gauss normal epoch (2.58 – 3.58 Mya) (Jones et al., 1986; Partridge, 1986).

Sterkfontein Member 2

The discovery of well preserved hominin foot bones from Member 2 of Sterkfontein (Clarke and Tobias, 1995), which lead to the unearthing of a near complete hominin skeleton (Clarke, 1998), renewed efforts to date Member 2 palaeomagnetically produced an age estimate of 3.22 to 3.58 Mya, with a most likely age of 3.30 to 3.33 Mya (Partridge et al., 1999; Partridge, Shaw and Heslop, 2000; Tobias and Clarke, 1995). This early age was criticised, and, based on the faunal materials derived from Members 2 and 4, the ages of less than 3.0 Mya and 1.5 to 2.5 Mya respectively were suggested, placing the Member 2 deposit much closer in time to Member 4 than the previous estimates (Berger et al., 2002; McKee, 1996). These revised ages have been criticised in turn (Clarke, 2002; Partridge, 2002; Tobias and Clarke, 1996). As mentioned previously, independent geochronological methods have fairly certainly supported a younger age for the Little Foot skeleton and the older suggested ages should most probably be abandoned.

Sterkfontein Member 5

Concentrated excavations in Member 5 of Sterkfontein brought to light a considerable archaeological assemblage, and suggested that what was once considered a homogeneous deposit was actually comprised of several discrete units (Clarke, 1994; Kuman, 1994a,b; Kuman and Clarke, 2000). It was proposed that the STW 53 breccia fell somewhere between 2.0 and 2.6 Mya, the Oldowan infill 1.7 to 2.0 Mya, the Member 5 West deposit 1.4 to 1.7 Mya, and the early Acheulean portion of the assemblage was estimated at approximately 1.5 Mya. Analysis of the fauna from the deposits (Cooke, 1994; Pickering, 1999) provided corroboration for these age estimates.

Swartkrans

As excavation proceeded at the site of Swartkrans, it became increasingly apparent that the stratigraphy of the site was considerably more complex than had been originally thought. Brain (1976, 1981) initially recognised that the hominin fossils had been retrieved from more than one deposit. The sub-deposits were termed Members 1 and 2 (Butzer, 1976), and significant mixing of the Member 2 assemblage was noted (Brain, 1976, 1981; Vrba, 1976). It was suggested that based on the fauna, Member 1 was probably between 1.5 and 2.0 Mya, while the mixed Member 2 deposit was regarded as much younger, perhaps 0.5 Mya to the present (Brain, 1976). Continued excavations at Swartkrans revealed even greater sedimentary complexity, such that five distinct Members were ultimately recognised (Brain, 1985b, 1993a, 1994; Brain et al., 1988). Member 1 was further divided into sub-deposits termed "The Hanging Remnant" and "The Lower Bank", both of which are thought to be between 1.5 and 1.8 Mya (Brain, 1993a,b; Brain et al., 1988). Controlled excavations of *in situ* decalcified Member 2 sediments produced an unmixed assemblage for this deposit that was faunally indistinguishable from Member 1 (Brain et al., 1988; Brain, 1993a,b). The Member 3 assemblage also did not appear to differ from that of Members 1 and 2, and the Members 2 and 3 deposits were considered to fall between 1.0 and 1.5 Mya (Brain, 1993a,b; Brain et al., 1988). Member 4 is comprised of a Middle Stone Age (MSA) tool assemblage, while a 14C date* placed Member 5 at approximately 11 000 years before present (BP). Recent re-analysis of the site (de Ruiter, in press) has suggested that the mixing evident in Members 2, 3 and 5 makes them unreliable for age estimation, though their faunal assemblages do not differ significantly from those of the Member 1 deposits.

Gondolin, Haasgat and Plovers lake external deposit

The earliest faunal report from Gondolin (Watson, 1993) correlated the pigs from the site with remains from Swartkrans and from Koobi Fora, Kenya and suggested an age of approximately 1.5 to 1.9 Mya. Based on a preliminary faunal list, Haasgat was initially considered to be broadly contemporaneous with sites such as Makapansgat, Sterkfontein, Swartkrans and Kromdraai, and therefore near the Plio-Pleistocene boundary. The small size of the assemblage precluded a more precise age estimate (Keyser, 1991; Keyser and Martini, 1990). An expanded faunal assemblage suggested a broad palaeontological bracket of 0.5 to 1.5 Mya, with the older date (ca. 1.5 Mya) considered the more likely based on the associated primate materials (Plug and Keyser, 1994). An early, preliminary report on excavations in the external breccia deposit from Plover's Lake correlated the pigs from the deposit to Olduvai Gorge Beds III and IV, and an age of approximately 1.0 Mya was indicated (Thackeray and Watson, 1993). Subsequent excavations have enlarged the faunal representation from this site, and these were discussed in the previous chapter.

Gladysvale

Although early estimates of the age of Gladysvale placed the deposit in the middle Pleistocene, subsequent excavations indicated that the ex situ breccia from this locality probably represented more than one discrete depositional event. As a result, it was hypothesized that the site encompassed a period spanning approximately 1.6 to 2.5 Mya; if two deposits were indeed present, the younger was thought to extend from 1.6 to 2.0 Mya, and the older from 2.0 to 2.5 Mya (Berger, 1993; Berger et al., 1993). Since it is not possible to determine the source of the fauna recovered prior to 1993, we have since then focused on provenienced, in situ material recovered since 1993. This latter assemblage has been dated to between 578 and 780 Kya via ESR and palaeomagnetism (Lacruz et al., 2002) for the external material and deposits aged between 50 - 250 Kya, 1.1 and 1.3 Mya and 1.5 Mya have been identified.

Drimolen

The initial announcement of the new hominin-bearing site of Drimolen suggested that the fauna associated with the hominins indicated an age of approximately 1.5 – 2.0 Mya (Keyser et al., 2000).

Motsetse

The site of Motsetse is a new fossil bearing deposit located about 16 km northeast of Sterkfontein. It has been assigned a preliminary age of approximately 1.0 to 1.6 Mya based on the carnivore component of the faunal assemblage (Berger and Lacruz, in press). Little is known of the fossiliferous deposit of Minnaars, located between Kromdraai and Plover's Lake. No excavations have taken place at the site, and only a handful of fossil specimens have been sporadically collected. Included in these specimens are several teeth belonging to Equus capensis (Churcher, 1970), thus broadly positioning the site between 2.36 Mya and several tens of thousands of years ago.

Other Methods of Dating the Sites

Recent attempts at dating the South African fossil localities employing electron spin resonance have met with some success (Curnoe, 1999; Curnoe et al., 2001; Schwarz et al., 1994; Schmid, 2002), though problems relating to the reworking of materials have not yet been satisfactorily resolved (Blackwell, 1994). Curnoe et al. (2001) produced an age estimate of 1.6 to 2.1 Mya for the Hanging Remnant of Swartkrans, a dating that accords well with

previous faunal estimates for the deposit (Delson, 1984; Vrba, 1982, 1985a,b). A study of the ESR of Sterkfontein produced an average estimate of 2.1 Mya (Schwarz et al., 1994). A preliminary report on ESR dating at Makapansgat suggested an average age of 2.0 Mya in Member 3 (Blackwell et al., 2001). The results of ESR are therefore encouraging, and may provide radiometric resolution of the problem of the ages of the South African cave sites. Calibration of ESR at K/Ar dated sites might represent a profitable line of future research. Several other methods of absolutely dating the sites including the use of Uranium Lead have shown great promise and will almost certainly result in greater confidence in the age of the Cradle of Humankind Sites in the near future.

A Brief Overview of Our Present Understanding of the Age of the Major Early Hominid Bearing Deposits in South Africa (the number in parentheses after Estimated Age is the author's estimation of the accuracy of the age estimation.

- ***1 = low accuracy, 10 = high accuracy***

- ***Mya = Million years ago, Kya = Thousand years ago***

Locality	Unit/Member	Estimated Age
Makapansgat	Member 3	2.4 – 3.0 Mya (5)
	Member 4	2.4 – 3.0 Mya (5)
Sterkfontein	Member 2	2.4 – 2.9 Mya (5)
	Member 4	1.9 – 2.5 Mya (6)
	Member 5	1.8 – 2.1 Mya (5)
Swartkrans	Member 1	1.1 – 1.5 Mya (6)
	Member 2	1.1 – 1.5 Mya (6)
	Member 3	1.1. – 1.5 Mya (6)
Kromdraai B	Members 2 – 5	1.3 – 1.8 Mya (4)
Coopers	B	1.1 – 1.8 Mya (5)
	D	1.3 – 1.7 Mya (5)

Plovers Lake	Internal Deposits	c70 Kya (6)
Gladysvale	Internal Deposits	80 Kya – 500 Kya (8)
	Peabody's corner	600 Kya – 1.3 Mya (7)
	External Deposits	
	Fill 1	600 Kya – 800 Kya (7)
	Fill 2	1.1 – 1.3 Mya (6)
	Fill 3	1.3 - ? (4)
Drimolen	Main	1.1 – 1.7 Mya (5)
Gondolin	-	1.1 – 1.7 Mya (4)
Taung	Type deposit	1.8 – 2.4 Mya (4)

Notes

MODULE 3

Research Methods Used In The Cradle Of Humankind
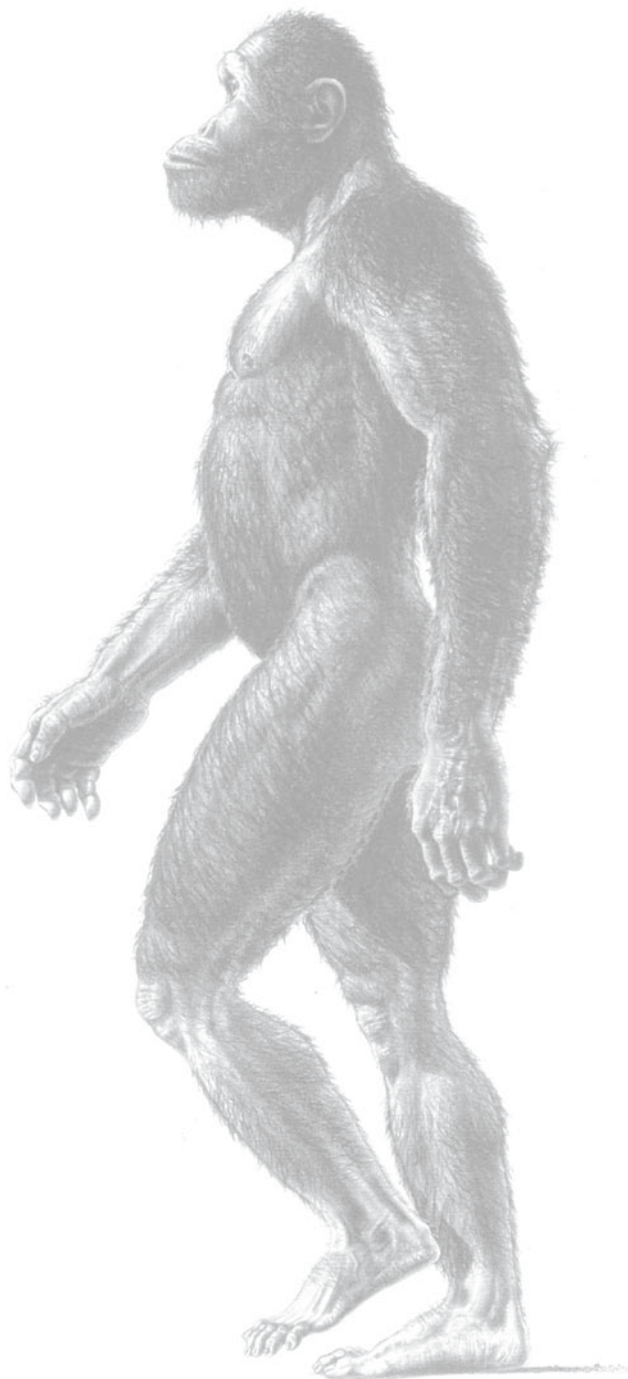
BASIC FIELD EQUIPMENT AND ITS USES

There is no single rule regarding what equipment you should carry into the field and you will certainly develop your own preferences as you gain more experience. There are, however, basic "tools of the trade" which, a competent palaeontologist or archaeologist should be familiar with, regardless of whether he or she decides to carry them or not. The following sections briefly outline some basic equipment and its uses. For more detailed information on any of the equipment you should consult the users' manuals and ask individuals who are familiar with the particular item. Remember that under field conditions there really is no substitute for specialised scientific equipment that has been tested under these rugged conditions!

Hand Lens

The hand lens is a small, usually collapsible, magnifying glass used by geologists and palaeontologists in the field to examine rock samples or details of fossils. Better quality hand lenses have metal housings while more inexpensive models have plastic housings. Hand lenses are best used by holding the lens close to the object and, while keeping both eyes open, looking through the lens at the object you wish to examine. A good magnifying glass can replace a hand lens but one must careful not to scratch or break the larger magnifying glass lens.

A standard 10x hand lens.

Compass

There are a variety of compasses available and prices vary according to quality. Unfortunately, as with most things, the more expensive the compass is, the better its quality is likely to be. As the compass is such an important item in your field kit, it is wise to invest in as high a quality one as you can afford. The more expensive compasses are usually more dependable, which is important when working in the African veldt. You do not want to get lost in the field because you have a broken compass! They also tend to have a longer lifespan, so at least you should be able to count on it lasting you for many years. When selecting your compass for field work in Africa, you should ensure that the compass body is well constructed of metal or strong plastic. A compass such as a Brunton compass has a built in sighting clinometer and bull's-eye level (see page 54), thus removing the need for carrying these items separately in the field kit.

A standard Brunton type professional compass with clinometer and bull's-eye level

Using the Compass

The basic function of a compass is to take a bearing. When a compass is held level, its needle will seek magnetic North from your location. The 'North-seeking' end of a compass is generally indicated in white although colours may vary. A compass bearing is the geographic direction from one point to another and is generally known as the cardinal direction which is noted as a degree from this cardinal direction using first the capital letter designating North (N), South (S), East (E) or West (W), next the degree bearing and the next cardinal direction nearest the needle bearing as in N 20 E (read as North 20 degrees East). An alternative way of stating this same bearing is through the use of the azimuth scale, which uses the face of the compass as a 360° circle with readings from 0° to 359°. Thus the bearing N 20 E would be stated as 20 in an azimuth scale and a reading of N 20 W would be read as 340 in an azimuth scale.

When sighting with a compass, it is critical to hold the compass level, centring the bubble in the bullseye level . Hold the compass at waist level. For compasses with no mirror rotate the bezel until North is in line with the direction of the travel arrow. Rotate the levelled compass on a vertical axis until the direction of travel arrow is pointing along the desired line of bearing. Check the compass level and read the bearing indicated by the North-seeking end of the needle (the North-seeking end of a compass is typically white although this may vary from compass to compass). The bearing indicated is the bearing sighted along the line of the direction of travel arrow. In more sophisticated compasses such as the Brunton that are equipped with a mirror, level the compass as above and adjust the mirror in the lid of the compass until the sighting tip and point sighted both appear in the mirror. Rotate the compass on a vertical axis until the sighting tip and the point sighted meet with the axial line of the mirror. The bearing indicated by the North-seeking tip is the bearing to the point sighted.

A properly centred bullseye bubble

Adjusting a Bearing for Magnetic Declination

Declination is the difference between magnetic North and true North. Magnetic declination at your location may be noted from the legend of almost any topographic map of an area and would usually be indicated in both text and with an illustration showing a pair of directional arrows forming a measurable angle. As local magnetic declination changes or 'drifts' over time, estimated change is usually also given. For accurate readings it is therefore wise to use as recent a map as is possible. A typical declination reading in the legend of a map might be stated as "Mean magnetic declination 20 00' West of True North (Jan. 1974). Mean annual change 3' Eastwards (1970 – 1975)." Declination is compensated for by adjusting the graduated compass circle the amount and direction of the local declination. In most compasses you simply turn the graduated circle on the outer ring of the compass. In the Brunton-type compass, declination is adjusted by means of a screw on the side of the compass. In the case of the example given above, for a reading taken in 1974 the graduated circle would be moved until the index pin located at the base of the sighting arm points to 20 on the side of the graduated circle marked with a W.

> *Tip*
>
> never take a reading near a metallic object or an object containing large amounts of metal. This includes items such as your belt-buckle, pocket knife, cars or even reinforced concrete. Steel and iron items such as these have there own magnetic fields and can cause magnetic irregularities or anomalies and your compass to misread. Magnetic anomalies may also be caused by certain features in nature, iron-bearing rocks or rocks containing magnetic material for example. Natural magnetic anomalies may be indicated when a foresight and back-sight on widely separated sighted points do not agree.

Taping, Electronic Measuring Devices and Pacing

Taping and pacing are crude methods of establishing distance in the field. They may be useful when marking the location of newly discovered locality or giving field note directions to fossil finds for future reference.

Measuring tapes come in a wide variety of types and materials including nylon, fibreglass, plastic and steel. They are usually mounted on a reel or in a self-retracting housing. There are advantages and disadvantages to each type of tape. Most modern field workers rely on the high quality nylon or plastic tapes in lengths greater than 25m. These modern materials have the advantage of not kinking like steel and because they are lighter, have less sag over longer distances. When purchasing a tape, make sure that the material does not stretch when pulled.

Electronic measurement devices or range-finding devices are now widely available and relatively inexpensive. They vary in accuracy from an error of a metre or so to centimetre-level accuracy. For general mapping or recording work in the field an inexpensive rangefinder that is accurate to a metre is usually adequate.

Pacing is a crude method of establishing distances in the field but useful when you do not have a tape or range finder. You should establish your pace before going into the field by measuring a double-step pace against a 100m measured course. You should be able to maintain a natural pace that your can repeat when you are in the field. An error of around 1 to 2m in 100 is generally considered acceptable by most field workers. Remember that your pace changes on uneven ground and this should be taken into account when calculating distance using this method.

GPS

GPS stands for Global Positioning System. It is a radio navigation system that permits users to determine their exact location, altitude, speed and time in all weather conditions, anywhere in the world. The GPS is an accurate navigation system that has effectively replaced most other positioning aids including the compass (until you run out of batteries for the device that is).

A constellation of 24 GPS satellites (21 active, 3 spare) are in orbit at about 20 kilometres above the earth. They were put in place by the U.S. defence department. The constellation are so spaced that from any point on Earth, there will be four satellites above the horizon. Each satellite contains a computer, an atomic clock, and a radio. With an understanding of its own orbit and the clock, the satellite continually broadcasts its changing position and time. Your GPS receiver on the ground contains a computer that "triangulates" its own position from three of the four satellites. The GPS will provide you with a geographic position - longitude and latitude. Receivers vary greatly in their accuracy. The most inaccurate receivers, inexpensive units designed for the general user, will give readings to within a few meters. More expensive units can give exceedingly accurate readings to within a few centimetres.

Some receivers are equipped with a display screen that shows a map. If a fourth satellite can be received, the receiver can also calculate your altitude. If you are moving, your receiver should be able to calculate your speed and direction of travel and give estimated times of arrival to specified destinations.

A standard GPS with map type display

Tips: always carry enough batteries! For most general surveying work and the location of new finds, an inexpensive hand held GPS is more than adequate. It may be useful to keep in mind that in times of military conflict the US Department of Defence reportedly places a random error in the signal from the satellites.

Theodolites and Levels

Levels are generally used for determining the height of a particular point or determining differences in height between points. They may also be used to determine the contours of a land profile. In palaeontology and archaeology we generally use levels to plot the surface of excavations although the use of theodolites and total stations is rapidly replacing the use of levels in excavations and geological mapping.

To determine the difference in height between different points it is necessary to produce a line of sight. This requires the use of an instrument known as a level. The instrument most commonly used is known as a "dumpy level". Whichever level you decide to use, it must consist of a telescope with cross hairs mounted on a device that enables you to orient the device in a horizontal plane. All levels and theodolites are generally mounted on high quality tripods with adjustable legs and heads.
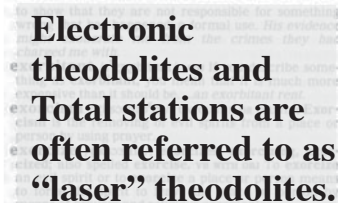
A typical Total Station with digital keypad

A theodolite on the other hand is a scientific instrument used for measuring angles in the horizontal and vertical planes. Most theodolites function in a similar way, but newer or more expensive models tend to have a higher degree of accuracy and are capable of downloading data directly to a computer.

Electronic theodolites are almost identical to the optical instruments but a different method is used to determine horizontal and vertical angles. Like all levels, the machines have a plate bubble, which is used to ensure that the instrument is vertical. Most modern instruments incorporate sensors that assist you by compensating for small errors in your levelling. Other instruments have an electronic display instead of a plate-bubble but work in the same way. Electronic theodolites generally use a reflective prism to bounce an infrared beam off an object in order to determine distance and angle.

A Total Station is really a combination instrument that integrates the functions of a theodolite for measuring angles, an EDM for measuring distances, digital data and information recording.

Electronic theodolites and Total stations are often referred to as "laser" theodolites.

Excavation Equipment

Despite the advances in mapping, basic excavation equipment differs little from that used decades ago. It is wise to develop a personal kit of your own for fieldwork although digs generally provide whatever equipment is necessary at a particular site. A typical set of excavation equipment would include a set of different sized brushes with different bristle strengths, a good quality trowel and a series of various sized picks. A useful trick for obtaining good excavation picks is to visit your local dental surgeon or dental school. Very often they will have large numbers of good quality stainless steel picks with a variety of tips that are extremely well suited to field work. As an added bonus, dental surgeons discard most of these picks after they have used them just a few times so they can be obtained either very cheaply or for free! Gloves, a personal measuring tape, and safety glasses are also useful items. A small fishing tackle box is a good place to store your personal gear.

Field Glues and Preservatives

There are a wide variety of glues used in the field today and advances in glue technology are being made all the time. As a general rule, glues are used in the field either as a repair agent or preservative. Glues should fit the following criteria:

- Be removable

- Have a known chemical composition

- Be clear in colour

- Have no negative properties such as crystallization or expansion

- Be dillutable in a solvent such as alcohol or acetone

Always consult the future curator of a collection before using any glue on a fossil. Many institutions have very strict policies concerning glues and preservatives. Also always keep in mind that some glues can adversely affect certain dating methods and other processes. Fossils that are going to be dated or used for other analytical procedures should not, as a general rule, come into contact with any chemical unless the geochronologist or physicist has been consulted in advance. As a general rule, try to avoid using glues in the field and save such intricate procedures as reconstruction for laboratory conditions.

Cameras

A good photographic record of an excavation is critical and important for historical purposes. While the site foreman or senior scientist will almost certainly be responsible for photography on the site, it is a good idea to have a personal camera for recording your excavation activities. The digital camera has virtually replaced the traditional film-based camera in the field, but remember that you may need your images for publication purposes so take your pictures in the highest resolution possible. If you are using a traditional 35mm camera, always use slide film rather than print film as slide film reproduces better and slide shots can always be converted to print film.

FIELD METHODS

Excavation

This chapter deals with the actual excavation process, the removal of evidence from the site, its care or curation in a laboratory, comparison and interpretation of the material and finally publication of the results. Scientists attempt to devise explicit research plans in advance of an excavation as not only is the act of excavating destructive, but a sound research plan ensures that testable hypotheses are produced and objectives met. Five basic stages are found in any sound research plan:

1. The formulation of the plan

2. The collecting and recording of evidence

3. Processing and analysis of the evidence

4. Interpretation of the evidence

5. Publication and dissemination of evidence

In the old days, focus was placed entirely on excavation of a site. Results were measured in the numbers of fossils found, and some scientists even reported their results in terms of cubic metres or yards excavated. However, modern palaeoanthropology has for the most part matured beyond this narrow 'treasure hunting' approach and research today in the COH is typically more concerned with context rather than with simple discovery. This trend is given momentum by the fact that the methods of preserving context are constantly improving. Moreover, the view that the single site provides the bulk of information about the past is rapidly fading and studies of regional landscapes and surveys of a number of sites are becoming more and more common. As little as five years ago, some researchers were still using string grids and plotting fossil discoveries to within a meter or so. While the tried and true grid method of excavation has its place, our improved understanding of the complexity of sedimentation in the caves of the Cradle of Humankind and the increased use of digital mapping with theodolites, Total Stations and other precision equipment, have made this method virtually obsolete.

There are some basic tenets of archaeological and palaeontological work that one should know before working in the Cradle of Humankind:

- It should always be understood that the pursuit of knowledge about the past is in the public interest.

- An archaeological or palaeontological site may have cultural or historical value to living communities and their descendants as well as significance as a resource for learning about the past. A worker must take these factors into account and choose a research approach that is most appropriate.

- Not all information about the past is equally important and thus not all archaeological or palaeontological sites are equally important for research purposes. While this may be so, it should also be kept in mind that the term "important" is a subjective one. In other words, what is considered important to one researcher, person or culture may not be to another. The idea of importance can also change as time passes and societies' values change.

- The recovery of information from archaeological and palaeontological sites is destructive, so it falls on the excavator to preserve the site as best he or she can for future researchers.

- Archaeological and palaeontological data recovery and research designs should take into account the priorities established for the landowner, the COH, the province, the Nation and UNESCO and be aware of the needs of land and resource managers, academic research interests, and other legitimate public interests.

- Human remains and funerary objects deserve respect and should be treated appropriately.

IDENTIFYING SITES AND POTENTIALLY FOSSILIFEROUS DEPOSITS IN THE COH

Cave deposits

Despite all the work going on in the COH, new fossil sites are constantly being discovered. The most common type of fossiliferous deposit in the COH and those found in dolomitic caves. Fossils are preserved in the infills of these sites through a process that begins with their burial and eventual cementation into a lime rich, concrete-like substance known as breccia. Breccia filled caves that have the potential for fossils may be easy or difficult to locate. Caves that have been mined for lime may be a good place for the novice to start. If mining has occurred at a specific site, one may see large dumps around cave entrances or old wagon tracks.. You can also look for small white lime-chips that often fell off the wagons indicating that a cave is nearby.

The easiest way to identify the presence of a cave in the COH is to look for the two most common trees that often grow in the entrance of caves – the white stinkwood and wild olive. A cluster of one of these distinctive trees is often a sign of a cave entrance or a sinkhole. New advances in satellite imaging and multi-spectral scanning and other remote sensing methods also show promise in the search for new sites.
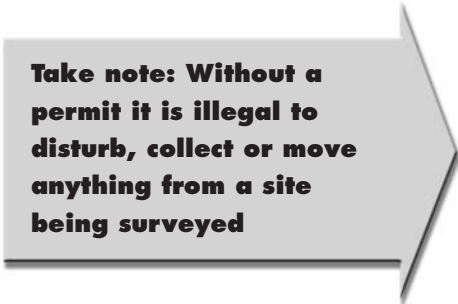
An image of the Gladysvale cave. Note the old miners track leading to the site (A), the white stinkwood and wild olive trees growing on the breccia (B) and the miners dumps (C) that all give clues as to the location of the cave site.

A simple way of assessing the quality of the fossil bearing deposits of a cave site is to conduct a brief survey of the site. One quick method that is often used by palaeoanthropologists is to examine the contents of the mine dumps. This can give you a good idea of the general contents of the breccia – bone density, quality of preservation and types of fauna (animals etc.) in the assemblage. The advantage of examining mine dumps is that they generally represent a cross-section of the caves contents. The disadvantages are many, however, the most important being that the context of the material you are examining is generally lost. One can only really be sure of the quality of the fossil bearing cave by examining the *in-situ* breccia.

Be sure to follow proper safety procedures before entering a cave. If you don't have caving experience, it is best to accompany a professional. Proper equipment such as cave lights and ropes may be necessary and never forget that wild animals often still occupy these caves. Many of the bones in the COH were deposited by wild animals and they still continue to contribute to the fossilization process there. Please do not allow yourself to become another fossil!

Mining and natural weathering processes often obscure cave sites. The sites of both Coopers D and Motsetsi were just small exposures of breccia with some bone before excavations revealed that there were significant deposits underneath. So do not let the initial size of a deposit fool you into thinking that it is the whole extent of the deposit. Examine the surrounding terrain carefully. Is there slumping that might indicate the deposit is greater in extent than you see? Are there more rocks in the miners dumps than can be accounted for by the size of the holes excavated by miners? Are there large trees growing in unusual areas that might indicate the soil has been disturbed underneath? These may be clues to deposits as yet unseen.

Take note: Without a permit it is illegal to disturb, collect or move anything from a site being surveyed

Surface Archaeological Sites

There are also a number of surface sites in the COH area. Surface sites are sites that are scattered about the land surface and not found in caves. The most common types of surface sites are Iron Age rock structures and stone tool assemblages of the Early, Middle and Late Stone Age.

The easiest way to gain an understanding of the extent of a surface site is through a brief survey. Study the distribution of features such as stone walls or tools scattered on the ground. These can give you an indication as to whether the site is in its primary context or secondary context. A site in a primary context is effectively unchanged from its original situation except by the processes of natural weathering, while a site in a secondary context has been moved from its original position by natural or man-made processes. Many of the surface tool sites in the COH are secondarily deposited, having been eroded and transported by water from their original positions over time.

Site Survey

A careful survey of a site may be used to create detailed maps, useful tools for future work. An initial map can be made using a tape and compass, a portable theodolite or other tools, but all such maps should be oriented using a fixed prominent feature in the area, preferably marked by a GPS position. It may be useful to build a cairn or marker from rocks in the area if there is no suitable natural feature.

Martini and Keyser (1988) made initial maps of many of the caves in the COH using just a compass and tape. These maps were really the first attempt at mapping the internal structure of the caves. While they cannot be compared with the maps we can produce with our technology today, Martini and Keyser's maps were nevertheless invaluable tools in the initial surveys of the area.

A map made in the 1980s using tape and compass of the Keeskooigat cave in the cradle of humankind by Martini and Keyser (1988). View from above, sections are viewed from the side.
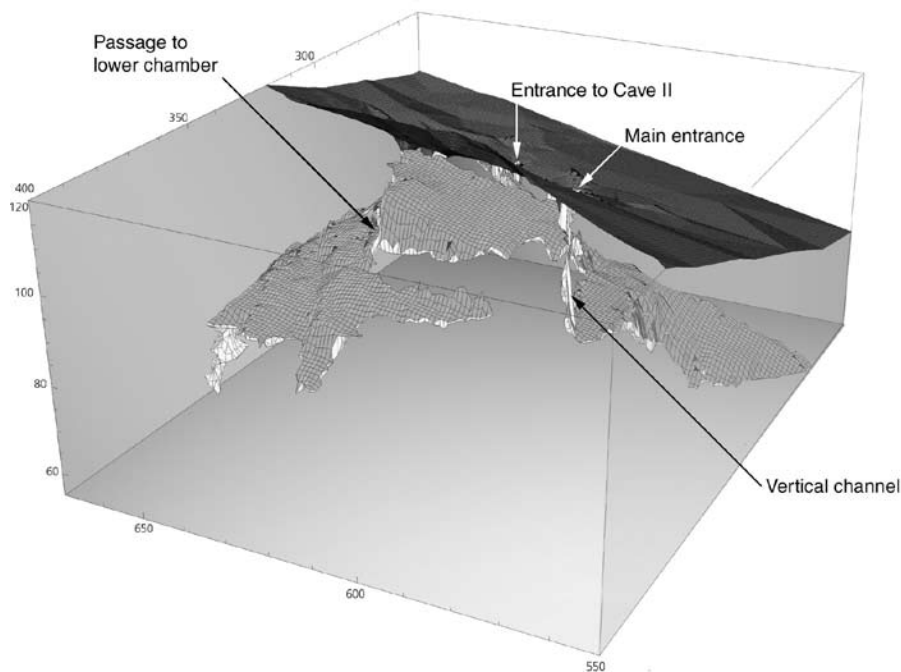
A 3-D map made in the mid- 1990s of the Gladysvale cave constructed using theodolite data.

SITE SELECTION

Basic philosophy

How does a palaeoanthropologist select a site to work in the COH? The answer is not a simple one. A researcher may be attempting to answer certain specific questions and certain sites may be more fruitful for his research than others. For example, a scientist interested in examining physical variation in baboons would obviously want to find as many baboon fossils as possible. It would be logical for the researcher therefore to look for the fossils where he or she is most likely to find them. Sites such as Gladysvale in the COH have relatively few baboon fossils and might not be appropriate for such a research question while sites such as Haasgat have many baboons.

Budget and the time available may also affect site selection. Cave sites cannot simply be opened up and the excavation completed in a few weeks. Most excavations carry on for a minimum of several months and progress is only achieved over many years of intensive work.

EXCAVATION

Excavation is the process by which the archaeologist or palaeontologist uncovers the past. To understand why we excavate, it is important to understand two basic concepts: horizontal and vertical dimensions. Broadly speaking, activities that take place **contemporaneously** occur horizontally in space, while vertical space relates to activities that occur over time. To understand these concepts better please refer to the figure below. On this plan, all of the activities taking place on the surface of the area are taking place more-or-less at the same time while things that happened previously are preserved underground.
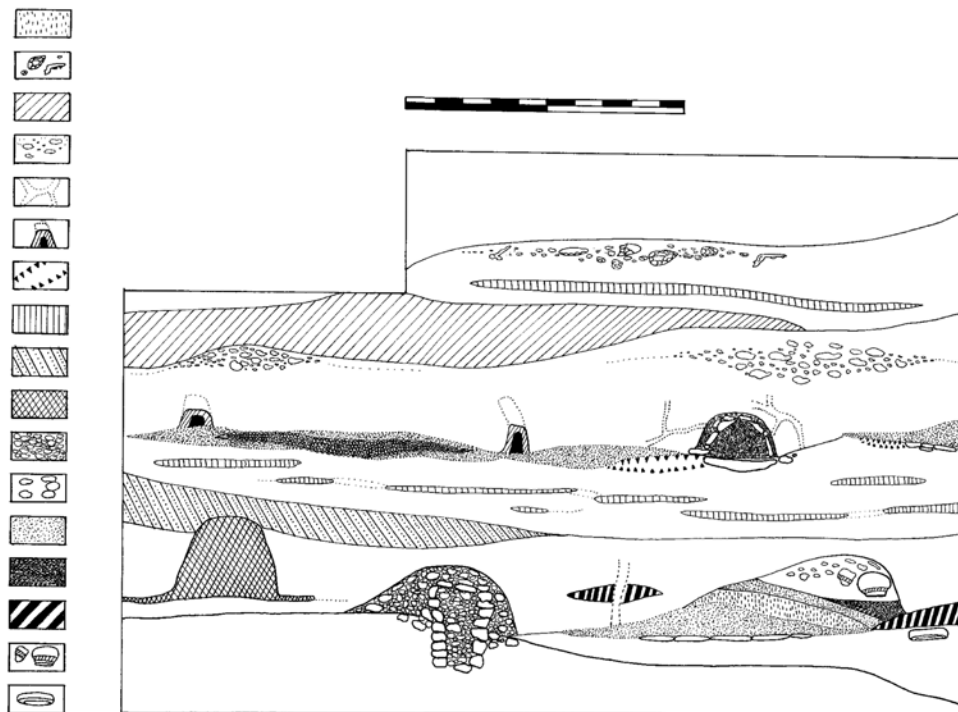
An excavation in profile showing various features – a key – such as the one on the left, assists future scientists in interpreting the diagram.

It is an important concept to understand that if you remove the top level, you will reveal an older, contemporaneous level underneath. This is a simple example of horizontal and vertical stratigraphy. As has been noted previously and will be elaborated on in later sections however, the caves of the COH are in no way simple systems and only a few sites contain extensively preserved horizontal and vertical stratigraphy. It is therefore necessary for the researcher conducting excavations in the COH to use methods appropriate to the situation which offer us the ability to interpret horizontal and vertical relationships.

Methods of Excavation

Excavation is destructive by nature. As has already been discussed, there is nevertheless great value in undertaking such an activity. In addition, there are many questions that cannot be answered by less invasive methods. So assuming that you have obtained permission to excavate from the landowner and have the necessary permits and funding in place, what are the best methods to use in your excavation of a COH site?

The first rule of establishing an excavation is, with the nature of the chosen site in mind, to go back to your research plan and carefully review your end goals. One must keep in mind the density of bones and artefacts, the quality of observable stratigraphy, and the type of sediments that you are going to dig in. An excavation into hard breccia is going to be approached somewhat differently to an excavation into de-calcified breccia and a site containing thousands of tools is going require a different approach to one with only a few dozen bones.

Keep in mind that the following sections are really only a general guide to the methods of excavation. You will learn more about excavation by spending a few weeks on a well-run site than any book can teach you. Nevertheless, I proceed with two basic rules in mind:
1)   Collect as much data as is possible under the circumstances; and
2)   Never remove more material than you have to.

spits / spits / a uniform, defined area of an excavation

It is always tempting to "hurry" through an excavation. Certain methods such as grid based excavation in **spits** allow for a quicker removal of material, but the provenience is not as good as in a piece plotted situation. If you don't have the funds, time or inclination to do the job correctly the first time, then it is probably best not to conduct the excavation at all.

Leaving material behind at your site is critical to modern scientific practice. The remainder of the site or deposit left after an excavation is called a "witness section" and this is the critical evidence left demonstrating to future researchers what the area you have removed looked like (thus it is a "witness" to your work). This is important as the field is advancing all of the time, new methods are developed and the capabilities of future scientists will almost certainly astound us. The methods we use today will probably be seen as crude in a few years time and there may be much that future researchers can learn from the material we leave behind.

A witness section should thus be representative of the area you were working in, not the part of the site you did not want to dig in because there was nothing there! Make sure you don't fall into the trap of removing everything in the hopes of making the next big find.

There are two basic approaches to extracting information from a site: the vertical approach and the horizontal approach. The vertical approach emphasises the vertical or theoretically temporal dimension by cutting deep into a deposit to reveal stratification. The horizontal approach is used to follow contemporaneous layers in order to examine spatial relationships. In the complex caves of the COH, both methods are often used simultaneously in order to extract information. Older methods of excavation such as the Wheeler box-grid , which employs a method of keeping square witness sections of earth between square excavation pits in order to maintain both a horizontal and vertical profile, are largely outdated. Most modern scientists use variations of an open-excavation technique, whereby large areas of the surface are removed and deeply cut sections are only made where one wishes to examine complex stratigraphy. Previous generations of scientists used cumbersome grids of string and wire in order to plot and orientate their excavations. Now that has largely become unnecessary as modern theodolites and other electronic mapping equipment have revolutionized the open-excavation technique.

One problem that is still encountered is the creation of deep, dangerous holes that run the risk of collapse. An excavation that proceeds without regard to this can run the risk of having their efforts covered by collapse or worse, someone might be injured or killed. Such a major collapse has occurred as recently as the late 1990s at Sterkfontein and it took years of effort to clear the rubble. One way to prevent such a disaster is to create step trenches. Step trenches are, as their name implies, cut like a staircase so as to prevent steep sides from being created. Unfortunately, not all sites allow proper step trenching because of the nature of the topography or the presence of walls or large roof blocks.

An image of the Swartkrans site with metal grid. Note that after several years the grid has warped and sagged in places.
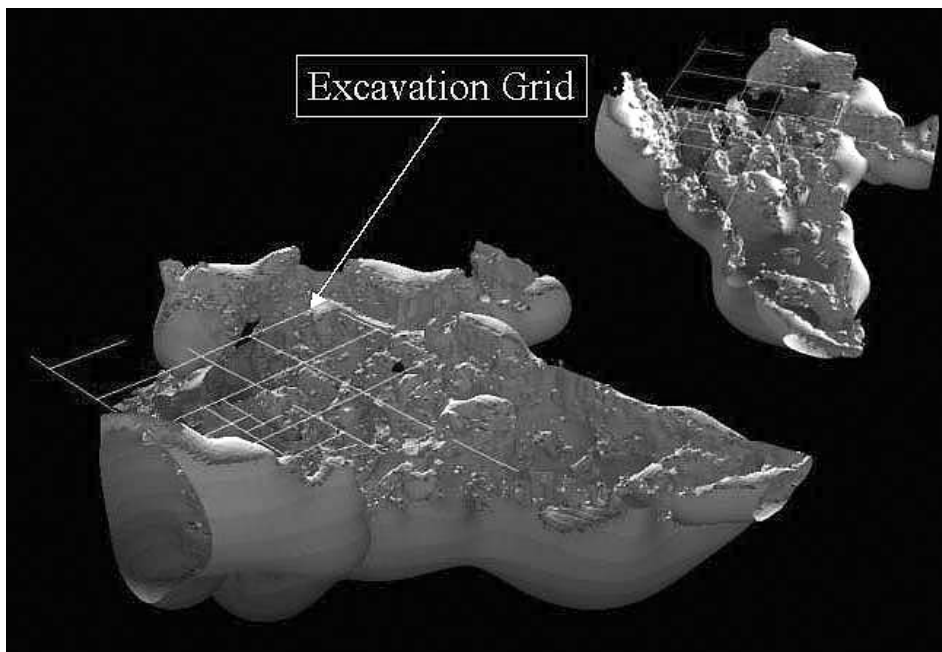
A 3-D GIS model of the same area of Swartkrans as above including the old grid generated by mapping with a theodolite (Nigro et al., 2003).

Whatever the methods of excavation used, it is critical that as much evidence of the work is recorded, because the context is destroyed once the material is removed from the site.

RECORDING THE 3-D PROVENIENCE AND CATALOGUING FOSSILS IN THE FIELD

The basic aim of any excavation should be to record the 3-D provenience of any item recovered and to record the 3-D topography of the excavation and important features. In decalcified parts of sites, it is best to work with trowels, dental picks and brushes. Small amounts of soil are worked free, examined for items of interest, collected in a receptacle such as a bucket and the material sieved through very fine wire mesh of less than 1.3 mm. In either a grid based excavation or a theodolite based excavation any identifiable pieces or objects of interest should be individually plotted. Spits, which are areas of excavation, should be as small as is possible given the constraints of the excavation. At most sites in the Cradle of Humankind no more than around 15cm x 2cm is removed at any one time. It is then sieved in order to ensure that a maximum amount of data is extracted.

Once an artefact or bone has been recovered its provenience must be recorded immediately. The specimen must be given an independent field number and its 3-D coordinates entered into a field book or directly into a computer or both. Modern theodolites allow for the internal recording of coordinates that may be downloaded at a later date. We have found through trial and error that this method, though efficient, should not replace the physical recording of the 3-D coordinates of a find in the field catalogue. The artefact or bone must be placed in a receptacle and either marked there and then, or placed with an identifying field tag. As most field situations do not allow instant marking on the bone (there are a number of reasons why such an approach may be undesirable) we rather use field tags that are filled out and placed in a sealed bag with the recovered item. In order to prevent damage to the tag, which, remember, is the only identifying marker of the items position, we tend to place the tag itself into a waterproof sealed bag.

Coopers Cave	locality: D	Date:	
#:	Name:		
in situ:		miners dump:	
E:			
N:			
H:			
Remarks:			

A field tag from the Coopers D site

Items recovered in the sieve should be given either a central point of reference from the area the spit was taken or (preferably) corner references of 3-D plots around the area and base of the excavated spit.

The recording and mapping of surface features and profiles should be handled in a similar manner. It is also important that a good photographic record is maintained. With the advent of digital cameras and mass storage devices such as CDs and personal computers, there is no excuse for the modern excavator not to keep a good record of the excavation's progress. Video cameras are also of tremendous assistance for documenting the progress of excavations for future researchers. While more time consuming, drawings may add more subtle and subjective features that are not as readily captured through other images.

When excavating in hard breccia the individual plotting of bone may be more difficult as drills are often necessary to remove either whole blocks or individual finds. When removing a large area of breccia, it is best to first plot many different 3-D coordinates on the surface of the rock. We have found it effective to use a black permanent marker to write the coordinates directly onto the rock surface after plotting them with the theodolite. If you are still using a grid-based method, then plumb down from the grid and mark these coordinates directly onto the rock. Generally, larger drills are used to put holes around the area to be moved and **"feathers and wedges"** are used to pry the rock loose. Removal of breccia and fossils by this method can be extremely dangerous for both the excavator and the fossils themselves, so initial work with large drills and feathers and wedges should only be done under supervision of an experienced technician or scientist. Once the block is removed however, the coordinates, or points mapped on its surface can be used to plot any individual finds within the matrix.

feathers and wedges / feathers and wedges/ a steel pick placed between two flat bars

A more delicate but also more time consuming method of extracting fossils from hard breccia in the field is through the use of an air or electrically driven fine drill that is much like an engraving tool. This method works best for the area directly around the fossil and thus should only be undertaken by an expert and under magnification.

It is preferable to do any fine work around a fossil in the laboratory rather than in the field. Most scientists today feel that acid preparation is usually preferable to manual preparation by fine needle drill as this does less damage to the surface of the bone. Acid preparation is conducted by a series of baths of the fossil in weak (acetic) acid (generally around 5% although this may vary based on calcium carbonate content). Preservatives such as Paraloid, a complex polymer, are used to protect exposed bone. Ideally, the acid removes the calcium carbonate but leaves the protected fossil bone intact. The fossil is bathed in clean water or buffered water for long periods of time between acid baths to prevent the build-up of acid crystals. Great care should be taken when conducting acid preparation as damage can easily

be done to the bone surface or to bones that are not yet visible, but reachable through cracks and holes in the rock. Again, acid preparation should only be conducted under supervision of trained technicians or scientists. Typically, a fossil will undergo both fine drill preparation and acid preparation. The use of hammers and chisels for preparation is outdated and should be avoided.

At the Palaeoanthropology Unit for Research and Exploration we use a guideline for excavation that is based on those of other major institutions around the World but are adapted for our specific situation. This work protocol gives the excavator a good guideline for a step by step procedure in the field:

Clean Area

Plot Identifiable Finds

Fill Out Field Tag and Initial

Take Finds to Appropriate Place

Collect Loose Soil for Sieving

Sieve Loose Soil

Prepare Field Tag for Sieved Material and Initial

Take Finds to Suitable Place

Plot and Record Any Features

Check With Supervisor as to Need of Photograph

Describe Context in Field Notes

Check with Supervisor as to Suitable Method of Excavation of New Area, Need for Sampling and Method of Finds Collection

Continue with Excavation Methods as Above

At End of Day Hand in Field Notes and Check With Supervisor on any Additional Measures to be Taken Concerning Securing Area

Do note that the keeping of field notes is in fact mandatory under South African law and these should eventually be permanently kept in the host institution.

Notes

MODULE 4

Conservation, Classification And Identification

CONSERVING FOSSILS IN THE FIELD

From time to time you may find it necessary to preserve a fossil in the field. This will be particularly necessary where a fossil is taking a considerable amount of time to extract or where the fossil is partially in calcified (hard) breccia and partially decalcified (loose soil-like sediment). As a general rule, any preservative used should be removable, or, in other words. non-permanent. This means that epoxies and plasters are not to be used if at all possible (many laboratories, such as those at the University of the Witwatersrand, ban the use of such substances). There are, however, many commercial substances available such as Paraloid that act as very good field preservatives and are completely removable. Caution should be exercised when handling these materials however, as they are often prepared by mixing with acetone, a very dangerous solvent. Always refer to the supervisor, site technician or responsible scientist before undertaking any preservation in the field.

PROCESSING AND CLASSIFICATION OF FOSSILS IN THE FIELD AND LAB

The laboratory, or lab as it is popularly known, is a continuation of the processes begun in the field. A permanent catalogue number will be given to the specimen and this is usually written directly on the specimen using a small amount of white enamel, which is then printed on with black India Ink. A thin coat of clear nail varnish is often applied to protect the number. The specimens are re-bagged and the field tag, along with the context, follows the specimen into this new bag. The catalogue number, 3-D coordinates and other information are put into a computer database. The fossil then undergoes a sorting process into various categories including Order, Genus and Species through a comparative process. Fossils are typically stored in wooden boxes for easy access by researchers.

The classification system used for fossilized animals is based upon the Linnaean system of classification. For convenience, in our labs animals are grouped into groups at the Order level and if possible sorted all the way to the Species level, extinct or extant (still living). The following table gives an example of the Linnaean classification for some of the more common extant and extinct African mammals found in the COH by Order, Family, Genus and Species.

Order	Family	Genus and species	
Primates	Hominidae	*Paranthropus robustus*	
		Australopithecus africanus	
		Homo erectus	
		Homo sapiens	
	Cercopithecidae	*Papio hamadryas robinsoni*	
		Theropithecus oswaldi	
		Papio ursinus	(baboon)
Carnivora	Felidae	*Panthera pardus*	(leopard)
		Panthera leo	(lion)
		Felis caracal	(caracal)
		Felis lybica	
		Dinofelis sp.	
		Megantereon cultridens	
	Hyaenidae	*Crocuta crocuta*	(spotted hyena)
		Parahyaena brunnea	
		Chasmaporthetes sp.	
		Proteles cristatus	(aardwolf)
	Canidae	*Canis mesomelas*	(jackal)
	Viverridae	*Herpestes ichneumon*	
		Suricata sp.	
		Cynictis penicillata	
	Mustelidae	*Poecilogale sp.*	
Hyracoidea	Procaviidae	*Procavia antiqua*	(hyrax)
		Procavia transvaalensis	
Perissodactyla	Equidae	*Equus burchelli*	(zebra)
		Equus capensis	
Artiodactyla	Suidae	*Metridiochoerus andrewsi*	
	Giraffidae	*Sivatherium maurusium*	
	Bovidae	*Raphicerus sp.*	
		Megalotragus sp.	
		Connochaetes sp.	(gnu)
		Damaliscus cf. dorcas	(blesbuck)
		Antidorcas marsupialis	(springbuck)
		Antidorcas recki	
		Hippotragus sp.	
		Redunca fulvorufula	
		Taurotragus oryx	(gemsbuck)
		Tragelaphus strepsiceros	
		Tragelaphus scriptus	
Rodentia	Hystricidae	*Hystrix africaeaustralis*	(porcupine)
	Pedetidae	*Pedetes gracilis*	(springhare)
Lagomorpha	Leporidae	*Lepus capensis*	(hare)

Identifying Fossils in the Field and in the Lab

One of the most bewildering aspects of palaeoanthropology for many students is the identification of fragments of bone, yet this is one of the most critical aspects of the job. When first encountering fragments and pieces of bone, it may seem impossible for one to identify even what bone the fragment came from, much less the Order, Genus or Species of animal. With practice, however, the identifying of specimens from fragments becomes less difficult and this can become one of the more enjoyable aspects of your work.

To begin with, you must obtain a general understanding of bony anatomy. An advantage that we have as palaeoanthropologists is that the human (Primate) skeleton is a rather good example of relatively primitive mammalian skeletal structure and that many of the African animals we find, extinct and extant, have derived skeletons to those of the Primate.

The following section is intended as a primer in basic African mammal bone identification only. I have chosen to illustrate three mammals: a human to represent hominins and Primates, a leopard to represent generalised carnivores, and an Impala to represent a generalised bovid. I have included a series of "tips" and "tricks" in this section that may help you in identifying bones as well as specific bones and hominin teeth. Don't be overwhelmed by the terminology. You'll gain quite a bit of practical experience in bone identification in the bone lab.

TIPS AND TRICKS

When encountering a bone fragment for the first time there are a few mental tricks that can help you to identify it. The following categories often work for me in the field, but you may wish to adapt them in order to develop a method that works best for you. Remember, these are not "anatomical" categories, but are field "identification" categories.

When you first study a bone fragment look at all aspects of the specimen. Turn the bone over in your hands and look at the back, front and sides. Take special note of any areas of morphology – namely bulges and indentations. Begin the mental identification process by asking yourself some basic questions that will help you identify what category the bone falls into.

• Is the bone a flat bone, a long bone or an irregular bone?

- Flat bones are generally bones of critical joint areas, parts of the ribs or cranial bones. I include the following bones, or parts of bones under the heading "flat":

    – Cranial bones from the top, back and sides of the skull.

    – The ascending ramus of the mandible

    – The middle part of ribs and the end of some ribs

    – The body of the scapula

    – The ilium and part of the ischium

Flat bones can be characterised as having either no, or compressed, marrow cavities. Obviously, a unifying character is a flattened area of bone which may or may not be curved depending on the species and particular bone. Keep in mind that some "flat" bones in my category are in fact "curved" (such as the bones of the skull and blade of the ilium in some species). Remember too that some parts of flat bones may have a joint area, such as the glenoid area or head of the scapula and the acetabulum of the pelvis.

- I include the following bones under "long bones" (even though the metacarpals and metatarsals of more primitive mammals are not that long, nor would you want to call one "long" in an anatomy exam!)

    – Humerus, radius and ulna

    – Femur, tibia and fibula

    – Metatarsals and metacarpals

The shafts of most long bones have a definitive marrow cavity, often rounded or oval in shape. The trick with long bones is to note that the articular surface (or joint surface) is often broken free from the shaft and thus might appear to you to be an "irregular" bone. Look at the broken edges for clues that the bone might have been attached to a shaft. You can often see the end of the marrow cavity in the interior of a broken head of a femur, humerus or tibia. Finally, keep an open mind when identifying a bone. The metatarsals of a bovid and those of a primate or carnivore are very different indeed.

- All other bones I include in the category "irregular bones"

Irregular bones can be difficult to identify and you should familiarise yourself with the unique shapes of smaller bones such as the tarsals, carpals and phalanges. There are, however, some aspects of certain "irregular" bones that can give you clues to their identity. For example, internal bones of the skull are often "spongy" or "bubbly" in appearance while irregular bones of the feet are often very dense.

Once you have categorised the individual specimen into a broad category, attempt to eliminate as many other possibilities as you can through a simple process of elimination before narrowing down your identification to one of a few possible bones. Using the above method, or one that works for you, it should be fairly simple to narrow your identification down to just a couple of possibilities. You can then enter a good comparative lab with a head start towards a final identification.

Tip

Tips and Tricks

- The **metapodials** of bovids have a **septum** running down the centre of the shaft because they are formed from the fusion of two bones.

- The navicular-cuboid of bovids is a very dense bone and thus is commonly found in fossil sites.

- Hominins have generally thicker skulls than most other mammals and exhibit three distinct layers. Tortoise shells, however, can closely resemble hominin skull fragments.

- The femoral head of hominins is extremely rounded although certain cats show a similar morphology.

- Both the acromion and coracoid process on the scapula of hominins is enlarged, whereas either one or both is generally reduced in other mammals.

- Hominins have "thick" enamel teeth, but that thickness is relative to the size of the tooth.

- The distal femora of lions and hominins are very similar.

- A broken fossil can be misleading – take time with your comparative analysis.

- There is no substitute for sitting down in a good comparative lab with a fossil and directly comparing it to complete bones.
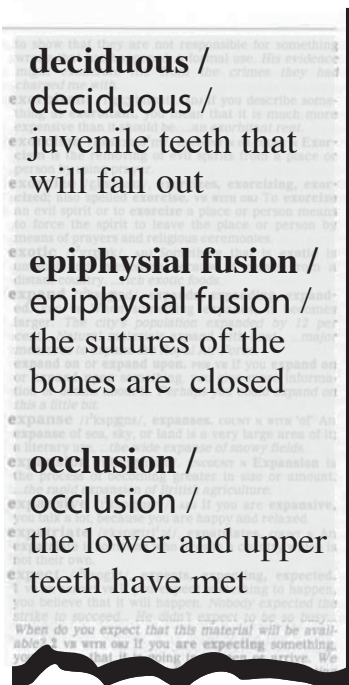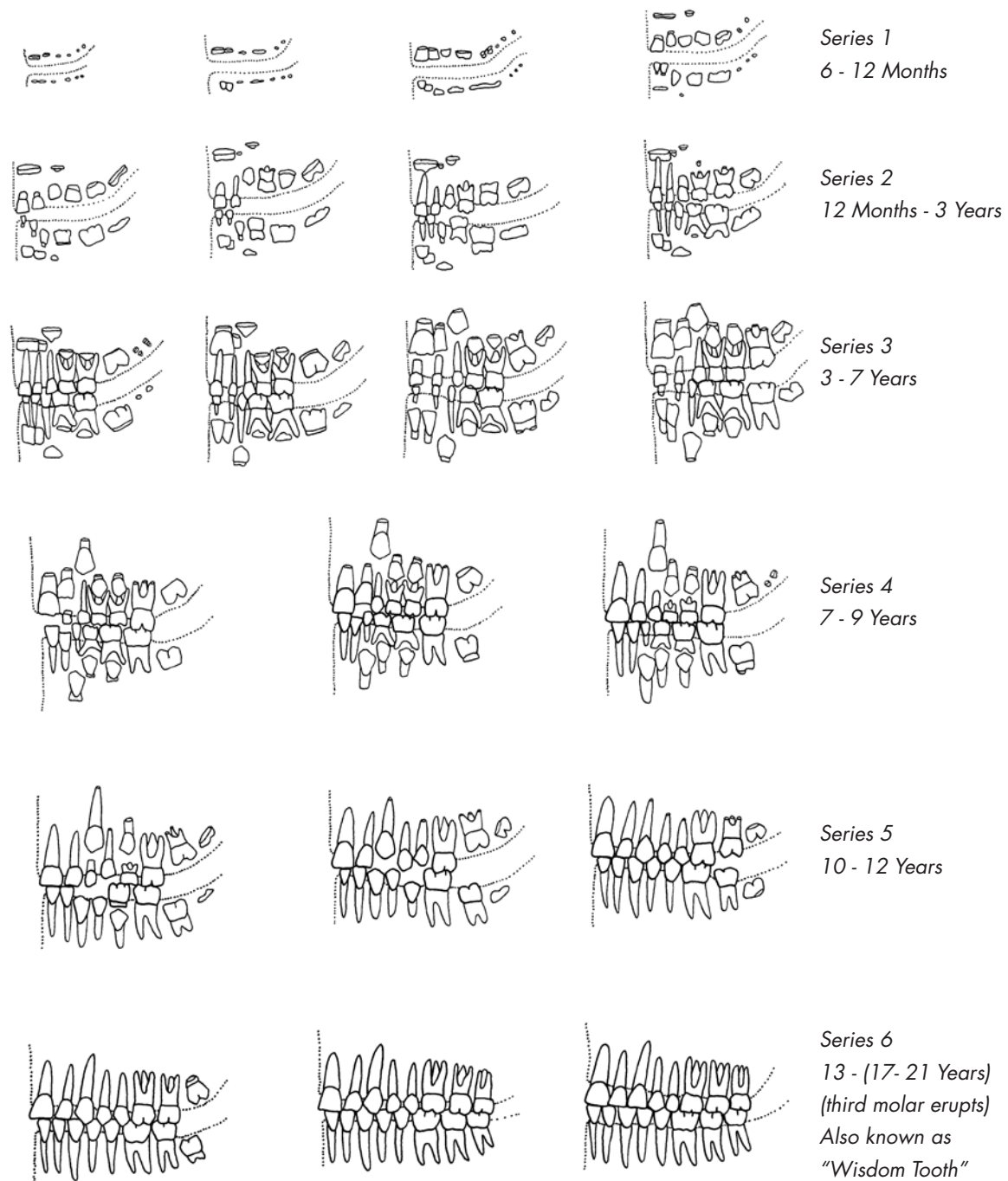
metapodials / metapodials / metacarpals and metatarsals in bovids

septum / septum / a fine line of bone

AGE ESTIMATION

Estimating the age of a specimen (that is, how old the animal was when it died) has to take into account a number of criteria. One of the main problems we face as palaeontologists is that for most of the animals we study or find in the fossil record, there are no good developmental series available, either for the postcrania or dentition. Age estimations for non-human animals may therefore involve a great deal of guesswork. Even for early hominins, the rate of maturation is often a point of debate and may vary from species to species making absolute age estimates difficult. For this reason, palaeontologists working in the field often only categorise individual bones as juveniles, juvenile-adult and adult. In the broadest usage of these terms, a juvenile would be an individual retaining all of its **deciduous** dentition and lack **epiphysial fusion**. A juvenile-adult has some permanent dentition emerging and some epiphysial fusion on selected bones. An adult has all of the permanent dentition in **occlusion** and full fusion of all epiphysis. One has to be extremely careful when attempting to assign an absolute age to an individual based on the evidence of just teeth or a few bones. For example, contrary to popular belief where it is thought that modern humans are "adult" at the age of 18, a modern human might not obtain full skeletal maturity until the age of 25! Teeth, however, are one of the best indicators of age in humans and early hominins. And there are detailed studies of the sequence by which teeth erupt in humans.

deciduous /
deciduous /
juvenile teeth that
will fall out

epiphysial fusion /
epiphysial fusion /
the sutures of the
bones are closed

occlusion /
occlusion /
the lower and upper
teeth have met

Series 1
6 - 12 Months

Series 2
12 Months - 3 Years

Series 3
3 - 7 Years

Series 4
7 - 9 Years

Series 5
10 - 12 Years

Series 6
13 - (17- 21 Years)
(third molar erupts)
Also known as
"Wisdom Tooth"

The sequence of eruption of teeth in humans after Bass (1987) and the authors own work.

The following table acts as a general guideline to age estimations in modern humans based upon the epiphysial fusion of individual bones. Early primary and secondary centres of ossification, such as those of the vertebrae, are not included in this table for simplicity's sake. Age of Fusion will generally refer to the final fusion of centres on the bone. Sources for ossification data include Bass (1987), Gray's anatomy (1989), Greulich and Pyle (1959) and the author's own work.

Bone	Age of Fusion
Vertebrae (spinous processes, centrum and transverse processes)	16 – 25 yrs
Sacrum	18 – 25 yrs
Scapula	15 – 24 yrs
Clavicle	23 – 25 yrs
Ribs	18 – 24 yrs
Humerus	14 – 21 yrs
Radius	15 – 21 yrs
Ulna	15 – 21 yrs
Metacarpals	15 – 23 yrs
Carpals	15 – 23 yrs
Phalanges (fuse distal first, proximal second and middle last)	15 – 21 yrs
Pelvis	16 – 23 yrs
Femur (proximal)	14 – 19 yrs
Femur (distal)	14 – 22 yrs
Tibia	14 – 20 yrs
Fibula	15 – 22 yrs
Tarsals	15 – 23 yrs
Metatarsals	15 – 23 yrs

STONE TOOL TYPOLOGIES

Stone tools have been found at most sites in the COH where more comprehensive work has been conducted. Stone tools are also scattered across the surface of the region with the highest levels of abundance on hilltops and in river gravels. Stone tools have typically been classified by typological or technological modes that allow identification of changes that have occurred over time. Originally, Goodwin and Van riet Lowe (1929) created a sequence of African stone ages and divided all stone tool technologies into the Early, Middle and Late Stone Ages. Clarke (1977) advanced upon the theme of global stone technological change and created Modes of Technology that were used to examine the history of stone tools through time. Foley and Lahr (2001) advanced upon Clarke's modes in their synthesis of stone tool technologies creating a framework that is useful for identifying African stone tools by either mode or industry.

| Technological Mode	Industry
Mode 1 $\pm$ 2,6 Mya - 1,8 Mya	Oldowan, Early Stone Age (comprising choppers and flakes)
Mode 2 $\pm$ 1,8 Mya - 250 Kya	Acheulean, Early Stone Age (bifacial hand-axes)
Mode 3 $\pm$ 250 Kya - 90 Kya	Middle Palaeolithic, Middle Stone Age (comprising prepared cores and points)
Mode 4 $\pm$ 90 Kya - 45 Kya	Upper Palaeolithic (retouched blades)
Mode 5 $\pm$ 45 Kya - Present	Mesolithic and Late Stone Age (microlithic composite flakes and blades)

See also Pg.'s 110 – 111 of the *Field Guide to the Cradle of Humankind* (2nd Edition) for more information on stone tools and their origins.

The following illustrations represent common tool types of the two earliest technological modes found in the COH.

*Below – early Acheulean (early Mode 2) or developed Oldowan artefacts from the site of Coopers (after **Hall et. al**., 2005)*

CO 13408

CO 13272

CO 8469
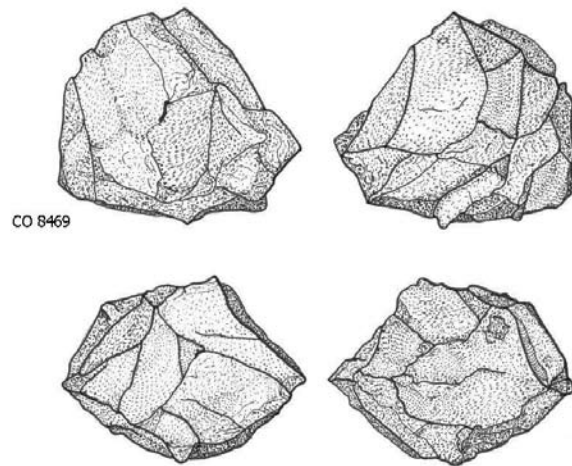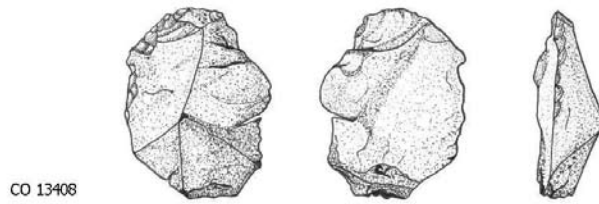
*A handaxe of the Acheulean type (middle to late Mode 2) from the site of Gladysvale after **Hall et. al**. (in press).*

pg. 88

pg. 87

pg. 89 + 90

pg. 91 - 96

pg. 97 + 98

pg. 99 +101

pg. 102
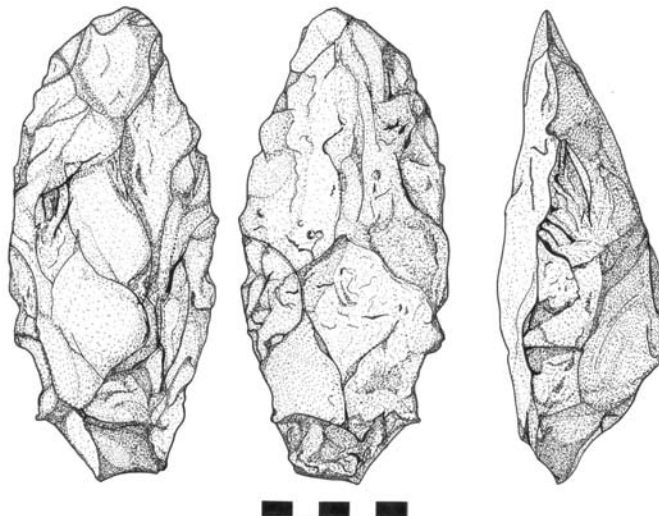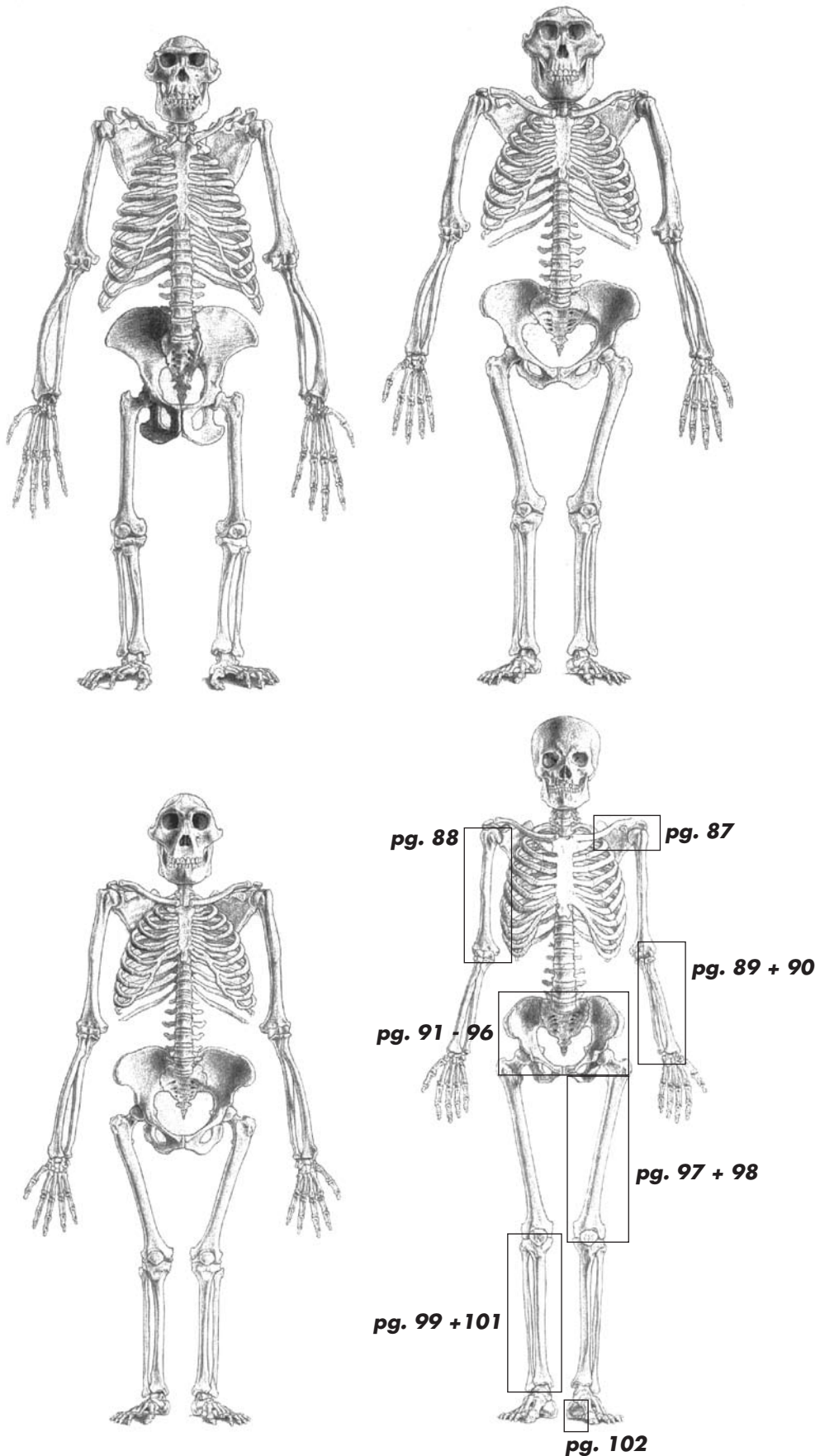
Reconstructions of the skeletons of (left to right, top to bottom) a chimpanzee Australopithecus Afarensis, Australopithecus Africanus, Homo Sapiens after Berger (1999). Note that page numbers refer to larger views of the bone indicated.

BONES

The following section illustrates selected bones of three mammals – a human (*Homo sapiens*), a leopard (*Panthera pardus*), and an impala (*Aepyceros melampus*). These illustrations should be used to familiarize yourself with the basic similarities and differences of the types of bones in these three species. Note that different views are given for each bone.
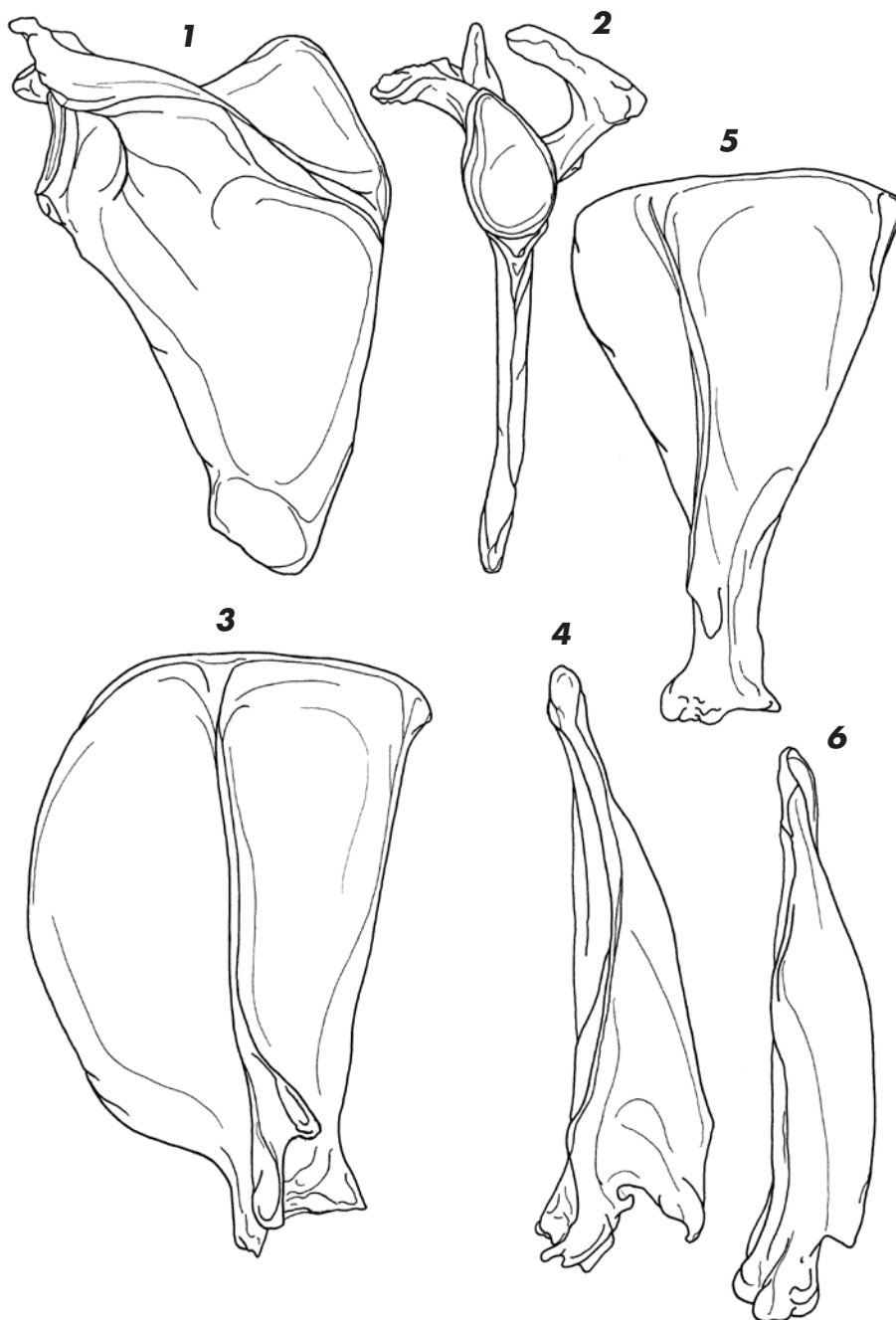
The scapula (common name "shoulder bone") – 1 & 2 human; 3 & 4 leopard; 5 & 6 impala
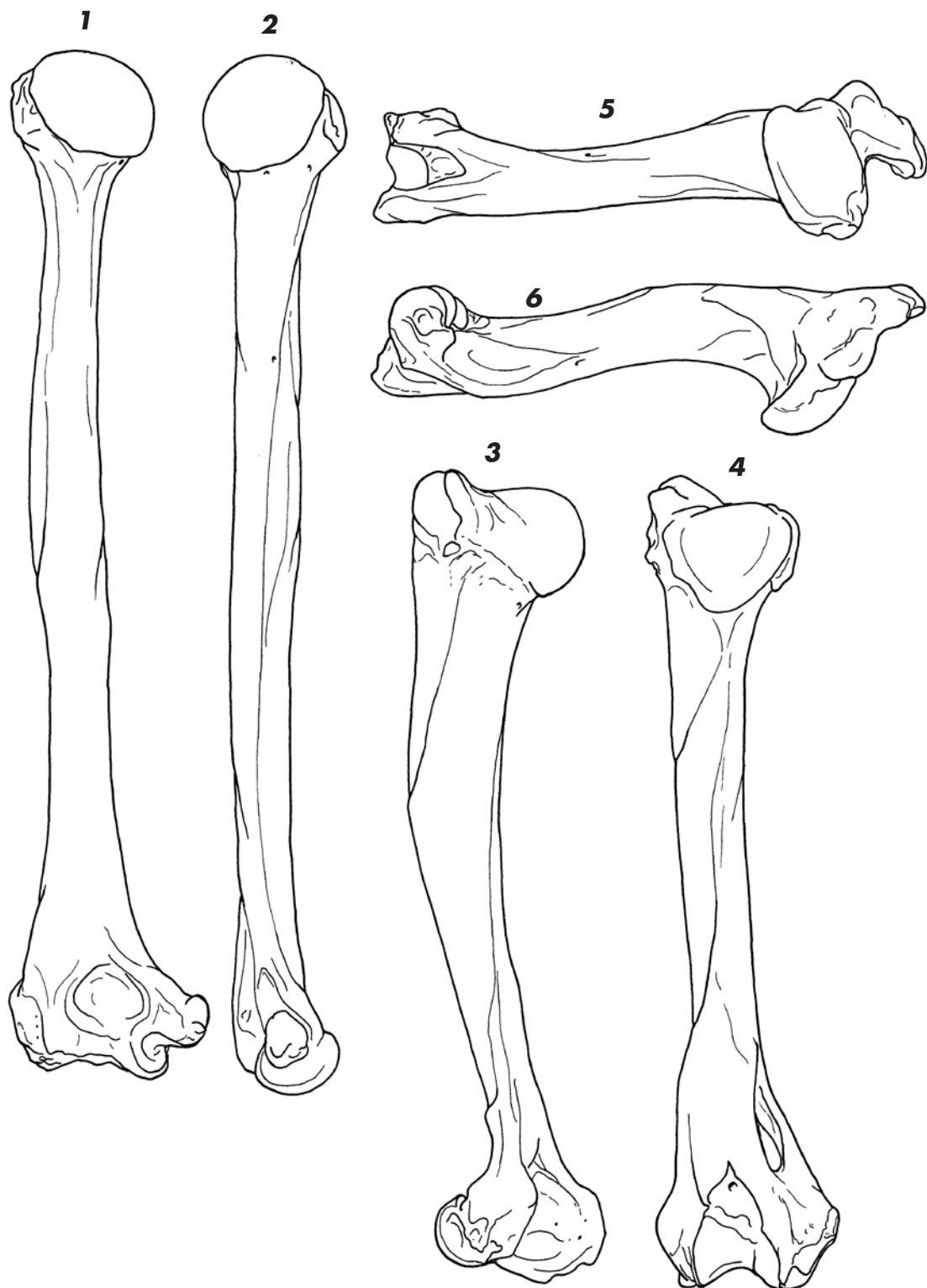
The humerus (common name "upper arm bone") 1 & 2 human; 3 & 4 leopard; 5 & 6 impala
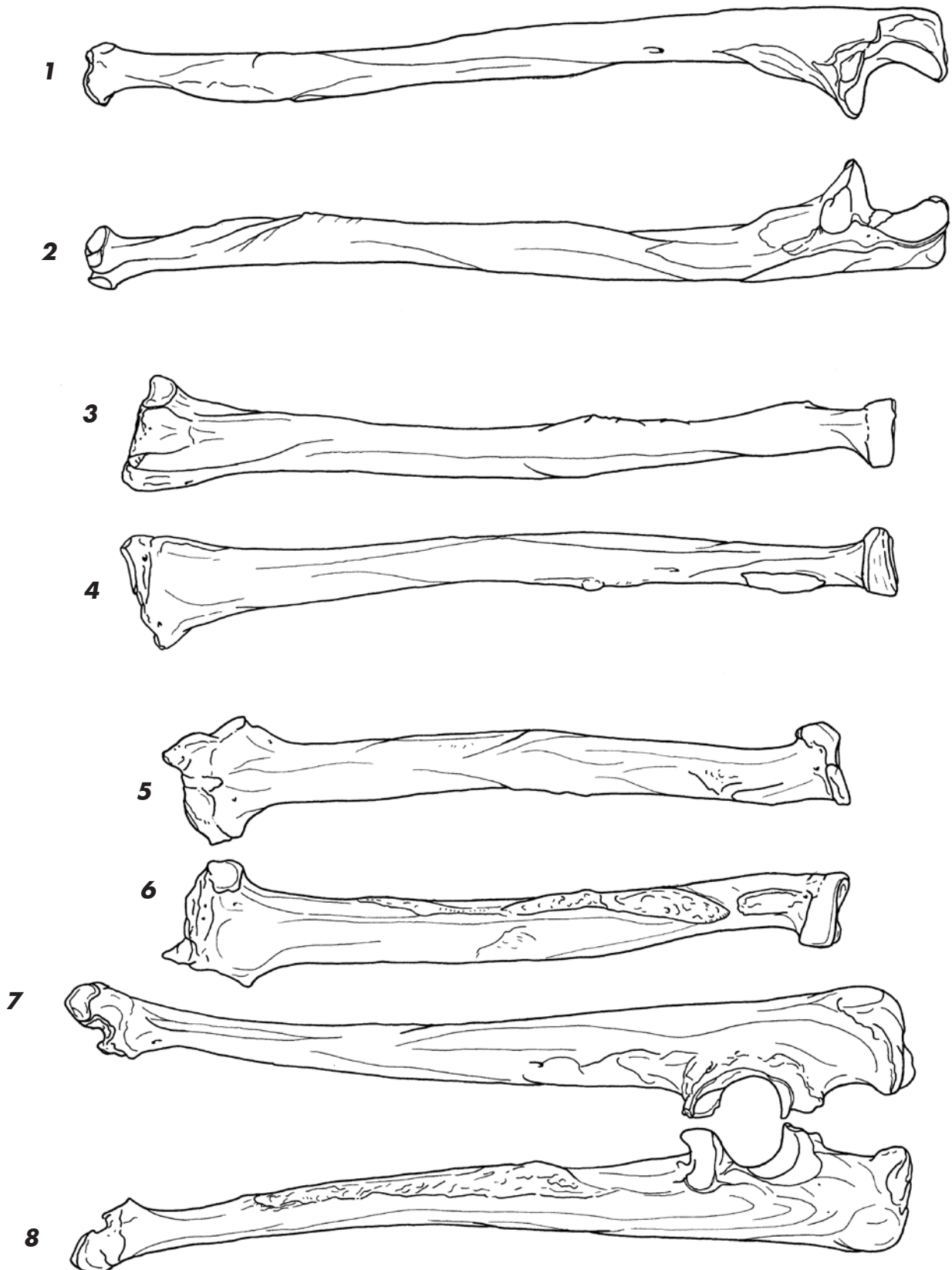
The ulna and radius (commonly known as the bones of the lower arm) – 1 & 2 human ulna; 3 & 4 human radius; 5 & 6 leopard radius; 7 & 8 leopard ulna
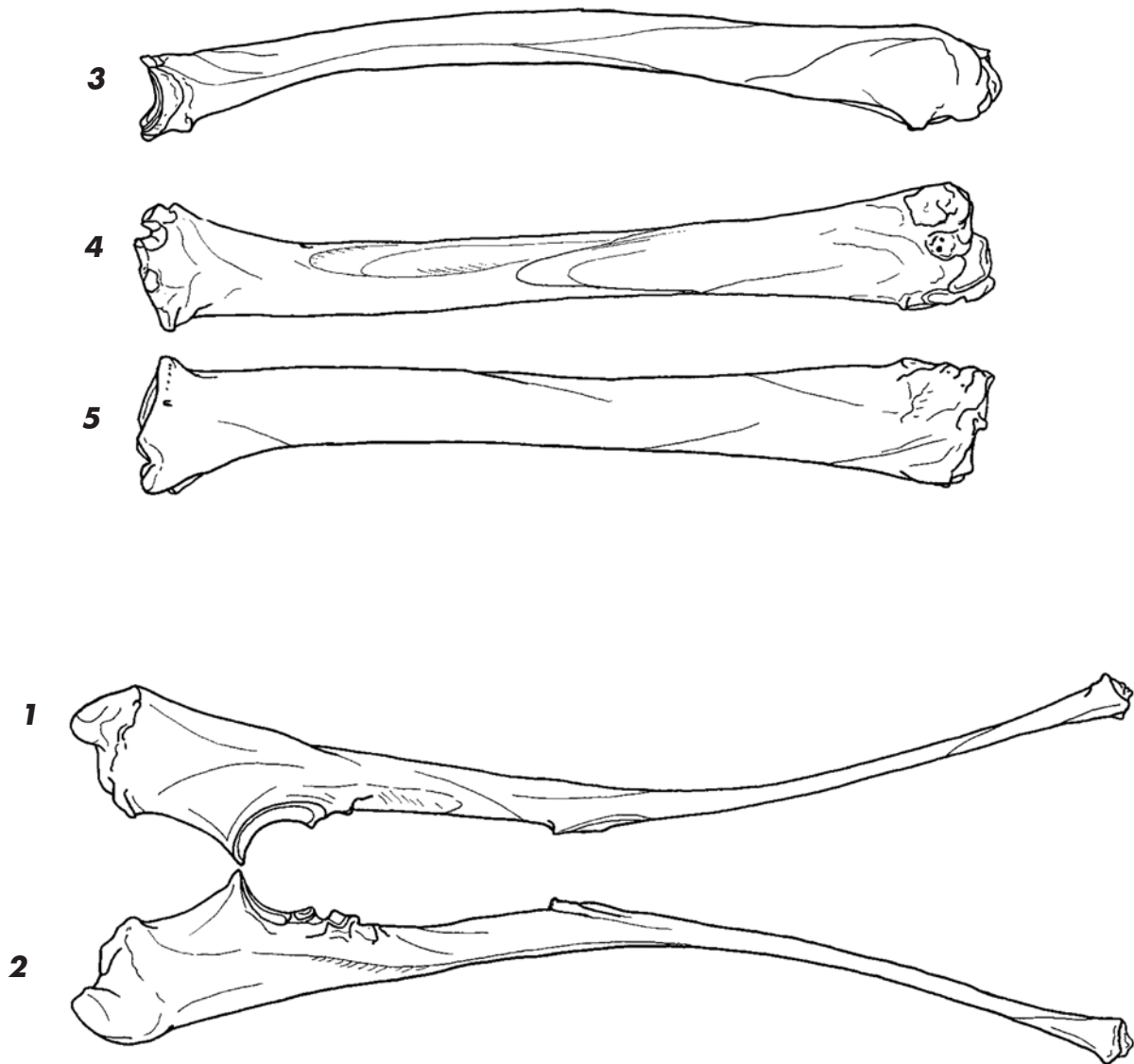
The ulna and radius – 1 & 2 impala ulna; 3,4 & 5 impala radius
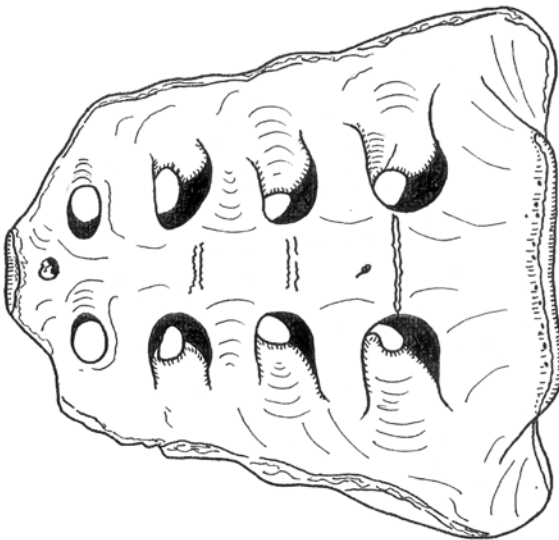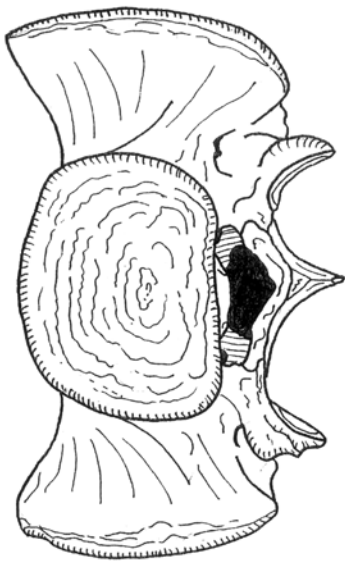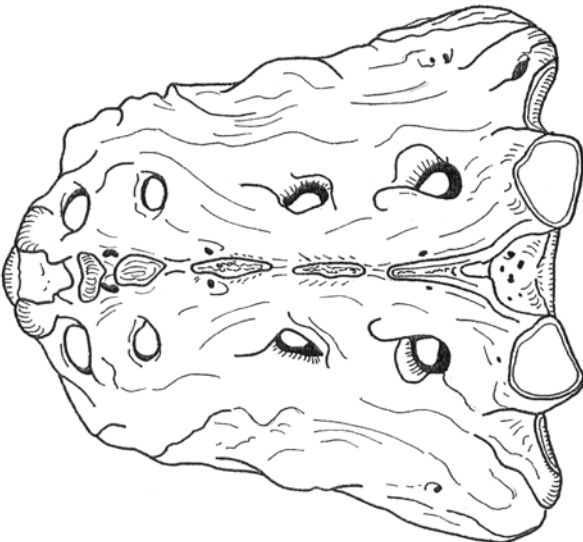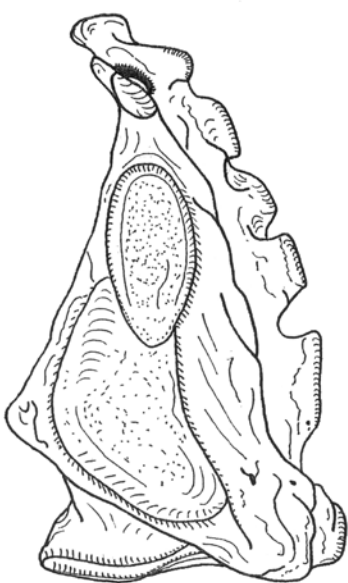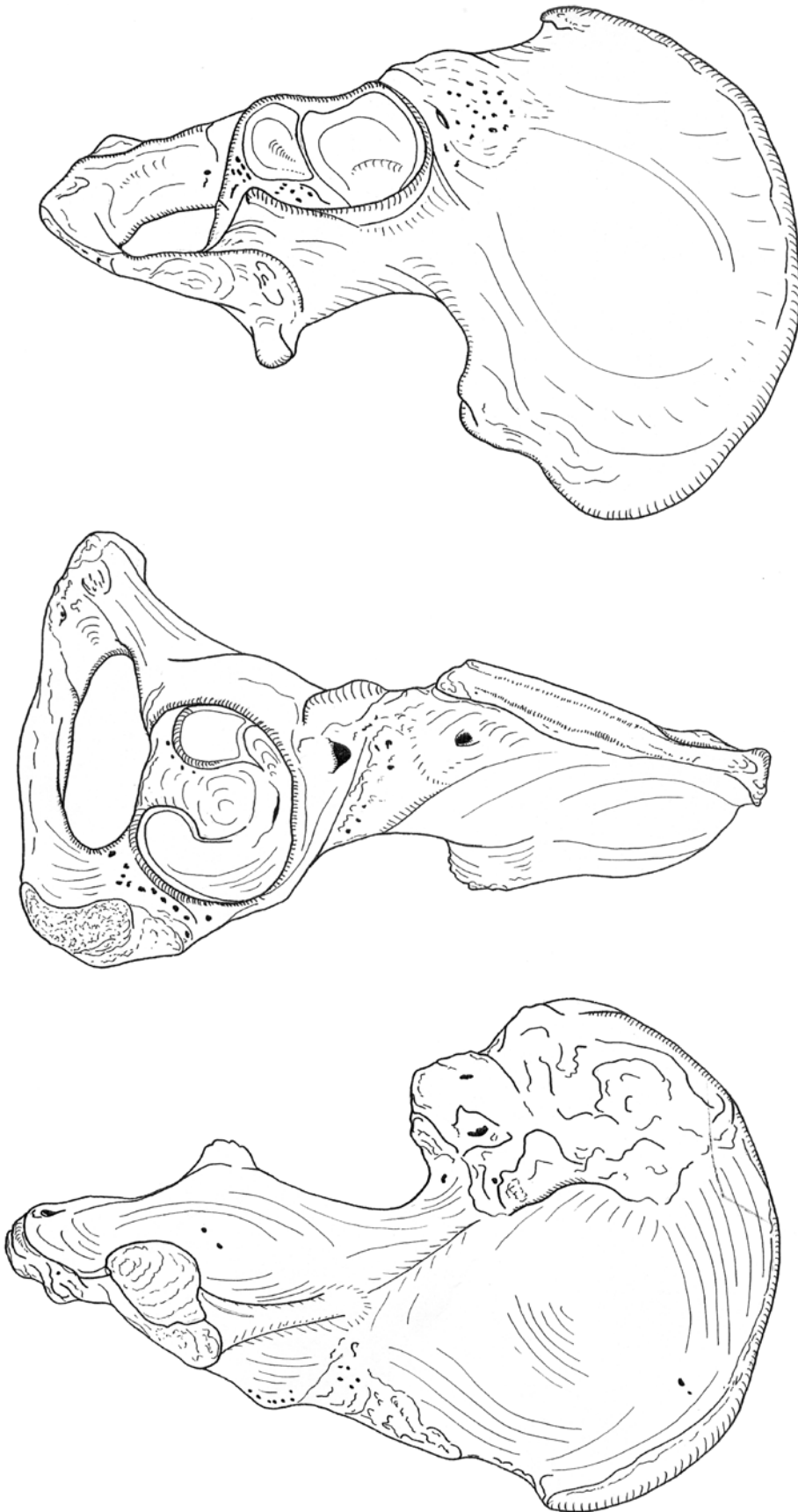
The Human Sacrum

The Human Pelvis
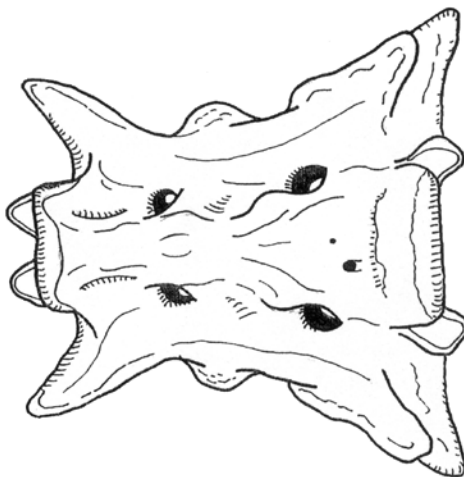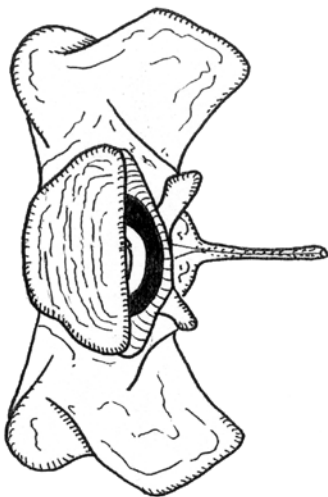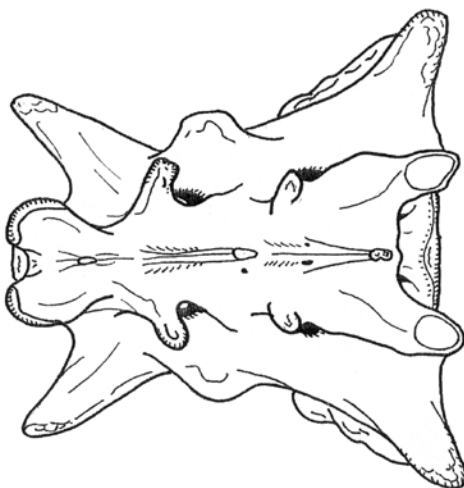
The Leopard Sacrum
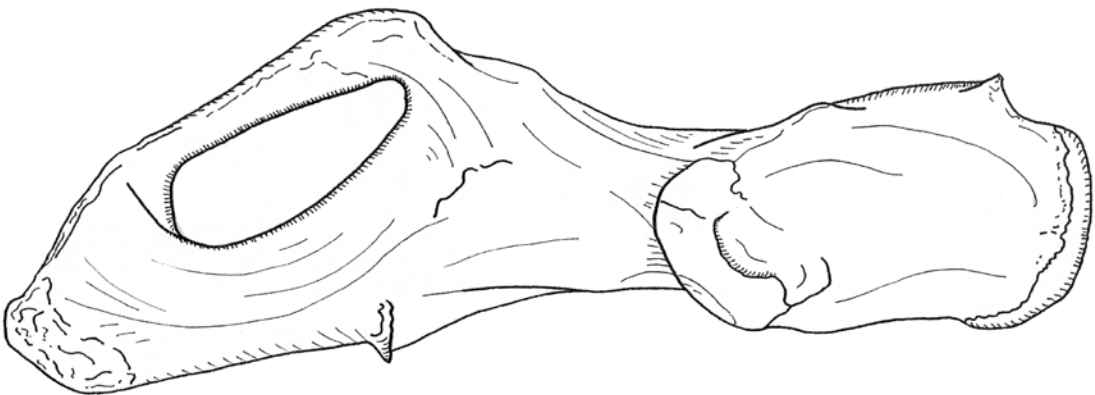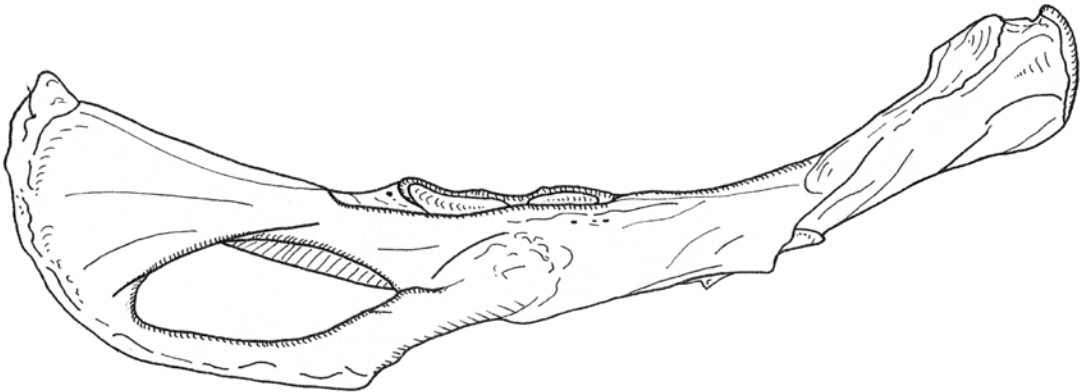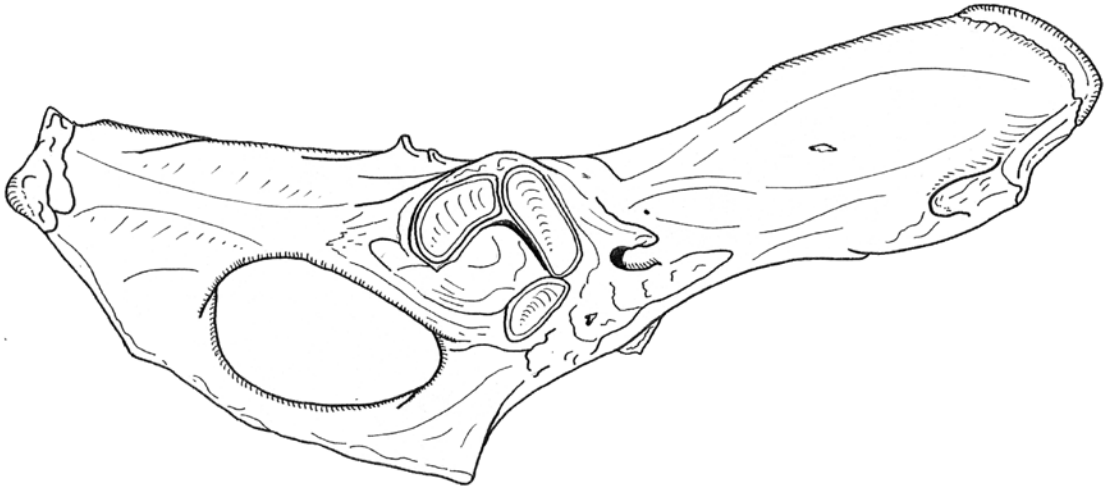
The Leopard Pelvis
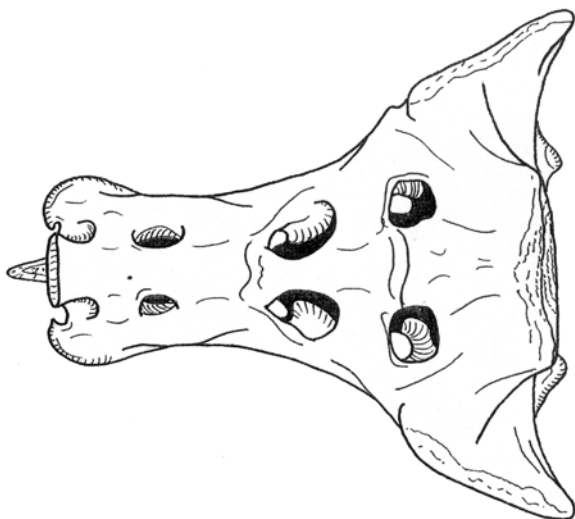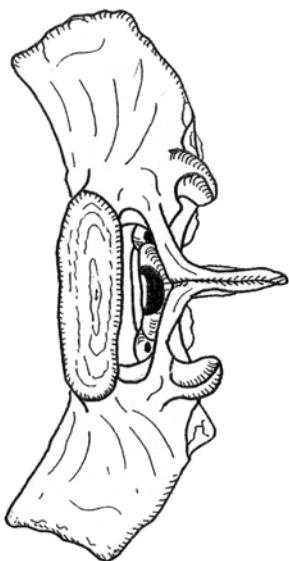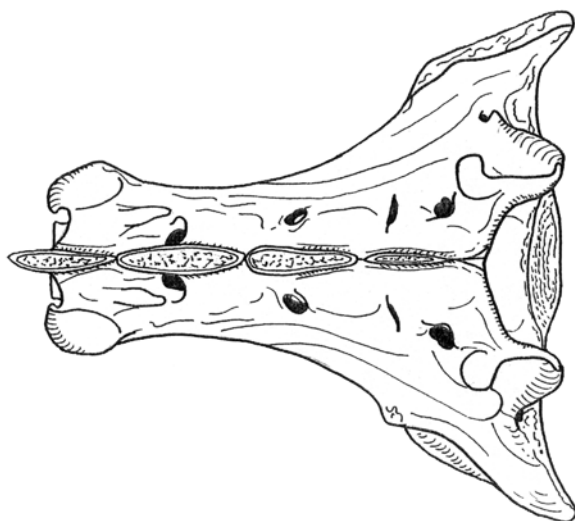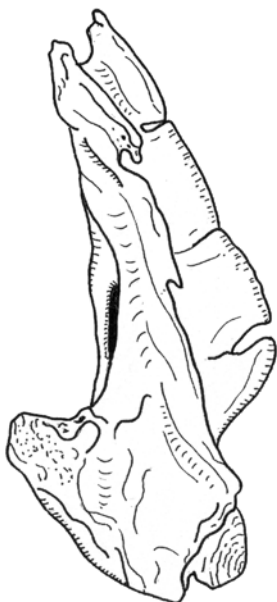
The Impala Sacrum
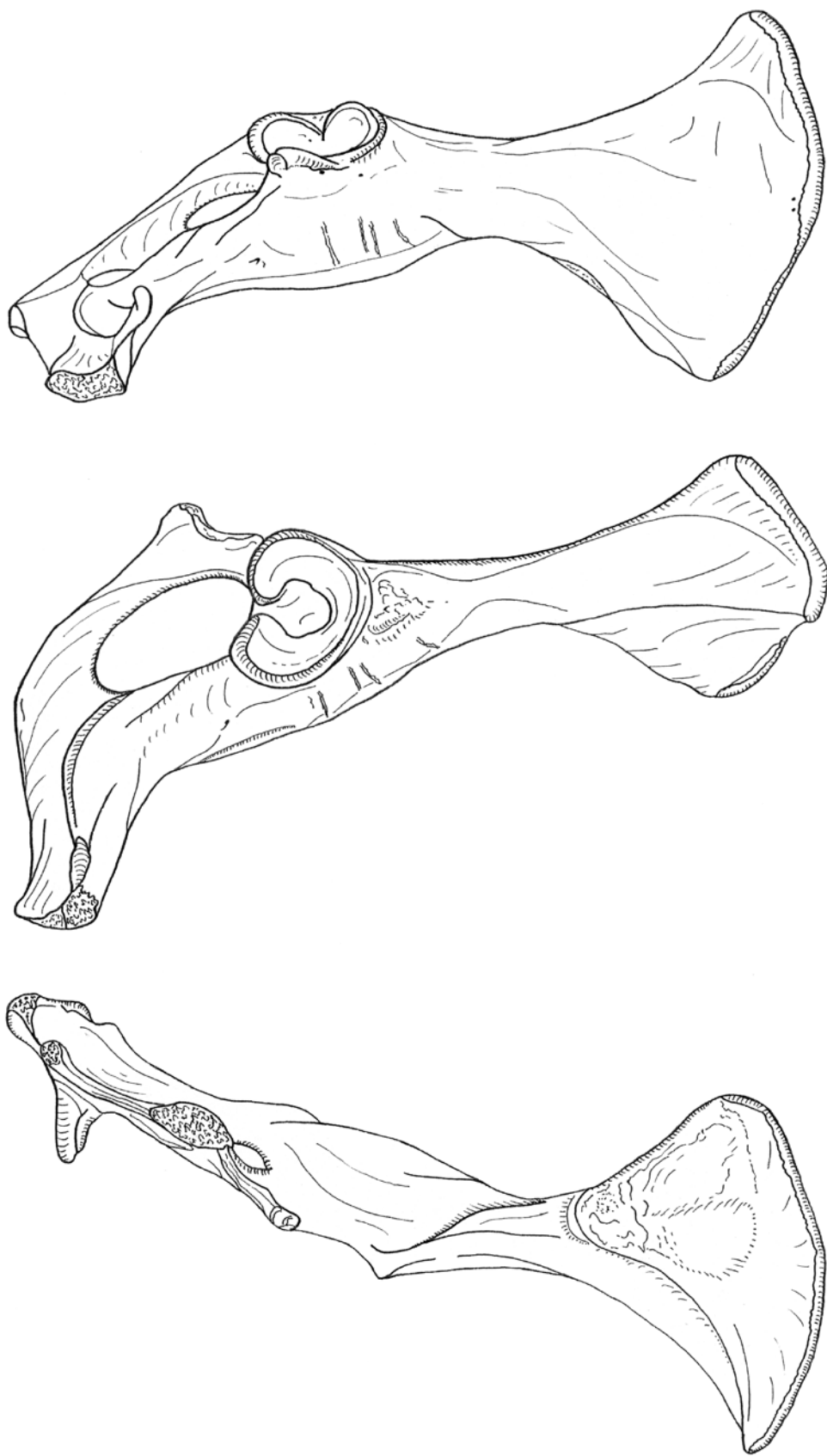
The Impala Pelvis
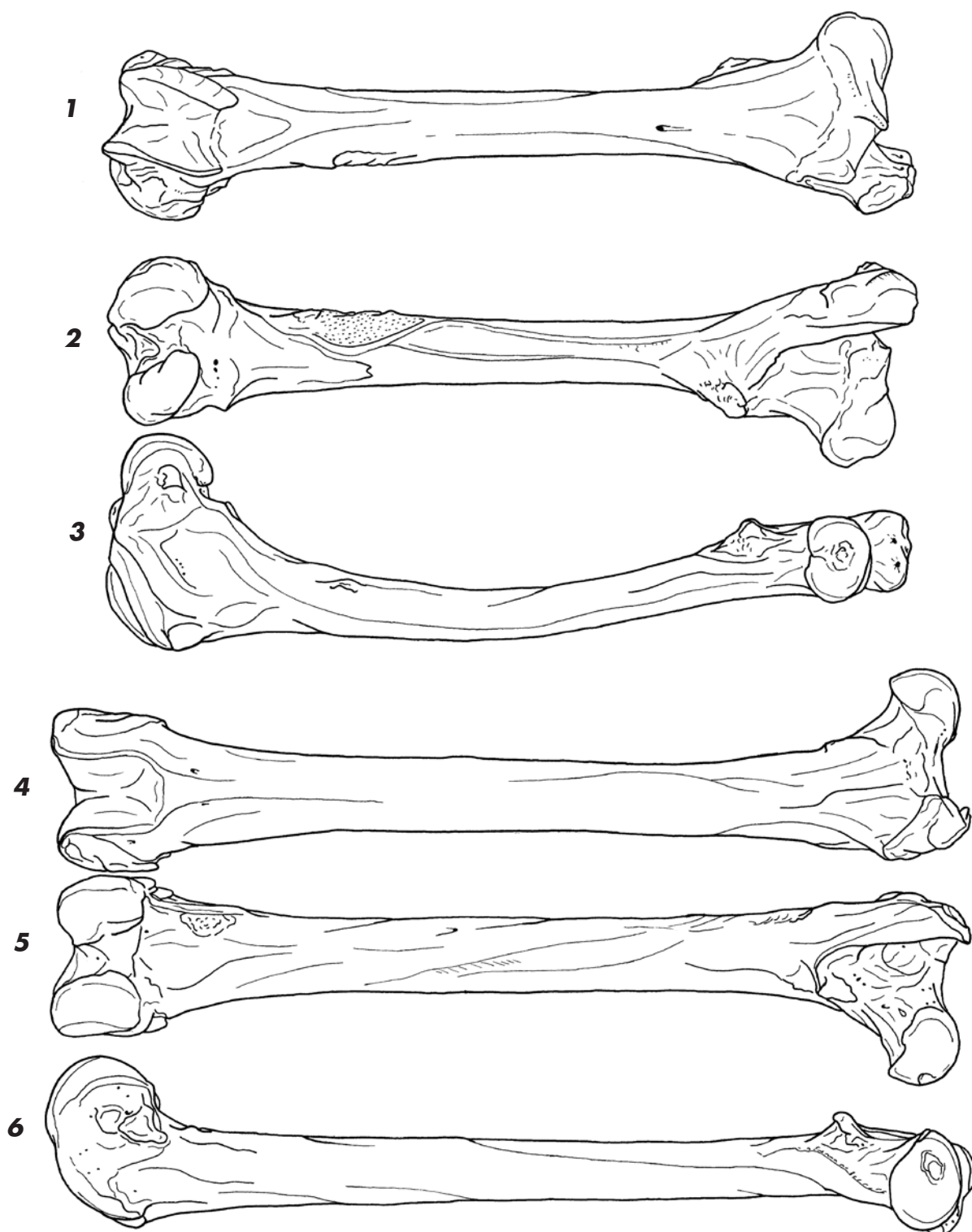
The femur (common name "thighbone")– 1,2 & 3 impala femur; 4,5 & 6 leopard femur

The femur – 1,2 & 3 human femur
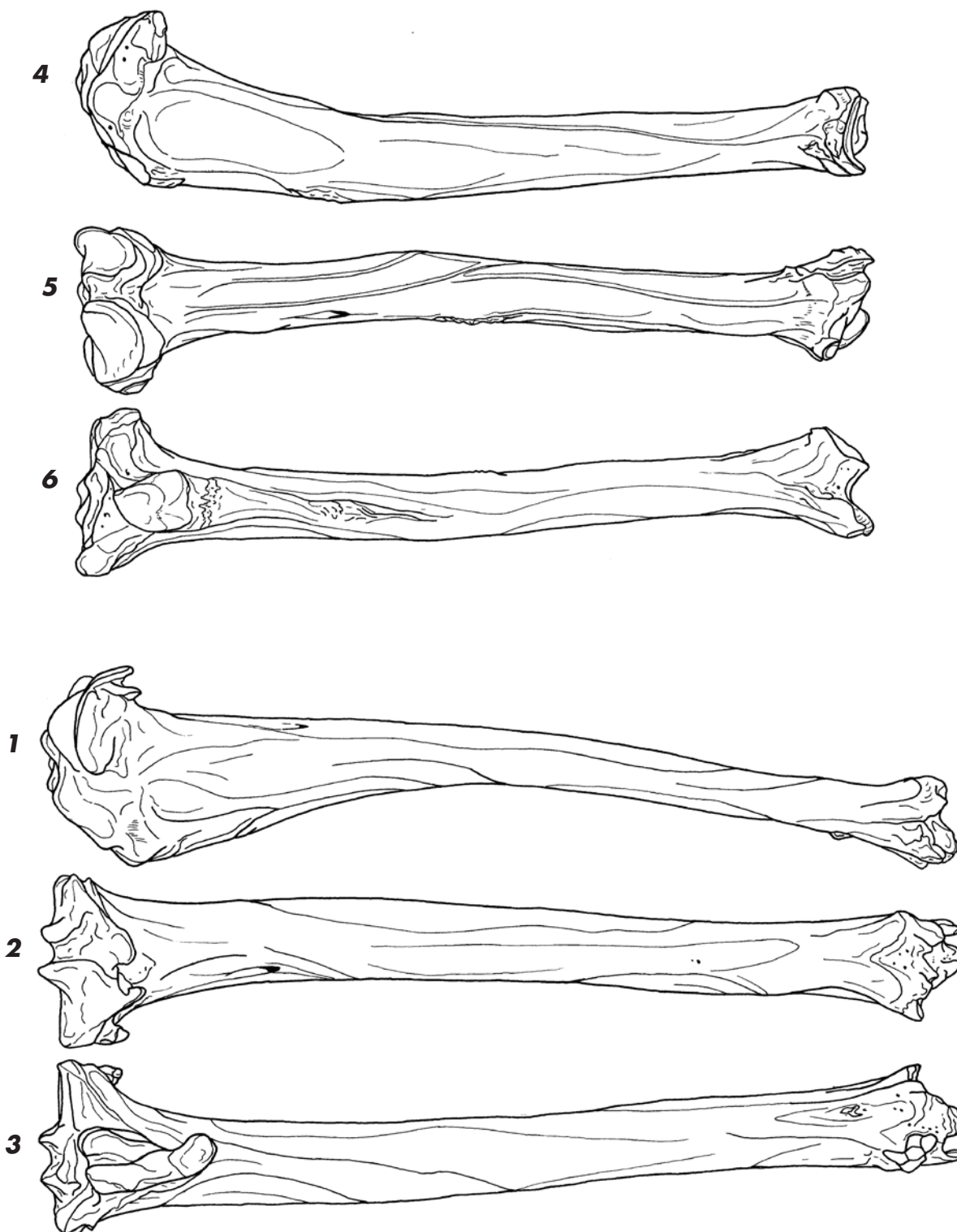
The tibia (common name "shin bone") – 1,2 & 3 impala tibia; 4,5 & 6 leopard tibia

1   *2*   *3*

The tibia – 1,2 & 3 human tibia
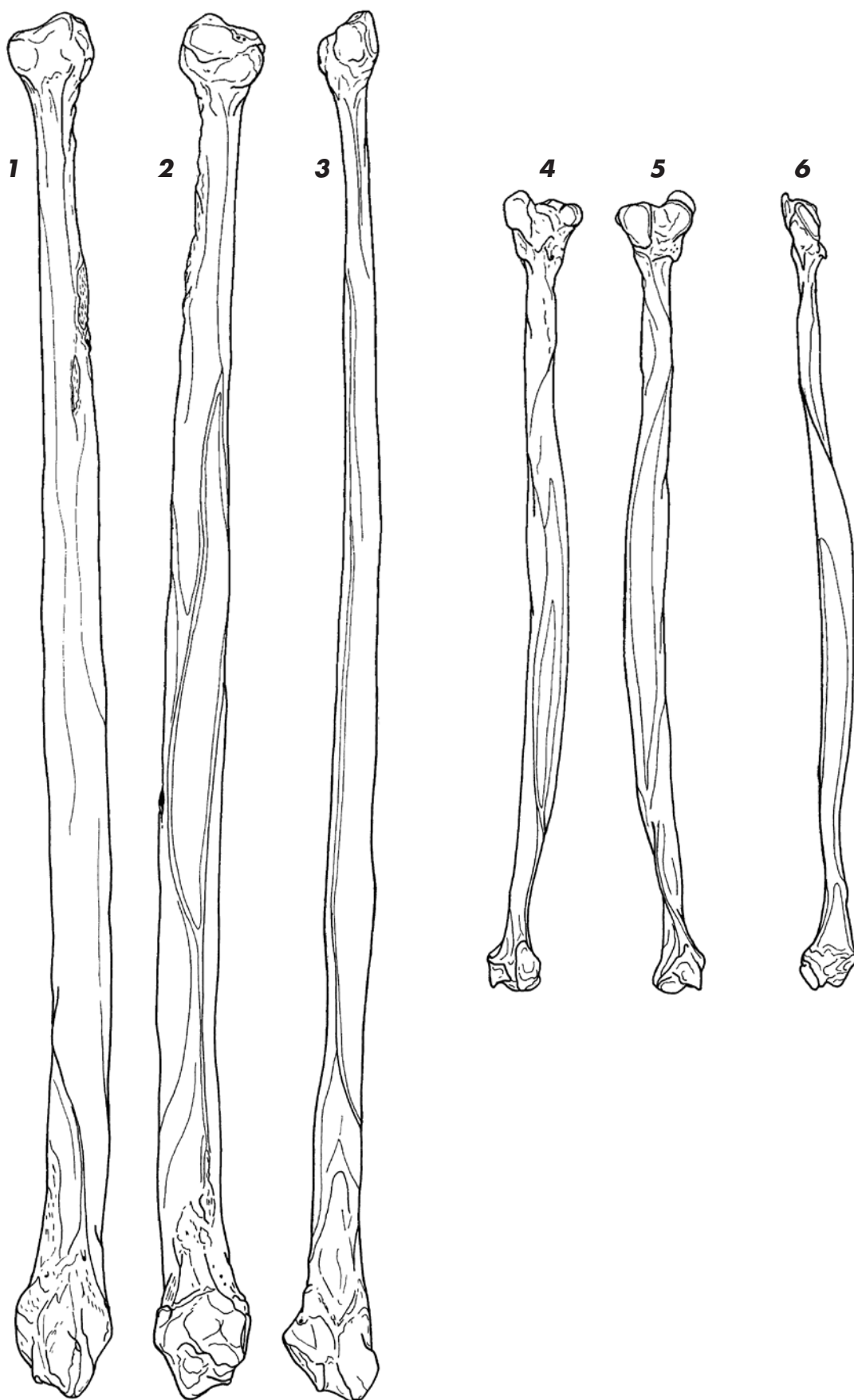
The fibula – 1,2 & 3 human fibula; 4,5 & 6 leopard fibula; note: in the impala the fibula is absent.

The calcaneus (common name "heel bone") – 1,2 & 3 impala calcaneus; 4,5 & 6 leopard calcaneus; 7,8 & 9 human calcaneus
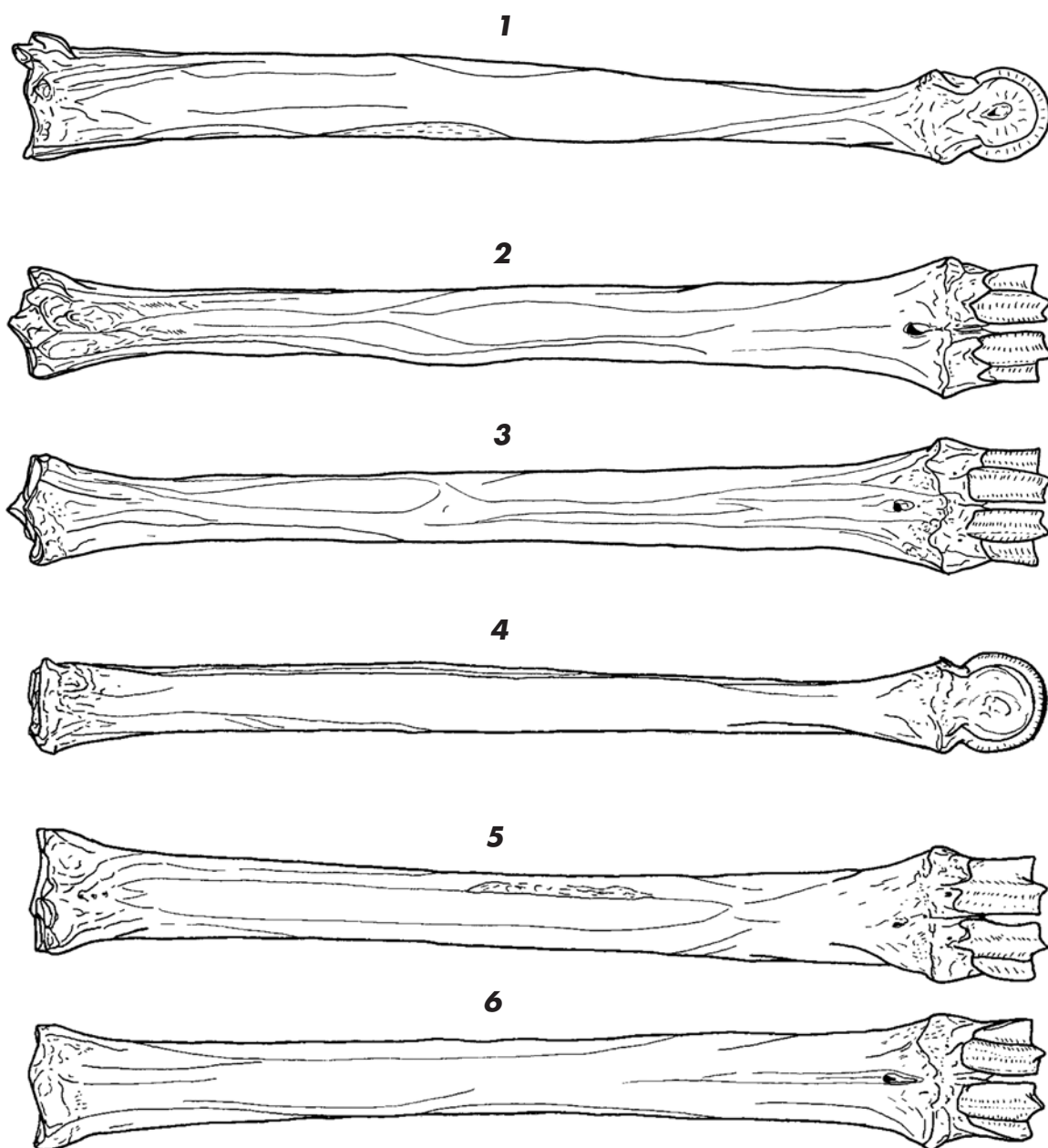
The impala metapodial – 1,2 & 3 impala metacarpal; 4,5 & 6 impala metatarsal

Notes

MODULE 5

The Living And Ancient World
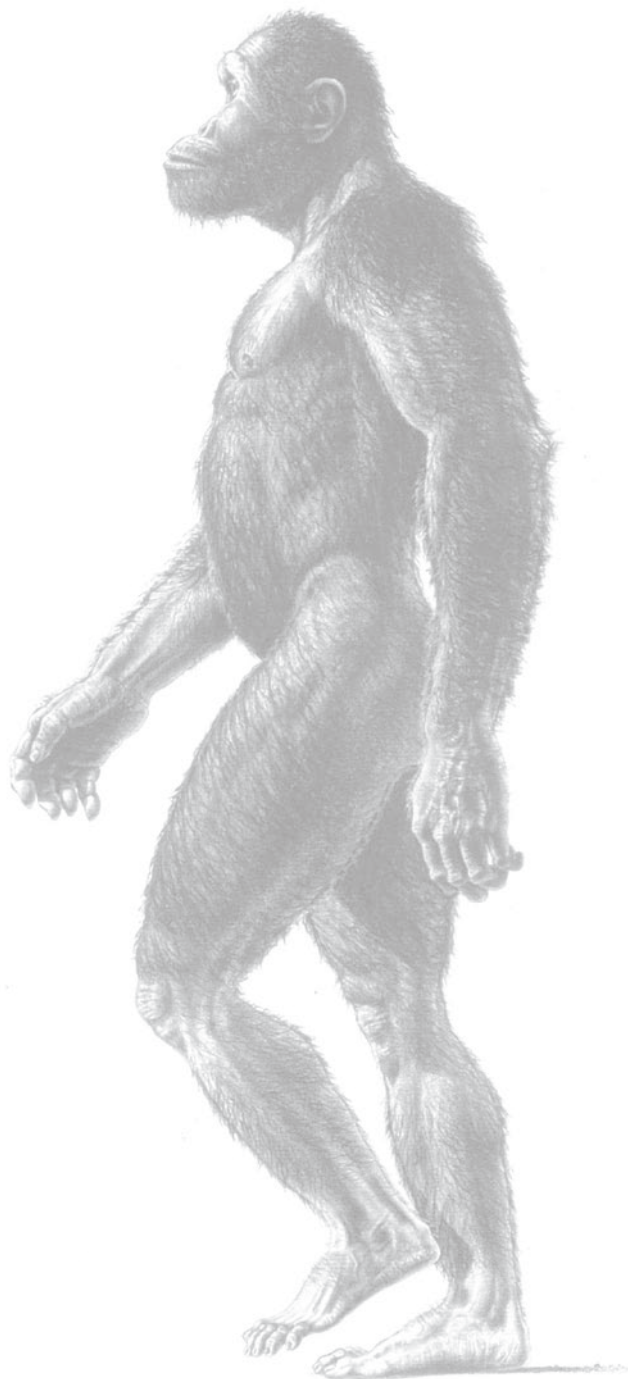
PRIMATES

Linnaean Classification of Primates

The taxonomic classification system devised by Linnaeus in 1758 is still used in modified form today. Animals are identified, in descending order, as belonging to a Kingdom, Phylum, Class, Order, Family, Genus, and finally a Species. The original classification system was based largely on the animal's physical characteristics: things that looked alike are placed together.

In the Linnaean system, humans would be categorised first as Animalia; then Chordata because we have a backbone; Mammalia because we have hair and suckle our young; Primates because we share with apes, monkeys, and lemurs certain morphological characteristics; Hominidae because, among a few other criteria, we are separated from the other apes by being bipedal; *Homo* because of our generic classification as human; and finally sapiens, a species name meaning, rightly or wrongly, "wise."

The Linnaean system also recognises such groupings as superfamilies and sub-families. In the case of the human lineage, the most often recognised superfamily is the Hominoidea (hominoids), which includes all of the living apes. It is from this point onward that most of the present human origins classification debate begins.

The traditional view has been to recognise three families of hominoid: the Hylobatidae, the Hominidae, and the Pongidae. The Hylobatidae include the so-called lesser apes of Asia, the gibbons and **siamangs**. The Hominidae include living humans and typically fossil apes that possess a suite of characteristics such as bipedalism, reduced canine size, and increased brain size such as in the australopithecines. The Pongidae include the remaining African great apes including gorillas, chimpanzees, and the Asian orangutan.

siamangs / siamangs / a close relative of the gibbon

For more discussion see Pg. 13 of the *Field Guide to the Cradle of Humankind* (2nd Edition)

New Molecular Evidence

Modern-day genetic research is providing evidence that morphological distinctions are not necessarily proof of evolutionary relatedness. Recent evidence suggests that humans are in fact more closely related to the chimpanzee and bonobo than either species is to the gorilla. Chimps and humans share something like 98 percent of our genes, indicating that we share a common ape ancestor.

Divergence times between the two groups based on a molecular clock suggest that the chimpanzee/human split occurred between five and seven million years ago. In turn, the African apes, including humans, are more closely related to each other than they are to the orangutan.

In recognition of these and other genetic relationships, some argue that we must overhaul the present morphologically based classification system to create one that is more representative of our true evolutionary relationships as evinced by our genes.

Reworking the Family Tree (Hominid vs. Hominin)

Under the new classification model, hominoids would remain a Primate superfamily, as has always been the case. Under this hominoid umbrella would fall orangutans, gorillas, chimps, and humans, all in the family Hominidae.

In recognition of their genetic divergence some 11 to 13 million years ago, the orangutans would be placed in the sub-family Ponginae and the African apes, including humans, would all be lumped together in the sub-family Homininae. The bipedal apes - all of the fossil species as well as living humans - would fall into the tribe Hominini (thus hominin). All of the fossil genera, such as Australopithecus, Ardipithecus, Kenyanthropus, Paranthropus and Homo, would fall into this tribe.

A few evolutionary biologists want a more extreme classification, which would include humans and chimpanzees within the same genus - the genus Homo.

Old Versus New

So hominid or hominin? Is it just a matter of semantics that only purists should be worried about? Both terms are correct in the broadest sense. In either the "old" or "new" classification system, hominid works, it just means different things. In the long run, hominin is likely to win

out against the term hominid. It is more precise and recognises the biological reality that moves beyond physical morphology.

Hominins in the World Heritage Site Area

The World Heritage Area provides important evidence of the evolution of hominins over the last 3 million years. They are represented by members of the genus *Homo* as well as the genus *Australopithecus*. The genus *Australopithecus* can be traced back as far as 4.1 million years in Kenya, where the oldest species currently attributed to the genus, anamensis, can be found. These earliest representatives of *Australopithecus* were already fully **bipedal**, though they were still characterised by small cranial capacities and **facial prognathism**. *Australopithecus africanus* from Sterkfontein shows the same adaptations to bipedalism, and has been referred to by some scientists as the direct, lineal ancestor to our own genus, *Homo* although this is a much contested point. Although very rare in the fossil assemblages of the World Heritage Area, a number of specimens of *Homo* have been found, providing a great deal of insight into the evolution of our ancestors. Thus the COH has a continuous record of human evolution over the past 3 million years. The area has effectively been continuously occupied by our ancestors and us throughout this entire period. Modern humans have of course been found in the area and the following descriptions relate to the extinct species of humans and their ancestors.

> **bipedal** / bipedal / they walked on two legs
>
> **facial prognathism** / facial prognathism / the face juts out

"Early modern" or "anatomically modern" Humans (Homo sapiens)

> **Homo sapiens** / Homo sapiens / Wise Man
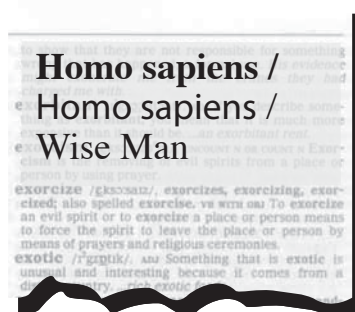
"Early modern" humans are early **Homo sapiens** are members of our same species, but are commonly thought to be relatively primitive compared to modern humans, and perhaps not as intellectually sophisticated. This view is an incorrect interpretation of the archaeological record based on European sites. In Africa, evidence of complex social and cultural traditions can be traced back nearly to the origin of the species 150 000 – 200,000 years ago. Recent finds in East Africa suggest the morphology of "modernity" may go back beyond 170,000 years ago.

Modern human remains have been found in the World Heritage Area, but most probably represent the remains of recent people living in the area as they tend to be associated with Iron Age implements and pottery. Modern humans have been recorded in Member 5 of Swartkrans at 11 000 years of age, but significant mixing of this deposit makes such a designation uncertain. They have also been found in Middle Stone Age deposits at Plover's Lake internal deposits dating back more than 70,000 years.

Extinct Human Ancestor (Homo erectus)

Homo erectus is recognised by most scientists as the last direct ancestor of modern humans though some recognise an intermediary stage, *Homo heidelbergensis* (if correct, this view would distance *Homo erectus* by one stage in evolution, but not remove it from our family tree). *Homo erectus* was the first hominin species to move out of Africa, and therefore they were widespread throughout Africa, Europe, Asia and Indonesia.

Homo erectus /
Homo erectus /
Erect man
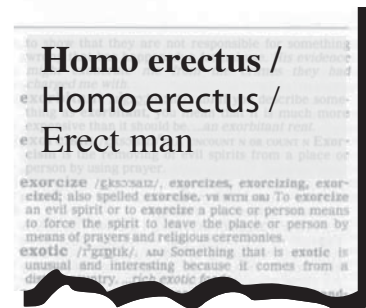
Homo erectus was probably the first hominin species to become dependent on meat, as there is significant evidence that hunting and meat eating played an important role in their diet. A limited 'toolkit' is known from this species, though technological innovation over a period of nearly 1 million years is almost entirely lacking after the appearance of the earliest *erectus* tools. They almost certainly had a wide habitat tolerance, and probably migrated at least seasonally. Tantalizing evidence in Indonesia has raised the possibility that *Homo erectus* was a capable woodworker, producing spears and perhaps even boats.

Homo erectus has been recovered from Swartkrans Members 1 and 2, Drimolen, Coopers and possibly Gondolin. It is known from numerous localities in East Africa as well. This species first appears across Africa at about 1.8 million years ago, and it probably vanished about 800,000 years ago in South Africa, though it may have survived to a younger age.

Handy Man (Homo habilis)

Homo habilis /
Homo habilis /
Handy man
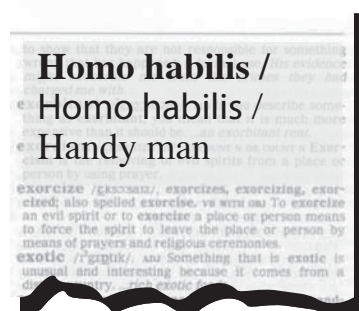
Possibly ancestral to *Homo erectus*, **Homo habilis** was smaller in size, weighing approximately 30 - 50 kg. Little is known about this species, in large part because there is little agreement as to exactly which fossils can be ascribed to it in both East and South Africa. It has been suggested that they had the capacity for complex language, but confirmation of this is difficult as it is based largely on poorly preserved

endocasts, It is possible that the earliest stone tools in Africa at 2.5 million years of age in Ethiopia were produced by *Homo habilis*, but again confirmation is difficult and there are several other early *Homo* species and even australopithecines that are temporally associated with these early tools. Some researchers have removed habilis from the genus *Homo* and placed it with the genus *Australopithecus* based on issues of morphology.

endocasts / endocasts /cast of the brain made by making an impression of the interior of the skull
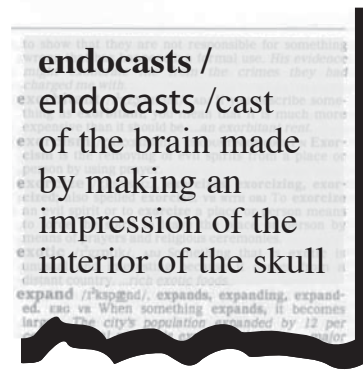
Homo habilis has been recorded in Member 5 of Sterkfontein exclusively in South Africa, though this identification is being questioned. It is also known from Olduvai Gorge in Tanzania, as well as Koobi Fora in Kenya. Its estimated time range in Africa is from about 2.5 million years until about 1.5 million years when it became extinct.

Gracile Australopithecine (Australopithecus africanus)

Australopithecus africanus is hypothesized to be ancestral to the genus *Homo*, making it potentially very important in our evolutionary history. They have been reconstructed at a body weight of 45.5 kg (males), with females being as small as 30 kg. . Research indicates that their arms were quite long relative to their legs, indicating a more chimpanzee-like body shape. This implies that they still spent some of their time in the trees, a conclusion supported by close observation of their hand and foot bones. *Australopithecus* africanus is endemic to South Africa, not being found in East Africa at all. Their social organisation might have been similar to chimpanzees, though they presumably would have lived in somewhat more cohesive family groups. Their diet probably consisted of fruits and leaves, though recent isotopic studies have suggested that they also ate a significant quantity of meat. They probably occupied open environments such as woodlands and grasslands, and may have included some form of grasses or sedges in their diet.

Australopithecus africanus is known only from Sterkfontein Member 4 and Gladysvale in the World Heritage Area, though fossils of this species are also known from Makapansgat and Taung. The time range of this species is from around 3.0 million years to about 1.9 million years ago.

Robust Australopithecine (Australopithecus or Paranthropus robustus)

The "robust" australopithecines are called such because of their more pronounced and powerfully developed cranial (head) architecture. Although it was originally thought this

robusticity applied to the entire body, discoveries of their postcranial bones have show that they were not significantly larger than the gracile australopithecines, weighing in at about 30 – 50 kg. They are certainly more robust in the development of their skulls which display massive attachments for powerful chewing muscles. They also had enormous teeth, and clearly did a significant amount of heavy chewing. Their diet most likely consisted of tough, fibrous vegetation such as roots, tubers and roughage. They also probably supplemented this vegetarian diet with termites, as tools found at Swartkrans appear to have been used to break open the mounds of these insects. Paranthropus robustus is endemic to South Africa, and they probably had a wide habitat tolerance, being found in both open grassland and more closed woodland environments.

Paranthropus robustus is known from Swartkrans Members 1-3, Kromdraai B, Drimolen, Coopers and Gondolin in the World Heritage Area. They are not known anywhere outside of the World Heritage Area. The time span of this species is from about 2.0 million years ago until approximately 1.0 million years ago, though they may have survived later.

Other Species of Hominin Not Found in the Cradle of Humankind

Sahelanthropus tchadensis

This species was named in July 2002 from fossils discovered in Chad in Central Africa. It is the oldest known hominin or near-hominin species yet recovered, dated at between 6 and 7 million years old. This species is known from a nearly complete cranium nicknamed "Toumai" and a number of fragmentary lower jaws and teeth. The skull has a very small brain size of approximately 350cc. It is not known whether it was bipedal. *S. tchadensis* has many primitive apelike features, such as the small brain size, along with others such as the brow ridges and small canine teeth, which are characteristic of later hominids. Some researchers suggest that Toumai may be an ancestral gorilla or other ape.

Species name: *Orrorin tugenensis*

Time range: around 6 million years ago

This species was named in July 2001 from fossils discovered in western Kenya. The fossils include fragmentary arm and thigh bones, lower jaws, and teeth and were discovered in deposits that are about 6 million years old. The limb bones are about 1.5 times larger than those of Lucy, and suggest that it was about the size of a female chimpanzee. Its finders have claimed that *Orrorin* was a human ancestor adapted to both bipedality and tree climbing,

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and that the australopithecines are an extinct offshoot. Given the fragmentary nature of the remains, other scientists have been sceptical of these claims so far.

Species name: *Ardipithecus ramidus*

Time Range: 4.4 – 5.8 million years ago

This species was named in September 1994 and was originally dated at 4.4 million years, but has since been discovered to range as far back as 5.8 million years. Most remains are cranial fragments but there is a partial skeleton that has yet to be described. The teeth are intermediate between those of earlier apes and *A. afarensis*. Fossils of other animals found with *ramidus* indicate that it may have been a forest dweller.

More recently, a number of fragmentary fossils discovered between 1997 and 2001, and dating from 5.2 to 5.8 million years old, have been assigned to a new subspecies, *Ardipithecus ramidus kadabba.*

Species name: *Australopithecus anamensis*

Time range: between 4.2 - 3.5 million years ago

The species *A. anamensis* is based on relatively few specimens from the lake Turkana region of Kenya. A large, surprisingly human-like tibia indicates that this species was well adapted to bipedalism while its more parallel tooth rows and relatively large canines (at least for a hominin) are more apelike. To many researchers, this species looks like a good candidate ancestor for all later hominins.

Species name: *Australopithecus afarensis*

Time range: between 3.5 – 2.9 million years ago

One of the most widespread of the early hominins and probably the best documented because of the well-known "Lucy" skeleton. First discovered by Don Johanson in the Hadar region of Ethiopia in 1973, A *afarensis* "The Ape from Afar" was initially believed to be the mother species of all subsequent hominins but the finds of earlier ape-men has begun to question this position, and there is ongoing debate as to where *afarensis* fits in on the human family tree. Males were larger than females, much like gorillas, and had a cranial capacity of around

400ccs. Found in Tanzania, Ethiopia and possibly Kenya and Chad, the species is also widely distributed.

There has been a great deal of debate among scientists as to whether *afarensis* was a dedicated tree climber or not. Recent discoveries, however, point to the species having lived in many different types of habitats. The famous Laetoli footprint trail in Tanzania in which the 3,2 million year old footprints have been preserved in fossilized ash, is attributed to this species.

Species name: *Australopithecus barelgazeli*

Time range: between 3.5 – 3.0 million years ago

This australopithecine was discovered in North Africa by the French palaeoanthropologist Michel Brunet. It has been suggested that it is a regional variant of afarensis. Only parts of the skull have been found so very little is known of the rest of its body.

Species name: *Kenyanthropus platyops*

Time range: about 3.5 million years ago

This species was named in 2001 from a partial skull found in Kenya with an unusual mixture of features (Leakey et al. 2001). It is aged about 3.5 million years old. The size of the skull is similar to *A. afarensis* and *A. africanus*, and has a large, flat face and small teeth. Little else is known about this species at this time.

Species name: *Australopithecus ghari*

Time range: about 2.5 million years ago

The last of the "definitive" *australopithecines*, this species is one of the newly added members of the genus *Australopithecus*. Discovered by Tim White's team in the Middle Awash region of Ethiopia, ghari appears to be more advanced than afarensis, displaying a combination of both gracile and robust tendencies. Named after the Afar word for surprise, *ghari* has been found in association with stone tools but there is no evidence yet that it was capable of making the tools. Based on fragmentary post-cranial evidence it has been suggested that *ghari* had both long arms and long legs, giving it unusual body proportions compared to other hominins.

The Paranthropines

Formerly classified as a robust form of *Australopithecus* but now more frequently put into the separate genus *Paranthropus*. *Paranthropus* fossils are well known for their massive teeth and jaw muscles which indicate a low nutritional vegetarian diet (lots of chewing to extract nutrients) which may have been an adaptation to the drier African environment from three million years ago. Recent examinations of its hand bones reveal that Paranthropus had the capability to manufacture and manipulate stone tools which are often found in association with fossil remains. However, there is still no definitive answer as to whether *Paranthropus* or *Homo* made the tools found in the fossil sites in the WHS. *Paranthropus* have relatively smaller brains than contemporaneous hominins in the genus Homo, but usually slightly larger brains than the gracile australopithecines.

Species name: *Paranthropus aethiopicus*

Time range: between 2.6 – 2.2 million years ago

Known from Kenya and Ethiopia, *aethiopicus* is the suspected common ancestor of most if not all later Paranthropines. The Black Skull, discovered in Kenya by Alan Walker in 1985, is the best example of this species. This is the first species in the hominin fossil record to exhibit the massive teeth and chewing muscles that characterise the shift to a vegetarian lifestyle brought about by the **aridification** of Africa and the disappearance of the Miocene forests.

aridification /
aridification /
drying out
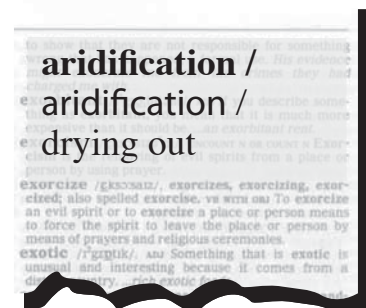
Species name: *Paranthropus boisei*

Time range: between 2.2 – 1.2 million years ago

With some of the largest fossil representatives of the robust australopithecines, *boisei* epitomizes a "hyper-robust" ape-man. With it huge teeth and massive jaws, males of this species are unmistakable, typically having bony crests atop their skulls just to support their massive jaw muscles. However, relative to body size, they have the smallest hominin braincase recorded (< 420cc) although some individuals have cranial capacities in the low 500cc range. The best known example is the "Nutcracker Man" discovered by Mary and Louis Leakey at Olduvai Gorge in Kenya in 1959 and described by Phillip Tobias. This specimen was also often referred to as "Dear Boy" as a play on the name *boisei*.

Early Homo

The key difference between the australopithecines and the lumped group "early *Homo*" is that the latter had a larger and more complex brain that may be linked to tool-making abilities. Typically, we characterise early Homo by its more generalised skull, less prominent brow ridges and a general reduction in facial prognathism. Early *Homo* tend to have smaller pre-molars and seemed to be omnivorous, adding substantially more meat to their diet.

The earliest known Homo fossil specimens have been dated to around 2.5 Mya, and show generalised characteristics. They are found throughout Africa and many have not been classified to species. *Homo habilis* or *Homo rudolfensis* are two later types of "confirmed" early Homo species but even their status is sometimes questioned, with some palaeoanthropologists wanting to place them in the genus *Australopithecus*. In South Africa, early *Homo* fossils are known from Sterkfontein, Kromdraai, Swartkrans and Drimolen.

Species name: *Homo rudolfensis*

Time range: between 2.4 – 1.8 million years ago

Rudolfensis got its name from Lake Rudolph, the colonial name for Lake Turkana, where its fossilized remains were found by Richard Leakey in the late 1960's and early 1970s.

The argument for *rudolfensis* as a separate species is a tenuous one because of the lack of strong fossil evidence. Indeed some scientists have described rudolfensis as a "garbage-can" species, consisting of all the "throw away" bits of fossils that can't be neatly ascribed to *habilis* or *ergaster*. It therefore, by default, has affinities with many of the hominins including *Homo habilis, Homo ergaster* and *Homo erectus*. It has been tentatively associated with simple flake tool technology.

Species name: *Homo habilis*

Time range: between 2 – 1.6 million years ago

With a larger brain than the australopithecines (around 650 – 800cc), *Homo habilis*, meaning "handy man" was the first species of extinct hominin placed in the genus *Homo*. The first specimen was found by the Leakey's at Olduvai Gorge in 1960. With its rounder head, reduced prognathism, more human-like teeth and less pronounced brow ridges, it was considerably more "human-like" in appearance.

Habilis has long been associated with the crude Oldowan tool industry. Based on a very fragmentary skeleton from Olduvai Gorge in Tanzania it has been suggested that Homo habilis had long arms and short legs. Homo habilis is unlikely to be the ancestor of Homo ergaster or *Homo erectus.* Recent work has even suggested that fossils attributed to Homo habilis would be better placed into the genus Australopithecus.

Species name: *Homo ergaster and Homo erectus*

Time range: between 2 million years ago and 400,000 years ago

Homo ergaster is often used as a synonym for "early African *Homo erectus*". Beginning about two million years ago we see a dramatic shift in hominin cranial and post-cranial morphology. With the appearance of Homo erectus a true human ancestor is easily identifiable. Reaching modern human statures but with a brain approximately three quarters the size of modern humans, the earliest Homo erectus must have been a formidable creature on the African savannah.

The hand-axe, an often enormous, tear-dropped shaped bifacial tool, is characteristic of Homo erectus. *Homo erectus* is the first known hominin to leave Africa. It developed the controlled use of fire, the earliest evidence in Africa so far being at Swartkrans in the Cradle of Humankind. By 700,000 to 1 million years ago erectus is found across the Old World. It may only go extinct as recently 25,000 years ago in isolated pockets in Indonesia, although it was extinct throughout the remainder of the Old World by 250,000 years ago.

Species name: *Homo georgicus*

Time range: about 1.8 to 1.6 million years ago

This species was named in 2002 from fossils found in Dmanisi, Georgia, which seem intermediate between *H. habilis* and *H. erectus.* The fossils, consisting of at least three partial skulls and three lower jaws, are spectacularly complete. The brain sizes of the skulls vary from 600 to 680cc. A partial skeleton was also discovered in 2001 but few details are available on it yet. (Vekua et al. 2002, Gabunia et al. 2002)

Species name: *Homo antecessor*

This variation of early *Homo* is restricted to southern Europe and possibly North Africa. Antecessor had a relatively "modern" looking face but with features of both erectus in the

cranium and later Neanderthals in the nasal region. *Homo antecessor* is a good candidate ancestor of *Homo heidelbergensis* and then *Homo neandertalensis*. It has a cranial capacity of around 1000cc. Its remains have been found at La Sima de los Huesos, near Atapuerca, in northern Spain.

Species name: *Homo heidelbergensis*

Time range: between 600,000 and 200,000 years ago

As tall as or taller than modern humans and more robustly built, *Homo heidelbergensis* was probably the forerunner of the Neanderthals in Europe and the possible ancestor of *Homo sapiens* in Africa. Based on archaeological evidence, this species was capable of hunting large mammals. There is a great deal of confusion as to whether the large robust human fossils found in Africa from this time period are members of this species or something different. Very large humans have been found in southern Africa that have tentatively been attributed to *Homo heidelbergensis*. These remains are mostly from the Cape coast, Zambia and Namibia.

Species name: *Homo neandertalensis*

Time range: between 230,000 and 30,000 years ago

Neanderthals appear to have evolved out of *H. antecessor*, and they were a species adapted to living in very cold climates. Their bodies were stocky and their nasal passages may have been adapted to processing icy air, a sort of "nasal radiator". First discovered in 1856 in the Neander Tal (valley) in Germany, Neanderthals shared many cultural and behavioural traits with modern humans. They seem to have been restricted initially mostly to Europe where they survived a series of ice-ages over the last several hundred thousand years. However, it appears that later adaptations of *neanderthalensis* allowed them to live in temperate climates and their remains have also been found in the Middle East, Asia and possibly even Northern Africa.

Species name: *Homo sapiens*

Time range: from 200,000 years ago to present

The genetic evidence and the fossil record point to an "out of Africa" origin for modern humans. Modern *H. sapiens* appear to have evolved from an archaic form that in turn developed out of *H. erectus*.   Southern Africa is rich in the evidence of the transitional species.

Genetic evidence examining both mitochondrial DNA (from the female line) and Y chromosome DNA (from the male line) add support to the hypothesis that modern humans arose out of Africa between 150 000 and 200,000 years ago and spread rapidly across the whole of the Old World. Modern humans reached Europe, and Indonesia and Australia, probably via coastal routes, by around 50,000 – 60,000 years ago, and North and South America only after 20,000 years.

Until recently, it was believed that modern human behaviour as expressed through art work, burial of the dead and a complex tool-kit, were relatively recent, European phenomena attributable to Cro-Magnon around 25,000 and 35,000 years ago. Recent discoveries in Africa suggest that the earliest evidence for all of the "modern" attributes can be found in coastal sites that are as much as 50 to 100 thousand years earlier than this date.

EXTINCT AND EXTANT FAUNA IN THE CRADLE OF HUMANKIND

Non-Hominin Primates

The non-hominin primates in the World Heritage Area consist of several species of modern and extinct baboons and monkeys. Baboons first appeared in the late Miocene, probably 5 to 7 million years ago, and

have a good fossil record. It is difficult to determine the precise evolutionary history of the baboons in southern Africa, but among the oldest specimens of Papio (the genus of modern baboons) are to be found at Sterkfontein. Both the extinct and extant baboons found in southern Africa are mostly omnivorous and terrestrial. *Cercopithecus* monkeys are the most widespread and abundant monkeys in Africa. Their fossils, however, are extremely rare, and none have yet been found in South Africa. A single type of extinct leaf-eating monkey, Cercopithecoides, is known from the fossil caves of southern Africa, though leaf-eating monkeys are not found here today.

Chacma baboon *(Papio ursinus)*

Chacma baboons tend to be dark brown in colouration, with an admixture of yellow or black hairs. They exhibit a large degree of sexual dimorphism, with males weighing approximately 32kg, and females roughly 15kg. Troop size is highly variable, and may number up to 150

individuals in optimal conditions. In larger groups several adult males may be present, but there is always a dominant, alpha male leading the troop. Baboons are omnivorous, subsisting mainly on fruit and leaves, but also including invertebrates, grasses, seeds, roots, flowers, bark, gums, mushrooms and occasionally reptiles, birds and mammals in their diet. Baboons are widespread throughout southern Africa, and are capable of adapting to a wide variety of habitats. They are restricted only by their need for suitable sleeping sites such as caves or cliffs for protection from predators.

Papio ursinus is known from Member 5 of Swartkrans and is estimated to be approximately 11 000 years in age. They almost certainly existed long before this, but their fossils are only poorly known.

Hamadryas baboon *(Papio hamadryas robinsoni)*

Although originally accorded status as a separate species, *robinsoni* is now referred to as subspecies of the modern hamadryas baboon. Although the *hamadryas* baboon still exists today, it is no longer found in southern Africa, being restricted to the semi-desert Horn of Africa. In the past this was one of the most common baboons in the World Heritage Area. Modern hamadryas baboons are smaller than chacma baboons, with males weighing about 19kg, and females around 14kg. The fossil *hamadryas* baboons of the World Heritage Area were slightly larger than their modern counterparts. The hamadryas' have a unique social system whereby individual males "own" 2 or more females as part of a harem. Troops of male dominated harems and bachelor groups band together at night to sleep on high cliffs, away from predators. These combined troops average between about 100 and 150 individuals, but can grow as large as 350 animals. By day they forage for grasses, roots, flowers and fruits. The fossil form, *Papio hamadryas robinsoni*, almost certainly had a similar lifestyle to the modern hamadryas baboon.

Papio hamadryas robinsoni is known from Swartkrans Members 1-3, Kromdraai A and B, Coopers, Bolt's Farm, Schurweburg, Gladysvale and Drimolen. This subspecies probably arose in South Africa some 2.0 million years ago, and disappeared sometime in the Pleistocene.

Extinct large baboon *(Papio (Dinopithecus) ingens)*

The genus *Dinopithecus* was recently sunk into Papio, demonstrating the great similarities between the two types of baboon. This baboon is one of the biggest *Cercopithecoids* known,

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being notably larger than modern baboons. Body size estimates would place the largest specimens (presumably males) at more than 40kg in weight. A great deal of sexual dimorphism is evident in the cheek teeth of this species. The shape of the skull and teeth are so similar to modern "savannah" baboons that we can infer a similar behavioural interpretation. *Papio ingens* probably consumed a similar diet, including grasses, leaves, roots and fruits. The cheek pouches of this species were slightly different from modern baboons, suggesting there was some difference in feeding behaviour. No post-cranial remains are securely attributed to this species, so we cannot directly examine their locomotor behaviour.

This species is known exclusively from the Hanging Remnant and the Lower Bank of Member 1 at Swartkrans. As such, its known time span is somewhat limited to approximately 1.5-1.8 million years of age, though it presumably existed both prior to and subsequent to Swartkrans Member 1 times.

Extinct gelada baboon *(Theropithecus oswaldi)*

This species of large, extinct baboon is closely related to the modern gelada baboon, found today in Ethiopia. Theropithecus oswaldi was much larger than its modern relatives, weighing in the neighbourhood of 40kg. It probably had a diet similar to modern geladas, which are dedicated savannah grazers, eating a diet of grass and grass seeds. Their adaptation to terrestrialism is the most developed of all non-hominin primates. The teeth of modern geladas and Theropithecus oswaldi are high-crowned to cope with excessive wear from eating grass. Their third molars erupt relatively late in life compared to other baboons so that when the earlier molars are wearing down, the third molars are just beginning to wear, prolonging the potential life span of the teeth in a fashion similar to elephants. Modern geladas have the most opposable thumb of all primates except humans. This provides them with a precision grip, as well as the ability to dig for rhizomes, roots and tubers during the dry season. The finger bones of *Theropithecus oswaldi* from Swartkrans appear similar to modern geladas. The social grouping of modern geladas is similar to hamadryas baboons, with smaller one-male harems and groups of bachelors banding together into groups of 50 to 250 individuals, but sometimes numbering up to 600; it seems likely that the extinct form would have had a similar social organisation.

Theropithecus oswaldi is known from Members 1-3 of Swartkrans and from Gladysvale. Elsewhere in Africa fossils of Theropithecus dominate primate faunas from the late Pliocene until the mid to late Pleistocene, when they began to be replaced by savannah baboons (Papio).

Extinct small baboon *(Parapapio jonesi)*

Of the Plio-Pleistocene baboons found in southern Africa, the genus *Parapapio* is the most primitive. There are actually 4 species assigned to this extinct genus, though there is some question as to the actual separation of the groups, since the main criterion for distinguishing the species is molar size. *Parapapio jonesi* is the smallest of the *Parapapio* species, with an estimated body weight of approximately 18kg. Parapapio jonesi was probably a fruit and leaf eater, and its limb bones suggest it was arboreal or tree dwelling. It was most likely adapted to forested environments.

Parapapio as a genus is known from Sterkfontein Member 4, Swartkrans Member 1 and Kromdraai A. They range in time in South Africa from 3.0 to 2.0 million years ago, as they are well represented at Makapansgat. Several species of Parapapio are known in East Africa, the oldest of which are more than 4.0 million years old, and it is possible that *Parapapio* could represent the ancestral African baboon.

Vervet monkey *(Cercopithecus aethiops)*

The vervet monkey of southern Africa is greyish in colour with a black face surrounded by a band of white hair. Males weigh about 5kg, slightly more than the 4kg females. They are widely distributed across Africa, preferring to live in drier areas but near permanent sources of water. However, they have a wide habitat tolerance, and will live in riverine woodlands if fruit is available.

diurnal / diurnal / active during the day

gregarious / gregarious / live in groups

Vervets are **diurnal** and **gregarious**, living in small groups of up to 40 individuals with several unrelated males coexisting. They are mainly vegetarian, eating a diet of fruits, flowers, leaves, seeds and seed pods, although they are known to eat insects as well as the occasional bird or bird egg.

The genus *Cercopithecus* is known from the late Pliocene, though there are no known fossils of this genus in South Africa. The only fossil of this genus are known from East African fossil localities.

Extinct colobus monkey *(Cercopithecoides williamsi)*

The only true monkey found in the Sterkfontein Valley caves, this species is actually a colobine, or leaf-eating, monkey. They were larger than vervet monkeys, weighing approximately 13kg. Living colobine monkeys are arboreal, restricted to evergreen forest areas in equatorial Africa. The extinct monkey *Cercopithecoides* may have been able to live in less thickly wooded areas than are necessary for their closest living relatives, and were probably somewhat more terrestrial. The chewing muscles in Cercopithecoides were less powerfully developed than in modern colobines, but the teeth are often heavily worn. This suggests a diet with less tough and fibrous material, thus they were more likely to have eaten softer, grittier items than modern colobines. These probably consisted of fruit and leaves.

Cercopithecoides is known from the late Pliocene until the middle Pleistocene throughout Africa. In the World Heritage Area, their fossils have been recovered from Sterkfontein Member 4, the Lower Bank of Member 1 at Swartkrans, Member 2 at Swartkrans, Kromdraai B, Gladysvale, Coopers and Drimolen. Cercopithecoides is also known from Makapansgat, so its fossils are recorded in South Africa from about 3.0 million years ago until just less than 1.5 million years ago.

Lesser bushbaby *(Galago moholi)*

Lesser bushbabies are small and furry, with long tails, large eyes, and highly mobile ears. They are quite small, weighing on average 150g, with little sexual dimorphism. They are found in savannah woodlands throughout southern Africa, commonly associated with Acacia woodlands. Lesser bushbabies are nocturnal and almost exclusively arboreal. During the day they rest in groups of 2 to 7, but forage separately. They may build themselves nests, or will occasionally occupy disused bird nests. Their diet consists exclusively of insects and gum particularly from Acacia trees. Galagoes in general have specialised anklebones designed for quick running and leaping.

Galagos are known as early as the Early Miocene in Africa, but have never been recognised in fossil form in South Africa.

Large Felids

The large cats found in the fossil caves of the World Heritage Area can be divided into 3 main groups: the sabre-tooth cats, the false sabre-tooth cats, and the modern Pantherines (lion, leopard, cheetah). The sabre-tooth cats found in the World Heritage Area belong to the

Subfamily *Machairodontinae*, and are typified by remarkably enlarged upper canines and reduced lower canines. These cats were the first successful large felid predators, overshadowing other carnivores from the *Oligocene* until their extinction in the *Pliocene*. The false sabre-tooth cats are characterised by the genus *Dinofelis*, the oldest representative of which is found at Langebaanweg in South Africa. The modern large felids of Africa first appeared about 3.5 million years ago in southern Africa.

Lion *(Panthera leo)*

The lion is the largest living terrestrial carnivore in Africa. Males are larger than females, the former weighing on average about 200kg, and the latter around 125 kg. Lions once ranged across Africa, Europe and Asia, though today they are restricted to sub-Saharan Africa. Lions are predomimantly **crepuscular**. They are distinctly social animals, operating collectively in prides ranging in size from a few individuals to as many as 30 lions. There is usually a single male dominating a pride of closely related females and their offspring. Occasionally there is more than one dominant male, but in this situation the males are usually closely related, most commonly brothers. Lionesses do the majority of the hunting, with the dominant male seizing kills to feed before the females are allowed. Lions take a wide variety of prey, from insects to buffalo. They have even been recorded taking a sub-adult bull elephant. Lions have a wide habitat tolerance, only avoiding forested areas. They do well in desert conditions, and can go months without drinking, gaining moisture from the blood of their prey.
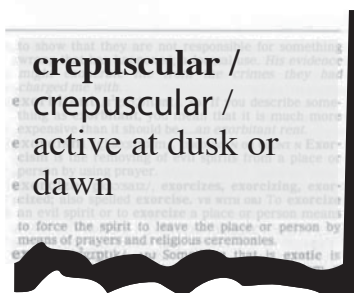
crepuscular /
crepuscular /
active at dusk or
dawn

Lions are known from Sterkfontein Members 4 and 5, Swartkrans Members 1-3, Kromdraai A and Gladysvale. They first appear roughly 3.0 million years ago, and were widespread across Africa during the *Plio-Pleistocene*.

carnassial /
carnassial /
specially adapted
teeth for slicing
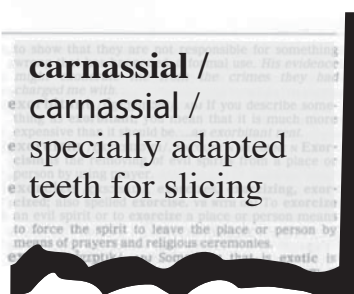
Extinct sabre-tooth cat *(Homotherium crenatidens)*

Only distantly related to lions, these largest of South African cats had the typically enlarged canine teeth that define the sabre-tooth cats. The enlarged upper canines are serrated on both edges, and are almost delicately thin. Their **carnassial** teeth are especially well adapted to slicing meat, but they

would have had very little bone cracking ability. The body size for Homotherium is estimated at around 215kg, larger than modern male lions. These cats had powerfully built bodies, and would have been able to take down the largest of prey. They most probably used a stabbing hunting technique, driving their large canines into the soft parts of their prey and then using a slicing motion to **eviscerate** them. It has

eviscerate / eviscerate / to remove stomach content

been suggested that Homotherium may have hunted cooperatively in prides, perhaps as a mechanism to penetrate the protective shield 'walls' adult *Proboscideans* form around their young when threatened. They were almost certainly the top predators until their extinction. It is unlikely that Homotherium was a major threat to the hominins in the World Heritage Area, since primates are particularly "bony" animals and an attack on such an animal would entail a serious risk of damage to their enlarged canines. Their large size, post-cranial anatomy and presumed prey preferences indicate that these large cats would have preferred more open habitats as opposed to woodlands.

Homotherium is known only from Kromdraai A and Coopers in the World Heritage Area, though it is also known from the grey breccia of Makapansgat, as well as E Quarry at Langebaanweg in the Western Cape. As such this genus spans from the Pliocene until the mid-Pleistocene (5.0 to 1.5 million years).

Extinct sabre-tooth cat *(Megantereon cultridens)*

Machairodontinae /Machairodontinae/ family of sabre tooth cats

Similar to *Homotherium*, *Megantereon* also has the specialised upper canine teeth that mark the **Machairodontinae**. However, Megantereon does not have serrated sabre-teeth, though their canines are recurved with very sharp edges. The carnassial teeth in Megantereon are also specifically adapted to the slicing of meat, and not the cracking of bone. It is

possible that their stouter canine teeth would have been used to pierce the hides of thick-skinned ungulates, causing significant trauma and blood loss in their victims. Megantereon is a smaller sabre-tooth cat, weighing approximately the same as a large female lion (150kg). They probably favoured more closed habitats, but would have been capable of taking larger prey than modern felids such as leopards and lions, although their skeletons were clearly not adapted for fast movement. It has been suggested that Megantereon dragged prey into trees much like leopards, but such a behaviour would have posed significant risk of damage to their canines while transporting heavy loads, and is therefore unlikely.

Megantereon is known from Sterkfontein Members 4 and 5, the Hanging Remnant of Swartkrans and perhaps Members 2 and 3, Kromdraai A and B and possibly at Motsetsi. The earliest appearance of this genus is at Langebaanweg at 5.0 million years ago, and it survived until at least Elandsfontein times, just over 500, 000 years ago.

Leopard *(Panthera pardus)*

The modern leopard is arguably the most successful of the modern large cats, being widespread across Africa, the Middle East, through Siberia and into Malaysia and Sri Lanka, even in the face of human encroachment. Their distinctive spots make them easily recognised, though very difficult to spot when in grassy or wooded cover. Leopards are much smaller than lions, with males weighing on average 60kg, and females 32kg. Leopards have a very wide habitat tolerance, from deserts to forests, though they prefer areas with rocky outcroppings. Leopards are solitary and nocturnal, hunting primarily by stealth. In order to prevent theft of their kills leopards will drag carcasses into trees. However, leopards will also drag their carcasses into the depths of the caves for safekeeping, a behaviour that had significant impact on the bone accumulations in the fossil caves in the World Heritage Area. Leopards are capable of subsisting on any form of animal protein, from insects to large bovids. Their preferred prey size range is around 70kg, though they have been documented killing animals as large as zebras and eland.

Leopards are one of the most common carnivores in the World Heritage Area, being found in Sterkfontein Member 4 and maybe Member 5, Swartkrans Members 1-3, Kromdraai A and B, Gladysvale and possibly Coopers. They first appear just over 3.0 million years ago in South Africa, though they are known from sediments over 3.5 million years old in East Africa.

Extinct false sabre-tooth cat *(Dinofelis piveteaui)*

Dinofelis lack the elongated, curved canines of the Machairodontinae, and therefore are placed within the Felinae. They are referred to as false sabre-tooth cats. Their canine teeth are somewhat elongated, though not as long as in the sabre-tooth cats. Their canines are also much stouter, similar to those of a lion, but significantly larger. The estimated body size of *Dinofelis* was probably in the neighbourhood of 150kg, similar to a large female lion. *Dinofelis* ranged from Europe, through East Africa and into South Africa. Their preferred habitat was probably a more closed environment, and are hypothesized to have been rather similar to leopards in behaviour. Thus they are thought to have been solitary, nocturnal predators. Whether they preyed upon the hominins in the area is uncertain. Their larger body size and

better prey-grappling abilities would probably have allowed them to regularly take larger prey than leopards. Dinofelis would have had some tree climbing ability, though its large size would have been a limiting factor. It has been suggested that Dinofelis may have occasionally scavenged carcasses dragged into trees by leopards. Their large size and powerful build would have made them one of the top predators in the Plio-Pleistocene.

Dinofelis are found in Sterkfontein Member 4, the Hanging Remnant and Member 2 of Swartkrans, Kromdraai A, Drimolen, Gladysvale and Bolt's Farm. It is also found in Langebaanweg, about 5.0 million years ago, as well as in East Africa. By about 1.0 million years ago this genus had become extinct.

Cheetah *(Acinonyx jubatus)*

The modern cheetah is regarded as the fastest terrestrial animal in Africa. Their spotted coats and distinctive "tear-marks" under the eyes make them readily identifiable. Cheetahs are lightly built, with males averaging 54kg and females 43kg. They range all over modern Africa, though the encroachment of humans has significantly impacted on their distribution. Cheetahs live in open plains, but they are equally at home in savannah woodlands. Cheetahs are primarily diurnal, and dedicated terrestrial, running down their prey with short bursts of incredible speed. Cheetahs are at the bottom of the predator hierarchy, frequently losing their prey to hyenas, leopards and lions. To compensate for their timidity, they have evolved very efficient slicing teeth and rapidly eat as much of a carcass as possible before they are disturbed. Cheetahs are normally solitary, though they will band together to hunt larger prey such as young giraffe and Waterbuck. Groups are usually comprised of closely related individuals, usually mother and sub-adult or recently adult offspring.

Cheetahs are known only from Swartkrans Members 2 and 3. However, they can also be found at Makapansgat in South Africa, and Omo and Laetoli in East Africa. They range in time from about 3.0 million years old in South Africa, though they are older than 3.5 million years in East Africa.

Hyenas

During the Plio-Pleistocene in the World Heritage Site, there were several types of hyenas, about half of which went extinct. Hyenas may have developed their advanced bone-crushing abilities in order to process the carcasses that the sabre-tooth cats, with their exclusively meat slicing teeth, left behind. Extinction in one part of a food web will affect other parts of the ecosystem, and it has been hypothesized that when the sabre-tooth cats became extinct, some of the hyenas followed suit, since the carcasses they depended on were no longer available. Some of the hyenas did survive though. Although spotted hyenas used to be present in the World Heritage Area, today only brown hyenas can still be found in the area.

Spotted hyena *(Crocuta crocuta)*

The peculiar spotted coat and sloping back of the spotted hyenas make them readily identifiable. Their powerful neck and forequarters allow them to tear apart the largest of carcasses and drag the heaviest remains with them. Females tend to be larger than males, averaging 69kg and 62kg respectively. Spotted hyenas are widely distributed in sub-Saharan Africa, though their range has shrunk as a result of human encroachment. They are a savannah species, preferring open plains or open woodlands; they avoid forested areas. Spotted hyenas clans are **matriarchal**, with groups ranging from 4 to 18 or more adults occupying clearly marked territories. They tend to be nocturnal, with extremely well developed senses of smell, sight and hearing. They also have a highly developed repertoire of communications. Spotted hyenas are effective hunters, though they often lose prey to scavenging lions. Lions are the greatest threat to hyenas, as male lions will instinctively kill any hyenas they come in contact with. Spotted hyenas have a wide range of prey preferences, and can process bones from the largest of carcasses. They will crack a bone open, swallowing the fragments to extract nutritious content, then later regurgitate the remaining material.

matriarchal /
matriarchal /
female dominated

Spotted hyenas are known from Sterkfontein Members 4 and 5, Swartkrans Members 1-3, Kromdraai A and Gladysvale. In South Africa Sterkfontein Member 4 and Makapansgat Member 4 have produced the oldest Crocuta remains at just over 2.5 million years of age. This genus may extend as far back as 4.0 million years in East Africa.
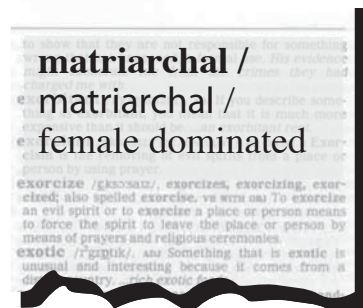
Extinct giant hyena *(Pachycrocuta brevirostris)*

This extinct giant hyena was significantly larger than its closest living relative, the spotted hyena, weighing just less than 100kg. This genus has a very wide distribution, being known from Africa and Eurasia. Similar to spotted hyenas, they probably avoided forested and closed areas, preferring more open grasslands and woodlands. The large size and powerful build of *Pachycrocuta* means it would have been able to process the largest of carcasses, and eat bones that other hyenas simply could not. It has been suggested that Pachycrocuta may have operated in clans similar to spotted hyenas, which would have made them formidable predators on the Plio-Pleistocene landscape. Their extinction has been linked to the extinction of the sabre-tooth cats. Once these felid super-predators had vanished, the large carcasses they would have produced would no longer be available for Pachycrocuta. The giant hyenas would then have had to directly compete with the smaller hyenas for smaller carcasses.

Pachycrocuta is known from Sterkfontein Members 4 and 5, Kromdraai A and Gladysvale. It is also known from Makapansgat, extending its time range in South Africa from about 3.0 million years ago until about 1.5 million years ago. The genus survived in Eurasia until about 0.5 million years ago, and thus may have been present in Africa until that time, but the sites in southern Africa in the late Pleistocene have not shown evidence of its survival.

Brown hyenas *(Hyaena brunnea)*

Brown hyenas have the typical hyena build, with high shoulders and a sloping back towards the rump. Males are larger than females, with the males weighing roughly 47kg and females weighing 42kg. Brown hyenas are restricted to southern Africa, though in the past they were found throughout Africa. They tend to be found in arid areas such as deserts, but this may be more a result of their being forced into more marginal areas, as they are known to prefer rocky areas with notable bush cover in certain areas. Brown hyenas are nocturnal and extremely shy of humans, and are therefore rarely seen. They are solitary foragers, though they live in groups in fixed territories and raise their young in communal dens. Group size can range from 5 to 14 individuals. Their senses are particularly well developed, and they can detect carcasses from several kilometres away. Brown hyenas are mainly scavengers, though they will kill small mammals, birds, reptiles and insects. They will also eat ostrich eggs and wild Tsama melons, the latter probably for their moisture content. Brown hyenas provision their young, taking portions of carcasses to their dens. As a result, it is thought that they contributed to the accumulations of fossils in the World Heritage Site.

Brown hyenas are known from Sterkfontein Members 4 and 5, Swartkrans Members 1-3 and Kromdraai A and B. They are also known from Makapansgat, thus this genus is known in South Africa from 3.0 million years ago to the present. They are also known from the same time range in East Africa.

Extinct hunting hyena (*Chasmaporthetes nitidula*)

cursorial /
cursorial / adopted
for running
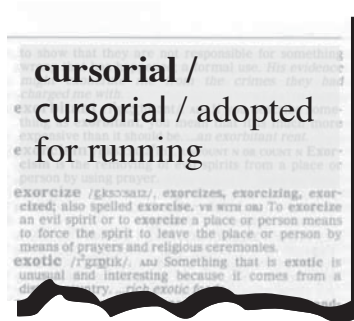
Chasmaporthetes has been referred to as a long-legged hunting hyena. It is about the size of a brown hyena, with an estimated body weight of 40kg. This genus has a wide distribution, being found throughout Africa and Eurasia. The long legs of this animal suggest it was more **cursorial** than modern hyenas, and may have engaged in more active hunting. Their teeth do not show the same specialisations for bone crushing as modern hyenas, and they were probably about as adept at this task as large felids. Chasmaporthetes may have been pack animals, and their meat-slicing tactics may have left significant scavengable carcasses in the palaeoenvironment.

Chasmaporthetes is known from Sterkfontein Members 4 and 5 as well as Swartkrans Members 1-3. It may also be derived from Member 2 of Sterkfontein; therefore the genus has a time range of over 3.0 million years ago until about just over 1.0 million years ago when it vanished from southern Africa. In East Africa and Eurasia *Chasmaporthetes* is much older, exceeding 4.0 million years.

Aardwolf (*Proteles cristatus*)

The Aardwolf is evolved from a hyaenid ancestor, and this ancestry is still visible in the high shoulders and sloping back. Males and females are approximately the same size, weighing about 9kg each. They are distributed throughout southern Africa and East Africa. They have a wide habitat tolerance, generally preferring open areas. Like hyenas, they tend to avoid forested areas. This may have more to do with the distribution of their main food source, harvester termites. Unlike other termites, harvester termites forage on the surface instead of underground, and are thus an easy source of food for the aardwolf. One species of termite the aardwolf feeds on is nocturnal, and thus so is the aardwolf; however, in winter in South Africa it is often too cold for the termites to forage, so the aardwolf switches to another species of termite that is diurnal. They are entirely solitary unless with their young. Aardwolves are so adapted to their termite diet that their teeth have become reduced to the point that they can no longer be used to feed on any other form of animal protein.

Fossil representatives of aardwolf are known from Sterkfontein Member 5, Swartkrans Members 1-3 and Kromdraai B. As a result, their time range in the World Heritage Area is restricted from about 1.5 million years ago until the present. Fossil aardwolf are apparently unknown in East Africa.

Canids

The fossil canids of the World Heritage Site are only poorly understood, having been eclipsed by the more spectacular felids and hyaenids. It is becoming apparent that many more types of canid were present in the fossil caves than have been recognised to date. Canids in general are remarkable for having remained generalised feeders, capable of consuming both animal and plant matter. Canids have preserved most of their dentition, as opposed to hyenas and cats which have lost most of their molar teeth as a result of evolutionary processes. Canids therefore tend to have elongated snouts that also have a considerable sense of smell. Foxes and bat-eared foxes are represented in the assemblages from Sterkfontein, Swartkrans and Kromdraai, though they are extremely rare. The genus *Nyctereutes*, the racoon-dog of Asia, has even been recognised at Kromdraai, the first record of this animal in Africa.

Black-backed jackal *(Canis mesomelas)*

Black-backed jackals are distinguished from other jackals by the broad, dark saddle that covers their back from the neck to the tail. Males weigh about 8kg, and females weigh about 7kg, their small size making them subordinate to felids and hyaenids in confrontations over carcasses. Jackals are found throughout southern Africa as well as East Africa. They have a wide habitat tolerance, occurring from savannahs to arid zones, but preferring drier areas. Jackals show both diurnal and nocturnal activity patterns in response to the activities of their principal prey, rodents. The call of the jackal is one of the distinctive sounds of the African bush. Jackals subsist on insects, rodents, reptiles and birds. They also scavenge whenever possible, putting significant pressure on hyenas in competition for carcasses. Jackals do not hunt larger animals than springhares, but will occasionally kill small young bovids.

Jackals are well represented in the fossil caves of the World Heritage Site, but the taxonomy of these small carnivores is not well understood. The genus *Canis* is known from Sterkfontein Members 4 and 5, Swartkrans Members 1-3, Kromdraai A and B, Gladysvale, Drimolen and Coopers. *Canis* is also known from Makapansgat; therefore its range extends from 3.0 million years ago to the present.

Wild dog *(Lycaon pictus)*

The blotched black, white and yellow coat of the wild dog, along with its large round ears make this animal unmistakable. Wild dogs weigh about 30kg in South Africa, with males slightly larger than females. They used to be widespread throughout Africa, but there has been a remarkable reduction in their distribution and population size. Wild dogs prefer open plains or open savannah woodlands, and since they hunt mainly by sight, they avoid forested areas, or woodlands and grasslands with tall grass cover. They are diurnal, and have evolved the specialised pack behaviour of dogs for hunting. Packs range in size from 3 to 28 individuals on average, though some larger than 40 animals have been recorded. The young are well cared for by all members of the pack, and all the animals in a group are highly interdependent. Wild dogs hunt by coursing after their prey: they start chasing an animal, and relentlessly follow it at moderate to high speed until the animal falls from exhaustion or trauma inflicted by the dogs. This technique is highly effective, and large packs are very successful. Once an animal has been caught it is completely consumed within a short period time.. Wild dogs will defend kills from hyenas, often causing severe injury to hyenas as a result of their mobbing behaviour.

Claims for the presence of wild dogs in the fossil sites of the World Heritage Site have been received with scepticism. The oldest confirmed record to date of Lycaon in South Africa is from Elandsfontein at about 0.5 million years ago. Lycaon pictus is known from East Africa about 2.0 million years ago.

Extinct wolf-like dog

This recently discovered species of wild dog may represent the oldest evidence for wild dogs in South Africa. It is a large animal, approximately the size of a modern North American wolf. It probably had an omnivorous diet, as a seed from a wild date palm was found in its abdominal cavity. It has so far only been recovered from Gladysvale, and is estimated to be just less than 1.0 million years old.

Smaller Carnivores

Numerous small carnivores inhabit South Africa, and many have been found in the fossil caves in the World Heritage Area. For the most part they are very rare, being found in very small numbers. These smaller animals probably did not play a significant role in the accumulations of bones in the fossils caves. Rather, they were most likely themselves brought into the caves by animals such as leopards and brown hyenas. Brown hyenas in particular will provision their young with the small carnivores they hunt, possibly as a defence against attacks on their offspring or to decrease competition for limited food resources.

Caracal *(Felis caracal)*

Caracals are reddish-brown in colour with conspicuous tufts of hair at the tips of their ears. Males average about 14kg in weight, while females reach about 12kg. Caracals are widespread across Africa, inhabiting arid open country and savannah woodlands where cover is minimal. They have a varied diet, including small bovids, hyraxes, rodents and other small carnivores. They occasionally take birds and even fish. Caracals are solitary and mainly nocturnal, even in areas undisturbed by humans. Although mainly terrestrial, like most cats caracals are good tree climbers. Caracals are difficult to spot making field observation troublesome.

Caracals are known from Kromdraai A, the Lower Bank of Swartkrans and from Drimolen. They are also known from Makapansgat, and therefore have a fossil record extending from 3.0 million years ago to the present in South Africa. They can be traced back to about the same time in East Africa.

Meerkat *(Suricata suricatta)*

Meerkats tend to be silvery brown, with a long tail and stocky hindquarters. Both males and females weigh on average around 750g, though the males are usually slightly larger than the females. They are restricted in distribution to southern Africa, being well adapted to open, arid regions with hard or stony substrates. Meerkats are diurnal, operating in tightly knit social groupings of 2 to 30 members. Their characteristic habit of sitting on their haunches to survey their immediate environment is well known. They are extremely wary and always on the alert for eagles and jackals. Their diet consists in large part of insects, as well as reptiles, amphibians and birds.

Meerkats are known from the Hanging Remnant of Swartkrans, Members 2 and 3 from Swartkrans, and possibly from Drimolen. Their range therefore extends from approximately 1.5 million years ago to the present in South Africa.

Proboscideans and Hyracoids

The *Proboscidea* refer to animals with a mobile proboscis, or, nose. This includes elephants and their extinct ancestors. The closest living relatives of the elephants are the hyraxes, or dassies. Elephants have played an important role in the study of the evolution of mammals in East Africa. The depositional environments in East Africa often preserve whole elephant skulls intact. In South Africa, the collecting agents that caused the accumulation of bones in the fossil caves rarely brought elephants into their lairs, and as such less is known about the evolution of these large animals in South Africa. For the most part, elephant remains consist of tooth fragments derived from juveniles. Hyraxes on the other hand are abundant and well known in South Africa, while they are less well known in East Africa.

Elephant *(Loxodonta africana)*

The largest of all modern terrestrial mammals, the tusked and trunked elephants are readily identified. Bull elephants weigh on average 5000kg, and cows average 3000kg. As a result of human encroachment, elephants exhibit a patchy distribution across Africa today. With the recent ban on the ivory trade, elephant populations are beginning to recover, and they are moving back into their previous habitats. Elephants have a wide habitat tolerance, living everywhere from deserts to lush woodlands, their main requirement being a water source. Elephants are social animals, living in groups of 2 to several dozen individuals. Groups are composed of several related females and their offspring, lead by a dominant matriarch. At puberty males leave the herd, rejoining female herds only when one is in oestrus. Elephants are both diurnal and nocturnal, ranging long distances in search of food. They are known to both browse and graze, eating a variety of different plants. Although their eyesight is poor, elephants have very good hearing and smell senses.

The genus *Loxodonta* is known only from Bolt's Farm in the World Heritage Site. In East Africa *Loxodonta africana* can be traced back to just over 1.5 million years ago.

Extinct elephant *(Elephas recki)*

This extinct elephant was slightly smaller than the modern elephant. They differ from modern elephants in having smaller tusks and reduced premaxillae, the bones in which the tusks grow. The face of *Elephas recki* became more compressed, and the back of the skull became larger compared to *Loxodonta*. Elephas recki is known from East and South Africa. This species of elephant probably had a diet similar to the modern elephant, consisting of both browse and graze. Virtually all of the remains in the World Heritage Site fossil sties are juveniles.

Elephas recki is known from Sterkfontein Member 4, Swartkrans Member 1 and Member 3 and Gladysvale. Its existence is probable at Makapansgat as well, giving it a time range of 3.0 million years to about 1.0 million years ago in South Africa. It has a similar span in East Africa.

Rock hyrax *(Procavia capensis)*

Rock hyraxes are small, compact animals lacking tails, with a curved grooming claw on the second digit for grooming. Males weight about 4.5kg, with females slightly smaller. This species is widely distributed, ranging from the Middle East, along East Africa, across the equatorial belt and into southern Africa. Rock hyraxes live in rocky krantzes and outcrops with associated bushes and trees to provide browse. Their main requirement is nooks and crannies where they can hide in case of danger, which usually comes in the form of eagles, pythons and leopards. Hyraxes are mainly diurnal, living in social groups, which can number in the hundreds and be divided into a series of harems. They have padded, permanently moistened feet that provide them with a firm footing on the rocks. They eat a variety of grasses, forbs and shrubs, some of which are poisonous to other mammals.

Procavia capensis is a recent species that appears only in Member 5 of Swartkrans, dated to approximately 11 000 years of age.

Extinct giant hyrax *(Procavia transvaalensis)*

This species of extinct hyrax is about one and a half times the size of the modern rock hyrax, between around 6.5 and 7.0kg in weight. Apart from the size difference, *Procavia transvaalensis* are very similar to modern hyraxes. They therefore presumably had a similar

diet and lifestyle. The species was originally named for a large hyrax recovered from Coopers in 1936. Many of the crania known from sites such as Swartkrans show evidence suggesting they were eaten by leopards and eagles, much like the hyraxes of today.

Procavia transvaalensis is known from Sterkfontein Members 4 and 5, Swartkrans Members 1-3, Kromdraai A and probably B, Gladysvale, Coopers and Bolt's Farm. They are also known from Makapansgat, therefore this taxon can be found in South Africa from 3.0 million years ago until its disappearance sometime in the Pleistocene.

Equids

Horses have a long evolutionary history, extending back as far as the Miocene in Africa. The equids can be divided into two basic groups in southern African fossil sites: the three-toed Hipparion and the single-toed Equus. Hipparion is the more primitive form, first appearing in the Miocene and extending into the end of the Pleistocene at which point it became extinct. The more advanced Equus first appears in the Pliocene of North Africa, and soon after that in southern Africa. The genus Equus is of special importance for dating the fossil localities in Africa since the genus first appears about 2.4 million years ago in South America. Therefore, any fossil locality containing Equus cannot be older than 2.4 million years of age. Equids are rare fossils in the World Heritage Site.

Zebra *(Equus burchelli)*

The characteristic striping of the zebra makes them readily identifiable, though it also provides camouflage in tall grasses. Burchell's zebra males weigh on average 313kg, while females tip the scales at approximately 302kg. They are restricted in distribution to the northern part of southern Africa and into East Africa. Burchell's zebras are adapted to open savannah plains, preferring open areas of woodland, scrubland and grassland where water is available. The bulk of the zebra diet is comprised of grasses, though they have been known to browse on occasion. They are capable of subsisting on all parts of the grasses, including leaves, sheaths and stems. Zebras live in social groups of 3 to several dozen individuals, lead by a dominant stallion and one or mares and their foals. Non-dominant stallions are forced out of the group at puberty, and join other stallions in bachelor herds until such time as they can depose a dominant stallion and take the mares.

Equus burchelli are known from Sterkfontein Members 4 and 5, Swartkrans Members 1-3, Kromdraai A, Gladysvale and Coopers. The oldest record of Equus in South Africa therefore comes from Sterkfontein Member 4, suggesting that this deposit may be younger than the 2.5 million year age estimate currently provided.

Giant Cape horse *(Equus capensis)*

Equus capensis, the giant Cape horse, was first described by Broom in 1909 based on fossils recovered near Cape Town. This horse is significantly larger than modern zebras, weighing an estimated 895kg. Its skeleton was proportioned differently from modern zebras, with a more powerfully built but short body, and a larger head. Equus capensis had a wide distribution, being recovered across southern and East Africa. The social organisation was probably very similar to that of modern zebras. The diet of *Equus capensis* can be reconstructed to have been predominantly graze, as is seen across all members of the genus Equus.

Equus capensis has been recovered from Sterkfontein Member 4, Swartkrans Members 1-3, Kromdraai A, Gladysvale and Coopers. Equus capensis makes its last appearance at Equus Cave near Taung, in early Holocene times.

Extinct 3-toed horse *(Hipparion lybicum)*

The three-toed *Hipparion* is the most primitive horse in the World Heritage Area. The three toes on each foot were fully functional, whereas in *Equus* only the third toe bears the weight of the animal, with the other toes being reduced in size to useless "splint" bones. The estimated body size of Hipparion is larger than modern zebras at approximately 489kg. *Hipparion* can be found throughout East Africa, indicating they were widely distributed in Africa. *Hipparion* was most likely a grassland grazer that was quite water dependent.

Hipparion lybicum can be found in Swartkrans Members 1-3, Kromdraai A and possibly at Gladysvale. Elsewhere in South Africa, *Hipparion* is known at Langebaanweg 5.0 million years ago, and again at Cornelia between 0.4 and 0.8 million years ago. They apparently disappeared sometime after their appearance at Cornelia.

Vary Large Mammals

The two types of modern rhinoceros in Africa display different evolutionary histories. The ancestors of the white rhino first appear in Kenya just over 7 million years ago. The ancestors of the black rhino first appear in Europe, Asia and North Africa nearly 12 million years ago,

while the first appearance of the modern species occurs about 4 million years ago at Kanam West in East Africa. Conspicuous in its absence, no rhinoceros fossil has yet been identified in the World Heritage Site. Hippopotami are known in the World Heritage Site. The earliest hippopotamus is found in the Miocene in Kenya, about 7 million years ago. In the early Pleistocene of Uganda we see the direct ancestor of the modern hippopotamus, and by the mid-Pleistocene modern hippos had already evolved.

White rhino *(Ceratotherium simum)*

The white rhino can be best identified by its square lips. The name "white" rhino comes from the Dutch word "wyd" meaning wide, a reference to the lips of this animal. This was mistranslated into English. White rhinos are actually grey in colour, much like the black rhinos. Male rhinos weigh between 2000 and 2300kg, while females are smaller at 1600kg. The characteristic horns of the rhino have long been prized by hunters. Although their range was significantly larger in the past, white rhinos are now very limited in distribution, and they are concentrated in South Africa. White rhinos require flat grasslands with adequate bush cover and standing water for drinking and wallowing. They are found in small groups comprised of a dominant, territorial bull, subordinate bulls, cows and their offspring. White rhinos are mostly grazers, preferring short grasses that they crop with their sensitive upper lip (they have no incisor teeth). They are active mainly in the daytime, and although their eyesight is poor, they have excellent hearing and smell. They do not react as aggressively towards intruders as black rhinos.

No white rhino fossils have been recovered in the World Heritage Area, though they are known from Makapansgat, giving them a time range from 3.0 million years ago until the present in South Africa. It is interesting to note that isotopic studies of Ceratotherium simum from Makapansgat indicate that they included much more browse in their diet than do their modern counterparts, suggesting that in Makapansgat times they had not yet adapted to a full grass diet.

Black rhino *(Diceros bicornis)*

The black rhinoceros can be easily distinguished from the white rhino by its rounded upper lip which is **prehensile**. Otherwise it is a similar dull grey colour. The black rhinoceros is significantly smaller than the white rhino, with males weighing

prehensile / prehensile / can be used like fingers
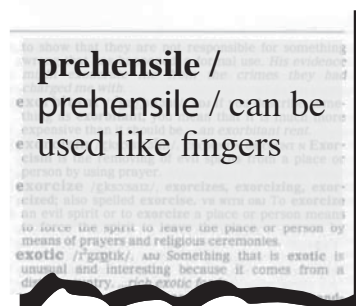
and average of 852kg and females averaging 884kg. They used to be widely distributed in southern Africa, though today only a few thousand scattered black rhinos remain. Habitat requirements of the black rhino include shrubs and young trees up to 4m high with well-developed woodlands for shelter. Water for drinking and wallowing is also very important for black rhinos. Black rhinos are mostly solitary animals, operating mainly during the daytime. Like the white rhino, they have notoriously poor eyesight, but a well developed sense of smell and hearing. Black rhinos are much more aggressive than white rhinos, and attack intruders more readily. Black rhinos mainly browse on grasses, manipulating food into their mouths using their prehensile upper lips.

Diceros bicornis fossils are unknown in the World Heritage Area, though they have been recovered from Makapansgat. They are therefore known in South Africa from 3.0 million years ago until the present.

Hippopotamus *(Hippopotamus amphibius)*

Hippos have large, barrel-shaped bodies, with short, stout legs. Male hippos average about 1500kg, while females are somewhat smaller at 1300kg. They are widely distributed from southern Africa, through equatorial Africa, and into East Africa. The basic habitat requirement of the hippo is a body of standing water in which they can submerge completely. They are primarily nocturnal, ranging over long distances on dry land in search of food. During the day they rest in their pools or bask in the sun. Hippos gather in groups during the day of varying size and composition, usually comprised of females with calves and associated bachelors. They will graze alone or in mother-offspring groups. They are selective grazers, preferring open areas of short green grass. Hippos are one of the most dangerous animals in Africa, accounting for more human deaths than all carnivores combined.

Hippopotamus is known from Swartkrans Members 1-3, as well as Makapansgat, and are therefore present in South Africa from 3.0 million years ago until the present. Hippopotamus fossils are much more common in East Africa, where depositional environments are much more amenable to the collection of remains of these large ungulates.

Suids (pigs)

The evolution of suids in Africa has been intensively studied for several decades. As a group suids tend to evolve at a rapid rate, and thus are very important for biostratigraphic comparisons between the well dated East African fossil deposits and the less securely dates South African ones. It is therefore unfortunate that suids are exceedingly rare in the fossil assemblages in the World Heritage Site. The only exception is the newly opened site of Coopers which has already produced a wealth of fossil suids. The oldest ancestors of the Suidae are to be found in the Oligocene, though the ancestry of the suids found in South Africa is much younger. *Phacochoerus*, the genus of the modern warthog, can be traced back to near the beginning of the Pleistocene, approximately 1.8 million years ago. The other "common" fossil suid in South Africa, *Metridiochoerus*, also has its origins at this same time. Both fossil species are found in Kenya.

Warthog *(Phacochoerus aethiopicus)*

Warthog males average about 100kg in weight, while females are more petite at 70kg. They are widely distributed across Africa, and are typically associated with open grasslands, floodplains, vleis and open areas around waterholes. They will also occupy open scrublands and woodlands. Warthogs prefer to graze on short, fresh grasses, but will also eat sedges, herbs, shrubs and wild fruit. While rooting for food, warthogs kneel on their front legs and use their snouts to dig in the ground. Warthogs are diurnal, hiding out in burrows at night to protect themselves from predators and harsh weather. They are social animals, living in family units called sounders, comprised of an adult male, adult female and her offspring, and usually the group is 5 or less in number.

The genus *Phacochoerus* is known in Members 1-3 of Swartkrans, Kromdraai A and B, Gladysvale and possibly Coopers. Warthogs are therefore known from approximately 1.8 million years ago in South Africa until the present.

Extinct pig *(Metridiochoerus andrewsi)*

Metridiochoerus looked similar to warthogs, except that their tusks were essentially straight, projecting laterally from the sides of the muzzle. It was larger than the warthog, probably weighing in excess of 120kg. Metridiochoerus is known throughout East Africa, highlighting the wide geographic distribution of these pigs. They were most likely grazers, probably living in open, watered areas similar to warthogs.

Metridiochoerus is known from Swartkrans Members 1-3, Kromdraai A and Bolt's Farm in the World Heritage Area. It is also known from Makapansgat at 3.0 million years of age, as well as Elandsfontein at 0.5 million years of age.

Giraffes

The earliest giraffids in Africa are found in the Miocene of Libya. The entire giraffe lineage probably originated in Africa, and then spread into Eurasia. All non-African lineages of giraffe subsequently went extinct, leaving two types surviving in Africa, the giraffes and the okapis. The first member of the genus Giraffa appeared in the late Miocene, while the modern giraffe (Giraffa camelopardalis) appears in the early Pleistocene in East and South Africa. The extinct short-necked giraffe *Sivatherium* first appears in the early Pliocene, but is distinctly separated from its long-necked cousins.
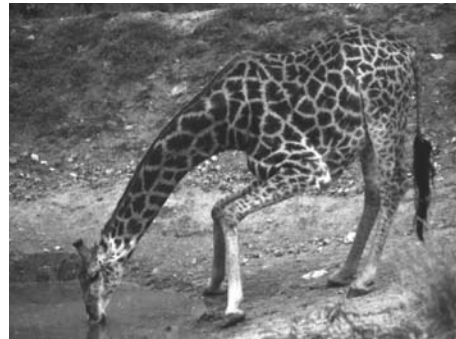
Giraffe *(Giraffa camelopardalis)*

The long neck of the giraffe, along with its enormous size, make this animal one of the most enduring images of Africa. Bull giraffes weigh on average 1200kg, while females are lighter at about 830kg. Giraffes have a moderate distribution in Africa, being found in southern Africa, East Africa, and in various localities of West Africa. They can live in a variety of habitats, ranging from dry savannahs to woodlands, provided their preferred food plants are present. Giraffes usually browse, including a variety of food plants in their diet. They are predominantly diurnal, though they do occasionally move at night. Giraffes are only loosely social, and herds tend to be made up of females and their young, though bachelor herds and mixed herds are sometimes encountered.

Modern long-necked giraffes are not known in the World Heritage Area, though their immediate predecessor, *Giraffa jumae*, is known from Makapansgat at 3.0 million years of age. Giraffa camelopardalis first appears in the late Pleistocene of South Africa, at sites such as Cornelia and Florisbad.

Extinct short-necked giraffe *(Sivatherium maurusium)*

The short-necked giraffe *Sivatherium* is the largest and most massive giraffe that ever existed in Africa, weighing as much as 2000kg. They were widely dispersed, being found throughout

East Africa. *Sivatherium* probably lived in similar habitats as modern giraffes, ranging from savannahs to woodlands. Based on isotopic studies of their fossils, it can be determined that this giraffe was a dedicated browser that may have been more dependent on water than modern giraffes. They may have also fed at a lower level of vegetation than modern giraffes.

Sivatherium maurusium was previously known only in the World Heritage Area from a single deciduous tooth in Member 2 of Swartkrans, though recent examination of the faunal collections has revealed giraffid post-cranial remains in all members of Swartkrans. Elsewhere in Africa, this species is known from Makapansgat and Langebaanweg, as well as the Pleistocene sites of Florisbad, Cornelia and Elandsfontein. This species is present in South Africa from approximately 5.0 million years ago until as recently as 0.4 million years ago.

Bovids

Bovids are typically the most abundant type of animal in the fossil sites of the World Heritage Site, often markedly dominating the assemblages. Their ability to adapt to open country and very arid regions is at least partly responsible for their remarkable success. Bovids are easily separated from cervids (the deer of North American and Europe) because they possess keratin-sheathed horns as opposed to seasonally shed antlers. These horns are always diagnostic criteria by which living and fossil bovids can be readily identified. The earliest bovids in Africa are probably Oligocene in age, but it is difficult to separate them from their ancestral forbears. By the time of Langebaanweg in the Western Cape (5.0 million years ago) species recognisable today had emerged in South Africa. Bovids are particularly important when studying the caves in the World Heritage Area. They are useful for biostratigraphic comparisons when attempting to assess ages of the fossil caves. They provide a great deal of insight into the palaeoenvironment in which the hominins lived. And, they can inform us as to the taphonomic history of the deposits, answering such questions as how the fossils came to end up in the caves, and what types of carnivores may have fed on them. Most of the bovid species found in the fossil caves are still around today, though a number have gone extinct in the past 2.5 million years.

Blue wildebeest *(Connochaetes taurinus)*

The blue wildebeest have humped shoulders and a deep neck, sloping towards more lightly built hindquarters. Males average about 250kg, while females are closer to 180kg. Today they are found in two main, isolated areas, a southern one from Botswana to South Africa, and a northern area from Mozambique to Kenya. Blue wildebeest are associated with arid

environments, including savannah woodlands and open woodlands. Their main requirements are the availability of shade and drinking water. Blue wildebeest are grazers, preferring short green grasses, and particularly fresh sprouting grass. They are gregarious and occur in herds of 20 or 30 individuals into the many thousands. Their social organisation consists of territorial males, female herds and bachelor groups. In East Africa and in Botswana blue wildebeest migrations occur on a massive scale, often involving hundreds of thousands of individuals. These migrations also occur on a smaller scale in South Africa.

Blue wildebeest are quite widespread in the World Heritage Site, being found in Sterkfontein Members 4 and 5, Swartkrans Members 1-3, Kromdraai A and B, Gladysvale, Drimolen, Coopers, Bolt's Farm and Motsetsi. Fossils of blue wildebeest are also commonly found throughout East Africa. Elsewhere in South Africa their fossils are common at sites such as Elandsfontein, Cornelia and Florisbad. The species appears to range from about 2.5 million years ago until the present.

Black wildebeest *(Connochaetes gnou)*

The black wildebeest is smaller than blue wildebeest, with a long white tail almost reaching the ground, as opposed to the shorter black tail of the blue wildebeest. Males weigh approximately 160kg, while females average around 130kg. Black wildebeest are endemic to South Africa, being found no farther north than the 27th parallel. They are adapted to the open plains and grasslands of the Free State, being predominantly grazers. During the winter months they will also supplement their diet with browse from karroid bushes. Similar to blue wildebeest, black wildebeest are gregarious, with a social organisation consisting of territorial males, female herds and bachelor groups. They do not migrate.

Black Wildebeest appeared only recently, and are therefore not found as fossils in the World Heritage Area. Fossils have been recovered from such South African sites as Elandsfontein, Cornelia and Florisbad. As a result, the species appears to have evolved about 0.5 million years ago, surviving until the present.

Red hartebeest *(Alcelaphus buselaphus)*

The red hartebeest have high, humped shoulders, sloping backs and elongated heads with horns pointing backwards. Males have a body weight of about 152kg, while females are closer to 120kg. The red hartebeest is found in an equatorial band just south of the Sahara, and in southern Africa through Namibia, Botswana and South Africa. They are typically found in

open country, including grasslands, vleis, open woodlands and semi-desert bush savannah. Red hartebeest are predominantly grazers, also taking a very small amount of browse. They are gregarious and occur in herds ranging from 20 to 300 individuals depending on the time of year. Males are territorial, controlling harem herds that consist of the male, several females and their offspring, plus some younger bulls.

Red hartebeest appeared very recently, and are therefore not known in the fossil sites of the World Heritage Site. Their fossils are however, known from Elandsfontein, Cornelia and Florisbad in South Africa, and from Kabwe in Zambia. The species probably has a similar time span as the black wildebeest, from 0.5 million years ago until the present.

Giant wildebeest *(Megalotragus priscus)*

The giant wildebeest *Megalotragus* is possessed of enormous, sweeping horns, even fragments of which can be readily recognized. Their body weight has been estimated at 534kg, larger than the blue wildebeest, but not as massive as a bull eland. The genus *Megalotragus* is found throughout South Africa and East Africa, indicating this animal had a wide distribution in the Plio-Pleistocene. The giant wildebeest is closely related to the blue wildebeest, strongly suggesting they occupied a similar habitat, namely open grasslands. They also have very high-crowned teeth, an adaptation seen in all grassland grazers, but not in browsers.

Megalotragus is found in Sterkfontein Member 4, Swartkrans Members 1-3, Kromdraai A, Gladysvale, Drimolen and Coopers. Its fossils have also been recovered from such South African sites as Elandsfontein, Mahemspan, Cornelia, Erfkroon and Florisbad, as well as Makapansgat. In South Africa this species ranges from about 3.0 million years ago until approximately 12 000 to 10 000 years ago when it became extinct.

Blesbok *(Damaliscus dorcas)*

The blesbok has a brown coat with white underbelly, and distinctive horns. Male body weight is approximately 61kg, while females are slightly smaller and lighter. Blesboks are endemic to South Africa, though in the past they ranged all the way into Botswana. They are restricted to grasslands, requiring a nearby water source. They graze predominantly and are partial to sprouting grasses, but will occasionally browse to supplement their diet. They are gregarious diurnal animals, with a social organisation consisting of territorial males, female herds and bachelor groups. They normally stand facing the sun with their heads held low, but will begin to shake their heads up and down when approached.

Blesbok are common the World Heritage Area sites, being found in Sterkfontein Member 5, Swartkrans Members 1-3, Kromdraai A, Gladysvale, Drimolen and Coopers. No blesbok fossils are known from East Africa. Elsewhere in South Africa blesbok are known from Florisbad and Vlakkraal. This species ranges from about 1.5 million years ago until the present in South Africa alone.

Extinct blesbok *(Damaliscus niro)*

Damaliscus niro appears very similar to the modern blesbok except that it is larger and has slightly different horns. A body weight estimate of approximately 120kg can be computed for this animal. This species has been recovered in East Africa and throughout South Africa, making it a widely dispersed animal. Like the modern blesbok, *Damaliscus niro* was almost certainly an open grassland grazer, with a diet of almost exclusively grass. They had high-crowned teeth and deep mandibles, as well as a skeleton adapted for moving on relatively flat, open ground.

Damaliscus niro is found at Sterkfontein Member 5, Swartkrans Member 2 and possibly Gladysvale. They are also known from Olduvai Gorge and Peninj in East Africa, as well as Cornelia, Florisbad and Vlakkraal in South Africa. *Damaliscus niro* ranged in time from about 2.0 million years ago until relatively recently, perhaps about 12 000 years ago when it went extinct.

Extinct ovibovine *(Makapania broomi) 263 kg*

This large, extinct bovid is remarkable in that its horns spread laterally. It has been referred to as an Ovibovine, making its closest living relatives the Muskox of North America and the Takin of Tibet. Its estimated body weight is approximately 263kg. Makapania has been tentatively identified in East Africa; therefore this species may have a wide distribution. It probably had a rather 'catholic diet', eating both browse and graze. It probably preferred grasses, and would have required a nearby source of permanent water.

Makapania broomi has been found at Sterkfontein Members 4 and 5, Swartkrans Members 1-3, Gladysvale and possibly Coopers. It has been recovered from 3.0 million year old sediments in East Africa, and the type specimen was found at Makapansgat. Therefore this species existed from about 3.0 million years ago until 1.0 million years ago, or perhaps more recently.

Springbok *(Antidorcas marsupialis)*

The springbuck are a sleek, trim looking animal, bright brown on top, white on bottom with a black stripe down the side. Males weigh around 31kg while females average 27kg in South Africa, while males in Botswana are 41kg and females 37kg. They are restricted exclusively to these two countries. Springbuck are adapted to arid conditions living in open grasslands and desert scrublands. They are mixed feeders, eating sprouting green grasses and herbs in the summer months and browsing on shrubs and trees in the winter months. Springbok are gregarious, living in small herds that in the past occasionally coalesced into vast herds of hundreds of thousands of animals. Males are territorial, while female herds generally wander in and out of male territories as they see fit. When suddenly alarmed springbuck will "pronk", leaping up to 2m in the air with the legs held stiffly downwards, repeating the move several times, possibly signalling danger to other members of the herd.

Springbok fossils are found at Swartkrans Members 1-3, Gladysvale, Coopers and possibly Sterkfontein Member 5. Elsewhere in South Africa, springbok fossils are known from Elandsfontein and Swartklip. This species probably first appeared around 1.5 million years ago, and continues to the present in southern Africa.

Extinct springbok *(Antidorcas bondi)*

The extinct springok, *Antidorcas bondi*, is somewhat smaller than the modern springbuck, weighing on average about 25kg. This species is unknown in East Africa, though some fossils have been recovered from Chelmerspruit, Zimbabwe as well as Vlakkraal and Florisbad in South Africa. Antidorcas bondi is referred to as hyper-hypsodont, meaning that it has extremely high-crowned teeth. Its teeth are so high-crowned that the lower edge of its mandible is seriously distorted to fit the teeth. Such teeth are typically found in dedicated grazers, as they resist wearing better than low-crowned teeth. Isotopic evidence also suggests that the diet of *Antidorcas bondi* was that of an exclusive grazer. It is possible that this small springbok followed larger antelope as they grazed, feeding on the new growth that sprouted up after the larger herbivores had moved through an area.

Antidorcas bondi has been recovered from Sterkfontein Member 4, Swartkrans Members 1-3, Kromdraai A and B, Gladysvale, Coopers and possibly Drimolen. Apart from being found at Vlakkraal and Florisbad, Antidorcas bondi is known from the LSA layers at Border Cave.

This species therefore extends in South Africa from 2.5 million years ago until about 36 000 years ago when it finally became extinct.

Impala *(Aepyceros melampus)*

The impala is considered one of the most graceful antelopes in Africa, with a shiny, reddish-brown coat and long, slender legs. They are distributed widely across southern and eastern Africa, though they are not found north of Kenya. Impala are consistently associated with woodlands, particularly acacia and mopane. Cover and surface water are necessities. Impala are mixed feeders, including both browse and graze in their diet depending on their locality and the time of the year. They are gregarious, typically grouping

rutting / rutting / competition for dominance by males

together into small herds of 6 to 20 individuals normally, but forming themselves into groups of 50 to 100 in the rainy season and early cold season. Males are territorial during the **rutting** season, otherwise they group into female and bachelor herds. Territorial males will vigorously defend female herds during the rut, sometimes resorting to head-pushing with interlocked horns.

Impala have never been convincingly demonstrated to exist in the World Heritage Area fossil sites. Impala are known from East Africa from about 2.5 million years ago, while impala fossils have been identified at Makapansgat, thereby extending the time range of this species from 3.0 million years ago until the present.

Klipspringer *(Oreotragus oreotragus) 12kg*

Klipspringers are small antelope with distinctive stiff, bristly hair which act as a cushion against bumps as it moves around its rocky environment. Males tend to be smaller than females, the former weighing about 11kg, while the latter averages around 13kg. They are extensively distributed in southern and East Africa. Klipspringers are specifically evolved to occupy rocky habitats, requiring krantzes or koppies. They are predominantly browsers, eating mostly leaves, berries, fruit, seed pods and flowers. Klipspringers are most commonly found in mated pairs, as solitary individuals, or in small family groups including offspring. They walk on the very tips of their toes, hopping from rock to rock with tremendous agility. Klipspringers do not aggressively defend its territory from others and most confrontations are resolved without violence.

Klipspringer fossils are known from Swartkrans Members 1-3, Gladysvale, Drimolen and Gondolin. While klipspringers are not known as fossils in East Africa, they have been recovered from Makapansgat. Thus this species can be traced from 3.0 million years ago until the present.

Cape buffalo *(Syncerus caffer)*

Buffalo are extremely stocky, heavily built animals, and in old males the horns can grow to truly massive proportions. Males weigh on average near 700kg, while females are somewhat smaller at 580kg. Buffalo are widespread across southern Africa, East Africa and equatorial Africa. They require a plentiful supply of grass, shade and water. They typically occupy woodlands, and avoid open grasslands or floodplains. Buffalo are grazers, preferring freshly sprouted grass, though they will just as readily feed on old grass. They are gregarious, occurring in relatively stable herds of up to several thousand individuals. Bulls maintain a strict hierarchy in the herd, and older individuals may be expelled. These old bulls are particularly vulnerable to lions. Buffalo are probably the most dangerous bovid in Africa. Their large horns can stop bullets, and wounded bulls have been known to circle hunters and attack from behind with great persistence.

Buffalo are known from Swartkrans Members 1-3, Kromdraai A and Gladysvale. They are also known from East Africa, as early as 1.5 million years ago. Buffalo probably first appeared about 1.5 million years ago, and continue to be found throughout Africa to the present.

Extinct giant buffalo *(Pelorovis antiquus)*

The giant buffalo was considerably larger than the modern buffalo, with enormous horns stretching as much as 3m. Their body size may have exceeded 1000kg. The genus *Pelorovis* is found throughout both East Africa and South Africa, though distinct species are known in the respective areas. The large size of the horns would make movement in closed environments difficult, so it is most probable the giant buffalo preferred more open areas. Their extremely high-crowned teeth support a diet rich in grasses. Like modern buffalos, they probably were dedicated grazers, and dependent on water.

Giant buffalo are found in Swartkrans Members 1 and 2, as well as Gladysvale. Elsewhere in South Africa they are known from Elandsfontein, Cornelia and Florisbad. They first appear in South Africa at Swartkrans about 1.5 million years ago, and survived until about 10 000 years ago when they at last became extinct.

Eland *(Taurotragus oryx)*

Eland are the largest African antelope, with a brown coat and straight, spiral horns. Bull elands weigh an average of 600kg and females 400kg. Eland are widely distributed in southern and East Africa south of Uganda and Kenya. They are quite versatile in habitat requirements, being equally at home in semi-desert scrublands and montane grasslands. Eland graze in summer and browse in winter. They can subsist in arid environments only if there is a sufficient quantity of succulent forage to replace permanent water sources. Elands are gregarious and usually occur in small herds though they sometimes congregate into groups as large as 700 individuals. During the calving season females join together with yearlings and sub-adults in nursery herds, while the males associate together in independent herds.

Eland are known from Sterkfontein Member 5, Swartkrans Members 2 and 3, Kromdraai A, Gladysvale and probably Coopers. Fossils of a closely related species of Taurotragus are known in East Africa about 1.5 million years ago. Elsewhere in South Africa the eland is known from Elandsfontein. This species is therefore known in South Africa from about 1.5 million years ago until the present.

Kudu *(Tragelaphus strepsiceros)*

The kudu is one of the most magnificent antelope in Africa, with its remarkable spiral horns and distinct white stripes on its face and sides. Male Kudu are about 230kg on average, and females around 160kg. Kudu are widely distributed throughout southern and East Africa in spite of heavy hunting pressure. They area savannah woodland species, avoiding desert, forest or open grassland areas. They are partial to areas of broken, rocky terrain with woodland cover and a nearby source of water. Kudu are mainly browsers, though they may take fresh grass. They eat a wide variety of plants, preferring leaves and shoots but also taking seed pods. Kudu are gregarious, though herds rarely number more than 12 individuals, usually being closer to 4 or 5 individuals. They are mostly diurnal, but can adapt to nocturnal activity in disturbed areas (e.g. farming areas).

Kudu fossils are known from Sterkfontein Member 4, Swartkrans Members 1-3, Kromdraai A, Gladysvale and possibly Drimolen. They are also known in East Africa approximately 2.5 million years ago. The kudu can be traced from about 2.5 million years ago to the present in Africa.

Bushbuck *(Tragelaphus scriptus)*

Bushbuck are the smallest of the spiral-horned antelope, distinguished by their white stripes and spots. They weigh just under 50kg, with females slightly smaller than males. Bushbuck are widely dispersed across southern Africa, East Africa and Equatorial Africa. They are closely associated with riverine underbrush next to permanent water supplies. Bushbuck are browsers, though they occasionally eat small quantities of grass. They are typically solitary animals, though they are sometimes seen in groups of 2 or 3 individuals. Bushbuck normally lie up in the daytime, feeding at night or twilight. They have excellent senses of sight, hearing and smell, and are extremely shy of humans. These factors allow them to live close to human developments in spite of hunting pressure.

Bushbuck are known from Swartkrans Member 2 and Kromdraai A. They are known in East Africa from sites almost 3.5 million years of age, yet in South Africa they can only be traced back to about 1.5 million years.

Sable *(Hippotragus niger)*

Sable have a black, satiny coat with a pure white underside and long, backwardly curved horns. Males weigh approximately 235kg on average, and females are about 220kg. Sable are restricted to southern Africa, though they do extend north as far as Kenya on the east coast of Africa. They are a savannah woodland species that require cover and available water. They prefer open woodlands adjacent to grasslands with medium to high grass. They are mainly grazers, though they are known to browse to a small extent. Sable are gregarious and occur in herds of 20 to 30 individuals, but do occasionally band together in groups of up to 200 animals. Their social organisation consists of territorial bulls, nursery herds and bachelor groups. One or more females tend to dominate and lead the herd.

Sable are known from Swartkrans Members 1-3, Kromdraai A, and possibly from Sterkfontein Members 4 and 5. No sable fossils have been recovered in East Africa. Sable are therefore known from at least 1.5 million years ago in South Africa, and perhaps as much as 2.5 million years ago.

Gemsbok *(Oryx gazella)*

Gemsbok are grey with a white underside and dark brown stripes on their sides, back and face, and with elongated almost straight horns. Body weight in males averages 176kg, and near 162kg in females. Gemsbok are found in two widely spaced areas, the western half of southern Africa and around the Horn of Africa. They are well adapted to open, arid areas, preferring open grasslands, savannah bushlands or light open woodlands. They are predominantly grazers, able to digest fibrous roughage, though they do switch to browse when transplanted out of their typical habitats. Gemsbok are gregarious and can be found in herds of up to 300 individuals. They occur in mixed herds, nursery herds and solitary males. Gemsbok are not indigenous to the World Heritage Site, having been brought into the area by humans.

Gemsbok fossils have never been recovered in the World Heritage Area sites, most probably since their preferred environment did not exist in the area during the Plio-Pleistocene. Scanty remains of the genus *Oryx* have been recovered from Olduvai Gorge from about 1.5 million years ago, otherwise the remains of Gemsbok are unknown elsewhere in Africa.

Waterbuck *(Kobus ellipsiprymnus)*

Waterbuck have long horns that are swept back and upwards, and have thick brown hair and a broad white ring encircling the rump. Males weigh in the neighbourhood of 236kg, and females about 186kg. They are found distributed along the eastern coast of southern Africa and East Africa. They are intimately associated with water, always being within a couple of kilometres of water at any given time. They are roughage feeders, grazing on a limited number of grasses and occasionally including a small amount of browse in the diet. Waterbuck are gregarious, usually occurring in herds of 6 to 12 individuals, but sometimes as many as 30 animals. They form into groupings of territorial males, nursery herds and bachelor herds.

Waterbuck fossils are rare in the World Heritage Area sites, occurring only in Members 1 and 2 of Swartkrans. They are also known in East Africa from about 2.0 million years onward, though in South Africa they occur from 1.5 million years to the present.

Mountain reedbuck *(Redunca fulvorufula)*

Mountain reedbuck are greyish in colour with a white underside and short, upturned horns. Males average about 30kg in weight, while females are around 29kg. Mountain reedbuck distribution is patchy as a result of their specialised habitat requirements. They tend to occupy grass-covered stony slopes of hills and mountains with tree or bush cover. They graze a very coarse, low quality diet of specially selected grasses that vary with season. Mountain reedbuck are gregarious, and live in small groups of 3 to 8 individuals, and occasionally up to 40 individuals in certain seasons. Socially they are organised in to groups of territorial males, non-territorial males, herds of females with young and bachelor herds.

Mountain reedbuck are not known in the fossil deposits of the World Heritage Area, nor have they been recovered in East Africa. This probably stems from the fact that their preferred habitats are not conducive to fossilization. The ancestry and time range of this species is uncertain.

Extinct reedbuck *(Redunca darti)*

The extinct reedbuck is slightly larger than the mountain reedbok, weighing approximately 53kg. The horns of this species were positioned differently to those of the mountain reedbuck, which are more upright. The species is endemic to South Africa, although a horn core from East Africa may belong to this species. The diet of *Redunca darti* was probably comprised of fresh grasses, similar to, though not as specialised as, the modern reedbuck. They were probably also quite dependent on water.

Redunca darti is known only from Gladysvale in the World Heritage Site, although it has been tentatively identified at Coopers. Elsewhere in South Africa it is known from Makapansgat, thus it ranges in time from 3.0 million years until at least 2.0 million years and perhaps younger.

Large Rodents

Several species of large rodent that qualify as large-bodied mammals occur in the World Heritage Site. A large-bodied mammal generally weighs more than 1kg. The distinction between large-bodied and small-bodied mammals is important in terms of the collecting agents of fossil material in the area. Small-bodied mammals in the fossil caves were most

likely brought into the caves by the actions of animals such as owls. Large-bodied mammals, on the other hand, probably entered the caves either of their own choice or via a large mammalian carnivore.

Springhare *(Pedetes capensis)*

The springhare is a rodent rather than an actual hare, resembling a miniature kangaroo more than anything else. Springhares weigh on average about 3 kg, with females slightly smaller than males. They are distributed throughout southern Africa. Their most important habitat requirement is a compacted sandy soil in which they can dig their burrows. They are generally associated with open, grassy areas, avoiding areas with heavy cover. Springhares are grazers, subsisting almost entirely on grass. They are nocturnal, and are very wary when out of their burrows. They have reason to be, as they are preyed upon by a wide variety of predators.

Springhares are known from Swartkrans Members 1-3, and may be present in other World Heritage Area sites as well. The genus *Pedetes* is therefore at least 1.5 million years old.

Porcupine *(Hystrix africaeaustralis)*

The modern porcupine is easily distinguished by its covering of sharp quills. They average about 12kg in weight, with females slightly larger than males. Porcupines are widely distributed across all of southern Africa, and have a wide habitat tolerance, existing in a variety of vegetational regimes. They display a marked preference for broken country with rocky hills and outcrops. Porcupines are adapted to digest a variety of foods, though they are predominantly vegetarian. Their food includes bulbs, tubers and roots that they dig up. Porcupines live in extended family groups, comprised of a male, female and successive generations of offspring still living at home.

Porcupines are found at Sterkfontein Members 4 and 5, Swartkrans Members 1-3, Kromdraai A, Gladysvale and Coopers. They have also been recovered from Makapansgat. The species can be traced from 3.0 million years ago until today.

Extinct porcupine *(Hystrix makapanensis)*

The extinct porcupine is about one third larger than the modern porcupine, weighing about 16kg. *Hystrix makapanensis* probably had a diet similar to the modern porcupine, but may have eaten more grasses. They probably had a similar wide habitat tolerance.
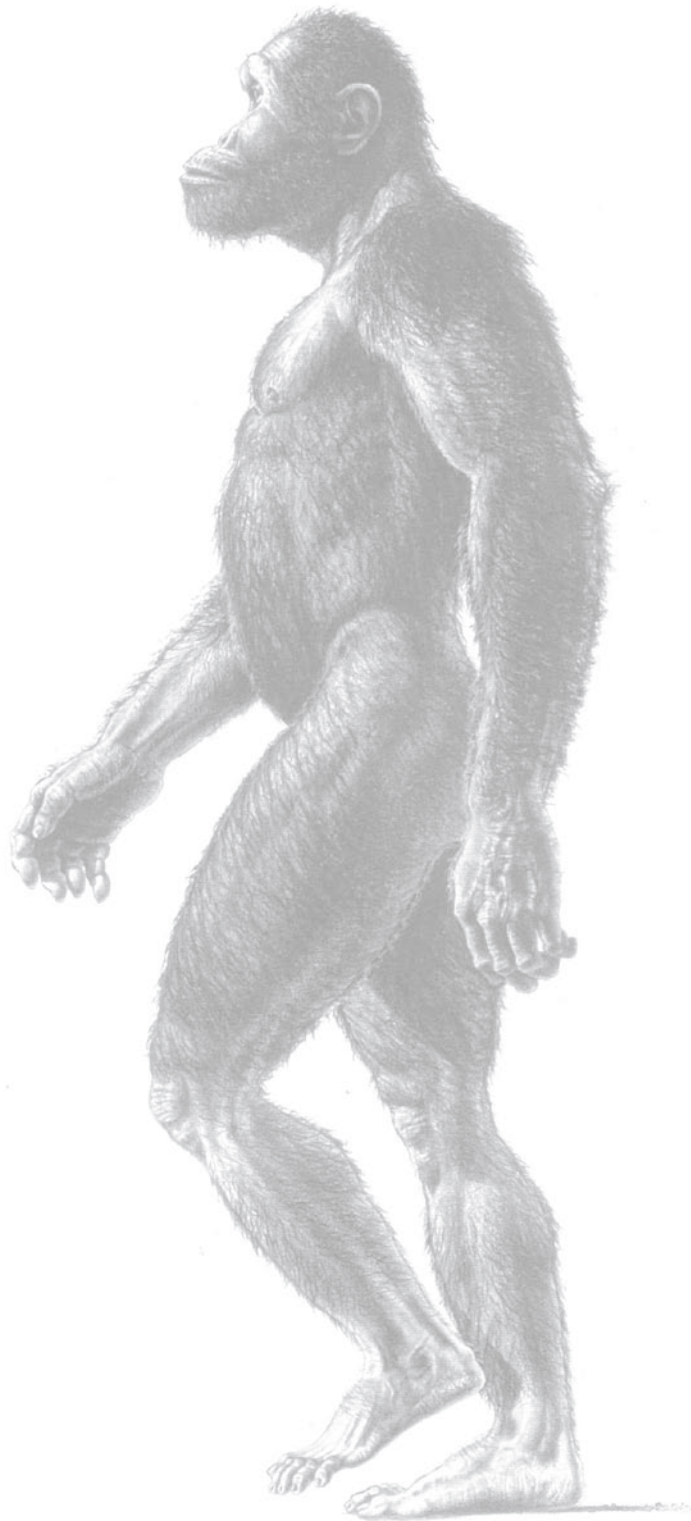
Hystrix makapanensis has been found in Swartkrans Member 1 and Kromdraai A, as well as from Makapansgat. The species is clearly present from 3.0 million years ago until at least 1.5 million years ago, if not more recent.

Notes

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