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Palaeoenvironments of the Middle Stone Age at Sibudu Cave, KwaZulu-Natal, South Africa: An analysis of archaeological charcoal

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CHAPTER 1. INTRODUCTION

1.1. Introduction

Charcoal is one of the most commonly recovered materials from archaeological sites. It is, however, seldom studied as a routine part of post-excavation analyses. Charcoal analysis (anthracology) is a research field that requires specialised knowledge of wood anatomy, plant ecology and archaeology, thus permitting interpretation of the charcoal assemblage.

Charred plant remains, and more specifically charred wood, are influenced by cultural selection and also by the environmental conditions from which the plants are derived. Charcoal can therefore be used to examine uses of wood at an archaeological site as well as the vegetation environments in which the site occupants lived. Evidence for changes in palaeoclimate can be inferred from the charcoal assemblage and this analytical approach forms the focus of the current study.

1.2. Aims

Primary aims of this study are:

To establish whether the charcoal from Sibudu Cave can be used to infer palaeoclimatic conditions during the Middle Stone Age occupation.

To reconstruct the vegetation types which were in existence around Sibudu Cave in the Last Glacial.

To infer palaeoclimatic conditions and changes in climatic conditions using the charcoal data.

To compare and contrast the evidence for changes in palaeoclimate with evidence from other proxies at Sibudu Cave and proxies from other sites with palaeoenvironmental records in South Africa.

To establish whether the climatic conditions at Sibudu Cave were the result of global changes in climate or whether the data show evidence for localised vegetation and climate change.

These primary aims are broad and several intermediate steps are necessary for these aims to be achieved. It is necessary to develop the existing modern wood comparative collection to include taxa that are found in the Sibudu Cave region and also from neighbouring regions. Each taxon has a unique set of anatomical characters that can be likened to a fingerprint. These anatomical features are compared to features recorded in the modern reference material and in doing so it is possible to identify the specimens. As the research focus is based on establishing evidence for changes in vegetation and climate, it is imperative that the reference collection includes a wide range of taxa from different vegetation communities. Developing the reference collection will facilitate charcoal identification in this study and the collection will provide a resource for future research projects undertaken at Sibudu Cave and other sites.

Using charcoal as either an indicator of culturally influenced activities or as an indicator of palaeoenvironments requires several assumptions to be made. The statements made below will be tested as hypotheses. Assumptions surrounding these hypotheses and ways of recognising patterns in the data are proposed here and elaborated on in later Chapters of the thesis.

Wood was selected and brought to the site primarily for use in fires.

If this hypothesis is true the assemblage is likely to be biased towards good fuel wood types. Information in the literature on the cultural uses of wood will be drawn upon for the identified taxa to establish whether good fuelwood has been collected in

preference to poor fuelwood. Evidence for activities undertaken at the site that may have required wood will also be documented. It is necessary to assess the impact of cultural selection upon the assemblage to help establish the degree to which the charcoal data can be used as an environmental indicator.

Taxa in the assemblage will be indicative of the vegetation environment around the cave during the MSA occupations.

For this hypothesis to be true, wood selection must not over-shadow the evidence for the palaeovegetation. An assemblage with low taxon diversity or an assemblage that does not contain many indicator species, may restrict the palaeoenvironmental interpretation. It also implies that the wood was acquired from vegetation habitats in the immediate surrounds of the cave. It is possible that wood may have been brought to Sibudu Cave from several vegetation habitats, however, it must be assumed that the majority of taxa were collected from the immediate cave surrounds. Circumstances in which taxa would be collected from more distant sources include harsh climatic environments, over-exploitation of the resources around the cave that may have led to a reduction in the available wood resources, or the requirement of a special type of wood not present in the cave region. It is shown in Chapter 2 that palaeoenvironmental data from sites in southern Africa do not indicate that climates were ever harsh enough during the Last Glacial to produce such marginal vegetation environments. It is harder to prove that over-exploitation was a problem in the MSA, however, the fairly low density of people (when compared with the Holocene) does not support this suggestion. Woody taxa that are anomalous, either environmentally or culturally, will be treated with caution

Changes in the charcoal assemblage will provide evidence for environmental and climatic changes.

It may be possible to infer climatic changes from the charcoal data, however, the degree to which this will be possible will rely upon the assemblage composition. Charcoal analyses make use of data on the modern distributions, habitats and

environmental requirements of the plants. This approach assumes that plant requirements have changed little through time and that the associations of plants with each other in the past were similar to their modern associations. As with most other palaeoenvironmental studies it is necessary to assume that modern scenarios can be applied and are relevant to the past. Some plants are heterogeneous, occurring in a range of habitats and adapting to different climatic conditions. Other taxa are habitat or niche specific, and it is these that will be most valuable for reconstructing an image of the past vegetation. In this thesis niche specific plants are referred to as indicator species or taxa. The modern data are then projected onto the archaeological data to construct an impression of both the vegetation and the likely climatic conditions in which the identified taxa could have grown. Modern data can be used for combinations of taxa as well as for an individual taxon. The merits of this type of approach are critically assessed in Chapters 4 and 5.

Several studies of archaeologically recovered charcoal have been undertaken in South Africa. Most of these have focussed on assemblages from Later Stone Age (LSA) contexts. This is because preservation of charred remains from LSA sites tends to be good and the resolution of dates for the associated deposits has, until recently, been better than in older archaeological site contexts. Two exceptions to this study focus are Scholtz's (1986) and Esterhuysen's (Harper 1994) exploratory studies of Middle Stone Age charcoals from Boomplaas Cave and Rose Cottage Cave respectively. In recent years dating methods for deposits older than 40 000 years ago have improved dramatically in terms of their resolution and also the types of materials that can be dated. These developments have enabled re-dating and the reassessment of sequences that had previously been difficult to correlate with one another.

A common feature of charcoal studies in South Africa is the use of combinations of palaeoenvironmental proxy data to which the charcoal sequences have been compared. Most palaeoenvironmental proxies provide a biased view of palaeovegetation, fauna, or climatic conditions and this is particularly true of

archaeologically derived proxies. To overcome this, combinations of data have been drawn on by past researchers in order to provide the most comprehensive image of the palaeoenvironment as possible. This type of approach will also be used for this study.

The charcoal analysis forms a small part of a larger research project being undertaken at Sibudu Cave. As a whole, the research objective is to understand the environmental constraints (if any) in which the Sibudu Cave occupants lived. It will be possible in the future to correlate cultural and palaeoenvironmental sequences from the site to establish whether environments influenced the behaviour of the site occupants. Environmental determinism as a theory for driving cultural adaptations has been very much out of favour. In southern Africa there is very little basis for suggesting that changes in stone tool technologies were coincident with climatic changes. It remains a possibility, however, that changes in vegetation and the resultant migrations of fauna may have influenced the activities undertaken, the locations of people and the plant and food resources available. Evidence for changes in behaviour need not be present in stone tool technologies but rather in the composition of archaeological charcoal assemblages, ephemeral structures (such as hearths), or faunal assemblages. By gaining a clearer knowledge of regional palaeoenvironmental records through studies such as this, and by combining or comparing the results of these studies to produce an image of broader scale environmental changes it will be possible to assess the effects of climate change upon MSA populations. This study is intended to fill a gap, both spatially and temporally, in the palaeoenvironmental record for the Last Glacial in southern Africa and thus contributes region specific data to the available records for southern Africa.

1.3. Chapter Summary

The chapters of this thesis can be divided into several broad topics including; background information and literature, methodologies, and analysis. Although these have been separated using chapters there is some overlap, particularly in the placement of information summarised from existing literature.

In Chapters 2 and 3 data are given on palaeoclimatic conditions during the Last Glacial. Chapter 2 includes a literature review of palaeoenvironmental data derived using proxies from palaeoecological and archaeological sites in South Africa. Common threads of information are highlighted to produce a summary of palaeoenvironmental conditions in the summer and winter rainfall regions of South Africa. Palaeoenvironmental data from Sibudu Cave are presented in Chapter 3. This chapter also includes information on the study site, its location, geology, stratigraphy, archaeology and the absolute dates that are currently available for the MSA deposits.

In Chapters 4 and 5 I examine the methods used for charcoal identification and analysis. Chapter 4 contains a literature review of commonly used methodological approaches and this data is presented as a theoretical discussion. Methods of identification and analysis that are employed in this study are presented separately in Chapter 5.

In this thesis two different analytical approaches are used, the results of which are presented in Chapters 6 and 7. In Chapter 6, descriptive, qualitative analyses are used, while in Chapter 7 the results of statistical and other quantitative analyses are presented. Similarities and differences noted using the two approaches are summarised at the end of Chapter 7.

The main discussion of the results is given in Chapter 8. In this discussion the charcoal analysis results are compared to data from other palaeoenvironmental proxies from Sibudu Cave and to data obtained from other sites in South Africa. A discussion of the evidence for differing climatic conditions between Oxygen Isotope Stages (OIS) 3 and 4 is also presented. Similarities and differences that are evident from a range of environmental proxies studied both at Sibudu Cave and other sites in South Africa are discussed.

In Chapter 9, conclusions reached during this project are presented and palaeoclimatic conditions that are evident through the charcoal analysis are summarised. Assumptions that were presented above (pp 2 to 5 this Chapter) are returned to and the accuracy and value of these assumptions are discussed. Queries arising from the project and directions for future research are suggested. The suggestions are specific to this project and to the future of charcoal analysis in southern Africa.

CHAPTER 2. EVIDENCE FOR PALAEOENVIRONMENTS IN SOUTHERN AFRICA DURING THE LAST GLACIAL

2.1. Introduction

Many environmental reconstructions in southern Africa have focussed upon the Late Quaternary, including the Last Glacial Maximum (LGM) at about 18 000 years ago and the Holocene from 10 000 years ago to present. There are, however, scattered environmental records for the preceding period encompassing OIS 4 and 3 between 70 000 and 18 000 years ago. Evidence from these studies is reviewed and synthesised here to provide an overview of some of the global environmental changes that occurred during this period and to examine shifts in climate and vegetation in southern Africa. Evidence has been drawn together from a range of contexts, including archaeological sites in the region.

Palaeoenvironmental reconstructions for the MSA have, in the past, been constrained by a lack of secure absolute dates for deposits close to, and older than, the limit of ^{14}C dating techniques, that is, about 40 000 years ago (Aitken 1997). Hiatuses occurring in archaeological deposit sequences (Grün & Beaumont 2001), variable sedimentation rates over time, and episodes of sediment erosion (Deacon & Geleijnse 1988; Goldberg 2000), have exaggerated uncertainties concerning the duration of the MSA. Projecting older dates on the basis of sediment accumulation rates can be problematic. Consequently, other methods, such as comparing proxy environmental records from archaeological deposits with known climatic time frames (such as oxygen isotope records) are used. Many of these studies become circular (Thackeray A. 1992) because the patterns observed in the proxy data are used to infer the age of the deposits; for example by comparing patterns such as temperature indices to

changes observed and documented in oxygen isotope records from deep sea and terrestrial sediment cores. Parkington (1990) discusses some of the problems associated with fitting data to the isotope chronology. This type of approach must be used cautiously, particularly when dates are not secure.

Interglacial and glacial periods, observed globally through deep sea and ice core records, affect terrestrial parts of the world in many ways. The extent of their influence may be reliant upon proximity of the study region to the coast, its latitude and/or altitude, and more localised climatic conditions such as the summer and winter rainfall phenomenon which is currently evident in southern Africa. It would therefore be misleading to assume that the effects of increased or decreased continental ice volumes are visible to the same degree in all terrestrial regions. Studies incorporating data from a range of sites, as well as a range of proxies, will assist in highlighting the differing effects of global climatic shifts upon vegetation biomes, faunal distributions, temperature, precipitation, and seasonality of both temperature and precipitation.

This chapter examines the evidence for changes in climate and vegetation between the Last Interglacial at ca. 125 000 years ago and the end of OIS 3. The wealth of data available for the LGM is not discussed in great detail here because deposits from this period have not yet been discovered at Sibudu Cave. Marine and terrestrial oxygen isotope records, the evidence for palaeoshorelines, and the effects of changes in continental ice volumes and therefore shoreline, are discussed in relation to their influence upon vegetation and climate. Research carried out on environmental proxies from palaeoecological and archaeological sites within South Africa is reviewed. There is great diversity in the types of environmental proxies from these contexts. Equally, there is diversity in the approaches to data analysis.

2.2. Global Environmental changes between the Last Interglacial and the Last Glacial Maximum

Fluctuations in shoreline are caused by a complex set of processes, many of which are determined by glacial and interglacial cycles of global climate change. These changes in sea level are directly related to the differing quantities of water locked up in continental ice masses during glacial and interglacial cycles. The oxygen isotope composition of the oceans, which is recorded as the ratio of ^{16}O to ^{18}O, fluctuates as a result of global changes in climate. As continental ice volumes increase during glacial periods, more of the lighter isotope ^{16}O is incorporated into the ice than the heavier isotope ^{18}O (Lowe & Walker 1997: 150). The reverse is true of the oxygen isotope composition of the oceans. Thus, during these glacial periods the ocean becomes enriched in ^{18}O and relatively depleted of ^{16}O. The ocean was isotopically heavier during glacials (Williams *et al*. 1998). As continental ice masses melt in interglacial cycles, water enriched in ^{16}O is returned to the sea and the isotopic composition of the oceans becomes relatively less enriched in ^{18}O than it is during the glacial phases (Lowe & Walker 1997). Although this is the basic premise behind the study of oxygen isotope ratios, the relationship is somewhat more complicated. For this study it is only necessary to discuss oxygen isotope ratios as palaeoenvironmental indicators.

During their formation process, carbonate structures of marine organisms such as foraminifera trap the isotopic ratio that is present in the surrounding ocean (Lowe & Walker 1997). Fossilised planktonic foraminifera from deep-sea sediment cores provide one of the best records for changes in oxygen isotope composition and thus change in ice-mass through time (Williams *et al.* 1998). Foraminifera are also important indicators of sea surface temperature because they are temperature sensitive in that changes in the distribution of taxa on a global scale are related to fluctuations in sea surface temperature (Williams *et al.* 1998).

Emilliani (1955) noted that oxygen isotope records could be used to produce temperature records. Subsequently, Shackleton (1967) made the observation that changes in isotopic composition of oceans through time were also directly related to global ice volume and changes in sea level. As a result of these initial observations, the oxygen isotope records from Core V28-238 were used to produce a curve for sea level changes for the last 130 000 years (Shackleton & Opdyke 1973). The sea level curve provided by Shackleton & Opdyke (1973) is referred to as a "glacio-eustatic sea level curve" because it records changes in ice sheet volume (Lowe & Walker 1997). Landmasses are known to respond isostatically to significant and extended changes in sea level, or continental ice loading. Therefore, although changes in sea level occur on a global scale, the eustatic reaction, and in particular the response time of landmasses in different parts of the world, varies.

At the height of the Last Interglacial at ca. 125 000 years ago there was a marine transgression and sea level was probably ca. 6m (Broecker *et al.* 1968) above its current level. Two subsequent peaks in sea level at 100 000 and 80 000 years ago are also evident from studies in Barbados (Broecker *et al.* 1968); however, these high sea level stands were not as high as those at the height of the Last Interglacial, or as high as the present sea level. During the ensuing glacial (ca. 75 000 – 13 000 years ago) encompassing OIS 4, 3 and 2 (Shackleton & Opdyke 1973), sea levels dropped again. In some regions there was a significant lowering of sea level, coincident with the cold stadial of OIS 4, to about 80m below present (Shackleton & Opdyke 1973). In the following interstadial, OIS 3, sea level rose again to about 50 m below the present level. This is evident from coral reef formations in New Guinea (Veeh & Chappell 1970). During the LGM, in OIS 2, sea levels dropped to ca. 120 m below modern shorelines (Shackleton & Opdyke 1973).

Core RC17-69 (Bé & Duplessy 1976), in the Western Indian ocean, provides an oxygen isotope record, a documentation of changes in planktonic foraminifera assemblages, and an indication of the location of the Sub-tropical Convergence (STC)

zone over the last 500 000 years (Prell & Hutson 1979; Prell *et al.* 1979). The STC zone is an oceanic boundary marked by characteristic temperature and salinity where the sub-tropical and sub-polar waters converge (Prell *et al.* 1979). This boundary can also be recognised by the planktonic foraminifera assemblage (Prell *et al*. 1979). It has been noted that the STC zone is characterised by equal proportions of sub-polar and sub-tropical foraminifera assemblages. Thus, shifts in this boundary during the Quaternary would imply an expansion or contraction of polar waters associated with glacial and interglacial periods. Bé & Duplessy (1976) initially suggested that the STC zone moved to approximately 31ºS (a shift of ca. 9º latitude) during glaciations occurring in the last 500 000 years. Studies of planktonic foraminifera assemblages from the core do not provide evidence for this major northward shift and suggest instead that any movement of the STC zone during the Quaternary was minimal (Prell *et al.* 1979). At the height of the last glacial the STC zone was displaced less than 5º to the north of its current position, between 38º - 40ºS, by an expansion of polar waters (Prell *et al*. 1979). Shifts southwards during the interglacials were more marked than northward displacements associated with the glacials (Prell *et al.* 1979).

The oxygen isotope record from the core mirrors other oxygen isotope records and indicates two phases with ^{18}O enrichment. These have been interpreted as colder periods (OIS 4 and 2) of the Last Glacial. Prell & Hutson (1979) record a warmer period between these cold phases that can be interpreted as the slightly warmer stadial (OIS 3) within the Last Glacial.

2.3. Local Palaeoenvironmental evidence

Evidence for change in sea level along the South African shoreline has been recorded both on and offshore. There is evidence for a high sea stand in the form of a marine mollusc assemblage from Lake Nhlange (Cooper 1990). The evidence for low sea level stands during glacial periods is mainly preserved offshore in the currently

submerged topography (Cooper 1990). Ramsay (1996) has documented a series of four beachrock formations off the East Coast of South Africa. These provide evidence for the position of ancient shorelines between the Last Interglacial and the LGM. River channels also preserve evidence for changes in sea level. In KwaZulu-Natal, for example, there is evidence of both marine regressions and transgressions in the major river channels and palaeochannels flowing into the Indian Ocean (Orme 1976; Cooper 1990; Maud 2000). Sediment cores containing pollen (Oschadleus *et al*. 1996) indicate shifts in vegetation though time, which may be related to changes in sea level. I discuss the results and interpretations from these and other studies to develop an image of the climatic changes that occurred between 125 000 and 18 000 years ago.

2.3.1. Local Sea Levels

An approximate coastline has been reconstructed (Fig. 2.1) by projecting a predicted LGM sea level onto a bathymetric map (Zhiv 1975). This reconstruction shows that the profile of the East Coast of South Africa would have altered a little (see Fig. 2.1) during the glacial. Many sea-level curves suggest that the LGM sea level was 120 m below the modern shoreline and therefore this measure has been used for the reconstruction. Offshore topography of the Tugela Canyon (Zhiv 1975) (Fig. 2.1) to the south of Durban and at Durban itself is significantly steeper than it is further north towards the mouth of the Tongati River. Further north again, at Richards Bay the topography becomes steeper close to the coast although the continental shelf remains wide with relatively shallow inclines further from the present shoreline (Fig. 2.1). This is clearly a simplified view and the local geomorphological evidence, outlined below, provides more specific data for the region.

Ramsay (1996) has provided evidence for changes in the coastline to the north east of Sodwana Bay. Four episodes of beachrock formation, representing palaeoshorelines, have been distinguished (Fig. 2.2). Ramsay (1996) has correlated the location of each formation below modern sea level to a sea-level curve (Fig. 2.3) produced by

Williams *et al*. (1981). Absolute dates for the outcrops are not available; however, by placing them on the sea-level curve, Ramsay (1996) has defined periods in which they were most likely to have formed.

Palaeocoastline 1 has been attributed to OIS 5e, forming about 117 000 years ago when the sea level was 27 m below its current position (Ramsay 1996). Evidence for palaeocoastline 2 can be found 13 to 45 m below the modern sea level. Ramsay (1996) has correlated it to OIS 5c between 100 000 and 97 000 years ago on the Williams *et al*. (1981) sea-level curve. A third palaeoshoreline outcrops between 50 and 60 m below the modern shoreline (Ramsay 1996). This outcrop could have formed at any stage between 97 000 and 23 000 years ago. The final outcrop (palaeocoastline 4) has been attributed to the LGM at about 23 000 to 22 000 years ago (Ramsay 1996). At the furthest point from the modern shoreline, palaeocoastline 4 lies ca. 4 km offshore from the current coastline. The palaeocoastline occurs at a depth of 70 to 95 m below the modern shoreline. These outcrops suggest that, although the shoreline has shifted since the Last Interglacial, the profile of this stretch of coast was not altered as much as was indicated above using global changes in sea level. Although changes in sea level can be predicted from oxygen isotope records, it is more valuable to correlate the global observations with local evidence.

Radiocarbon dates for estuarine sediments (Table 2.1) from St. Lucia, Richards Bay and Durban provided more local evidence for palaeoshorelines along the East Coast (Maud 2000). Measurements from Richards Bay (Maud 2000) of –46 m and –52 m for sea level at >45 200 BP and 39 100 ±1530 BP, respectively, are in broad agreement with the evidence from Ramsay's (1996) study. They are also in agreement with evidence from New Guinea (Broecker *et al.* 1968) and the glacio-eustatic curve provided by Shackleton and Opdyke (1973). Studies at St. Lucia have provided anomalous measurements of –15 m and –7.6 m at 42 000 $\pm^{2800}/_{2100}$ and 33 400 ±910 BP, respectively (Maud 2000). If these measurements were accurate it would suggest brief fluctuations in sea level during OIS 3. The sea-level curve

produced by Williams *et al*. (1981) indicates that there may have been several fluctuations in sea level during OIS 3; however, none of the high stands are as shallow as those recorded at St. Lucia.

Tankard (1976) suggests that between 47 000 and 25 000 years ago there were no significant fluctuations in local sea level. Offshore topographic formations such as the "Rocky Bank", south of the Cape Peninsula (Flemming 1976), and a currently submerged cliff which formed along the West Coast of the Cape Province (Wright 1964) indicate a relatively stable sea level of –20 m for this period.

Cooper (1990) documents evidence for a high sea level stand near Lake Nhlange in northern KwaZulu-Natal. Mollusc shells became exposed during a flood of the Gezisa River, which drains into Lake Nhlanga from the west. These shell rich deposits have been attributed to the Last Interglacial at about 120 000 years ago during OIS 5e (Cooper 1990). This assumption is based on the composition of the shell assemblage, its state of preservation, and the elevation of the terrace from which it originated (Cooper 1990). The deposit contains taxa from fully marine environments, from tidal flats and estuarine localities, as well as a freshwater taxon. These taxa indicate a higher sea level and also the presence of a river. One taxon does not currently occur in the region but can be found further north, in warmer waters, along the Mozambique coast (Cooper 1990). Its presence in the shell assemblage indicates warmer ocean temperatures that might be expected during the Last Interglacial. Cooper (1990) proposes that the region experienced a sea level of 6-8 m above the modern sea level, and further suggests that the modern Gezisa River valley was probably a sheltered bay during this high sea stand. Lake Nhlanga, now a fresh water lake approximately 5 km inland, would have been under the sea (Cooper 1990). Combining the data from Cooper's (1990) and Ramsay's (1996) studies indicate there was a relatively quick lowering of sea level immediately following the Last Interglacial, which does not conflict with Ramsay's Palaeocoastline 1 (27 m below sea level) at 117 000 years ago. Ramsay (1996) records evidence at Lake St.

Lucia for the high sea stand of the Last Interglacial at 3.5 m above the modern sea level. This broadly supports the evidence provided by Cooper (1990).

2.3.2. River Geomorphology and Palaeochannels

Just offshore along the east coast of South Africa there are deeply cut palaeochannels that are associated with many of the current river courses such as the Tugela River (Orme 1976), the Tongati and Mgeni (Maud & Botha 2000). These offshore river channels formed during marine regressions when this part of the continental shelf was exposed. Channels could have been incised during the penultimate glacial or Last Glacial periods and even during previous marine regressions. Sea levels of the Last Glacial were lower than during the penultimate Glacial; therefore, the offshore topography seen today is most likely a result of the Last Glacial marine regression and erosion. At Richards Bay, a valley system has been recorded offshore of the current Mhlatuze River mouth (Orme 1976). The base of this valley occurs 55 m below the modern sea level. This can be correlated with Ramsay's (1996) Palaeocoastline 3 at 50-60 m below modern sea level.

Geomorphological features, which formed during low sea-stands, are also preserved in the estuaries of many of the rivers feeding the Indian Ocean. Orme (1976) notes that there are narrow channels in the estuaries which cut the broad channels found at the mouths of these rivers, including the Tongati River, along which Sibudu Cave is located. Narrow channels tend to be associated with rivers with steeper gradients and higher energy flow than broad channels are (Orme 1976). During marine regressions the rivers incised their way across the continental shelf to the sea, forming these narrower channels within the previously cut riverbeds. Onshore, the deeply incised rivers that are characteristic of this region were also incised. Episodes of erosion elevated above current onshore river channels (such as along the Tongati River) provide earlier evidence of downcutting.

2.3.3. Sediment and Pollen Records

Pollen profiles are often obtained by analysing sediment cores removed from palaeopedological sections. These sediment cores can also be used to provide other palaeoenvironmental records, such as the proxy rainfall record from the Pretoria Saltpan (Partridge *et al.* 1997), that compliment the results of the pollen analyses. Pollen types within the sediments tend to originate from a range of sources and can often provide a better representation of the surrounding vegetation community than pollen from relatively closed, anthropogenically influenced and potentially discontinuous archaeological cave site deposits. A disadvantage of pollen records from non-archaeological contexts is that correlating them to archaeological assemblages can be inaccurate.

2.3.3.1. Port Durnford and Kosi Bay Formations

In a recent summary of onshore deposits, Maud and Botha (2000) present evidence for changes in Quaternary sedimentation processes in four regions along the coast of South Africa. These regions are divided on the basis of geographical and chronostratigraphic differences. The Maputaland Group is of specific interest for this study because it has its southern extent in the Durban region in close proximity to Sibudu Cave. Botha (1997) proposed a new nomenclature for Pleistocene and Holocene sediments within the Maputaland Group. Those considered here include the Port Durnford (PD) Formation, which is thought to be middle to late Pleistocene in age, and the Kosi Bay Formation of late Pleistocene age. Both formations were initially classed as the PD Formation; however, the PD Formation has been restricted to the section containing the mudrock and sand deposits (Fig. 2.4). The overlying deposits have been placed into the Kosi Bay Formation (Fig. 2.4) (Maud & Botha 2000). The sand of the PD Formation contains fossil remains of fish, crustaceans, foraminifera and marine molluscs as well as larger mammalian fossil bones (Maud & Botha 2000). This fossil assemblage was used to date the PD Formation to the Pliocene (du Toit 1954); however, the date was subsequently revised to the early to middle Pleistocene (Scott *et al.* 1992). More recently, further support for a younger

age has been provided through $^{230}Th/^{234}U$ dating of an associated exposure. A date of 70.0 ±5.0 ka was extracted from a beach exposure (Oschadleus *et al.* 1996) that is believed to be contemporaneous with the lignite bed, now considered part of the Kosi Bay Formation. The date places it in the cold stadial, OIS 4, of the Last Glacial. Unfortunately, the dating of this deposit remains uncertain because a significantly older and as yet unpublished date, referred to by Maud (Maud & Botha 2000), was obtained by Dr. N. Porat using Luminescence techniques on sand deposits overlying the lignite within the Kosi Bay Formation. A date of 350-250 000 years ago was obtained and, if correct, would indicate that the deposit dated to 70 000 is not contemporaneous with the PD Formation contained in the borehole sample.

Pollen was analysed from the borehole extracted to the north of the lighthouse at Port Durnford. Units 3 and 2, encompassing the Lignite Member (now part of Kosi Bay Formation) and the lower most section of the Upper Arenaceous Member, are of particular interest for this study. Unit 3 contained a high proportion of arboreal pollen, including *Morella* and *Syzygium* species. Towards the base of this unit *Ficus* pollen was more prominent in the assemblage. The pollen spectrum from this section of the sequence has been interpreted as "open sedge marshland surrounded by *Syzygium* and *Ficus* trees" (Scott *et al.* 1992).

The lower part of unit 2 and the top of unit 3 were dominated by *Podocarpus* pollen and contained small quantities of Fynbos taxa. *Podocarpus* is not common in modern vegetation or pollen spectra recorded in the area and Fynbos vegetation is predominantly confined to the Cape and the winter rainfall region of South Africa. Scott *et al.* (1992) believe that the pollen spectra in these units are a result of significant changes in the vegetation community caused by climatic changes. The climate was probably cooler and there is evidence to indicate the presence of fresh water conditions (Scott *et al*. 1992). There is no evidence for brackish conditions so it is probable that the sea was further from the locality. Both sedimentary and palynological evidence indicate that the lignite formed further inland than it is

currently located (Maud & Botha 2000). This interpretation lends support to the 70 000 BP date (Oschadleus *et al*. 1996).

Although the PD and Kosi Bay Formations may be useful for reconstructing both the palaeoshoreline and the palaeoenvironment for the region, it is imperative that the chronology is resolved before the data can be used with confidence.

2.3.3.2. Voordrag

A study of soil profiles at Voordrag in KwaZulu-Natal has provided a dated sedimentological sequence (Botha *et al.* 1990; Botha 1996; Clarke *et al.* 2003) as well as a pollen spectra for deposits post-dating 40 000 years ago (Botha *et al.* 1992). This site is in relatively close proximity to Sibudu Cave (Fig. 2.5). Palaeoenvironmental interpretations of the conditions under which this site formed are therefore of great importance to this study. The site provides an indication of changes in climate and vegetation that might be visible in proxies from the MSA sequence at Sibudu Cave. The soil profile consists of periods of colluvium accumulation interspersed with the development of palaeosols. Colluvium accumulates during dry periods, while the formation of palaeosols implies more stable conditions during relatively mesic periods (Clarke *et al.* 2003).

Three of the periods of colluvium accumulation are relevant to this study. The first was dated to 96.0 ±9.5 ka and 99.2 ±9.1 ka, the second to 56.5 ±5.2 ka, and the third to 30.7 ±3.7 ka and 28.0 ±2.8 ka using IRSL techniques (Clarke *et al.* 2003) (Fig. 2.6). The dry period at the end of OIS 4 has been correlated with a dry phase recorded at the Pretoria Salt Pan at 61 000 years ago (Clarke *et al*. 2003). Sporadic periods of colluviation have been recorded at several sites across KwaZulu-Natal between the Last Interglacial and the LGM (Botha 1996). These dry periods are dispersed between relatively moister periods represented by palaeosol formation. Pollen samples have been taken from these palaeosols at Voordrag. Botha (1996) discusses the results of the pollen analysis. In the following discussion the new dates

for the Voordrag sediments (Clarke *et al.* 2003) are given and have been combined with the interpretation provided by Botha (1996).

Palaeosol 4L, which has a ^{14}C date of 42 300BP (Clarke *et al.* 2003), contains elements from two vegetation regions that are currently distinct from one another. There is evidence for sclerophyllous bush and fynbos as well as tropical vegetation (Botha 1996), which must indicate the presence of distinctly different vegetation in the area and therefore a significantly different climate when compared with the current climate and vegetation. The fynbos taxa present in the pollen, as well as some spores that are commonly found in Asteraceae dominated grassland, indicate cool moist conditions during the formation of Palaeosol 4L. The presence of *Podocarpus* in this soil horizon lends support to this interpretation.

There are two ^{14}C dates, 40 700BP and 36 800BP (Clarke *et al.* 2003), for palaeosol 4U. The pollen from this palaeosol displayed an increase in the grassland indicators and a decrease in *Podocarpus* (Botha 1996). Moist woodland taxa, such as *Celtis*, Oleaceae, Proteaceae and *Syzygium*, were also present (Botha 1996). Although the pollen spectra of 4L and 4U are quite different, the taxa found in both indicate cool and humid conditions.

Palaeosol 3 lies between two horizons which have been IRSL dated to 22.3 ±2.9 ka and 28.0 ±2.8 ka (Clarke *et al.* 2003). Botha (1996) suggests that the pollen and spore spectra, including Cyperaceae and Bryophytes respectively, are indicative of soil that is poorly drained. Asteraceae grassland is also evident.

Palaeosol 2 formed during the LGM. This horizon is not directly relevant to this study; however, it is interesting to note the increased Ericaceae pollens and further increase in Asteraceae grassland components (Botha 1996). Taxa identified from these younger palaeosols suggest that the area was significantly drier than it was earlier in the Last Glacial. Botha (1996) suggests there is evidence for an altitudinal

drop of 1000 m in the location of vegetation belts. This is indicated by the presence of taxa currently found in the Drakensberg mountain fynbos.

Botha (1996) discusses pollen profiles from several other sites in KwaZulu-Natal. These localities are divided into those providing evidence for vegetation during and just after the Last Interglacial (OIS 5e and younger), and those that are dated to the Last Glacial (within OIS 3).

Sites that formed during the earlier period contain indications of moister and cooler environments. The Zungwini profile contains a broad range of taxa including arboreal pollens such as Asteraceae, *Podocarpus* and Oleaceae. There are clear indications of cooler conditions (Ericaceae) and moist conditions (Cyperaceae). Moist environments are also represented at both Nqutu and Masotcheni although the cool temperature indicators are not present at these sites during this period.

The Nqutu donga and St. Paul's donga contain sediments dated to before 53 000 years ago and before 46 000 years ago, respectively. Pollen from Nqutu is representative of vegetation similar to the vegetation in palaeosol 4L at Voordrag (Botha 1996). In addition to the wetland indicators there are also taxa from forest, upland bushveld, and dry grassland vegetation. Although the Nqutu pollen indicates a combination of environments, the dominant taxa is from Poaceae (meadow grassland). This grassland pollen increased significantly prior to 41 000 years ago. St. Paul's donga pollen sequence also contains a high proportion of Poaceae grassland indicators with relatively fewer Asteraceae (Botha 1996) or other small shrubby taxa.

2.3.3.3. Tswaing Crater and Wonderkrater

These sites have yielded pollen records for the Quaternary that suggest fairly large-scale vegetation and environment changes. These sequences have been examined using Principle Components Analysis (PCA) to produce temperature reconstructions for the region (Scott 1999). Although both records contain sediment and pollen

hiatuses, these records have been correlated to one another on the basis of the taxa and vegetation communities represented in each profile. The Holocene and Late Pleistocene portions of these can be correlated using the available ^{14}C dates, while correlations of the older portions of the sequences are based on pollen content and extrapolated dates. Scott (1999) has shown that there are major trends common to both profiles that seem undoubtedly associated. The associations between zones are shown in Figure 2.7.

Zones W1–W3 (Wonderkrater) and Z8-Z12 (Tswaing Crater) are of greatest relevance to this palaeoenvironmental study because they pre-date the LGM. Consensus is apparent between W1b-c and Z9, during which time *Podocarpus* dominated the pollen profiles at both sites. It is likely that vegetation in the area was dominated by forest, and a PCA showed temperatures were generally cool (Tswaing) to moderate (Wonderkrater). Interestingly, a warmer temperature was suggested for W1a, which correlates with Z8. Z8 is also a warmer phase within the generally cool conditions observed at Tswaing between Z6–Z12. The vegetation indicated for Z8 was a savanna community. At Wonderkrater this community is not apparent in the pollen profile, but its presence is implied in the PCA temperature index (Scott 1999).

Zone W2 pollen correlates well with the pollen from Z10. Both zones contain elements of savanna vegetation. The temperature index for W2 suggests that warmer conditions prevailed; at Tswaing, Z10 is noted as a warmer episode during the cooler conditions of Z6-Z12.

Scott (1999) has suggested that a non-pollen rich, sandy deposit that accumulated at Wonderkrater can tentatively be correlated with Z11 at Tswaing. Z11 represents one of two zones for which coldest conditions are apparent. The other, Z12, correlates with W3 during which temperatures began to drop. The vegetation at Tswaing is significantly different during this period from all other periods as it contains a shrubland vegetation community, including fynbos elements. These zones are likely

to have accumulated during the colder conditions that can be observed globally at the end of OIS3 with the onset of the LGM.

2.3.4. Oxygen Isotope Records

2.3.4.1. Cango Cave

Isotopic composition of a stalagmite from Cango Cave, north of Oudtshoorn in the Eastern Cape, was examined and a record of palaeotemperatures and vegetation changes for the last 47 000 years produced (Vogel 1983). Talma & Vogel (1992) found there was not a clear change in stalagmite composition between the last glacial and the ensuing interglacial conditions of the Holocene. From about 30 000 to 13 800 years ago temperatures were 4-7ºC colder than the current temperatures in the area (Talma & Vogel 1992). Carbon isotope measurements provide a proxy for changes in vegetation community. C3 vegetation was dominant in the area during stalagmite growth from 47 000 to 13 800 years ago (Talma & Vogel 1992), implying cool conditions and a winter rainfall regime. C4 grasses currently dominate the Cango Cave valley although C3 vegetation is more common in the winter rainfall region. Vegetation in this region is considered marginal and Talma & Vogel (1992) suggest that the vegetation composition is likely to be easily influenced by changes in climate, thus indicating a relatively stable climate towards the end of OIS 3.

2.4. Palaeoenvironmental Indicators from Archaeological Contexts

Sites included in this synthesis are shown on Fig. 2.5. Distributions of the current winter and summer rainfall regions are also indicated. Sites from the winter rainfall region are considered first, followed by sites from the summer rainfall region. The discussion draws upon environmental proxy data, including micro and macrofauna as well as charcoal and pollen from archaeological contexts, to present an image of both vegetation and climate through the Last Interglacial/Glacial cycle of the Quaternary.

2.4.1. Winter Rainfall Region

2.4.1.1. Die Kelders

It was initially assumed that the MSA deposits at Die Kelders dated to between 80 000 to 35 000 years ago. Die Kelders has recently been re-dated using Electron Spin Resonance (ESR) (Schwarcz & Rink 2000) and Luminescence techniques (Feathers & Bush 2000). Both techniques indicate that the majority of the occupation units were deposited between 60 and 70 000 years ago, thus placing site occupation in the last glacial during the cold stadial OIS 4 and perhaps the beginning of OIS 3. The suggestion that the deposits accumulated rapidly over a relatively brief period of time is contrary to previous interpretations of the site. Thackeray (2002) suggests that the accuracy of the techniques used to obtain these new dates may be influenced by changes in moisture through the deposits. He provides support for the longer sequence using microfauna evidence first presented by Avery (1982a), and obtains temperature indices using factor analysis. The temperature indices correlate well with oxygen isotope records, suggesting the deposits may lie within OIS 3 with small sections deposited during the colder phases of the last glacial (corresponding with OIS 2 and 4) (Thackeray 2002). The absence of Howiesons Poort lithics at the site supports Thackeray's interpretation. The Howiesons Poort industry has been dated to between 55 000 and 80 000 years ago (youngest and oldest occurrences) at several sites across South Africa, for example Rose Cottage Cave (Cochrane 2003a), Klasies River (Feathers 2002), and Border Cave (Grün & Beaumont 2001). It is, however, difficult to assess whether temperature indices are robust enough to provide both environmental data and a proxy dating method, and it is hard to reject absolute dates on the basis of a lack of lithics or the results of a factor analysis.

Until these dating issues are resolved, two scenarios for palaeoenvironmental change can be given. The microfauna evidence has not yet been reinterpreted within the shorter timeframe. Hence, Avery's (1982a) original interpretation is summarised

here. The original palaeoenvironmental interpretation provided by Tankard & Schweitzer (1974) is included in this description. A scenario for the shorter occupation is given below with reference to macrofauna remains.

Avery (1982a) recognised three distinct palaeoenvironmental units in the Die Kelders microfauna assemblage. These units were created on the basis of differences in the microfauna assemblage and the results of a factor analysis. Units 3 and 2, including levels 14-12 and 11-3, respectively, contain MSA artefacts and occupation debris, whereas Unit 1, including levels 2 and 1, does not. Level 1 preserves evidence of a LSA occupation with shell, pottery and domesticated animals and the environmental interpretation of this unit is considered briefly below.

Unit 3 (including levels 14-12) – These levels contained microfauna that indicated grassland was quite extensive (Avery 1982a). This grassland would have been present on flat ground near the cave (Avery 1982a), possibly both above and below it. In addition, there was a dense vegetation type which may have been near a marsh or lake. Avery (1982a) suggests that this habitat may now be submerged under the sea, and further suggests that the grassland (requiring open flat land) and the presence of the lake indicate that the sea may have been considerably lower and further from the site than it is at present. This unit is ascribed to a cold, wet phase and was thought to have accumulated during considerably colder conditions when the sea may have been about 100 m below modern sea level (Tankard & Schweitzer 1974).

Unit 2 (levels 11-3) – In this series of deposits the evidence for grassland is not as prominent as it was previously, and there is a stronger indication of dense vegetation on the available flat ground. Avery (1982a) suggests that the lack of another vegetation type may be taken as an indication that the sea level was higher than in the previous period. A higher sea level would effectively reduce the available habitat types near the site from which micromammals may have originated. Vegetation on the hillsides remained the same through Units 3 and 2; however, the proportion of

hillside vegetation indicators was reduced in Unit 2. The reduction of indicators was also not counterbalanced by the occurrence of other vegetation indications. Avery (1982a) recommends that this adds strength to the proposal of a raised shoreline and thus a lack of available habitats. The climate is described as warmer and drier than in previous periods.

Unit 1 (levels 2 & 1) – The conditions during this time were similar to those discussed for Unit 3 (Avery 1982a). Indicators of grass and dense vegetation on flat ground increased, while indicators of scrub vegetation were dominant for the hillside habitat. The microfauna from Unit 1 implies that climatic conditions were warm and wetter. Avery (1982a) also suggests on the basis of the increase in grassland indicators that the sea may have retreated again from the high stand associated with Unit 2. Tankard & Schweitzer (1974) interpreted the stratigraphy and palaeoenvironmental conditions during this period differently. Level 2 was recorded as a sterile layer and they associated it with a higher sea level. Further, they suggest that during the accumulation of level 1 the sea level was as high as it is currently and that the climate was also equivalent to modern climate (Tankard & Schweitzer 1974).

It has been noted in studies of both macro and microfauna from Die Kelders that the vegetation and climatic conditions in the site vicinity during the MSA differed significantly from during LSA occupation and historic periods (Avery 1982a; Marean *et al*. 2000a). Most noticeably, the faunal assemblage in the MSA contains species that have not been recorded in the vicinity either historically or in the contemporary habitat. The LSA assemblage does contain taxa recorded historically. The site currently lies in the Fynbos biome of South Africa with sclerophyllous scrub and bush dominating the vegetation (Marean *et al.* 2000b). The cave overlooks the sea; however, in OIS 4 it may have been as much as 8 km away (Marean *et al.* 2000a). The marine regression would in part be responsible for some of the changes in vegetation that are evident from the faunal analysis.

The presence of grazers such as black wildebeest, southern springbok and bontebok indicate grasslands, as does the extinct quagga. Eland are mixed feeders and may support the evidence for open grassy conditions. Reconstructions of the now submerged topography (Lenhof 1995) show that there was probably a sandy coastal plain (Marean *et al.* 2000a) which may have been consolidated by grasses and shrubs. This is indicated by the presence of grazers and some browsers (Marean *et al.* 2000a). Offshore topography provides evidence for an erosion channel that cut this sandy platform when the sea was further from the cave (Lenhof 1995). Southern reedbuck, which is found in habitats with tall grasses and reed beds (Smithers 1983), and hippo in the faunal assemblage supports the presence of a fresh water supply.

In addition to the habitat requirements being used to reconstruct the palaeovegetation and physical conditions, Klein and Cruz-Uribe (2000) have used body size of adult individuals to interpret climatic conditions during the short MSA occupation. These studies require comparison of the archaeological assemblages with modern data sets and historic evidence. There is evidence for the region being cooler than it is today; grey mongoose tend to be larger than would be predicted for the area with its current climatic conditions (Klein & Cruz-Uribe 2000). The presence of large adult Cape dune molerats suggests that rainfall was higher in the region during the MSA than it is at present (Klein & Cruz-Uribe 2000). Klein and Cruz-Uribe (2000) arrived at this conclusion by comparing the archaeological assemblage to modern assemblages and the association of body size to rainfall. In extant Cape dune molerat populations a positive correlation exists between body size and rainfall (Klein & Cruz-Uribe 2000); therefore, larger molerats in an archaeological assemblage would tend to indicate higher rainfall. The indication of higher rainfall equates well with other evidence for moist conditions suggested by sediment and fauna.

To quantify the amounts of rainfall, rock hyrax body sizes were also measured (Klein & Cruz-Uribe 2000). The relation of hyrax body size to rainfall is not linear; rather, their size increases up to about 700 mm of rainfall/annum and then decreases as

rainfall continues to increase, producing a curvilinear relationship (Klein & Cruz-Uribe 1996). When compared against the LSA data, the MSA hyrax body size plots did not show significant evidence for higher rainfall averages; although, the evidence may be masked by the curvilinear relationship (Klein & Cruz-Uribe 2000).

To summarise, the MSA macrofauna assemblage from DK1 indicates cooler and wetter conditions than are in existence today. The current rainfall is ca. 400-500 mm/annum (Marean *et al*. 2000b); however, the region may have received more than 700 mm/annum during the MSA occupation (Klein & Cruz-Uribe 2000). The area would have been grassy, with a coastal plain providing an open habitat for the grazers, and there is evidence for a body of fresh water, probably a vlei (Marean *et al*. 2000a; Klein & Cruz-Uribe 2000). This open grassy environment is also indicated through the microfauna assemblage (Avery 1982a). It is possible that the microfauna was affected by localised climatic conditions that could have given rise to variation that is not evident in the macrofauna. It may be appropriate to accept the ESR (Schwarcz & Rink 2000) and Luminescence (Feathers & Bush 2000) dates and research potential localised changes that could have influenced the microfaunal assemblage in such a way as to produce the temperature anomalies.

2.4.1.2. Blombos Cave

The macrofauna assemblage from Blombos Cave displays similar trends to those for Die Kelders. These sites are relatively close and currently lie within the same vegetation region although, on the whole, the area around Blombos Cave is a little drier than the Die Kelders region (Henshilwood *et al.* 2001). The stratigraphic units considered here are referred to as BBC 1, BBC 2 and BBC 3 (Henshilwood *et al*. 2001). A series of optically stimulated luminescence dates have been obtained for a sterile sand dune layer that caps the MSA sequence (Jacobs *et al.* 2003a; 2003b). Each technique used has provided dates in the region of 65 000 to 70 000 years ago (Jacobs *et al.* 2003a; 2003b).

The taxa in the MSA indicate that the area may have been grassier and probably received higher annual rainfall than it does today. The increase in grasses in the vegetation is a tentative suggestion (Henshilwood *et al.* 2001) as the amount of specific information is limited. Large mammals do not tend to be as habitat specific as the smaller ones and the presence of some of the taxa could be interpreted in a number of ways. The springbok, which is present in BBC 3 and 2, provides the strongest indication of grasses. Henshilwood *et al.* (2001) propose that the suite of MSA faunas, which includes the extinct Cape zebra (a grazer), could not have been sustained in the region unless grasses were a larger part of the vegetation than they have been recorded to be historically or in the modern vegetation.

It has already been discussed in reference to the Die Kelders assemblage that molerat body size is related to rainfall. The MSA molerats tend to be larger than those from the LSA assemblages. Body sizes of adults from the MSA at Blombos Cave suggest the environment was moister overall, but there is some variation within the molerat sizes. The mean size of the molerats from the BBC 3 assemblage is almost as large as for the MSA at Die Kelders. The BBC 1 and 2 molerats are smaller than the BBC 3 molerats, implying that moisture in the region declined through the MSA occupation. A moister environment is also indicated by the presence of hedgehog and southern reedbuck (Henshilwood *et al.* 2001). Additionally, tortoises from the Blombos Cave assemblage provide some evidence for change in environment. As at many other sites in the Cape region the MSA tortoises are larger than those in the LSA; however, the relationship of tortoise size to environmental conditions is influenced by anthropogenic factors such as the intensity with which they were collected (Henshilwood *et al.* 2001). Larger human populations will effectively prevent tortoises from growing to their full size while small human populations may have little impact on the tortoise population and their growth patterns.

2.4.1.3. Boomplaas

The cave site of Boomplaas lies in the Cango Valley, north of Oudtshoorn, near the Cango Caves (Fig. 2.5). This site contains MSA and LSA deposits and, unlike many South African sites, it contains deposits dating to between 40 000 and 20 000 years ago. One of the focuses of the excavation and research project at Boomplaas (and Klasies River, which is discussed below) was to gain palaeoenvironmental data from a variety of proxies (Deacon 1995), and to establish the effects of climate change upon communities during the MSA and early LSA. Evidence was drawn from charcoal, fauna, pollen, sediments and speleothems for this collaborative project. Deposits at Boomplaas are thought to extend as far back as 80 000 years, although techniques suitable for dating deposits of this age have not yet been used to confirm the age of the site.

Charcoal assemblages have been studied from LSA and upper MSA layers (Scholtz 1986). Charcoal analysis results have been published for layers BLD to OLP (Fig. 2.6) (Deacon *et al.* 1983; 1984). Identifications from layers BOL and OCH are probably most comparable with the Sibudu Cave deposits; however, they have unfortunately not yet been published. Deacon *et al*. (1983; 1984) report that the oldest layers contain *Olea* species as well as indicators of shrubland vegetation. Layer BP, with a date of 32 000 BP, also contains taxa that are indicative of shrubland. *Erica* species are also prominent in this assemblage. Unlike the earlier layers, deposits dated to the LGM did not contain *Olea* species. *Olea* were noted to reappear in assemblages dated to the terminal Pleistocene, ca. 10 000 years ago. On the basis of changes in the taxon composition, as well as taxa diversity, it was concluded that conditions preceding the LGM were not as cold as they were during the LGM.

In Klein's (1978) study, deposits associated with the MSA occupation are referred to as Earlier Upper Pleistocene (EUP) Units and were sub-divided into Units 1, 2 and 3. The EUP Unit 3 assemblage accumulated at the site from before 40 000 to ca. 21 000

years ago and includes layers OLP to GWA/GGU. Maximum ^{14}C dates are available for the older deposits, EUP Units 2 (layer BOL) and 1 (layers LOH and OCH), thus placing them before 40 000 years ago. Based on their faunal contents, dates for these deposits have been suggested. Fauna from the base of the sequence is more akin to the fauna recorded in the area historically and during the LSA occupation at the site (Klein 1978). It was proposed that the base of the sequence formed during the Last Interglacial period (Klein 1978) when conditions in the area would have been similar to current conditions. In contrast, taxa recorded in the area historically are not well represented in EUP 3 or in the younger assemblages containing "Robberg" artefacts. Grazing ungulates are present in larger numbers in these assemblages and their presence contributes to and confirms evidence from other sites. Grassland appears to have been more prominent in the Cape during the Last Glacial than it was historically or during the Last Interglacial (Klein 1978). It is shown below that other environmental proxies from the site support this interpretation.

Microfauna from Boomplaas was analysed by Avery (1982a). Two taxa, Saunders's vlei rat and the forest-shrew, were found in assemblages dating to the LGM as well as earlier deposits. Frequencies of these taxa display an overlapping but inverse relationship. Forest-shrew, which is reliant upon moist habitats, was present in greater numbers in the earlier deposits, while Saunders's vlei rat was more dominant in the layers centred upon the LGM. The Saunders's vlei rat has a restricted distribution and is found in the east and south western Cape and Lesotho (Deacon *et al.* 1984). It tolerates cooler and drier climates than the forest-shrew. The evidence suggests that the Boomplaas region was cool and moist at ca. 40 000 years ago. Summary statistics produced for the microfaunal assemblage show that by 30 000 years ago conditions were drier and cooler than they were previously (Avery 1982a; Thackeray 1987)

Palynological studies at Boomplaas reveal that pollen was preserved to about 32 000 years ago (Deacon *et al.* 1984; Scholtz 1986). The oldest pollen samples, from the

BP member, show that *Elytropappus* was common in the region (Deacon *et al.* 1984). This is a shrubland taxon and is a component of sclerophyllous vegetation (Allaby 1998; Acocks 1988).

Sediment accumulation processes have also been assessed for this site (Webley 1978). The analysis showed that some deposits contained significantly more roof spalls than were found in other layers. Deposits containing roof spalls lie within the Last Glacial. It is possible that the episodes of roof spalling occurred as a result of cooler climates, although there is no evidence for frost shattering. Deacon *et al.* (1984) attribute the lack of frost shattering to insufficient moisture.

2.4.1.4. Klasies River

Klasies River, in the Eastern Cape, has been the focus of much research into MSA technologies (Deacon & Wurz 1996; Singer & Wymer 1982; Thackeray & Kelley 1988; Thackeray 1989; Wurz 1999; 2002) and palaeoenvironments (Klein 1976, 1978; Avery 1987). Many of the early studies attempted to extrapolate evidence for the length of occupation using quantitative methods and palaeoenvironmental interpretations based on the archaeological remains. A variety of techniques have been used to propose dates for the site (Avery 1987; Shackleton, 1982; Singer & Wymer 1982; Bada & Deems 1975; Binford 1984), with varying degrees of success. More recently, Grün *et al.* (1990a) and Feathers (2002) have acquired sequences of dates using ESR and Luminescence dating techniques, respectively. The Klasies River main site contains deposits dating to between about 115 000 and 50 000 (Feathers 2002). This occupation encompasses OIS 5 to OIS 3. Palaeoenvironments changed significantly during site occupation and evidence for these changes is presented below.

Avery (1987) carried out microfauna analysis with the aim of producing an environmental reconstruction and to suggest dates for the site. The microfauna samples were grouped (Avery 1987) according to the lithic industries with which they

were associated (MSA I, sample 41; MSA II, samples 40–31; HP, samples 30–20; and MSA III, samples 19–3). Feathers (2002) also refers to these lithic industry divisions; therefore, easy correlation of the microfauna to the Luminescence dates has been possible (MSA I - 110-115 ka; MSA II - 70-85 ka; HP - 55-60 ka and MSA III - 50 ka) (Table 2.2).

The Klasies River microfauna assemblage shows that closed vegetation is evident through much of the deposit; however, the taxa coinciding with early MSA III lithics (samples 20-10) are indicative of open graminoid vegetation (Avery 1987). In this phase there is an increase in Saunders's vlei rat and a corresponding decline in the herbaceous habitat taxon *Rhabdomys pumilio*. Avery (1987) notes that the composition of the assemblage generally correlates well with the macrofauna and Klein's (1976) interpretations.

Microfauna and macrofauna assemblages suggest that between 120 000 and 100 000 years ago vegetation was probably similar to the modern Knysna Afromontane Forest. The Howiesons Poort assemblages dated between 55-60 ka (Feathers 2002) contain fauna indicative of open vegetation (Klein 1976). Grazers rather than browsers dominate the HP deposits and overlying MSA III units. This suggests that temperatures were cooler, enabling the development of grasslands rather than the bushier vegetation that is associated with the last interglacial occupation (Deacon & Lancaster 1988).

In addition to the faunal remains, shellfish and sediment deposition provide evidence for the proximity of the coastline to the site. The high shellfish content of the SAS member suggests that the coast was close to the site during deposition (Deacon & Geleijnse 1988). Layer 22, which overlies the SAS member, provides a contrast. There is a lower frequency of shellfish in layer 22 (Deacon & Geleijnse 1988), suggesting the resource was not as readily available. This has been interpreted as indicating a drop in sea level (Deacon & Geleijnse 1988). Saunders's vlei rat, which

Deacon refers to as a glacial indicator, and grazers in the macrofauna increased in frequency at the same time. The overlying deposits, including the HP and MSA III assemblages, also provide evidence for a marine regression, which is referred to as the "Klasies River Regression" (Deacon & Geleijnse 1988). An approximate age for the regression was obtained by comparing Klasies data with a sea level curve produced by Chappell & Shackleton (1986) for the Huon Peninsula (Deacon & Geleijnse 1988). It was assumed that the deposits dated to between 60 and 80 000 years ago. These deposits have now been dated to between 50 and 60 000 years ago (Feathers 2002), coinciding with the marine regression of the last glacial, although probably not with the extreme low sea level stand associated with OIS 4 as it was originally postulated.

2.4.1.5. Elands Bay Cave

A pollen record from Elands Bay Cave in the western Cape has been presented in conjunction with wood charcoal data from the same site (Parkington *et al.* 2000). Deposits from Elands Bay Cave span more than 40 000 years (from >40 000 BP to about 300 years ago) (Cartwright & Parkington 1997). Records from this site therefore provide evidence for palaeoenvironments at the end of the Pleistocene as well as during the Holocene. The taxa indicate a significantly different vegetation community when compared with the modern vegetation. Prior to 20 000 years ago afromontane rainforest and riverine woodland taxa are present. Many of the identified taxa are currently found further south in mesic thicket and afromontane forest (Cowling *et al.* 1999). In these regions there is a greater amount of soil moisture available and the summer drought is less severe. Taxa found at Elands Bay Cave thus indicate that the region was significantly wetter and less seasonal prior to, and during, the LGM than it is today. In particular, Cowling *et al.* (1999) have recorded the presence of *Celtis africana*, which is a deciduous tree, and they suggest that it would not have survived extremely dry summer climatic conditions.

Parkington *et al.* (2000) postulate that there may have been a shift in the rainfall regime. Currently the area receives the majority of its rainfall in the winter months and the summer period is often extremely dry. In addition, some of the oldest samples contain *Ficus sur*, a component of tropical and sub-tropical forests. Their southerly most extent today is in the eastern part of the Fynbos biome (Cowling *et al.* 1999). They conclude that the greater amount of overall moisture available was probably spread more evenly though the year. The faunal assemblage from Elands Bay Cave also implies wetter and cooler environments in the Late Pleistocene. There is evidence to suggest, as with many other sites from this period in the Cape, that the vegetation was grassier during this phase than at present. Although the fauna coincides with interpretations from other winter rainfall sites, the indication of higher quantities of less seasonal rainfall does not. Archaeobotanical remains from Elands Bay Cave indicate that two climatic and vegetation scenarios were present in what is today classed as a single climatic region. Most sites in the Cape suggest that towards the end of OIS 3 and at the beginning of OIS 2 conditions were cool and dry. This is certainly not the case for Elands Bay Cave where conditions may have been cool and moist (Cowling *et al.* 1999).

2.4.1.6. Oyster Bay

The record discussed here is particularly important because it provides pollen data for the Eastern Cape. Although this record has not been dated directly, coprolites containing pollen were found in association with faunal remains that indicate a Late Pleistocene age. Artefacts attributed to the Howiesons Poort lithic industry were also found at the site; however, the relationship of the artefacts and coprolites is not as secure as that of the coprolites to the fauna (Carrión *et al.* 2000). Fauna from Oyster Bay is dominated by terrestrial taxa and there are few seal bones present. The fauna is diverse with three possible environmental niches represented. There is evidence for open grassland and a closed habitat as well as the presence of still water. This combination of taxa corresponds well with evidence from the Last Glacial from other sites, such as Klasies River.

The small amount of pollen preserved in the coprolites was insufficient to enable a detailed reconstruction of the vegetation in the region. However, Carrión *et al.* (2000) observed some differences between the pollen spectra of the ancient samples and the spectrum of a modern sample for the area. These identifications support the faunal interpretation. *Morella* species dominated the pollen samples, while *Stoebe-Elytropappus* (sclerophyllous bush taxa from the Asteraceae family) and Poaceae (the grass family, also called Gramineae) were also fairly prominent.

The identified taxa, in particular *Stoebe-Elytropappus*, provide evidence for a significant change in the vegetation (Carrión *et al.* 2000). *Stoebe-Elytropappus* grows further inland than the current location of the site and at altitudes >800 m a.m.s.l. in the Cape region. Its presence therefore indicates a drop in temperature as well as a lowering of sea level. The limited number of marine components in the fauna supports these indications (Carrión *et al.* 2000). On the basis of dates for other HP lithic assemblages (Feathers 2002; Grün & Beaumont 2001; Cochrane 2003a) it can be suggested that this lithic industry, and possibly the site, date to ca. 70 000 – 60 000 years ago.

2.4.2. Summer Rainfall Region

2.4.2.1. Border Cave

The microfauna from Border Cave was analysed by Avery (1982b). An updated and more detailed interpretation of vegetation and climate has been provided (Avery 1992) following publication of ESR dates (Grün *et al.* 1990b) for the MSA sequences at Border Cave. The dates of this sequence have subsequently been revised (Grün & Beaumont 2001). The relationship of the old and new dates is outlined in Table 2.3. The environmental evidence is summarised here. The earliest MSA occupation periods, represented by Unit 6BS, are probably >200 000 years ago, although they are, as yet, undated (Grün & Beaumont 2001). This Unit was dominated by

micromammal species that are indicative of Miombo (*Brachystegia* dominated) type woodland (Avery 1992). Miombo vegetation, which is currently only found north of Border Cave in Mozambique and Zimbabwe, persists through the MSA 1 sequence and changed slightly as the area became drier (Avery 1992). Avery (1992) suggests that the area had more savanna elements (indicated in units 4WA.A + B) at ca. 120 000 years ago. At this time both temperature and rainfall were higher than they are today (Avery 1982b; 1992).

The HP layers at Border Cave have been dated to between 60 and 80 000 years ago (Grün & Beaumont 2001). During this time grassland vegetation continued to increase and the trees, while still present, were not as well indicated through the micromammalian assemblage (Avery 1992) as they were in previous levels. Zululand Thornveld or tree/scrub savanna developed as annual rainfall and winter rainfall decreased (Avery 1992). Temperatures were lower than they are today while the Summer Aridity Index (SAI) increased concurrently. By about 40 000 years ago the area may have been significantly drier. The drying trend continued towards the end of the MSA and beginning of the LSA occupation (Avery 1992), between 30 000 and 40 000 years ago (Grün & Beaumont 2001). Avery (1992) indicates that the average temperatures remained constant - between 17-19ºC - throughout this period; however, the SAI increased and rainfall, when compared with today's rainfall for the area, decreased significantly.

2.4.2.2. Rose Cottage Cave

Palaeoenvironmental studies at RCC have predominantly focussed upon the Holocene with small studies of proxies from the Late Pleistocene deposits. This focus is in part due to the nature of preservation of organics in the MSA. Bone preservation is extremely poor in deposits older than 20 000 years. Plug and Engela (1992) examined macrofauna from the Robberg/Late MSA phase and from the Robberg phase of the Wadley excavation. The identifiable bone was very limited especially for the older deposits, with only eight specimens in the MSA and 120 specimens from

the Robberg. Palaeoenvironmental interpretations from these samples were also limited, but Plug and Engela (1992) attributed the low taxa numbers to "low primary production during these cooler periods". In the Robberg assemblage they found that larger bovid taxa were more common than medium size bovids. Changes in hunting strategies are proposed as a possible reason for this. The Robberg/late MSA phase cross cuts the LGM and it is unfortunate that the palaeoenvironmental information from the macrofauna is extremely restricted. Older MSA occupation phases contain very small quantities of bone, and when present it is fragmentary and unidentifiable.

RCC yielded a very small amount of pollen. Scott extracted pollen samples from Butzer's units, Malan and Beaumont's excavation of slumped deposits, and subsequently from Harper's excavation (Harper 1994). Louis Scott and Anne Cadman analysed these samples and found very little pollen in them.

Esterhuysen (1996) studied charcoal from RCC. Her study focussed on environmental changes in the Holocene (Esterhuysen 1996; Esterhuysen & Mitchell 1996); however, she also carried out a study of older charcoal from Harper's first MSA excavation (A. Esterhuysen pers. comm.). Charcoal displays a similar pattern of preservation to the macrofauna, with significantly better preservation in the LSA when compared with the MSA assemblage as a whole (A. Esterhuysen pers. comm.). Much of the MSA charcoal was analysed using a Scanning Electron Microscope to assist in overcoming some of the preservation problems. Harper (1994) discussed this analysis, which remains unpublished; however, Esterhuysen (pers. comm.) undertook the analysis, vegetation description and palaeoenvironmental interpretation.

Layers KUA and EMB are from the top of the pre-Howiesons Poort and the base of the Howiesons Poort, respectively. These layers have single grain optically stimulated luminescence dates of 61.0 ±4.0 and 66.0 ±4.0 ka (Cochrane 2003a). Charcoal from these layers was limited in both quantity and taxa diversity. Although

these deposits contain more than one type of lithic industry, their charcoal assemblages indicate that the environment did not change across the lithic technology boundaries. The combination of taxa suggests the region received sufficient water to maintain a "streambank community" with "cliff scrub and *Protea*" also in the cave vicinity (Harper 1994; A. Esterhuysen pers. comm.).

Layers EMA–BRE lie within the Howiesons Poort lithic industry phase, which was dated to 59 000 to 66 000 years ago (Cochrane 2003a). The charcoal assemblage indicates a continuity of environment during the accumulation of these deposits. This suite of layers has a low diversity of taxa. Esterhuysen (pers. comm.) proposes this may be a result of a lower diversity in the environment, which would be likely in cooler, drier conditions. Esterhuysen also suggests it may be an indication of drought in the region, during which time both the streambank and forest communities, evident in the previous layers, would not be as well supported. Although the streambank community may have been significantly reduced there is evidence for some water in the area because *Leucosidea sericea* is still present.

Assemblages from the upper Howiesons Poort (59.0 ±4.0 ka; Cochrane 2003a) and the post-Howiesons Poort deposits contained taxa that suggest a slight amelioration of the climate. This is evident through the return of some of the forest pioneers, and the streambank community, represented by *Leucosidea sericea*, is more prominent in the assemblage again (Harper 1994; A. Esterhuysen pers. comm.). This series of layers probably represents the majority of OIS 3 and possibly a small portion of the end of OIS 4, spanning some 30 000 years. Charcoal included in this grouping is from layer TOB in the first Harper excavation, upwards to layer Ge from the Wadley test pit excavation. Ge was initially dated to 31 600 BP. It is suggested that during this time, while glacial on the whole, conditions were a little warmer between the colder phases of OIS 2 and 4 (Harper 1994; A. Esterhuysen pers. comm.). Charcoal from the final MSA indicates a drier and cooler episode during which time vegetation was limited again. These layers accumulated towards the end of OIS 3 when temperatures were

cooling with the onset of the LGM. New dates for Rose Cottage Cave, presented by Cochrane (2003a), reveal that layers from TOB to Ge cover an extremely long time span. It is therefore possible that this grouping should be reinvestigated to establish whether vegetation environments changed within this period.

2.5. Summary

The evidence for global climate changes during this period is well known; however, the effects of these major climatic shifts are less well understood on a regional scale. I summarise the evidence for sites from the winter rainfall region and the summer rainfall region.

2.5.1. Winter Rainfall Region

The earliest environmental data comes from Klasies River in the Cape. During the Last Interglacial there was bushier vegetation and the sea level would have been at a similar height to the current shoreline. Climatic conditions may also have been similar to current conditions. Data for this period in the winter rainfall region are scarce because there are very few sites with deposits from the Last Interglacial.

The Last Glacial is better represented than the Last Interglacial period and it is now evident that many of the sites have deposits dated to the cold stadial OIS 4. Blombos MSA deposits accumulated before 70 000 years ago. The environmental indications are that the vegetation was grassier and wetter than it is today although there is evidence for a drying trend towards the end of the MSA occupation. The drying trend may coincide with the beginning of OIS 4. Die Kelders deposits show the same trend with grassland vegetation in the oldest deposits and a subsequent development of denser vegetation that may be indicative of warmer and drier climates. The macrofauna suggests that throughout this short MSA occupation the climate was colder than today and the area received more rainfall than at present. At each site

there is evidence for lower sea levels during OIS 4. At Oyster Bay and Die Kelders this is indicated by the presence of proxies for open grassland vegetation that could only have been present if the sea level was lower. These sites also provide evidence for fresh water environments, such as vleis, which are currently not present. Wetter conditions are also indicated at Boomplaas in the earliest layers, which may date to 80 000 years ago. A marine regression is evident at Klasies River between 50-60 000 years ago. This coincides with the Howiesons Poort occupation and the younger MSA III sequences. It appears, therefore, that although there is evidence for a drying and warming trend, it remains within the parameters of the glacial climates.

During OIS 3 after 50 000 years ago there is still evidence for moister conditions from Boomplaas Cave. However, deposits of this age have not been securely dated at this site. By 32 000 years ago shrubland had developed in the region. This suggests that conditions were drier. The interpretation also indicates that it may have been cooler, although without secure dates for the preceding occupation period it is not possible to know when it had been warmer. It is unlikely that it was warmer during OIS 4 and therefore it is possible that the older deposits may predate the cold stadial.

During the LGM, conditions were colder and grassland developed again. The Boomplaas data indicate that it was drier in this region. This is in contrast to the previous cold stage (OIS 4) during which time grasslands were prominent, but much of the evidence indicates the Cape region received higher rainfall than it currently does.

Elands Bay Cave has produced conflicting environmental signals for the region. The site has deposits dated to > 40 000 BP. Most sites in the Cape suggest that towards the end of OIS 3 and at the beginning of OIS2 conditions were significantly cooler and drier than in the preceding periods. At Elands Bay Cave, however, wetter conditions and less seasonal rainfall is indicated. This is evident through the presence of botanical remains that are unable to survive summer drought and also the presence

of taxa from afromontane vegetation in the current winter rainfall region. The fauna suggests that it was cool and wetter and that it may have been grassier. It is probable that the different proxies are providing evidence for a range of environmental niches during the last 40 000 years, which is why there is seemingly conflicting evidence for afromontane vegetation, riverine woodland and grasslands.

2.5.2. Summer Rainfall Region

The summer rainfall region encompasses a large area with distinct vegetation biomes and climatic conditions. This is particularly notable from east to west. It is therefore not unexpected that this region was characterised by varying climatic regimes in the past. Archaeological sites with palaeoenvironmental records for the Last Interglacial/Glacial cycle are scarce. There are very few cave sites with MSA deposits encompassing this period. Cave sites tend to provide the best stratigraphic control and in many cases preservation of environmental proxies is better than it is in open sites.

One of the most detailed records from an archaeological site has been obtained from Border Cave. Its relatively close proximity to Sibudu Cave makes it a good site for comparison. The record is particularly valuable because the MSA deposits contained a range of proxies, secure dates have been obtained for the sequence, and the environmental data have been reassessed in light of these new dates. The oldest MSA records at Border Cave provide evidence for wetter, warm climates. There is a drying trend towards the end of MSA I, although the area probably still received more rainfall and had higher temperatures than today. This warm, wet climate was present during the Last Interglacial. By the Howiesons Poort occupation grassland vegetation had increased. There is evidence to suggest that temperatures and rainfall decreased and the SAI increased. During OIS 3 at 40 000 years ago the region was still drier than at present and this continued towards the end of the MSA. The MSA to LSA transition is dated between 40-30 000 years ago, at which time the temperatures were

steady. However, rainfall continued to decrease and the SAI correspondingly increased.

The Rose Cottage Cave sequence supports the evidence from Border Cave. Between the pre-HP occupation and the final MSA the charcoal assemblage suggests dry climates, cooling during OIS 4 and again in OIS 2. At Rose Cottage Cave there was a slight amelioration during OIS 3 and forest was able to begin to develop. Cooler conditions are also evident from Port Durnford/Kosi Bay at 70 000 years ago and drier conditions are suggested at Voordrag at 100-95 000, 56 000 and 31-28 000 years ago. These dry phases coincide with the relatively cooler phase after the Last Interglacial, the end of the cold stadial (OIS 4) and the beginning of the warmer interstadial (OIS 3), and the onset of the LGM (OIS 2). Immediately following the Last Interglacial there is evidence for wetter conditions in Northern KwaZulu-Natal although this is not evident at all sites. During OIS 3 a combination of vegetation types are indicated at Nqutu and there is evidence for increased grassland before 41 000 years ago.

The evidence, presented above shows that climatic conditions were variable across southern Africa during OIS 4, 3 and 2. Although these sites all lie within the summer rainfall region they have quite distinct modern vegetation habitats and climatic conditions. Vegetation and climate would have varied considerably across this region in the past and some areas may have been affected by global climate change more than other areas. Nevertheless, trends can be extracted from this data indicating that, on the whole, the region underwent a significant period of drying after the Last Interglacial. This is indicated by periods of increased colluviation, evident at Voordrag (Clarke *et al.* 2003) in northern KwaZulu-Natal, and also by an overall drop in precipitation noted in the proxy rainfall record from the Tswaing Crater (Partridge *et al.* 1997). The Port Durnford Unit 2 sequence supports this interpretation, with an absence of pollen suggesting redistribution of sands occurred in the drier and cooler conditions. Approximately concurrent with this the micromammalian evidence from

Border Cave indicates that forest vegetation or thick bush was present and that the region may have been quite damp (Avery 1982b). This appears to contradict the evidence for drier conditions; however, it may have been a localised occurrence. The micromammalian fauna does indicate cooler temperatures.

Currently, the MSA deposits at Sibudu Cave and the layers from which charcoal has been analysed fall within OIS 4 and 3. By drawing upon a range of data types and researcher's interpretations of palaeoenvironmental conditions across South Africa, it will be possible to correlate the Sibudu Cave data, with the data summarised above. The following chapter focuses upon Sibudu Cave, its location, archaeology, and the palaeoenvironmental research being undertaken.

CHAPTER 3. SIBUDU CAVE LOCATION, EXCAVATIONS AND ENVIRONMENTAL PROXIES

3.1. Site Location and Archaeology

Sibudu Cave is located in KwaZulu-Natal, South Africa (Fig. 3.1). The site is situated in a sandstone cliff face overlooking the Tongati River and it lies about 40 km north of Durban, 15 km inland of the Indian Ocean and 100 m above mean sea level. The cave is about 55 m long and 18 m wide at its deepest point (Fig. 3.2). The cave is fairly open and it may be better to refer to it as a shelter; however, the original name has been retained for consistency in publications. Sibudu Cave formed as a result of erosion of the sandstone cliff face caused by fluvial action of the river. Downcutting, caused by glacio-eustatic sea-level changes, has occurred since the formation of Sibudu Cave. At present the river is about 20 m below the cave but in the past it would have been considerably higher. A series of different erosion events can be seen as small pockets within the cliff face. The largest erosion event formed Sibudu Cave.

The excavation is located in the northeast of the cave beginning 1 m from the cave wall (Fig. 3.2). Archaeological deposits contain Iron Age and MSA artefacts. There is no evidence for LSA occupation at the site.

In 1983 Aron Mazel excavated a 1 m deep test pit and obtained two ^{14}C dates (Table 3.1) for the MSA deposits. In 1998 Lyn Wadley began excavations at Sibudu Cave and since then there have been biannual excavations at the site. Initially a 1x2 m^2 trial trench (comprising B5 and B6) was opened. Further 1 m^2 grid units have been opened and the excavation now consists of 24 1 m^2 units. The trial trench is currently

about 2 m deep and the majority of the rest of the excavation is excavated well into the MSA deposits. MSA deposits consist of microstratigraphic lenses that are defined during excavation using texture, colour, sediment content and stratigraphic relationships. These lenses have been excavated within 50 cm^2 grid units and have been grouped into larger layers or members (Wadley and Jacobs 2004) on the basis of common characteristics. These larger stratigraphic layers are also defined during excavation. The stratigraphy at Sibudu Cave is shown in Figures 3.3 (a & b) and 3.4. I discuss the stratigraphy of the MSA layers shown in the North and East section walls of B5 and B6, focussing upon layers included in this analysis.

The oldest layers currently excavated at the site contain a Howiesons Poort (HP) lithic industry. These layers are labelled on Figure 3.3 (a & b). HP industries have been excavated at many MSA archaeological sites in southern Africa and they are defined by the presence of backed blades and segments. The Sibudu Cave HP assemblage contains segments made of dolerite, hornfels and quartz and may contain a higher proportion of blades than is found in other MSA layers, although this is an intuitive observation (Wadley & Jacobs 2004) that was made during excavation and artefact curation. At Sibudu Cave the HP layers lie between 1.4 and 1.8 m below the surface of the trial trench and the upper HP units date to about 62 000 years ago (Z. Jacobs pers. comm.). The lower layers may be older although this remains to be determined. At other MSA sites the industry has been dated to between 50 and 80 000 years ago and it is expected that all the HP layers at Sibudu Cave, which are overlain by deposits dating to 60 000 years ago, will fall within this range. The HP lithics are currently being analysed (Lyn Wadley, Paola Villa and Anne Delanges pers. comm.). Marlize Lombard is undertaking a microwear and residue study on segments and backed blades from the deposits. More detailed results of these studies and absolute dates are pending.

The HP deposits also contain bone, seeds and charcoal. Bone is very well preserved but other organic remains appear to be less well represented in the HP layers than

they are in the overlying deposits. Charcoal fragments were sampled from layers GS, GR2 and GR. GS is a homogeneous grey sandy deposit which contains very few rock-spalls, whereas GR2 and GR contain large quantities of cave rock. Each HP layer contained some well-defined hearths, although charcoal from these is not included in the analysis.

Overlying the HP layers there is a long sequence of post-HP deposits (Fig. 3.3). This sequence has been further divided to differentiate the final MSA layers (late post-HP), currently dated to about 35 000 years ago, from the early and middle post-HP layers, dating between about 60 000 and 50 000 years ago. In the charcoal analysis and interpretation I have divided these older layers into two groups on the basis of their OSL dates. Post-HP charcoal has been analysed from Eb, SPCA, BSp, RSp and OMOD (oldest to youngest) (Fig. 3.3). Dates for these and other layers at Sibudu Cave are provided in Table 3.1. Eb lies within a series of layers dated to 59.6 ±2.2 ka (OSL) and 57.0 ±2.3 ka (OSL) (Wadley & Jacobs 2004). SPCA is undated but layer BSp is dated to 56.7 ±2.3 ka (OSL). There is also an OSL date of 61.5 ±2.2 ka for layer Or which is lower in the stratigraphy than SPCA. Some of the dates in this section of the MSA sequence are reversed; however, when the error margins are applied it becomes clear that the dates are overlapping and thus it can be concluded that these layers were all deposited within a short occupation period between 60-55 000 years ago. Eb, SPCA and BSp are grouped as the early post-HP in the discussion (Chapter 8). RSp and OMOD are OSL dated to 53.4 ±3.2 ka and 51.8 ±2.1 ka, respectively. Layer MOD from the Mazel excavation was originally dated to 26 000 ±420 BP (PTA-3765). A recently obtained single grain luminescence date shows that MOD is in fact significantly older. It has been dated to about 50 000 years ago (Z. Jacobs pers. comm.). These three layers have been grouped as the middle post-HP.

The late post-HP layers are present in the eastern section of the excavation. Charcoal was sampled from Bu (Fig. 3.4), which has a date of 35.2 ±1.8 ka (OSL). The final MSA layers in the eastern section of the site contain some bifacially worked tools as

well as hollow based points (Wadley & Jacobs 2004). These were not found in the youngest MSA layers in the northern part of the excavation. This observation was initially postulated (L. Wadley pers. comm.) as evidence for the distinction between the east and north sections of the excavation, which has subsequently been confirmed through dating. Final MSA layers also contain more standardised MSA retouched artefacts including scrapers, bifacial and unifacial points and notches (Wadley & Jacobs 2004).

3.2. Modern Vegetation and Local Climate

Sibudu Cave lies within the Tongaland-Pondoland vegetation mosaic (Moll & White 1978). More specifically, it is situated on the boundary of the coastal and riverine ecozones (Grant & Thomas 1998) within the savanna biome (Low and Rebelo 1996; 1998) of southern Africa. There are various sources that document the vegetation for this region. The terminology used is variable between these sources. Low & Rebelo (1996; 1998) record the vegetation in the Sibudu Cave area as Coastal Bushveld-Grassland (Veld Type 23). To the west are their Veld Types 24 (Coast-Hinterland Bushveld) and 5 (Valley Thicket) (Low & Rebelo 1996; 1998). Veld Types 23 and 24 form part of the savanna biome, whereas Veld Type 5 is in the thicket biome (Low and Rebelo 1998). According to Acocks (1988) the vegetation around Sibudu Cave is Coastal Forest and Thornveld (Veld Type 1), to the north Valley Bushveld (Veld Type 23) extends along the river, and 'Ngongoni Veld (Veld Type 5) is also in close proximity to the site (Fig. 3.5). Acocks's (1988) Veld Types 1, 5 and 23 are roughly equivalent to Low & Rebelo's (1998) Veld Types 23, 5 and 24, respectively.

Local botanists Geoff Nichols and David Styles have compiled preliminary species lists for the vegetation in the immediate vicinity of the cave. These lists include woody species, with some of the smaller shrubs, vines and grasses also noted. Vegetation in the cave vicinity is diverse with over 140 species recorded; however,

this number may represent only a fraction of the vegetation that was present prior to the introduction of the sugar-cane plantations. At present the list is incomplete and members of the ACACIA programme add taxa to it on each visit to the region. The high diversity of vegetation is supported by a variety of growth conditions: from dry and shallow, well-drained soils on the cliffs, to wet poorly-drained soils in the river valley. Soils are predominantly sandy and are loosely consolidated. The area receives a high annual rainfall with about 501-750 mm in the summer months and about 251-375 mm during the winter (Grant & Thomas 1998). Average temperatures vary between 22-25°C in the summer and 17-20°C in the winter (Grant & Thomas 1998).

3.3. Local Geology and Lithic Raw Material Sources

Sibudu Cave lies within the Natal group sandstones which formed during the Palaeozoic. The sandstones were deposited at the same time as those of the Cape Supergroup, which is the dominant rock formation in the winter rainfall region of South Africa. The eastern and northern extent of this sandstone is in Natal. Dominant raw material types in the MSA at Sibudu Cave are hornfels, a metamorphic rock forming along contact points of igneous intrusions into shale, and dolerite, an intrusive igneous rock. Partially baked shale is exposed a few kilometres east of the site; however, this shale is not sufficiently metamorphosed to be considered true hornfels. Bedding planes are still evident, the shale is very soft, and it does not fracture conchoidally (pers. obs.). A likely source for the hornfels has been recorded at Verulam - approximately 30 km from Sibudu Cave (Fig. 3.6) - by the Geological Survey (G. Cochrane pers. comm.). Sources for the dolerite are clearer. A dolerite dyke crops out at the base of the cliff (Fig. 3.7) and dolerite cobbles that have been washed downstream are sometimes found in the riverbed. Analysis of lithics from RSp shows that hornfels and dolerite were obtained from several different raw material sources (Villa *et al.* in press). Cortex on MSA lithics indicates that cobbles

were collected from riverine localities, and blocks were removed directly from the outcrops (Villa *et al*. in press). MSA people also used blocks of hornfels and dolerite that had weathered off the outcrops (Villa *et al.* in press). Cortex on these suggests that they had not been transported far (Villa *et al*. in press). About 15-20 km inland of Sibudu Cave, sandstones give way to granite and gneiss (Fig. 3.6). Quartz, which is less common in the MSA, may have been removed from quartz veins within the granite (R. Maud pers. comm.). Quartzite artefacts are also present but uncommon. Quartzite is metamorphosed quartz-rich sandstone. This raw material is likely to originate from the quartzitic sandstones surrounding the cave. The locations of the different raw material sources suggest that throughout the MSA occupations people were routinely travelling at least 15 km to obtain good quality stone for manufacturing tools.

3.4. Sibudu Cave Research

Research on the MSA at Sibudu Cave aims to address questions concerning the activities undertaken at the site, site formation processes, and the palaeoenvironments in which the site occupants lived. Lithic analysis forms a large part of the research. Projects are wide ranging and include technological studies (Villa *et al*. in press; Wadley in prep), residue analysis (Lombard 2002; Wadley *et al.* 2003; Williamson 2004) and actualistic studies (Lombard *et al*. 2004; T. Hodgeskiss pers. comm.; L. Wadley pers. comm.). Taphonomic analyses of bone (Cain 2004; in press; Hanson in prep.; Wells 2003) examine evidence for the accumulating agents as well as providing detail about bone breaking and burning activities. Some of these studies are discussed in reference to site formation processes in Chapter 5. One of the research focuses at Sibudu Cave has been on obtaining palaeoenvironmental data. Preservation of charred organic remains is excellent and the suite of palaeoenvironmental proxies includes macro and microfauna, seeds and charcoal. Phytoliths and some pollen are also present although burning has not assisted in their

preservation. The results of preliminary studies are discussed below and are summarised in Table 3.2.

3.4.1. Fauna

Macrofauna has been identified by Ina Plug (formerly of the Transvaal Museum, Pretoria). Plug (2004) divided the MSA into three groups. These groups are final MSA (MOD layers), MSA below MOD (including BL), and lower MSA (below BL). At the time of analysis the lowest layer excavated was Y Mix (Mix Y) in B6 North wall (Fig. 3.3.a). That study focussed upon macrofauna, although some of the smaller faunal elements, such as birds and rodents, were also documented.

Plug (2004) found that many of the taxa present in the MSA may have been present in the region historically and some are present today. There are also some taxa that have not been unequivocally recorded in the region. Of these, some have been recorded elsewhere in KwaZulu-Natal. These include blue wildebeest, sable/roan, impala, and waterbuck which are found further north and red hartebeest, which is found in western-most KwaZulu-Natal.

The MSA layers below BL contain a less diverse range of taxa than is found in younger MSA layers. Large and very large bovids are dominant and some of these, such as *Megalotragus priscus* (giant hartebeest/wildebeest), *Pelorovis antiquus* (giant buffalo) and *Equus capensis* (Cape horse), are extinct. Of the small bovids, the klipspringer suggests the presence of rocky outcrops. Environmental indicators include giraffe, which is indicative of dry, savanna conditions, and hinged tortoise, which also requires warm, drier conditions than the region currently receives. Plug (2004) suggests the region could have had conditions similar to those in the eastern-lowveld of South Africa, such as are found in the Kruger National Park.

The second group of layers, below MOD to BL (Table 3.2), contain a great variety of taxa. Bovids are well represented and there are also some more unusual elements,

such as the scaly anteater, rodents, birds and reptiles. Crocodile indicates the presence of the river. This is supported by identifications of hippopotamus. The suite of fauna is similar to those in the final MSA layers but the extinct Cape horse, giant buffalo and giant hartebeest, which were present in the older layers, are still present here. Of these extinct taxa, only the giant hartebeest is present in the final MSA. Medium to large bovids are present, but the larger bovids are dominant. As in the previous layers, the giraffe and the hinged tortoise may indicate dry and warm savanna conditions. These layers contain some marine fish and molluscs, which suggest that the cave occupants were able to travel to the coast. These are not present in large numbers and thus indicate that marine resources were not exploited regularly by people at Sibudu Cave during this phase of the MSA.

The final MSA layers contain some primates and carnivores. Lion, which is previously absent in the MSA, has been identified in these layers. There are large mammals such as elephant, hippo and rhinoceros as well as a possible identification of giant hartebeest. Burchell's zebra is very well represented in these layers. Medium to large bovids are prominent and small bovids are rare. The bovid class representation is similar to the representation observed in older MSA layer groupings. The giraffe are now absent but the presence of hinged tortoise again suggests warm, dry environmental conditions.

Microfauna is currently being studied by Wayne Glenny. Results of this analysis are not yet available for discussion.

3.4.2. Seeds

Wadley (2004) has analysed the MSA seed assemblage. These seeds provide an indication of vegetation in the region. Seeds may become incorporated into archaeological contexts as a result of human activity and/or animal activity in the cave. They may be deposited in the cave in bird guano, they may be blown into the site, or they could have fallen from trees on the cliff face above the cave (Wadley

2004). The seeds in the site provide data on a range of vegetation habitats such as bushveld and forest as well as vegetation niches within these habitats, such as canopy species to understorey elements within a forest. Anthropogenic influences upon the seed assemblages are not as great as they are for charcoal assemblages and the seeds may originate from other agents, such as birds and monkeys. Wadley's (2004) presence/absence analysis documents the types of environment from which the taxa originate, as well as individual taxon requirements. Table 3.2 shows the layer divisions established in the seed analysis. I have excluded unburnt seeds from this table. The unburnt seeds are probably contaminants from Iron Age layers (Wadley 2004) where unburnt seeds are common (C. Scott pers. comm.).

Evergreen taxa are better represented in the seed assemblages than deciduous taxa. Many of these evergreen trees are able to tolerate dry conditions (Wadley 2004). YA is the oldest MSA layer from which seeds were analysed. It is one of the oldest post-HP layers. Seeds have been recovered from HP assemblages but have not yet been analysed. Layers YA to Ch2 are dominated by *Erythroxylum emarginatum* (Wadley 2004). *E. emarginatum* has been recorded in Krantzkloof Nature Reserve (Styles 2001) to the west of Sibudu Cave. This taxon is a forest component and may be found as an element of understorey vegetation in evergreen forests (Coates-Palgrave 2002). It is also found in Malawi on exposed hills at high altitudes (White 1978). Other taxa from these layers support the evidence for forest. There are also some taxa that are commonly found in drier conditions, such as *Ziziphus mucronata* and the *Ochna* sp., although the exact interpretation is dependent upon the *Ochna* species present. The *Ochna* seed is kidney shaped and is therefore either *O. pulchra* or *O. arborea*, which are the only two *Ochna* taxa with such a distinctly shaped seed (L. Wadley pers. comm.).

Seeds are less well represented in layers between Or and BSp (Wadley 2004) than they were in the older layers. These layers, centred on the OIS 4/3 boundary, contain

strong evidence for the presence of forest. The identified taxa in these layers are also very similar to taxa currently in the vegetation around Sibudu Cave (Wadley 2004).

Erythroxylum emarginatum is absent from layers above BSp. YSp to RSp contain both evergreen and deciduous taxa. The identifications suggest a range of vegetation types including riverine fringe vegetation (*Phoenix reclinata*), forest (*Celtis mildbraedii* and *Rhoicissus rhomboidea*), forest margins (*Acacia* sp. and *Ochna* sp.) and Bushveld (*Ochna* sp.).

Wadley (2004) notes that deciduous taxa become more prominent in the assemblage above layer RSp (with the exception of OMOD). Layers OMOD2-BL to BMOD mark the beginning of this change. With the exception of the *Ochna* sp., however, all of these taxa can be found in the modern vegetation in the Sibudu Cave region.

OMOD contains only evergreen taxa. Wadley (2004) suggests that the taxa that are present and the absence of deciduous species, may provide supporting evidence for a wet phase at about 50 000 years ago as has been recorded elsewhere. MOD, also dated to about 50 000 years ago, contains some evergreen forest taxa that were absent in the younger layers Ore2 to Co. Overlying layers may date to the end of OIS3 and the taxa represented in Ore2 to Co (Fig. 3.4) may provide evidence for the onset of dry and cold conditions associated with the LGM of OIS2. The seed identifications from these layers are limited; therefore, this can only be suggested at present. OSL dates for these layers will help clarify whether these are all final MSA layers and whether they should be grouped or kept separate. This will have bearing upon the interpretation of the identified taxa in these layers.

3.4.3. Phytoliths

Phytoliths have been analysed as part of a sedimentological study to establish the presence and composition of burning episodes at the site. The study also aimed to resolve queries concerning the origin of some minerals - such as gypsum - found in

the archaeological deposits. Schiegl *et al.* (2004) documented the mineralogical contents of archaeological samples from hearths, sediment matrix, and one almost sterile MSA deposit. The layers sampled are included in Table 3.2. When analysing the sample contents Schiegl *et al.* (2004) noted whether the samples were composed of wood ash and grass phytoliths (Type I) or whether they contained wood ash (Type II) only. It might be expected that hearth contexts are likely to contain wood ash because it can be assumed that woody taxa were burnt, forming these contexts. Other contexts, such as sediment matrix, may be more likely to contain a combination of phytoliths originating from a variety of sources, such as grass blown into the cave or brought in for bedding, as well as phytoliths from food sources, such as fruits, and some wood phytoliths. The wood phytoliths would probably be present in lower proportions. Some of the samples analysed do support this theory; however, many of the sediment matrix samples contain only wood ash phytoliths and some hearth contexts contain both wood ash phytoliths and grass phytoliths. To gain a more detailed understanding of the relationship of phytolith types and archaeological contexts, it would be necessary to carry out a spatial study on samples from a range of contexts across archaeological horizons. The current study (Schiegl *et al.* 2004) provides intra-specific detail for samples from a small area within BSp. In BSp there are Type I and Type II sediments within a single hearth structure. It can be hypothesised that grass was used in the fire - perhaps as kindling - or it was accidentally incorporated into the fire.

3.4.4. Pollen

Fifteen samples were taken from the stratigraphic section of the North and East wall of the trial trench. These samples were removed from a range of contexts, including layers that had been noted during excavation as being highly burnt and layers with relatively little evidence for burning. All of the samples contained organic material but in many of the samples the organics could not be identified (R. Renaut pers. comm.). Bacterial or fungal decay was noted as a possible explanation for this (Renaut & Bamford 2003). Burning is fairly extensive at the site and this may also

have hindered preservation. On the one hand, burning activities at the site assist in preserving organic remains such as seeds and wood, but on the other hand these episodes of burning prevent good preservation of pollen and, to some extent, phytoliths.

Eight of the 15 samples contained very small quantities of identifiable pollen (Renaut & Bamford 2003). All of the taxa present can be found in Coastal Bushveld-Grassland (Renaut & Bamford 2003). Renaut & Bamford (2003) concluded that no detailed or meaningful palaeoenvironmental data could be obtained from these small data sets; however, it is interesting to note the co-occurrence of *Acacia* sp. in the pollen and seed samples from layers dating to between 60 and 50 000 years ago. Pollen identifications also provide evidence for some additional vegetation types in the region such as grasses and ferns. Seed or charcoal studies could not provide evidence for these types of vegetation. The pollen thus assists in developing a more comprehensive image of the vegetation near Sibudu Cave during the MSA.

3.5. Summary

A multidisciplinary approach is being used to study the evidence for palaeoenvironments and changes in these environments through time. There are several major trends that can be seen in the palaeoenvironmental proxy data. It is clear from the faunal remains that the site occupants were able to travel to the coast because marine fish and mussels have been documented in layers dating to about 62 000 years ago, although marine resources were not exploited frequently, as is evidenced by their small quantities. It is apparent that the site occupants also travelled to obtain raw materials, in particular the hornfels that is frequently used for manufacturing lithics. The seed and fauna assemblages contain taxa from warm, dry environments. Some of the identifications, such as giraffe and *Ochna* cf. *pulchra,* are only found further north in South Africa today. *Acacia* species are noted in small

numbers in MSA layers dated to between 60 and 50 000 years ago. Giraffes commonly live in areas with *Acacia* species and this is one of their primary foods. Large bovids are prominent throughout the MSA assemblage. Some of the large bovids that were hunted are now extinct. Small bovids are particularly poorly represented in the MSA at Sibudu Cave. Seeds and fauna such as hippo, crocodile, *Phoenix reclinata*, *Harpephyllum caffrum* and *Asparagus* sp. provide evidence for the presence of the river throughout the MSA.

These data will be considered with the evidence from the charcoal analysis in Chpaters 8 and 9.

CHAPTER 4. SAMPLING STRATEGIES AND ANALYTICAL THEORY

4.1. Introduction

The results and interpretations of a charcoal assemblage are highly dependent upon the methods used during excavation, curation and analysis. This chapter has been structured around two important components of charcoal analysis: Sampling Strategies and Analytical Theory.

Complexities of sampling, whether archaeological or non-archaeological, are considered first. The focus here is to isolate stages of sampling that contribute to, or detract from, the charcoal assemblage during its accumulation, deposition and subsequent excavation and analysis. Methods frequently used in archaeobotanical studies are discussed. The final part of the chapter presents and discusses charcoal analysis methods and their associated problems. I discuss the merits of qualitative and quantitative approaches to analysis in related studies and I examine the progression of the discipline.

4.2. Multiple Stages of Sampling

Charcoal that is incorporated into an archaeological site is affected by human activities as well as natural events. In some instances, accumulation processes are almost entirely independent of each other and can be easily distinguished. Hearth contexts provide charcoal that has almost certainly been collected for burning. The process of accumulation is thus human. A lens with little evidence of human

occupation other than charcoal may be a result of a natural fire passing through the site and burning the existing ground cover. Charcoal accumulation in this circumstance is clearly a result of natural processes and events. In other circumstances, for example in sediment matrix when charcoal is scattered with artefact remains, it is not possible to recognise agents of accumulation. Although in many instances humans are the most likely producers of charcoal in an archaeological assemblage, natural processes cannot be ruled out entirely. In most sites the environmental influences and the culturally determined selection of woody taxa are entwined to such an extent that it is impossible to separate the two when interpreting the data. This does not preclude the possibility of at least partial vegetation reconstructions, and postulations can be made about the nature of the palaeoclimate during occupation periods.

Wood undergoes a series of processes beginning with initial accumulation by the site occupants and ending with the selection, by archaeologist, of a sub-sample of charcoal from the assemblage. The processes can be divided into four broad divisions that separate the parent population, from which the assemblage is derived, and the final sub-sample that is analysed (Fig. 4.1). These processes have been outlined using theoretical models in the charcoal literature (for example Ford 1988; Popper & Hastorf 1888; Smart & Hoffman 1988; Dincauze 2000). In general, these models are used to establish the processes that significantly affect charcoal assemblage composition and all such models help to highlight complexities inherent to analysing charcoal. The stages of selection are quite easy to define on a theoretical basis but recognising different selection processes archaeologically is more difficult. Dincauze's (2000) model and corresponding discussion show that there may be loss of information at each selection stage. Such loss equates to the true representation of the original parent population being diminished and thus the sub-sample may bear little resemblance to the original parent population. It is shown in Fig. 4.1 that sections of the sampling process can be controlled and loss of information minimised.

Sampling bias is not a problem unique to charcoal assemblages; it also applies to seeds, fauna or other artefact classes found in archaeological sites.

Below I highlight some of the factors contributing to the accumulation of charcoal assemblages as well as those that detract from or change the assemblages. I focus on discussions that are directly relevant to the Sibudu Cave charcoal analysis.

4.2.1. Sampling Agencies for Archaeological Charcoal Assemblages

Wood collected to produce fire for heat, light and cooking is of prime importance (Archer 1990) and wood accounts for the largest quantity of plant material used by communities without electricity or access to other energy sources in southern Africa today (van Wyk & Gericke 2000). Various studies have shown that on a daily basis an average of about 15 kg of wood is used to make fire for a variety of household tasks (Archer 1990; Liengme 1983). It is likely that at least as much wood was used in the past. In many areas of southern Africa the danger from predatory animals was greater in the MSA than it is today; therefore, it is possible that more wood was used in order to maintain a fire throughout the night. In addition, wood may have been brought to a site for manufacturing hafts. These hafts may have been discarded and incorporated into fires. It is unlikely, however, that they are very visible in the archaeological record because if burnt they would fragment and amalgamate with other wood charcoal. MSA sites in southern Africa do not provide evidence for use of structures, and therefore the use of wood for tasks other than creating fire was probably minimal.

Humans can be considered the prime agents bringing wood to archaeological sites such as caves or rock shelters. This is because they are relatively closed environments and vegetation ground cover is often sparse. There is less potential for charcoal to be introduced as a result of veld fires in closed sites than there is at open sites. In addition to the risk of veld fires at open sites, burrowing animals can transport charred material within, into, or out of archaeological contexts (Wood & Johnson

1978; Smart & Hoffman 1988). For environmental interpretations it may be preferable to analyse charcoal from burrows, veld fire lenses or charcoal removed from beneath existing forest floors (February 2000) because the data may provide a less biased view of the local vegetation than could be gained from an assemblage that is a result of human selection (Smart & Hoffman 1988). Unfortunately, it is exceedingly rare to find non-humanly influenced sites with long sequences of environmental data, both of which are favourable for palaeoenvironmental reconstruction.

Even though humans are the prime accumulators of charcoal in archaeological contexts, the natural environment plays a large role in determining what is available to be incorporated into the deposits. These environmental influences may be visible through taxon representation in the assemblage, thus enabling the analysis of environmental change.

4.2.1.1. Wood selection

Proximity, accessibility and the purpose for which the wood is intended are also likely to influence wood collection. Fuelwood, hafts, and building materials are selected by modern communities using certain criteria because they are intended for tasks requiring specific wood properties. This is likely to be true of past communities as well as modern communities. In addition, social factors may play a role in influencing the collection of wood. Each factor is discussed with reference to examples from ethnographic studies and suggestions of how these may be recognised archaeologically are put forward.

Abundance of wood types varies significantly between biomes and communities. It was assumed in early charcoal studies (Salisbury & Jane 1941; Hadac & Hasek 1949) that the proportions of woody taxa brought to a site could be directly correlated to the abundance of taxa in the natural environment. If correct, this assumption would have allowed for a direct reconstruction of the vegetation and environment. The

assumption is flawed; however, because it places too many constraints upon the actions of people and their mobility within the environment (Esterhuysen 1996). Ethnographic studies provide strong evidence for preferential collection of some woody taxa over others (Archer 1990; Nicholson 1981; Neumann 1999). Early charcoal studies also assumed that proximity of fuelwood resources to a site played a large role in determining the composition of archaeological charcoal assemblages. It was theorised that people would have collected wood closest to the site, in preference to travelling further from the site to collect wood. Both assumptions are part of the principle of least effort (PLE) which stemmed from a hypothesis proposed in physics in the early 1800s (Esterhuysen 1996). In the early 1900s it was adopted to support hypotheses regarding physical behaviour (Esterhuysen 1996). Researchers have since suggested that the second assumption is also problematic (Tusenius 1986; Shackleton & Prins 1992; Esterhuysen 1996) and it is recognised that cultural preferences as well as availability may lead people to travel further for wood. Proximity of suitable wood sources also varies significantly from one site to another, adding a further source of inaccuracy. Although people do travel to acquire specific wood types this is seldom for fuelwood. More commonly, people will travel large distances for special wood types used for ritual purposes (Nicholson 1981; Smart & Hoffman 1988). The distinction between the two may not be clear once charcoal is accumulated in the archaeological sediments. Nonetheless, ethnographic studies have highlighted some general rules which are fairly common to fuelwood collection in modern societies in southern Africa.

Dead wood is preferred for fuel (Prior & Tuohy 1987) because it burns more effectively and with less smoke than fresh or wet wood. The yield of dead wood varies between taxa (Shackleton & Prins 1993) and therefore preferred wood types may be present, but dead wood may not be available at all times of the year. Archer (1990) noted that of the favoured fuelwood in her study region, *Acacia karoo* and *Rhus undulata* have significantly higher dead wood yield than another favoured taxon, *Datura stramonium*. Thus dead wood yield may influence collecting strategies

by determining which trees were routinely available to be utilised. This may have been especially important if the site occupants were semi-sedentary and aware that their local source of dry wood could become depleted over time. In addition, wood may be cut and stored before it is brought to the site (Shackleton 1993). This type of collecting strategy tends to be employed when there are insufficient fuelwood resources (Prior & Tuohy 1987), such as when population size in a region is large enough to place pressure on the available resources. Wood and other dry vegetative matter is sometimes collected from the ground, although this random collecting strategy (Archer 1990) is predominantly used for acquiring kindling.

Identifying these patterns archaeologically may be difficult but it is possible to speculate the effects of such collecting strategies upon the archaeological assemblage. First, gathering wood from the ground may create a bias in the record towards smaller branches or even small taxa such as understorey shrubs. Secondly, collecting dead wood from trees may produce a bias towards larger branches, because larger trees tend to have a higher dead wood yield than smaller ones (Mudekwe 1997).

There is abundant literature documenting that some wood types are avoided as fuel while others are preferentially collected. *Spirostachys africana* is an example of a taxon that is routinely avoided (Pooley 1997; van Wyk & van Wyk 1997; van Wyk & Gericke 2000; Coates Palgrave 2002). It burns with a noxious smoke causing headaches and even nausea (Pooley 1997; van Wyk & Gericke 2000). Archer (1990) found that firewood was often distinguished on the basis of its properties. For example, kindling and tinder are distinguished from fuelwood, while bad fuelwood is avoided altogether. In this instance bad firewood encompasses taxa that produce noxious fumes or smoke, and/or they do not create good coals for extended burning (Archer 1990). Fuelwoods that are commonly collected in southern Africa include *Acacia* spp., *Rhus* spp., *Combretum* spp. and *Erica* spp. (Archer 1990; van Wyk & Gericke 2000). These wood types all burn very well and for extended periods.

Cultural beliefs are particularly difficult to infer from charcoal assemblages especially when modern analogies are not available. It is possible to impose patterns, noted through ethnographic studies, onto the archaeological data if use/avoidance is primarily governed by obvious properties of the wood, but this should be done with extreme caution. Cultural fuelwood collection practices may be highly dependent upon physical properties but this is not always the case. Neumann *et al.* (1998) noted that archaeological charcoal from Saouga in northern Burkina Faso contained some taxa that were not included on a list of favoured fuelwoods compiled for the region by Von Maydell (1983). It had been expected that taxa in the archaeological charcoal and taxa on the list would have been comparable if the wood brought to the site was utilised as fuel. This find suggests that fuelwood collection may be relatively haphazard although, when asked, people will list wood types that they prefer to use. This does not mean that other types are never collected or that they would never become accidentally incorporated into a bundle of firewood. This point can be further illustrated with the results of a study carried out in KwaZulu-Natal (Ellery *et al.* 2000). The community was asked which wood types they preferred, used and avoided as fuelwoods and for manufacturing structures or objects (Ellery *et al.* 2000). *Spirostachys africana* was listed as "avoided" in both the fuelwood and structure manufacturing species lists; however, it was also listed in the structure manufacturing list as a "less commonly used" wood (Ellery *et al.* 2000). It is often not clear what drives cultural practices and in many circumstances more than one factor is likely to influence wood selection. There is therefore little basis for imposing modern practices upon data obtained from MSA archaeological sites.

4.2.1.2. On Site Sampling Processes

Selection processes continue to alter the assemblage composition at the site after the initial phase of wood collection. Human selection could have assisted or prevented the wood from being burnt and becoming preserved. A flow chart (Fig. 4.1) is used to show that there are two potential points of information loss at this stage. First, wood may be burnt completely, producing ash rather than charcoal. Second, wood

may not be burned at all, in which case it is unlikely to survive unless waterlogged or desiccated (Dimbleby 1967; Miksicek 1987; Dincauze 2000).

Charring can occur deliberately or accidentally (Neumann 1999). Deliberate burning refers to any wood that was intentionally burnt, whether as fuelwood or for another purpose. Accidental burning may occur if structures catch fire, or if material collected for another purpose becomes unintentionally incorporated in the fire. For example, it is possible that objects such as hafts or bedding materials caught fire accidentally. Such small-scale accidents may not be visible archaeologically and are mentioned only to display the potential for variability in the assemblage. Bedding, which may have consisted primarily of grasses and forbs (Wadley 1979), may be more apparent through phytolith studies than through charcoal analysis.

Charcoal will only be produced when there is a lack of oxygen within the fire, which prevents complete combustion from occurring. The heat each piece endures, its location within the fire as well as its resin content, moisture content and specific gravity, may also affect this process. Production of charcoal is in essence haphazard and therefore it is impossible to predict the quantity of charcoal that will be produced in a fire. Regardless of the nature of the study (environmental of cultural), this has a significant effect upon archaeological sampling strategies and analysis procedures that can be used. This will be discussed in greater detail below.

Once the wood is burned, and the site abandoned, a series of factors continue to influence the assemblage (Fig. 4.1). Post depositional trampling may cause further fragmentation although this depends upon the amount the site is used and rates of sedimentation subsequent to assemblage deposition. Trampling results from human and animal activity at a site. It is well documented that bones in archaeological deposits become fragmented if deposits are significantly trampled (Olsen & Shipman 1988). Charcoal would also be affected by trampling; however, this disturbance may not be as easy to recognise. Sediment compaction during later occupation periods

may result in further in situ charcoal fracturing. Other natural processes include water disturbances (Wood & Johnson 1978) caused by flooding or springs flowing through a site. The effects of such disturbances are often observed during excavation by noting the distribution and orientation of bone or lithic artefacts (Schick & Toth 1993) or through sedimentation patterns. Charcoal is easily floated by water but it may not be easy to detect small disturbances because the fragments tend to have an amorphous shape and show no preferential orientation. Significant water flow would probably remove charcoal fragments altogether. Dated charcoal fragments from two sites in northern Burkina Faso illustrate the need for caution when analysing charcoal from loose aeolian derived sediments (Vogelsang 1996; Neumann 1999). Dates ranged over 8000 years and 6000 years for charcoal fragments that had been removed from the same stratigraphic context within each of the sites.

Charred wood is relatively resistant to chemical weathering processes (Dimbleby 1967; Leney & Casteel 1975) and, therefore, although the charcoal will be rendered physically fragile, the fragments will not be altered chemically once charred. Most significant physical changes occur during charring. As wood dries it shrinks and further shrinkage occurs during charring. Based on experimental studies, Scholtz (1990) documented that shrinkage of about 25% is common and that the proportions of internal structures did not change in relation to one another. It has been recorded that shrinkage is variable between taxa and is dependent upon wood anatomical features, such as vessel distribution (Rossen & Olsen 1985). Preservation and fragmentation may also be dependent upon moisture content, the presence of gums and resins, as well as the temperature and duration of charring.

Prior and Alvin (1983; 1986) documented some of the structural changes that occurred in *Dichrostachys* and *Salix* during charring. Their study showed that certain wood anatomical characters were more prone to the effects of charring, while also illustrating that some taxa, in this case *Dichrostachys*, may be affected more than others (*Salix*). Some characters, including rays, were altered in both taxa and others

such as fibres were only significantly altered in *Dichrostachys* (Prior & Alvin 1983). The authors concluded that moisture content and chemical makeup were important factors in determining the effects of charring (Prior & Alvin 1983).

4.2.1.3. Archaeological Sampling

This stage of sampling can be controlled by archaeologists and charcoal analysts and thus information loss can be minimised. Archaeological sampling encompasses selection processes that occur during excavation, sorting, curation and sub-sampling prior to analysis. There are two main aims of archaeological sampling. The first is to produce a representative sub-sample of a manageable size when time and cost constraints are taken into consideration (Orton 2000). It is rarely possible, nor ideal, to analyse all charcoal recovered from a site or even from a layer within the site. The second aim is to ensure that the sample does not introduce further unnecessary bias into the analysis (Orton 2000). There are some common techniques used to obtain a representative sample and also to minimize loss of data or the introduction of bias. In general, the procedures employed are very much dependent upon the questions being asked of the data. Many of the methods discussed here have been published in reference to sampling other archaeobotanical remains, although they are also applicable for sampling charcoal.

Excavation and Sieving - It is often possible to remove charcoal fragments during excavation. To maximise recovery, flotation or dry sieving can be used (Wagner 1988). Flotation may be particularly useful at sites with relatively small charcoal fragments, where abundance is low, or when sediments are wet or consolidated; however, for many sites dry sieving is sufficient if a fine mesh is used. Large mesh sieves will bias the sample (Wagner 1988) towards larger fragments and may lead to a bias in the taxon representation if small taxa and shrubs are eliminated. During dry sieving, large and heavy artefacts such as lithics should be removed to prevent further fragmentation of charcoal.

Sampling in the laboratory - The following methods are commonly used to acquire a sub-sample. Some of these are more effective than others at reducing the introduction of bias. Sub-sampling is used to acquire a sample of adequate size and to target certain features or periods of occupation in order to answer specific research questions. The sample must be representative of the assemblage as a whole and the sampling method used must eliminate or reduce any potential for the introduction of bias.

Sub-sampling can be divided into two levels. First, it is necessary to decide whether material excavated from a certain section of the site will be analysed or whether the sub-sample will encompass material from across the entire site. It may be better to analyse charcoal from the sediment matrix rather than from contexts that may have been strongly influenced by a specific event, or series of events. For this reason hearth features should be avoided unless the analysis is being used to study fuel use or the relationship of one hearth feature to another, for example. The regions of the site to be sampled may be chosen randomly or may be selected for a specific purpose. The size of the sub-sample is often determined by time and cost constraints. Sub-sampling criteria should be outlined and justified for each individual study.

The second sub-sampling level is used to obtain the charcoal that will be analysed. The most effective methods of acquiring a sub-sample use random sampling, whether with randomly generated numbers (Orton 2000) or a riffle box (van der Veen & Fieller 1982). Both of these methods eliminate the possibility of subconscious bias being introduced to the sub-sample (van der Veen & Fieller 1982). It is also possible to take a graded sample. In this method the assemblage is divided into different size categories using graded sieves and random samples are then selected from each category. This type of method ensures equal representation of different size classes. Another frequently used method is grab sampling. This technique can introduce significant bias into the sample being analysed because the procedures used are rarely standardised (van der Veen & Fieller 1982). It is also often difficult to gain an

indication of how representative a sub-sample is of the assemblage from which it was selected (van der Veen & Fieller 1982). Grab sampling should therefore be avoided.

Cumulative sampling (van der Veen & Fieller 1982) incorporates random sampling and is generally used to assess how representative the sample is during the analysis. Initially the assemblage is divided into smaller samples using random sampling procedures; a sample is then analysed and the results plotted to produce a cumulative curve. This procedure is repeated until the cumulative curve produced indicates that the sample is representative of the assemblage as a whole. A cumulative curve that levels off will reveal when the optimum number of taxa have been found. Whether using cumulative sampling or not, cumulative curve plots can be useful for acquiring a rough indication of the sample size required (Smart & Hoffman 1988). Analysts also suggest that cumulative curves must be produced for each sample being analysed because it cannot be assumed that an adequate sample for one layer, context or site will be adequate for all analyses (van der Veen & Fieller 1982; Smart & Hoffman 1988). The use of cumulative curves for assessing sample adequacy in charcoal analysis is considered further in Chapter 5.

4.3. Analytical Theory

An appraisal of two theoretical approaches to analysis is provided below.

4.3.1. Qualitative versus Quantitative

Two approaches to charcoal analysis - qualitative and quantitative - are frequently referred to in the anthracological literature. The former is a descriptive approach to data interpretation, while the latter makes use of statistical queries to recognise patterns within the data that may not be immediately obvious to the analyst. Whether using qualitative or quantitative analyses several assumptions must be made about the data. First, for both approaches it is necessary to assume that modern plant

requirements, such as access to light and water, were similar, if not the same, in the past. The second, closely related assumption is that vegetation communities present today were also present in the past. This is in turn linked to the hypothesis that ecosystem composition has not significantly changed. The results of palaeoecological and palaeobotanical studies support the use of these assumptions because they show that plant communities as they are today originated in the Neogene (Scott *et al.* 1997), between 24 and 1.8 million years ago. A cautionary note made by February (2000) is that some taxa are able to grow in a wide range of environments and climates (including temperature and rainfall). February (2000) offers the example of *Podocarpus* species, which can grow in areas with high or low rainfall, from 1900 mm down to about 150 mm per annum. For this reason, single identifications should not be relied upon to determine the climate; it is better to use combinations of taxa. It is also important to consider effective moisture levels rather than precipitation alone.

The benefit of a qualitative or descriptive approach is that vegetation community data can be used in addition to information concerning individual taxon requirements, without relying upon percentage frequencies of taxa. Interpretation utilises combinations of indicator species to provide information concerning the growth conditions, associated vegetation and climate in the site vicinity during occupation. This method is often referred to as a presence/absence analysis. For example, the presence of a pioneer taxon may indicate the development of the vegetation type in which it is commonly found.

Due to problems inherent in all archaeological studies, little importance should be placed upon the absence of taxa. It may in fact be more appropriate to refer to this type of analysis as a "taxon presence analysis". Sudden absences of taxa, present in all other deposits, may be related to environmental change although their absence may also be due to change in cultural selection, taphonomic processes, or any permutation of these factors. Taxa groupings may be useful in establishing this.

In contrast, quantitative methods make use of the percentage frequencies of taxa as well as presence/absence data. Most early charcoal studies made the assumption that taxa in an assemblage reflect the population from which it was derived. It has already been mentioned that researchers initially did not question this assumption and interpreted percentage frequencies of taxa as an indication of their frequency in the surrounding vegetation (Salisbury & Jane 1941; Hadac & Hasek 1949). Thus, changes in frequency were interpreted as changes in the parent population, which could then be related to climate, the development of agriculture, and so on. In other studies the relationship was questioned (Goodwin & Tansley 1942) and researchers began to look for favourable approaches to analysis. Actualistic studies were carried out in an attempt to quantify the processes producing charcoal assemblages (Prior & Alvin 1983; Rosen & Olsen 1985). Interestingly, in recent literature there has been a return to the use and support of quantitative procedures (Piqué & Barcélo 2002), and some analysts suggest that "large enough" charcoal samples will provide an indication of the proportions of taxa in the environment (Badal Garcia 1992, Figueiral 1992). The accuracy of this assumption is dependent upon the amount and type of selection that has influenced the assemblage and this should be assessed for individual sites, rather than applying blanket procedures to all charcoal studies.

Statistics are primarily used to assist with finding patterns in the data, while interpretations rely upon knowledge of the modern vegetation communities, and conditions that give rise to these communities. Instead of relying on direct associations between taxon frequency in the sample and frequency in the environment, researchers look for trends in the data and for common influences that may have resulted in fluctuations in the taxa being brought to or preserved at the site. Statistical procedures such as factor analysis and correspondence analysis are often used to find these patterns in the data. In addition, many anthracologists now make use of graphing programmes, such as Tilia graph. This programme is more traditionally used for pollen analyses. Once patterns have been found it is then the

responsibility of the analyst to interpret these as accurately as possible by researching potential factors that could be responsible for producing the observed trends. These influences may be environmental, cultural or taphonomic.

4.4. Summary

The above discussion has highlighted some of the problems with charcoal analysis and interpretation, while also presenting some of the methods most often used to overcome these problems. The most important points are summarised here. First, sampling must be controlled where possible to minimise introduction of bias. Where this is not possible the excavator and/or analyst should note any evidence for origins of the charcoal, its context, association with other artefacts, and any obvious post-depositional disturbances that may bias the sample. Secondly, charcoal can provide a view of the palaeovegetation and the wood collecting habits of the site occupants. Where possible, taxon identifications should be interpreted in combinations rather than independently of one another. This type of approach will assist in obtaining a broader and more accurate view of palaeovegetation, climate and cultural practices. Thirdly, to assist the interpretation further, charcoal data is interpreted best when combined with palaeoenvironmental or cultural data from other proxies. Interpretations tend to be more accurate when based on multidisciplinary studies because the data provide a broader view of the palaeoenvironment, including vegetation, fauna, and climate.

The origins and influences upon a charcoal assemblage may be complex but it is possible to isolate some of the sampling stages the woody taxa have been subjected to before being excavated by archaeologists. It is apparent from the above discussion that the methods used for analysing charcoal assemblages may vary from one site to another depending upon the questions being asked of the data and the accumulation processes that contributed to the composition of the archaeological assemblage.

The following chapter presents materials and methods used to analyse the MSA assemblage from Sibudu Cave.

CHAPTER 5. SAMPLING, CHARCOAL IDENTIFICATION AND ANALYTICAL METHODS

5.1. Introduction

In this chapter I focus on the materials and methods used for sampling, identifying and analysing charcoal from Sibudu Cave. Comparative collections, their development and composition are considered in the context of southern African charcoal studies. A description of the University of the Witwatersrand collection is given, with particular reference to anatomical characters that are used for identification. This section also includes a discussion of the processes used to identify charcoal and the methods used for recording character data. Finally, the analytical methods chosen for this analysis are presented.

5.2. Sibudu Cave Charcoal Assemblage

5.2.1. Sampling Procedures

In this section I discuss some of the sampling processes, whether cultural or natural, that have contributed to and/or detracted from the Sibudu Cave charcoal assemblage.

5.2.1.1. Wood Selection

It has already been mentioned in Chapter 3 that charcoal is abundant in most MSA deposits excavated thus far at Sibudu Cave. Sedimentological and faunal evidence suggests that burning frequently occurred at the site. In some instances, this evidence takes the form of discrete hearths containing burnt bone, lithics and charcoal; while in other contexts, charcoal, ash and burnt sediments are scattered through the deposits.

Wood use is also indicated by the presence of points in the lithic assemblage, which can be considered proxies for hafting. In addition, residues found on many of the Sibudu Cave tools suggest extensive plant processing (Williamson 2004); however, this cannot necessarily be attributed to working woody plants, unless woody structures are observed. There is no other evidence for wood use in the MSA layers, although this may be related to visibility in the archaeological record rather than to actual wood use at the site.

5.2.1.2. Post-depositional Influences

Evidence for post-depositional disturbance at Sibudu Cave appears to be minimal. Taphonomic processes are being studied through various mediums. Schiegl *et al.* (2004) studied the phytoliths (discussed in Chapter 3) and mineralogical composition of sediments at Sibudu Cave to determine evidence for site formation processes. Sediment composition at the site suggests that many of the minerals could have been derived from plant ash or from decomposition of bone (Schiegl *et al.* 2004). Non-humanly introduced sediments of quartz and clay are local in origin. Schiegl *et al.* (2004) suggest that there may be evidence of sediment disruption in the form of ash scatters. Evidence for this disruption was observed during excavation and has been confirmed through microscopic analysis of samples (Schiegl *et al.* 2004). The ash scatters could be a result of trampling (Schiegl *et al.* 2004), cleaning of the hearths, or wind movement, after deposition.

Cain (in press) has studied the taphonomy of the Sibudu Cave macrofauna assemblage. The results of that analysis show that natural disturbances such as water movement and wind action have had little effect upon the bone. Bones in the MSA deposits are highly fragmented and burnt. The majority of the assemblage has been fractured prior to burning, suggesting that trampling was insignificant. The disturbances or ash scatters noted by Schiegl *et al.* (2004) are probably a result of re-deposition of hearth contents after being "swept out" (Cain in press) for hearth

maintenance. Percussion marks on the bone provide additional evidence for humans as the prime bone-altering agent.

Towards the back of the cave, in squares C2, D2 and E2 (Fig. 3.4), sediments in layer RSp are significantly thicker than they are in grid squares across the rest of the site. RSp is also artefact rich. This may indicate that the back of the cave was used more than sections further from the cave wall, or it may reflect natural sediment accumulation processes. Interestingly the late post-HP layers, above MOD, were only present in this section of the site. This also leads one to suspect a different pattern of use and/or accumulation towards the back of the cave.

5.2.1.3. Archaeological Sampling at Sibudu Cave

Excavation and Sieving - All excavated deposit is dry sieved through a 2 mm screen. Flotation has not been used because the sediment is very dry and rarely adheres to the artefacts. Residues on lithics may be lost during flotation and wetting bone can cause damage that is likely to hinder long term curation. During the 2003 and 2004 field seasons a finer 1 mm mesh was nested within the 2 mm sieve to maximise recovery of small seeds. This method appears to have improved seed recovery and it may have affected charcoal recovery. It remains to be seen whether there will be a significant effect upon the analysis and interpretation of the archaeobotanical remains. Fragments of charcoal that are smaller than 5 mm are rarely analysed. It is therefore likely that this fine mesh will increase bulk measurements of charcoal without altering the analysis results. Large and friable charcoal is removed in situ before screening to reduce subsequent fragmentation. This also reduces the potential for re-analysis of what was originally one piece. Sorting and initial curation take place at the site and all charcoal fragments are kept.

Sampling in the Laboratory - For this analysis sub-samples were taken from each of the layers analysed to obtain manageable sample sizes.

To gain information regarding change in the charcoal assemblage through time, it was initially decided that charcoal would only be analysed from the witness trench. This also enabled analysis of charcoal from a wider range of periods because the witness trench was significantly deeper than the rest of the excavation (Fig. 5.1). As dates became available for the site it was apparent that the youngest MSA occupation was only represented in layers found towards the back of the cave. Therefore, to gain samples from a larger spectrum of occupation periods, a sample was taken from layer Bu in this region of the site. Layers sampled are shown on Fig. 3.3 and Fig. 3.4. One section of the excavation, including layers GA, YA and YA 1, was avoided after initial analysis revealed that preservation was poor and may have hampered the identification process. Subsequently layer Eb and some of the HP layers were analysed as the assemblages became available.

Charcoal included in the analysis had been excavated from the sediment matrix only. Hearth charcoal was not included in an attempt to avoid adding unnecessary bias to the samples.

With the exception of the HP layers each layer was sampled from an area of 2 m^2. At the time of analysis only 1 m^2 of the HP layers had been excavated.

One hundred and twenty fragments were extracted from each charcoal assemblage. This number does not represent an equal portion of each assemblage because charcoal abundance and deposit volume vary between layers, however, it did provide a sample that could be analysed and documented within the time available. It has been noted in Chapter 4 that assemblage composition varies within and between deposits and that sampling should be specific to each layer analysed and each site. A sample of 120 fragments from each layer was used as a starting point for the analysis and for reasons discussed below it was not necessary to increase the sample size.

Stratified samples were taken from each of the eight layers analysed. Samples of 15 fragments were removed from each 50 cm^2 excavation grid unit ensuring uniform representation of charcoal and minimising the risk of analysing one branch repeatedly. The 15 fragments were removed from five size categories (<5 mm, 6-10 mm, 11-15 mm, 16-20 mm and >20 mm). Where possible three fragments from each category were analysed for each quadrant. For the HP sample 30 fragments were taken from each quadrant, totalling 120. These 30 fragments were distributed between the three HP layers (GR, GR II and GS) included in this analysis.

5.3. Identification

Charcoal is identified using comparative collections of modern wood specimens. These collections take many forms, from images only (Ilic 1991) or images with identification keys (Kromhout 1975) to computer identification manuals including images, descriptions, and interactive keys (Wheeler *et al.* 1986; Neumann *et al*. 2000; Schoch *et al.* 2004). In most cases less regionally specific texts of wood anatomical features are referred to for character lists used in the documentation and identification process (Barefoot & Hankins 1982; Jane 1970; Carlquist 1975; Desch & Dinwoodie 1981; Metcalfe & Chalk 1950a, 1950b; IAWA 1989; Wheeler *et al.* 1986).

5.3.1. Southern African Comparative Collections

Wood identification publications for southern African taxa are limited (Scott 1927; Kromhout 1975; Prior & Gasson 1990, Eichhorn 2002) and in the past each researcher or institute has gathered reference material specific to their current region of research. This regionally specific approach has also been employed because there is an exceptionally high diversity of taxa in southern Africa. The complex climate and vegetation regimes across sub-Saharan Africa make this the most practical approach. Archaeo-anthracologists rather than researchers with formal botanical training have undertaken much of the anthracological research in South Africa. There

are a few exceptions to this but even those with botanical training have predominantly analysed charcoal from archaeological sites and have thus targeted archaeologically oriented questions, working within limited archaeology budgets. The focus of many of these projects has been upon the outcome of the analysis and the palaeoenvironmental or palaeoethnobotanical interpretations rather than examining the comprehensive nature of the reference collection itself or difficulties encountered during identification. This is not to say that the research and identifications are inaccurate but rather that there are few publications for taxa from the region that provide detailed notes on identification problems at the family, genus or species level for example. An exception to this is a publication by Verhoeven & van der Schuff (1974) in which they discuss the wood anatomy of Combretaceae taxa and make specific reference to features that can be used to distinguish one taxon from another. Cartwright & Parkington (1997) have highlighted some problems encountered during charcoal identification and in particular they discuss problems associated with making species level identifications. They suggest that all identifications should be made to genus, with species being suggested using the prefix 'cf.', unless there is only one possible species in the study region (Cartwright & Parkington 1997). Neumann (1999) highlights the fact that it is not necessarily a reflection of the researchers ability if species identifications cannot be obtained and it is more often an indication of the complex nature of the wood anatomy of that taxon.

Scott (1927) published a review of microscopic wood anatomical features of thirty South African woods. Specimens were examined under a microscope and information was given on vessel size and distribution, ray types, their height and width as well as parenchyma distribution (Scott 1927). Growth rings were also noted. Scott's descriptions provide taxon information that is useful for verifying the presence of anatomical features that have been observed in the reference material collected for this study.

Kromhout (1975) published an identification key and images for some commonly occurring woody taxa in southern Africa. This publication provides a useful set of images of the three anatomical planes used for identification. The key is also useful although some of the characters, such as colour and smell, are inappropriate here because they can only be used for fresh wood. In addition his identification key includes characters, such as vessel diameter and frequency, that are not recommended or commonly used to identify charred specimens. Kromhout (1975) uses ray measurements to distinguish between *Acacia* species; however, ray widths and lengths can vary greatly within, and between, species. There is too much variation within the *Acacia* genus for specific level identifications to be made (M. Bamford pers. comm.). It is not surprising that *Acacia* species cannot be successfully identified to species when the difficulties of distinguishing species, using external plant anatomy of fresh specimens in the field, are considered.

Prior & Gasson (1990) used the International Association of Wood Anatomist's (IAWA 1989) list of features for hardwood identification to document anatomical characters observed in taxa from afromontane and bushveld vegetation zones in Swaziland. This publication is particularly useful because there is significant overlap between their taxa and those found within the Sibudu Cave study region. More recently Eichhorn (2002) has developed a collection with images, an identification key and anatomical descriptions for woody taxa in the Kaokoland region of Namibia. This collection includes some taxa that are also found in KwaZulu-Natal or nearby although on the whole there is little overlap. Eichhorn's (2002) documentation of the woody taxa provides a good benchmark for future studies. Data in each of these publications have been useful in supplementing the Witwatersrand reference collection.

5.3.2. The University of the Witwatersrand Reference Collection and Database

5.3.2.1. Scope

The collection at the University of the Witwatersrand was begun by Dowson (1988), continued by Jeannerat (Wadley *et al.* 1992) and further expanded by Esterhuysen to include taxa from Lesotho and the Drakensberg. It has subsequently been added to by members of the ACACIA (Ancient Cognition and Culture in Africa) research programme, including myself. The collection now holds 209 taxa and consists of Angiosperms, predominantly Magnoliopsida, and some Gymnosperms from the Coniferophyta division. There are a few taxa occurring in both summer and winter rainfall regions but on the whole the Fynbos of the Cape and other winter rainfall vegetation zones are not as well represented as vegetation zones in the eastern, summer rainfall region, of South Africa. This is because the collection composition reflects the vegetation in the research regions for which it has been used.

To prepare the collection for this project, reference specimens were collected from remnant forest vegetation in the immediate vicinity of the site. There were two clear zones to target; on the slopes and cliff faces around the cave, and along the Tongati River in the valley (Fig. 5.2). In addition, wood samples and identification vouchers were obtained from reserves near Durban that were visited. These reserves included Pigeon Valley and Burman's Bush (in the Durban conurbation), and Shongweni (between Durban and Pietermaritzburg). As this study was aimed at assessing the evidence for environmental change it was particularly important to broaden the collection to include woody taxa from a range of vegetation habitats and climatic regions. Specimens were collected from the Waterberg and other regions in the Limpopo Province to supplement the material already collected from Lesotho, the eastern Free State, KwaZulu-Natal, including the Drakensberg, and the Magaliesberg region of Gauteng.

5.3.2.2. Specimen Preparation

Comparative collections should ideally contain specimens prepared in a variety of ways. Thin sections of fresh wood provide clear detail of some features that are not present or become distorted after charring, while charred specimens provide a more direct comparison to archaeological specimens. Charred samples will only exhibit anatomical features that can be expected in the archaeological fragments and measurements of these features may be more comparable to the archaeological specimens (Esterhuysen 1996). Greater depth is visible in charred specimens than in thin sections and features, such as the back walls of vessels can be seen. These are often removed in thin sections (pers. obs.). The combination of both types of comparative material is ideal. It enables the analyst to observe changes that manifest as a result of charring. For the University of the Witwatersrand collection specimens have been charred and fractured. It is hoped that the collection will be developed in the future to include fresh wood thin sections. In so doing the collection will become more comparable with the collection developed in Cape Town, which consists of thin sections of fresh wood as well as charred wood specimens (Cartwright & Parkington 1997).

Branches of 25-30 mm diameter were cut (unless only smaller branches were present) and herbarium voucher specimens were taken to assist the identification process. Most taxa were identified while in the field, however, in some instances it was necessary to verify these identifications. This was done at the University of the Witwatersrand herbarium and through consultation with a botanist in Durban shortly after collection and while vouchers were still fresh. Young branches were avoided in an attempt to obtain specimens with mature wood features. Young wood contains anatomical features that are often not fully developed and they may be very variable within the taxon (IAWA 1989). Immature woods are therefore not very valuable for identification. It may be ideal in the future to include young specimens as well as mature specimens in order to document the development of features (Esterhuysen 1996).

Specimens were air-dried for about one month and during this time they were prepared for the charring process. Following Tusenius's (1986) methodology each specimen was cut down to 150 mm in length, wrapped in foil and charred in a muffle furnace at 350ºC for 2 hours. Using standardised procedures specimens were then fractured in three directions; along the transverse or cross section (CS), tangential longitudinal section (TLS) and radial longitudinal section (RLS) to produce flat surfaces (Leney & Casteel 1975). Fracturing was carried out by scoring the charcoal with a razor to guide the direction of the break and then either breaking the pieces manually or by applying additional pressure with the razor until the specimens split. The latter technique was frequently necessary for fracturing smaller archaeological specimens and for obtaining a clean TLS and RLS. Each section was viewed using incident light microscopy to verify the clarity of the surfaces obtained. These fragments were then mounted on SEM stubs with D.A.G. (a carbon based gluing agent) and submitted to the Electron Microscope Unit at the university where they were sputter-coated with gold palladium in preparation for viewing and photography.

Each new specimen for was viewed, and photographed in a JEOL 840 SEM. Many of the anatomical features were documented during viewing sessions. Taxa were viewed at magnifications of x30-1000 (occasionally higher magnifications were used). Images were taken at x50, x100 and, depending upon the wood specimen and the feature being photographed, magnifications of x200-1000 were used. Photographs were produced by the central photography unit at the University of the Witwatersrand and I subsequently scanned these images for incorporation into a database.

5.3.2.3. Computer Database

While expanding the collection it became apparent that a computerised database was required to make identifying charcoal from the MSA layers at Sibudu Cave viable. This was in part due to the large and unwieldy nature of the reference collection,

which at the time consisted of approximately 150 taxa. It was also due to the complexity and diversity of the Sibudu Cave MSA charcoal assemblage.

In the database each taxon is recorded according to family, genus and species. The nomenclature follows that used in Coates Palgrave (2002). Earlier contributions to the collection have been incorporated into this database and in some instances re-described from the available images.

The database used for this collection is in Microsoft Excel. Appendix A illustrates the form of the database spreadsheet and displays anatomical data recorded for each taxon in the collection. This database enables the analyst to query the data and thus eliminate taxa on the basis of wood anatomical characteristics. Digitised images for each taxon were linked to the database allowing for easy cross-reference between the data and images (Appendix B). In addition, images of more than one taxon can be viewed simultaneously.

Characters used in the reference collection and "Charcoal type" databases - Anatomical characters included in the database were mostly selected from the IAWA list (1989) although some features were described according to methods used by Wheeler *et al*. (1986) and Barefoot & Hankins (1982). These references were used to maintain consistency with identification records begun by Esterhuysen (1991), and in an effort to make the system comparable with other wood identification databases, such as Eichhorn (2002), Prior & Gasson (1990) and Neumann *et al.* (2000). Characters have been divided into the following categories; vessels, fibres, rays, axial parenchyma and miscellaneous features. The characters used are presented in Appendix C.

5.3.2.4. Identification Process

Specimens were grouped into one of two categories; identifiable or unidentifiable. Specimens classed as unidentifiable do not show sufficient anatomical features to

enable a secure identification to be made. Identifiable specimens were further divided into Charcoal Types or directly into identification groups. The same characteristics and database style were adopted for documenting Charcoal Types (Appendix D). This group mostly includes taxa not currently held within the collection. In some instances specimens similar to taxa in the collection have been classed as Charcoal Types because further specimens are required before an identification can be made. They all display fairly clear anatomical features and have been documented so that they may be identified in the future, either as the comparative collection is expanded or as more archaeological specimens are analysed. Images of each Charcoal Type have been taken to assist identification in the future. Charcoal Type images and their associated spreadsheet are included on a CD (see Appendix D).

Specimens may be identified to family, genus or species. Anatomical features are recorded for each fragment analysed. Species identifications are rare and, following Cartwright & Parkington's (1997) suggestion, they have in most cases been preceded with 'cf.' to indicate that they are most similar to the given species (Reitz & Wing 2000). Secure species identifications have been possible when there is only one species, either in the region or in a genus. When species identifications cannot be made the genus is given and is followed either by sp. (one species) or spp. (more than one possible species) (Reitz & Wing 2000).

5.4. Analysis of Sibudu Cave Charcoal

5.4.1. Sample Size Adequacy

Sample size and sample adequacy are important in archaeology for a number of reasons. First, accurate quantitative interpretations cannot be made if a study is carried out upon a non-representative sample. The second important point is that an adequate sample may be assumed informative of measures such as diversity of the

assemblage as well as of the particular sample. Diversity is an umbrella term for a suite of related measures including richness.

To develop a practical approach to analysis it is important to establish what the sample should be representative of, both ideally and realistically within the parameters of the study. Sufficient evidence has already been presented, in Chapter 4, to suggest that the sample cannot provide a direct representation of the vegetation zone(s) from which it was derived. It seems more valuable and feasible to assess the relationship between the sub-sample, upon which the analysis and interpretation will be based, and the parent assemblage from which it was randomly sampled. Effectively, one wants to assess the accuracy of the random sampling procedure used.

Cumulative curves are commonly used to examine the relationship of a sub-sample to a parent assemblage. Theoretically if a representative sample has been obtained the curve will reach a saturation point at which further sampling will not yield new taxa. For this study cumulative curves have been plotted to test the adequacy of the samples analysed. All specimens, whether identified, grouped as Charcoal Types or classed as unidentifiable, were assigned a number between 1 and 120. Using randomly generated numbers the occurrence of each specimen was recorded and plotted (Fig. 5.3 to 5.10) as it was drawn from the sample. Unidentified specimens were included, to maintain the sample size of 120 fragments, although they have not been recorded as new identifications. Samples from the HP layers and from BSp have levelled off more than sample from layers Eb or OMOD. The richness values (raw count of the number of different taxa) are greatest for layers Eb, OMOD and Bu.

In this type of assessment a sample with low richness will inevitably reach its saturation point before a sample of the same size that has a much greater richness, if the total of fragments drawn remains the same. This is intuitively the case however showing the adequacy of the sample size is in reality far more complicated. Samples were treated as finite when creating these cumulative curves, because specimens are

drawn without replacement. The appearance of the cumulative curve plot (produced without replacement) may be highly dependent upon the order in which the specimens are drawn.

A second approach to assessing sample adequacy is to make use of sampling procedures that do use replacement. When using replacement the sample is treated as infinite. One method that has been used for archaeological studies is bootstrapping (Cochrane 2003a; 2003b). Sampling with replacement is more rigorous than without replacement and the outcome of the graph will not be influenced by the order in which samples are drawn from the population.

Both methods do not, however, overcome the problems inherent to charcoal analysis. Any such measures are highly dependent upon the amount of fragmentation that has occurred, whether taxa were equally affected, or whether, as is more likely, fragmentation occurred randomly across the site as well as within and between taxonomic groupings. It must be concluded therefore that attempting to quantitatively relate the samples analysed to their parent assemblages is inappropriate for this study (P. Fatti pers. comm.). Although it is desirable to know the relationship of a sample to a parent population it may not be possible to achieve this using either cumulative curves or bootstrap assessments of the charcoal data. It is more appropriate to develop a model, such as that presented in Fig. 4.1, in which as many variables as possible are considered and a more descriptive approach is taken to discussing the origin of the sample and to interpreting the data.

5.4.2. Qualitative

In the previous chapter I discussed the assumption that taxa identified in the archaeological assemblage had similar environmental requirements to those recorded in modern ecosystems. This approach to analysis will be used to interpret the Sibudu Cave charcoal assemblage data. The method will be extended to encompass ethnobotanical data and physical properties of the wood as well as the environmental

niche data. Three different types of data; environmental, ethnobotanical and functional, are drawn together from a range of sources to provide a descriptive interpretation of the charcoal assemblage. Results of the qualitative assessment of the charcoal assemblage are presented in Chapter 6.

5.4.2.1. Environmental

This data category encompasses the environmental niches of taxa, their growth requirements, growth forms and common locations. For this study data concerning habitat, slope aspect, and climate requirements for example will be researched from tree identification field guides (for example, Pooley 1997; Moll 1992; Killick 1990) and reference texts (such as, Acocks 1988; Coates Palgrave 2002; Low & Rebelo 1998). The most accurate data can be provided for species identifications; however, where possible habitat trends will be given for genus and family level identifications. For large and wide-ranging families this may provide data that are too generalised, however, for less diverse, and spatially more confined families the data can be useful. Distribution maps will be drawn for species that are identified by using maps available in Coates Palgrave (2002).

5.4.2.2. Ethnobotanical and Functional

These two categories have been grouped because they are often closely entwined and data on wood function is frequently obtained through ethnobotanical research. Ideally the data should be considered separately however there are limited studies in which the combustibility of a specific wood is examined, particularly for this region and for the taxa identified at Sibudu Cave.

Cautions about the use of ethnobotanical data for interpreting MSA charcoal assemblages have already been presented. In the interpretation of the Sibudu Cave assemblage little emphasis will be placed upon this data; however, it is acknowledged that cultural selection may have been instrumental in the formation of the assemblage. Nevertheless, common uses of taxa and taxon avoidance (by modern societies) will

be discussed. Common wood uses are sourced from existing ethnographic (Archer 1990; Prior & Tuohy 1987; van Wyk & Gerike 2000) and botanical literature (Coates Palgrave 2002; Moll 1992; Pooley 1997; van Wyk & van Wyk 1997; Hutchings 1996).

5.4.3. Quantitative

In an attempt to assess the usefulness and accuracy of quantitative applications, and to assist with interpreting the assemblage, a series of analytical approaches will be used. None of these techniques are new, however, their combined use to facilitate an appraisal of the methods is not recorded in the charcoal literature. The methods are borrowed from closely related disciplines such as palynology and faunal analysis. In these methods greater emphasis is placed upon presence/absence data than upon percentage frequencies of taxa. This has important implications for the nature of the interpretations.

5.4.3.1. Graphs

Graphing techniques provide a visual representation of data and can be used to show changes in an assemblage over time as well as changes in the occurrences of taxa. A graph of a similar structure to those produced using Tilia Graph will be presented. The taxa can be divided into vegetation communities in which they commonly occur (as they would be using Tilia Graph). Frequencies of taxa will be included in the graph although the graph will be interpreted using the presence/absence data.

5.4.3.2. Factor Analysis

Factor Analysis is often referred to as a descriptive statistical procedure. This is because the results of the output are analysed in conjunction with known data that underlie or may influence the occurrence of each taxon, including, in this instance, data regarding the preferred environmental niches of taxa, their climatic requirements, the properties of each taxon as well as cultural significance. The purpose of the factor analysis is to group variables that display similar patterns within the data. The

assumption is then made that taxa within a grouping are influenced by similar environmental, cultural or taphonomic factors. It should be possible to identify the major influences upon the assemblage, and possibly the environment, by establishing whether taxa that are grouped in the factor analysis are found to grow together or have similar environmental requirements, such as moisture availability, soil types or access to light. It is also possible that grouped taxa all provide good fuel wood or building materials for example. The factor could then be related to trends in collecting wood for specific purposes.

Patterns produced by Factor Analysis can often be observed without using the analysis however this statistical procedure highlights those factors that have the most significant influence on the data. In studies similar to this, Factor Analyses are carried out on the correlation matrix, rather than upon the covariance matrix, to minimise the effects of fragment frequency bias (Thackeray 1987). This convention will also be followed here. The test thus analyses patterns underlying the data that occur regardless of taxa frequency.

Factor analysis will not easily utilise variables with very small values (F. Thackeray per.comm.). In an attempt to avoid problems associated with small data entries, taxa included in this analysis will be grouped. Small data points can bias the results of an analysis because they tend to be over-emphasised. In this analysis groups are created at the family level but the analysis will only include data from families for which genus identifications, or fairly secure suggestions of genera, are made. Generalist taxa will also be excluded to allow for more accurate interpretation of the analysis output. It is possible that by grouping the identifications some of the patterns will be obscured. This will be evident if the factors produced cannot be related to a clear environmental, cultural, or taphonomic influence.

5.4.3.3. Summary Statistics

To assist with interpreting the data, a second stage of factor analysis is often carried out. Factor loadings are fed through a series of equations (Appendix E) to produce what are referred to as "factor scores" and then "summary statistics" for each factor and each layer analysed (Thackeray 1987). Summary statistic values are plotted on an arbitrary scale, from 0-100 for example, to obtain an index and graphical representation for each factor. The values obtained using summary statistics do not reflect absolute changes in the underlying factor but are rather indices that can be used to show relative change in the factor through time, whether temperature or moisture for example. It is also possible to plot the summary statistics for one factor (for example temperature), against a second factor (such as moisture). A plot such as this would provide a clear indication of whether the environment from which the assemblage contents were derived was warm and wet, cold and wet, warm and dry or cold and dry (Fig. 5.11).

5.4.3.4. Correspondence Analysis

This test will be carried out in Microsoft Excel using a "plug in" device, XLSTAT. Correspondence analysis can make use of presence/absence data to find patterns within a data set. The researcher then determines underlying causes for these patterns. As in the factor analysis these patterns may be related to temperature, precipitation, soil moisture, humidity, fuelwood collection and so on. It is therefore also a descriptive statistical procedure and it can be used to produce a visual representation of the data similar to that described above (see summary statistics). The plot can be used to analyse relationships between the occurrence of row to row (taxa) points and column to column (layer/sample) points, in a data matrix, as well as the relationships between row and column (taxa and layer/sample) data. This method is used in faunal analyses and has recently been used for charcoal analysis (Heinz & Thiébault 1998; Piqué & Barceló 2002).

5.5. Summary

Methods used for studying MSA charcoal have been presented above. The discussion on sampling adequacy illustrates that it is not always clear when unbiased charcoal samples have been obtained. Reference materials available for this study have been discussed and the University of the Witwatersrand reference collection has been presented with a detailed description of many of the anatomical features used for identification. The methods chosen for analysing charcoal from the MSA at Sibudu Cave are essentially qualitative. Several descriptive statistical techniques have also been chosen to further develop the interpretation of the data. The methods outlined above are appropriate for analysing charcoal because they are not hindered by charcoal fragmentation problems.

CHAPTER 6. QUALITATIVE ANALYSIS RESULTS AND PRELIMINARY INTERPRETATIONS

6.1. Introduction

Data were analysed using two different approaches; qualitative and quantitative analysis. Qualitative analysis results are presented here, while the results of the quantitative analyses are presented in Chapter 7. Charcoal fragments have been identified to family, genus and in some instances to species. Charcoal Type identifications are documented in Appendix D and only the most commonly occurring Charcoal Types are discussed below. In the following section I present the results from each sample and I provide details of the taxa requirements, including environmental niches and their distributions within South Africa. Distribution maps, redrawn from Coates Palgrave (2002), are provided for species identifications (Fig. 6.1 - 6.8). A short description of the environmental implications of taxa distributions is given for each layer, by making reference to habitat descriptions recorded in commonly used field guides Table 6.1. I also present evidence for cultural uses of the identified taxa placing particular emphasis upon taxa used or avoided as fuelwood. Preliminary interpretations are given for each layer independently of the other layers. Detailed interpretations and discussions of similarities and differences between layers are reserved for Chapter 8.

6.2. Qualitative Analysis

6.2.1. Howiesons Poort (HP)

6.2.1.1. Layers GS, GR 2 and GR: The Assemblage

The HP layers can be distinguished from the overlying layers by their unique artefact content and their stratigraphic relationship. Preliminary OSL dates for layers GS2, GS and GR2 within the HP occupation are 60.7 ±2.3, 62.4 ±2.5 and 62.4 ±3.2 ka respectively (Z. Jacobs pers. comm.). The HP layers analysed here are labelled on Figure 3.3a. At the time of analysis 1 m^2 of HP deposit had been excavated. Charcoal has since been excavated from an additional square metre in the trial trench, but it has not yet been analysed. Charred wood fragments from the HP layers appear to be less numerous than in other layers. The decreased density of charcoal in the HP, when compared with the other layers, is consistent across these two squares; however, further excavation will reveal whether this holds for contemporaneous deposits. Charcoal from layers GS, GR 2 and GR contain characteristic HP lithic assemblages. These layers were combined to produce a sample of 120 specimens. Charcoal samples from individual layers within the HP occupation did not contain sufficient charcoal to obtain 120 specimens when analysed individually. The data from the three layers are presented as a whole (Table 6.2) and have been analysed as a single sample. It will be possible to analyse data from individual layers when a more substantial volume of the HP deposit has been excavated and more charcoal has been recovered. This may yield important information concerning changes in the climate or wood utilisation during the HP occupation. At present, analysing these layers individually would highlight patterns that are sample size dependent rather than indicating true changes in the charcoal assemblage.

Taxa present in the HP layers include *Podocarpus* spp., *Buxus* sp., *Brachylaena* sp., *Kirkia* sp., *Drypetes* sp. *Mystroxylon* cf. *aethiopicum*, *Ptaeroxylon obliquum*, *Ziziphus mucronata*, *Ochna* sp., *Curtisia dentata* and *Sapium/Spirostachys*. Specimens

identified at the family level (Table 6.2) include; Fabaceae, Proteaceae, Flacourtiaceae, Ebenaceae, Rubiaceae, Sapotaceae, Oleaceae, Lamiaceae and Apocynaceae. Genus identifications have not been suggested for these specimens for several reasons. First, the anatomical features may not be clear enough to distinguish between genera. Secondly, there may be several possible identifications within the family, and thirdly, the specimens may show similarities to taxa within a family but the family may be poorly represented in the collection. In addition, eighteen fragments have been identified as Rubiaceae/Apocynaceae. The fragments have similar characteristics to taxa in both families; however, it has not been possible to distinguish which family they are most similar to. Both families are very large and contain many taxa with similar anatomical features. Thirteen Charcoal Types were identified which in most cases were defined by one, two or three fragments. Charcoal Type 95 (Appendix D) is more frequent; however, it remains unidentified because some features were unclear in every specimen and, on the basis of those features that are clear, there appears to be no reference material of this taxon.

It is obvious from the data that *Podocarpus* spp. are present in larger quantities (based on fragment counts and percentage frequencies) in this sample than they are in any other samples analysed. In addition, *Podocarpus* and the Rubiaceae/Apocynaceae identification are the most abundant identifications in this layer, both with 18 fragments recorded. *Podocarpus* is present in two other layers (discussed below) and this specific Rubiaceae/Apocynaceae type has not been noted in any of the other layers analysed. The *Podocarpus* fragments are well preserved and it appears that there are two species present, however, the differences are not distinct enough to separate the taxa (M. Bamford pers. comm.). There are only four *Podocarpus* species in South Africa today and one of these is confined to the Cape region. Based on the species currently present in KwaZulu-Natal, it is possible to speculate which species may be represented in the archaeological assemblage. *P. falcatus* and *P. latifolius* have broad distributions in KwaZulu-Natal. *P. henkelii* grows in a small region in the southern part of the province. This taxon may have been more widespread in the

past. Although there are only three *Podocarpus* species that are possible identifications, the wood anatomy of modern reference samples display many similarities in their wood anatomy and therefore the archaeological specimens cannot be identified further.

Two genera - *Sapium* and *Spirostachys* - have been grouped together (Table 6.2) because the reference collection specimens display comparable wood anatomy (Appendices A and B) that cannot be satisfactorily distinguished. In KwaZulu-Natal, *Sapium integerrimum* is found at forest margins and in associated wooded grassland areas as a pioneer species (van Wyk & van Wyk 1997) as well as along the coast. This deciduous tree (Coates Palgrave 2002) is also noted to occur further north, in Limpopo, parts of Botswana and Mozambique (Pooley 1997). *Sapium elipticum* also grows in KwaZulu-Natal and has a similar distribution pattern to *Sapium integerrimum* (Coates Palgrave 2002). This taxon may display similar anatomical characteristics to both *Sapium integerrimum* and *Spirostachys*. It cannot be eliminated as a possible identification, as it is not held in the reference collection. *Spirostachys africana* is the only *Spirostachys* species in the region and it occurs at low altitudes. It is frequently found along rivers and streams in areas of bushveld (Coates Palgrave 2002). There are many references in the literature to this wood being unsuitable for burning (for example, Coates Palgrave 2002; Grant & Thomas 1998; Pooley 1997). This is because the fumes are toxic and may cause headaches or even nausea if inhaled (Coates Palgrave 2002; Grant & Thomas 1998; van Wyk & Gerike 2000). It is unlikely, therefore, that this wood was knowingly collected for fuel although it may have been picked up accidentally, when collecting kindling for example. Surprisingly it is used in small quantities for medicinal purposes (Hutchings *et al*. 1996).

6.2.1.2. Contemporary Distribution of Taxa and Environment Data

Generalised distribution maps (Fig. 6.1) show that most of the identified taxa in the HP layers can grow in KwaZulu-Natal today. Their distributions, for the most part,

appear wide-ranging with taxa documented from the Eastern Cape to southern Mozambique and into Limpopo. More detailed distribution data from Acocks (1988) and the National Botanical Institute Database (SANBI 2004) show that although many of the identified taxa grow at points within these mapped areas, they are not found within all the habitats encompassed.

Podocarpus spp. are distributed along the eastern coast of southern Africa from the Western Cape to the northern-most parts of KwaZulu-Natal (Fig. 6.1) and inland in Mpumalanga and Limpopo. According to Acocks's (1988) Veld Type descriptions, *Podocarpus* species can be found in his Veld Types 1, 3, 4, 5, and 7, of the Coastal Tropical Forest, Veld Types 8 and 9, of the Inland Tropical Forests, and Veld Types 44 and 45 that belong to the Temperate and Transitional Forest and Scrub group. *Podocarpus* spp. have not been recorded in the vegetation around the cave and the National Botanical Institute has not documented them (SANBI 2004) in regions close to the site (areas with co-ordinates of 2931CA and 2931AC, shown in Fig. 6.9). Some specimens do grow nearby in Krantzkloof Nature Reserve (Styles 2001). Their presence in some areas and absence in others may be due to the influences of modern occupation upon the natural vegetation stands, rather than being a true reflection of the natural vegetation communities. Each of the environments described above has high rainfall of at least 900 mm per annum, although the majority receive at least 1000 mm per annum (Acocks 1988). Killick (1990) has recorded *Podocarpus* spp. as the dominant taxa in forests on south and south-eastern facing slopes in the northern and southern Drakensberg. *Podocarpus* forests lie within river valleys in the montane vegetation belt, occurring below the Clarens Sandstone formation, at altitudes of 1280-1830 m a.m.s.l. (Killick 1990). These south facing slopes receive less sunlight and tend to be cooler with greater moisture availability than north facing slopes in the same area. Coastal forests in northern KwaZulu-Natal near St. Lucia are also dominated by *Podocarpus* spp. (Grant & Thomas 2004). *P. falcatus* and *P. latifolius* are present in these areas (Grant & Thomas 2004).

Podocarpus species grow in a variety of forest types, in areas that might be perceived to have significantly different environments; however, there is a common feature to these habitats. Whether the forests are warm or cool they all have high moisture availability. Caution must be taken in assuming that *Podocarpus* is always found in areas with high precipitation (February 2000). Water availability is dependent upon effective evapotranspiration, which is governed by many factors such as temperature, precipitation, humidity, soil moisture and the proximity of streams or rivers, rather than depending upon precipitation alone. For these reasons, *Podocarpus* spp. are able to survive in drier regions in habitat niches where moisture availability, but not necessarily precipitation, is high. It has been noted in Limpopo in kloofs (Grant & Thomas 2000; L. Wadley pers. comm.). In these sheltered locations there is often a good groundwater supply from springs and during the summer months the kloofs may harbour streams.

Buxus spp., *Ptaeroxylon obliquum* and *Brachylaena discolor* are found in the Typical Coast-Belt Forest of Acocks's Veld Type 1 (Acocks 1988). *Buxus* is also documented in Veld Type 23 (Valley Bushveld of the Karoo and Karroid *Types*) (Acocks 1988), which is commonly found in the river valleys of KwaZulu-Natal. *Ptaeroxylon obliquum* and *Brachylaena discolor* co-occur in Acocks's Veld Types 2 and 8, which both contain tall forest. *Ptaeroxylon obliquum* is a fairly versatile plant and although it is able to survive drought it flourishes in higher rainfall conditions. *Brachylaena discolor* is also predominantly found in regions with relatively high annual rainfall. This plant tends to grow along the coast in dune forest, coastal woodland and at the margins of evergreen forest. It can, however, grow further inland along rivers such as the Tongati, and in the woodland associated with bushveld-savanna (Grant & Thomas 1998).

Curtisia dentata does not grow along the coastal stretches of KwaZulu-Natal. It is recorded to the south in the Alexandria and Knysna forests (Acocks 1988). This taxon also grows inland in KwaZulu-Natal in higher altitude cooler forests where it

co-occurs with *Podocarpus* spp. Its wide distribution, which encompasses a range of rainfall patterns as well as varying temperature averages from the coast up to 1800 m a.m.s.l., suggests it is a versatile taxon.

Each of the taxa discussed above grows in evergreen forest or woodland habitats. With the exception of the *Kirkia* sp. the data for the HP layers show a lack of taxa from savanna woodland, thornveld or thicket environments. There are two possible *Kirkia* identifications; *K. acuminata* and *K. wilmsii*. *K. acuminata* is found in northern Limpopo and Zimbabwe. *K. wilmsii* tends to grow in the warm, dry savanna woodland of Limpopo and North West provinces; however, it also occurs in Mpumalanga and the northern parts of Swaziland (Fig. 6.1), which tend to be slightly moister. Acocks (1988) records *K. wilmsii* in his Veld Type 10, which is predominantly found in Limpopo and Mpumalanga. This vegetation zone has its southern-most representations in northern KwaZulu-Natal (Fig. 3.5), and in these regions it has a close affinity with the Valley Bushveld (Veld Type 23) where *Buxus* species and *Ptaeroxylon obliquum* are found. *K. wilmsii* has also been observed at the edges of kloofs, in association with *Podocarpus* species, in the Waterberg (L. Wadley pers. comm.). *K. acuminata* is only found in the far north of South Africa. Both species are elements of deciduous woodland savanna and both indicate a warm and significantly drier climatic condition than the Sibudu region receives today.

6.2.1.3. HP Summary and Environmental Interpretation

The identifications from the HP layers indicate the presence of evergreen forest vegetation. The identifications also suggest that rainfall, or available moisture, may have been fairly high although not necessarily higher than it is at present. In addition to this forested environment, the *Kirkia* identification provides evidence for a woodland savanna vegetation zone from which wood was also collected. This open vegetation may not have been far from the cave as *Kirkia* can grow just beyond sheltered kloof vegetation. It may have been warm during this occupation, although it would have been significantly cooler in the forest if the forest was tall. The

combination of taxa in this layer provides evidence for warm and moist conditions. There are similarities to vegetation communities found in northern KwaZulu-Natal where temperatures and humidity are high throughout the year. The combination of taxa observed in the HP layers is not recorded in South Africa today.

6.2.2. Post-Howiesons Poort (post-HP)

6.2.2.1. Layer Eb: The Assemblage

Layer Eb is not dated directly but it lies between layers P and SS which have OSL dates of 59.6 ±2.2 ka and 57.0 ±2.3 ka respectively (Wadley & Jacobs 2004). Charcoal is fairly abundant, however, it is also quite fragmented. When fracturing specimens, it was noted that some fragments were very soft and liable to disintegrate rather than producing clear surfaces. Pieces that were fractured without difficulty had clear anatomical structures. This layer has a diverse range of taxa and many specimens were identified to genus (Table 6.3). These identifications include *Morella* cf. *pilulifera, Leucosidea sericea, Ptaeroxylon obliquum, Rapanea melanophloeos, Brachylaena* cf. *discolor, Erica* spp., *Ximenia* sp., *Acacia* spp., *Bridelia* sp., *Deinbollia* sp., *Ochna* sp., *Diospyros* sp. and *Nuxia* sp.

Eighteen specimens have been labelled unidentifiable with the remaining 102 identified to 21 families including; Rhamnaceae, Proteaceae, Fabaceae, Celastraceae, Rubiaceaea, Lauraceae, Combretaceae, Sapotaceae and Anacardiaceae/Burseraceae. A large proportion of the sample was identified as *Erica* spp. In this layer there are two distinct *Erica* species that were initially labelled Charcoal Types B and C. Charcoal Type B was subsequently identified as *E. caffra*, but the species of Charcoal Type C remains unidentified. Twenty-one Charcoal Types were created that have not been identified. Only one of these, (Charcoal Type S), was represented by more than two fragments.

6.2.2.2. Contemporary Distribution of Taxa and Environment Data

Distribution maps (Fig. 6.2) show that many of the taxa identified in Eb co-occur along the coast of KwaZulu-Natal today. *Erica* species are numerous and wide-ranging in southern Africa. *E. caffra* can be found near the coast in the southern regions of KwaZulu-Natal. It has not been documented in the remnant forest patch around the cave, which lies at the easterly boundary of its modern distribution (Fig. 6.2). To the west it can be found in Krantzkloof Nature Reserve (Styles 2001). *E. caffra* occurs in areas with a good water supply from streams or rivers (Pooley 1997; Moll 1992; van Wyk & van Wyk 1997; Coates Palgrave 2002). The majority of *Erica* species are found in the winter rainfall region of South Africa (Schumann *et al.* 1992) or at higher altitudes in cooler mountainous areas such as in the Drakensberg range in KwaZulu-Natal. *Leucosidea sericea* is an important identification for a number of reasons. This taxon grows inland at higher altitudes and often, although not exclusively, in cooler localities (Fig. 6.2). Unlike *E. caffra* it does not grow along the coast of South Africa. Its absence at the coast may be an indication that it cannot survive in regions that receive coastal mists. The available literature does not provide a reason for the absence of *Leucosidea sericea* at the coast. It is also found in Limpopo and Gauteng, although it is most dominant in the Drakensberg regions in and around Lesotho. It is able to tolerate frost conditions (Killick 1990; Pooley 1997). As a pioneer species its presence may indicate a change in the environment. It is possible that *L. sericea* marks the development of forest in the area. The co-occurrence of *E. caffra* and *L. sericea* may provide an indication of an environment that was cooler than it is near the cave today.

Acocks (1988) documents *Ptaeroxylon obliquum*, *Rapanea melanophloeos* and *Brachylaena discolor* in Veld Types 1 and 2 of the Coastal Tropical Forests and Veld Type 8 of the Inland Tropical forests. *Rapanea melanophloeos* is also able to grow in cooler conditions and withstand some frost (Grant & Thomas 1998). Distribution and environment preferences have already been discussed for *Ptaeroxylon obliquum* and

Brachylaena discolor (see HP layers above). Their influence upon the interpretation of the Eb results is returned to below.

There are two *Deinbollia* species in southern Africa, *D. oblongifolia*, which can be found along the coast of KwaZulu-Natal and *D. xanthocarpa,* which grows in the north-east of South Africa and the central to southern sections of Mozambique. Both species grow in riverine fringe vegetation as well as in more open woodland. At the southern-most extent of the *D. oblongifolia* distribution it overlaps with *Erica caffra* (Fig. 6.2), however, on the whole the *Deinbollia* species prefer the warmer and moister habitats found along the coast and in the east of South Africa. The aspect of the slopes on which these plants grew could account for these slight differences in temperature that are indicated from their modern distributions. Unfortunately comprehensive data on slope aspect are not available for many of the identified taxa.

The Euphorbiaceae family, to which *Bridelia* belongs, is large and on the basis of the wood anatomy it has been divided into a number of reasonably distinct groups. *Bridelia* displays the most similar wood anatomy to the archaeological specimens although there are other taxa such as *Croton sylvaticus* and *Margaritaria discoidea* that have similar wood anatomy and cannot be excluded as possible identifications. If the identification of *Bridelia* is correct there are several possible species that could be represented. With the exception of *B. tenuifolia* (which is confined to northern Namibia) the other *Bridelia* species grow in the summer rainfall region, in the eastern half of Southern Africa. The remaining taxa occur in a broad range of habitats, from coastal evergreen forest to dry, deciduous woodland. Habitat variation is both inter and intra specific suggesting the species are highly versatile. One common feature is their relatively close proximity to rivers.

Morella pilulifera (previously *Myrica pilulifera*) tends to grow in mountainous places on well-drained soils near streams (Pooley 1997). Its preferred habitat is similar to that of *Erica caffra* and they can be found together in the southern part of the *Morella*

distribution. Acocks (1988) does not document the specific distribution of *Morella pilulifera* however he does record the genera as being present in his Veld Type 45, the Natal Mist Belt. This veld type is considered transitional to the Highland Sourveld, Acocks's (1988) Veld Type 44a, which contains other taxa that have also been identified in this layer, including *Ptaeroxylon obliquum*, *Erica caffra* and *Rapanea melanophloeos*.

There are two *Ximenia* species; *X. americana* and *X. caffra*. Either of these could be present in the Sibudu charcoal assemblage. The wood anatomy of *X. caffra* is documented in the University of the Witwatersrand collection and *X. americana* has been documented elsewhere (Eichhorn 2002; Neumann *et al.* 2000). Their anatomical structures appear to be very similar and therefore a distinction between the species has not been made here. They are both found in deciduous bushveld and often in dry woodland (Coates Palgrave 2002). *X. americana* grows in Limpopo, Mpumalanga, eastern Swaziland and northern KwaZulu-Natal and *X. caffra* has a similar distribution although it also extends southwards along the east-coast and in inland KwaZulu-Natal. Neither taxon is found in the Drakensberg range.

6.2.2.3. Eb Summary and Environmental Interpretation

Identifications from this layer could indicate several different environments. The taxa have been divided into three groups accordingly. The first encompasses the *Morella*, *Erica* and *Leucosidea* identifications. These taxa tend to be found in areas with high rainfall or where water is present in streams. They also grow across a range of altitudes, from about 450 m a.m.s.l. upwards and can withstand relatively cool conditions. The second group of taxa includes *Ptaeroxylon*, *Rapanea*, *Bridelia* and *Deinbollia*. These are more often found in the high rainfall coastal stretches where temperatures are warmer and the climate is more humid than at the higher altitudes of the previous grouping. Each of these species is often found along rivers in evergreen forests, however, they also occur further inland and are not strictly confined to regions with high humidity and warm climates. Some of these taxa are found in the

foothills of the Drakensberg. The third group may provide evidence for a drier environment. *Acacia* species, *Ximenia* species, and taxa from the Combretaceae family are all components of bushveld habitats. The presence of wide ranging taxa such as *Acacia* spp. and taxa from the Combretaceae family can be difficult to interpret, however in combination with the identification of *Ximenia* sp., which grow in relatively restricted regions of South Africa (Fig. 6.2), there is further support for the presence of a drier, and perhaps warmer environment with open woodland vegetation. The environment from which these taxa were collected would not necessarily have been far from the river valley and the cave.

6.2.2.4. Layer SPCA: The Assemblage

This layer is currently undated, but it lies between layers Or and BSp which have OSL dates of 61.5 ±2.2 ka and 56.7 ±2.3 ka respectively. Many of the lithic artefacts and bone removed from SPCA are burnt. This extensive burning is also evident from the large quantities of charcoal. Preservation within SPCA is variable with a wide range of fragment sizes present. Large pieces (>2 cm) are well represented, however it cannot be assumed that these large pieces are better preserved than the smaller ones. During analysis it was frequently noted that internal structures and even external form of some of the smaller fragments were better preserved than the structures of the larger ones.

Results for SPCA are given in Table 6.4. Thirty-one fragments from the sample have been classified as unidentifiable. This large proportion provides an indication of the variability of charcoal preservation within this layer. Eighteen families are represented in the sample and within these fifteen genera and eight species identifications have been made. Some of these are secure identifications, but others are suggestions indicated by the use of "cf.". In addition, 12 Charcoal Types were defined. The SPCA sample is dominated by *Erica* spp. and most of these are classified as *E. caffra.* Other identifications from this layer include *Morella* cf. *pilulifera, Celtis africana, Leucosidea sericea, Ziziphus mucronata, Rapanea*

melanophloeos, Sideroxylon inerme, Podocarpus spp., *Ficus* sp., *Cryptocarya* sp., *Calodendrum capense, Syzygium* sp., *Nuxia* sp., *Vitex* sp. and *Sapium/Spirostachys*. Family identifications include Rubiaceae, Sapotaceae, Annonaceae, Rhamnaceae, Euphorbiaceae and Anacardiaceae/Burseraceae.

Annonaceae identifications have only been noted in layers SPCA and OMOD. Taxa from Annonaceae are not numerous in southern Africa and it may therefore be possible to identify this specimen in the future if the reference collection is expanded to include genera from this family. Currently there are only two Annonaceae taxa in the reference collection, *Hexalobus monopetalus* and *Uvaria caffra*, and these have similar wood anatomy. Other possible genera include *Cleistochlamys, Spaerocoryne, Monanthotaxis, Xylopia, Artrabotyrs, Annona* and *Mondora.*

6.2.2.5. Contemporary Distribution of Taxa and Environment Data

The climatic implications of the presence of *Erica caffra* and *Leucosidea sericea* have been discussed in the context of the Eb identifications (see above). To summarise, they may provide an indication of a cooler environment than is found around the cave today and they both signify the presence of running water in the form of a stream or river although this may not have flowed perennially.

Taxa represented in SPCA are quite diverse and come from a range of habitats. Identifications of *Podocarpus*, *Cryptocarya*, *Morella pilulifera* and *Rapanea melanophloeos* suggest the presence of evergreen forest. *Ziziphus mucronata* may suggest the presence of a forest margin community within an open wooded environment and *Celtis africana* indicates there were some deciduous components present in the forest vegetation.

Ziziphus mucronata is found in 15 of Acocks's (1988) Veld Types, which are divided between all his major groupings. This is clearly an indication of the widespread distribution of *Z. mucronata*, which is also evident from the distribution map (Fig.

6.3). Although *Z. mucronata* is widespread, it provides evidence for a deciduous or semi-deciduous (Grant & Thomas 2000) component in the environment.

Nuxia and *Vitex* contain some species that are found in dry bushveld regions of southern Africa. *Nuxia* is also represented by taxa such as *N. congesta* and *N. floribunda* in the wetter eastern parts of South Africa. These trees both grow in evergreen forests. A third taxon, *N. oppositifolia,* grows along streams in riverine thicket (Coates Palgrave 2002). *Vitex* is represented by many species, most of which are found north of KwaZulu-Natal and often north of the Limpopo River. *Vitex* taxa found in KwaZulu-Natal like a variety of habitats including; thickets, rocky outcrops, seasonal rivers, bushveld, sandy soils and sand forest margins (Pooley 1997). It is clear that the *Vitex* identification provides environmental data that are extremely broad. To confine the habitat descriptions, species identifications are needed.

In addition to the *Erica* and *Leucosidea* identifications some of the forest taxa, such as *Rapanea melanophloeos*, and *Cryptocarya* sp., and bushveld taxa, including *Sideroxylon inerme* and *Calodendrum capense*, are also often found in association with water.

6.2.2.6. SPCA Summary and Environmental Interpretation

This sample does not contain many taxa from open, dry and warm environments. Most noteworthy is the absence of any taxa from the Fabaceae family, which are represented in all other layers sampled. This layer is dominated by taxa from forest and riverine environments. It has a strong evergreen component with only a few deciduous taxa.

In this layer Acocks's (1988) Tropical Coastal Forest Veld Types are well-represented (Veld Types 1, 3, 4, 5 and 7 in particular). Many of the taxa found in these vegetation zones are not confined to these regions and can also be found in the Inland Forest Veld Type 8, as well as the Temperate and Transitional Forest and

Scrub, Veld Types 44 and 45. Additionally many of the taxa, including *L. sericea*, *Erica* spp., *Podocarpus* spp., and *C. capense* grow in the foothills of the Drakensburg in South Africa (Killick 1990). They do not grow within one community but are found in relatively close proximity, in the forest vegetation and along rivers (Killick 1990). Most of the identifications fit into one or more of these Drakensberg vegetation groupings. *Calodendrum capense* is a semi-deciduous tree that can occur up to 2000 m a.m.s.l. and *Celtis africana* is a deciduous species that grows in open forest habitats (Pooley 1997). Both identifications support the evidence for a forest that may have been similar to that in existence in the Drakensberg foothills.

The interpretation of the rainfall for these taxa is similar to that of the Eb identifications. Most are found in areas with high rainfall whether along the coastal strip or further inland. Identifications of taxa that are found in drier regions, such as *C. africana* and *Z. mucronata* are wide ranging and although they can withstand drought they also survive and flourish in wetter regions. Identifications from SPCA and Eb indicate that the environments were probably very similar.

6.2.2.7. Layer BSp: The Assemblage

Layer BSp has been OSL dated to 56.7 ±2.3 ka (Wadley & Jacobs 2004). In this layer charcoal is abundant and fragments range considerably in size. The degree of preservation is also highly variable. Of 120 fragments analysed almost a third are classified as unidentifiable because of poor charcoal preservation. The remaining two-thirds have been identified to 21 families (Table 6.5). Seven species identifications have been suggested and their environmental implications are discussed below. It has been possible to define four Charcoal Types that may be identified when the reference collection is expanded. Identifications include *Morella* cf. *pilulifera, Cunonia capensis, Calodendrum capense, Ptaeroxylon obliquum, Rapanea melanophloeos, Erica caffra, Celtis* sp., *Ficus* sp., *Acacia* spp., *Buxus* sp., *Ziziphus mucronata*, *Syzygium* sp., *Manilkara* sp. and *Vepris* sp. There are also nine family identifications including Fabaceae, (and taxa from sub-families,

Papilionoideae and Caesalpinoideae), Oleaceae, Lamiaceae, Rubiaceae, Burseraceae, Tilliaceae, Malvaceae, Sterculiaceae and Euphorbiaceae.

6.2.2.8. Contemporary Distribution of Taxa and Environment Data

Many of the taxa identified in this layer have been found in Eb and SPCA and therefore their distributions and environmental data have been presented in the descriptions of the previous layers. There are also differences between the assemblages such as the presence of identifications from the Tilliaceae and Malvaceae families. *Leucosidea sericea* and *Nuxia* sp. were present in Eb and SPCA but not in the BSp charcoal assemblage. This layer also contains *Cunonia capensis*, *Buxus* sp., *Vepris* sp. and *Manilkara* sp. none of which have been noted in the Eb or SPCA charcoal. These taxa are discussed below.

Cunonia capensis tends to grow along the coastal stretches of South Africa from the Cape Peninsula to northern KwaZulu-Natal. This taxon is not confined to the coast, however, and the distribution map (Fig. 6.4) shows that it grows inland in KwaZulu-Natal, the Karoo, and parts of the Western Cape. Acocks (1988) only documents *Cunonia capensis* in his Veld Types 5 and 45 (the 'Ngongoni Veld and the Natal Mist Belt 'Ngongoni Veld, respectively). 'Ngongoni Veld is typified by the dominance of 'Ngongoni grass (*Aristida junciformis*) (Acocks 1988). The dominance of this grass is used to distinguish Veld Types 5 and 45 from Zululand and Eastern Province Thornveld (Acocks 1988). Its dominance in these vegetation types may be a recent phenomenon, however, Acocks (1988) records that it not clear why it has become so dominant. Although *Cunonia capensis* is currently found in these vegetation Types it cannot be ascertained as to whether the Veld Types provide a very good analogy for past vegetation. In addition, *Cunonia capensis* is considerably more extensive than is noted in Acocks's survey but it is perhaps not dominant or frequent enough in other regions to have been documented. This evergreen plant grows in warm, but damp forests near streams (Pooley 1997), and in forests similar to those around Knysna (Coates Palgrave 2002). Taxa such as *Morella pilulifera*, *Buxus* sp., *Rapanea*

melanophloeos, Ptaeroxylon obliquum, Celtis sp., and *Ficus* sp. provide supporting evidence for forest and riverine vegetation (Table 6.1).

Buxus macowanii is the only taxon from the Buxaceae family in the Witwatersrand reference material, however the wood anatomy of *B. natalensis* is probably similar and the habitat descriptions are given for both. *Buxus macowanii* grows in warm valleys along the coast to the south of Durban (Fig. 6.4) (Coates Palgrave 2002). It is also found sporadically in Limpopo Province (Coates Palgrave 2002; Pooley 1997). *B. natalensis* also grows along the coast of KwaZulu-Natal in warm forested valleys (Fig. 6.4). It was noted in the description of the HP assemblage that this taxon is often an understorey component of forest vegetation.

Manilkara belongs to the large Sapotaceae family. Many of the Sapotaceae taxa have similar wood anatomical traits and are difficult to distinguish beyond family. For this reason this genus is suggested only. There are four *Manilkara* species in southern Africa and all of them occur in the eastern part of the summer rainfall region. *M. discolor* and *M. concolor* are components of sand forest and *M. mochisia* is a component of hot and dry bushveld and woodland vegetation. This taxon is not present in southern KwaZulu-Natal. The fourth taxon, *M. nicholsonii* is found in a relatively confined area to the south of Durban where it grows in ravine forests and along streams (Coates Palgrave 2002).

Ficus species present in the charcoal from BSp add limited environmental data to the interpretation of the assemblage. *Ficus* is an extremely large and variable genus (van Wyk & van Wyk 1997), and the specimens may represent the presence of deciduous or evergreen shrubs, trees or climbers (Coates Palgrave 2002). Without species identifications, it is difficult to interpret their presence. *Syzygium* spp. occur over a diverse range of habitats (Coates Palgrave 2002; Pooley 1997; van Wyk & van Wyk 1997) and this genus therefore presents similar interpretation problems as *Ficus*. For this reason these taxa have not been used for specific environmental interpretations.

Syzygium species in KwaZulu-Natal grow in forest, occasionally swamp forest and in wooded grassland habitats (Grant & Thomas 1998). It may be possible with more reference material to refine the identification thus providing specific environmental niche data.

In addition to the *Calodendrum capense* another Rutaceae identification, *Vepris*, has been made. This identification is tentative because the wood anatomy of *Teclea*, also within this family, is similar. *Vepris* and *Teclea* both grow in the remnant forest around Sibudu Cave today.

Although the majority of taxa from BSp prefer forested and riverine habitats there are also some taxa in the assemblage that indicate the presence of a more open and perhaps drier environment. These taxa include *Acacia* species and some *Ziziphus* species. In this layer *Ziziphus* has not been identified to species because the specimens, although similar to *Z. mucronata*, do not display sufficient clear anatomical characteristics to make a secure identification.

Acacia is a large genus with species occurring throughout southern Africa. On the whole, *Acacia* species grow in open, dry and warm environments often at the margins of wooded areas and, with few exceptions, are found in the summer rainfall region.

6.2.2.9. BSp Summary and Environmental Interpretation

These charcoal identifications are representative of an environment with both evergreen and deciduous components. They also indicate the presence of river influenced forest vegetation. Most of the taxa identified can be found either in the immediate cave region or nearby in KwaZulu-Natal today.

There is a mixture of understorey vegetation with some larger forest taxa. The seeds support for this interpretation because various forest components, (Wadley, 2004) such as *Asparagus* spp. (many of which are understorey indicators) and *Celtis*

mildbraedii (an evergreen climax forest indicator) are present. *Erica caffra* could provide evidence for a slightly cooler environment than today as well as adding support to the indication of riverine vegetation, different from the riverine vegetation present today. *Acacia* spp. and possibly *Calodendrum capense* suggest an open, possibly warmer and drier environment than is found near the cave today. Although these identifications appear to provide contradictory environmental data they may be interpreted as indicating that a combination of vegetation niches were available for wood selection. It is also possible that different areas within a niche, such as slopes of a valley, were being exploited. Slope aspect is one factor that governs the amount of sunlight and thus the amount of heat and available moisture a plant receives. Unfortunately slope aspect is rarely recorded in the literature.

6.2.2.10. Layer RSp: The Assemblage

Layer RSp has an OSL date of 53.4 ±3.2 ka (Wadley & Jacobs 2004). Ninety charcoal fragments were identified and only three Charcoal Types were created. Twenty families are represented in this sample and 11 genera were identified (Table 6.6). Identifications include *Rapanea melanophloeos, Erica* sp., *Erica caffra, Kirkia* sp., *Ficus* sp., *Podocarpus* sp., *Ximenia* sp., *Diospyros* sp., *Albizia* spp. and *Acacia* spp. In addition each of the Fabaceae sub-families, Mimosoideae, Caesalpinioideae, and Papilionoideae are represented as well as taxa from a broad range of other families including Rutacaeae, Lamiaceae, Rubiaceae, Proteaceae, Sapotaceae, Euphorbiaceae, Combretaceae, Oleaceae, Burseraceae, Anacardiaceae, Celastraceae, Rhamnaceae, Loganiaceae. One specimen has been labelled Rubiaceae/Apocynaceae because it shows similarities to taxa in both families. This identification is different from the Rubiaceae/Apocynaceae specimens that were common in the HP layers. Anacardiaceae/Burseraceae identifications have also been made. These families have similar anatomical features and when anatomical structures are badly preserved they are difficult to differentiate.

In this layer, a large proportion of the charcoal analysed was unidentifiable. One or more of the sections obtained were often too unclear to see sufficient anatomical features. Charcoal preservation in this layer is similar to the preservation of the BSp assemblage. In addition, many of the RSp fragments demonstrated fractures along rays and the sandy component of the deposit had worked its way into these gaps causing damage to the anatomical features. In particular it was difficult to obtain clear Radial Longitudinal Sections.

6.2.2.11. Contemporary Distribution of Taxa and Environment Data

With the exception of *Albizia* and *Combretum*, all other genera present in this layer have been identified and discussed in previous layer descriptions. Taxa already mentioned are not discussed in detail here but are returned to in the preliminary summary given below for RSp.

Albizia species are predominantly components of open woodland and thornveld vegetation. In the lowveld *Albizia tanganyicensis* (Grant & Thomas 2000) grows on warm north facing slopes. There are 15 species present in southern Africa although some of these are unlikely identifications because they are confined to northern parts of southern Africa (Fig. 6.5). All *Albizia* taxa are found in the summer rainfall region. *Albizia adianthifolia* is the only species that grows to the south of KwaZulu-Natal along the Transkei coast. It is found in open forest and at forest margins (Pooley 1997).

The suggested identification of *Combretum* spp. provides limited environmental and distribution information because this genus is large with more than 30 species in southern Africa; however, all *Combretum* species grow in the summer rainfall region (Coates Palgrave 2002) and they can withstand drought, although they are not numerous in the extreme dry regions of the west. They are also not often found in areas which receive regular frosts. Some *Combretum* species that are restricted to the dry western parts of southern Africa can be excluded as possible identifications.

Eighteen *Combretum* species are found in eastern South Africa, in Limpopo, Mpumalanga and KwaZulu-Natal. Their habitat descriptions vary widely, from coastal evergreen forests to rocky hillsides in bushveld and woodland (Coates Palgrave 2002).

6.2.2.12. RSp Summary and Environmental Interpretation

Although there are limited environmental data available for the taxa discussed above it can be noted that both *Albizia* and *Combretum* species are found together with many of the other taxa identified in this layer. They are often found to co-occur with *Kirkia, Acacia, Ximenia* and *Ziziphus* in warm environments in northern parts of South Africa.

The preferred habitats of *Ximenia* and *Kirkia* (Table 6.1) provide a contrast to the environmental niches indicated by the presence of *Erica, Rapanea* and *Podocarpus*. This is emphasised by the fact that *Rapanea, Erica* and *Podocarpus* are evergreen, whereas *Kirkia, Ximenia* and *Ziziphus* are deciduous taxa (Table 6.1). As discussed in the HP description, *Kirkia* and *Podocarpus* do not necessarily indicate completely different environments.

While there is evidence for a warm bushveld type environment that is not currently in existence around the cave, the evidence for a forest environment remains strong, with identifications such as *Podocarpus* and *Rapanea melanophloeos*. Many of these forest taxa and riverine elements can be found in combination in KwaZulu-Natal. Acocks (1988) describes a series of forest environments within his Veld Type 1, "Coastal Forest and Thornveld", some of which contain elements found in the RSp assemblage. The "Typical Coast-Belt forest" (Acocks 1988) with its associated shrubs and climbers, and the forest of the "Zululand palm veld" (Acocks 1988) also contain many taxa found in the archaeobotanical assemblage.

Identifications from RSp are particularly interesting because there appears to be an increase in warm and possibly drier environments indicators, such as *Ximenia* and *Kirkia* and a decrease in frequency of cooler climate indicators, such as the *Erica* spp. *Leucosidea sericea* is no longer present in the assemblage. The implications of this observation are considered in greater detail in the following chapter.

It is possible that the wide range of taxa identified in layer RSp provide evidence for a complex mosaic of environments that were being utilised for wood collection.

6.2.2.13. Layer OMOD: The Assemblage

OMOD has an OSL date of 51.8 ±2.1kya (Wadley & Jacobs 2004). Many of the fragments from this layer have been identified as belonging to the Fabaceae family and sub families including identifications of *Acacia* spp., *Albizia* spp., cf. *Burkea africana*, cf. *Afzelia* sp. and cf. *Erythrina* sp. (Table 6.7). Other genus identifications include *Erica* sp., *Celtis* sp., *Mystroxylon* sp. and *Buxus* sp. There is also a possible identification of *Heteromorpha arborescens* (= *H. trifoliata* Pooley 1997), which belongs to the Apiaceae family. This family contains three other genera, of which none are represented in the collection. The identification is therefore suggested rather than secure because it may belong to one of these other genera. In this layer 20 Charcoal Types were defined and have not yet been identified. Many of these Charcoal Types were determined from single fragments only and therefore some anatomical characteristics were not visible for recording, making identification at this stage problematic.

A small percentage of the total sampled was classed as unidentifiable. This is partly due to the relatively good preservation. Most fragments had sufficient clear anatomical features to enable identification or for the specimens to be described as Charcoal Types. The high proportion of identifiable fragments can also be attributed to the fact that many pieces belonged to the Fabaceae family, which has distinct features, including vestured pits, aliform to confluent parenchyma and often storied

parenchyma, which allowed for quick classification. Fragments that did not fall into this group were significantly harder to identify especially beyond family. This is evident from the small number of genus identifications, and the large number of Charcoal Types.

As in previous layer, RSp, a wide range of families are represented. Identifications include Rubiaceae, Apocynaceae, Loganiaceae, Oleaceae, Rhamnaceae, Meliaceae, Annonaceae, Proteaceae, Lamiaceae, Rhizophoraceae, Anacardiaceae, Euphorbiaceae and Fabaceae. Within Fabaceae, sub-families Caesalpinioideae and Papilionoideae are represented by specimens that cannot be identified to genus at present. There are also identifications of Malvaceae/Tilliaceae and Rubiaceae/Apocynaceae.

Rhizophoraceae and Meliaceae identifications are only present in this layer. The identification of Rhizophoraceae is interesting because this is the Mangrove family. There are only four genera in southern Africa and of these three are strictly found along the coast and often in estuarine conditions (Coastes-Palgrave 2002). The fourth genus, *Cassipourea* is the most likely identification. *Cassipourea* species are not confined to the coast and although they are within the Rhizophoraceae family they are not mangrove taxa (Coates Palgrave 2002). Two *Cassipourea* species are present in the reference collection, however, there are five other possible species, although two of these only grow in isolated regions in Zimbabwe and Mozambique. It is very unlikely that mangrove taxa would have been present in the Sibudu region because the coast would not have been close enough to the cave to support such a habitat. There are several possible Meliaceae identifications, including *Turraea*, *Trichilia* and *Ekebergia* that are held in the reference collection. Unfortunately the reference specimens and images of these are not very clear and the wood anatomy of these needs to be better documented to enable further identification.

6.2.2.14. Contemporary Distribution of Taxa and Environment Data

Burkea africana and *Afzelia quanzensis* provide quite specific environmental data because their distributions within South Africa are reasonably confined. *Burkea africana* grows in woodland (Coates Palgrave 2002) and mixed bushveld on plains in Limpopo and North West Provinces (Grant & Thomas 2000). It occurs across a range of altitudes, but at higher elevations it preferentially grows on north and west facing slopes (Grant & Thomas 2000) which receive sun for longer periods than south and west facing slopes. *Afzelia quanzensis* grows in northern KwaZulu-Natal, Mpumalanga and Limpopo Province. This large deciduous tree occurs in woodland and dry sand forest at low altitudes (Coates Palgrave 2002; Pooley 1997). In Swaziland and Northern KwaZulu-Natal it grows in the Lebombo mountains (Pooley 1997).

Erythrina species belong to Papilionoideae, a subfamily of Fabaceae. They are found in summer rainfall regions of southern Africa. On the whole they prefer open wooded grassland and bushveld habitats. *Erythrina humeana* can grow in mountainous areas and on rock outcrops; *Erythrina caffra*, is found in forest and riverine fringe forest along the east coast of South Africa; while *Erythrina lysistemon* also grows along the coast, in scrub forest, but is found in drier regions (Pooley 1997). The Witwatersrand reference collection contains *Erythirina caffra* and *Erythrina lysistemon*, which display similar anatomical traits to each other and to the archaeological specimen.

Mystroxylon belongs to a large family with many genera. The taxonomic relationships between genera in the Celastraceae family are not well established and in recent literature (Coates Palgrave 2002) many taxa have been reclassified. Although the specimens from OMOD display characteristics found in *Mystroxylon* spp., other genera cannot be excluded as possible identifications. Currently there are two species belonging to *Mystroxylon*, *M. aethiopicum* and *M. burkeanum*. Both taxa are found in South Africa. *M. aethiopicum* is widespread in the eastern half of the

country (Fig. 6.6) and grows in a range of habitats, including evergreen forest, dune forest, riverine fringe forest, and open woodland (Pooley 1997; Coates Palgrave 2002). *M. burkeanum* is less widespread, growing only on the highveld. There are many similarities between these taxa and in some instances living specimens cannot be distinguished from one another (Coates Palgrave 2002). In such cases the later species may even be considered a subspecies of *M. aethiopicum*. The complex nature of this family has clear implications for identifying and classifying charred specimens on the basis of their wood anatomy alone.

Identifications of *Buxus* sp., *Celtis* sp. and *Heteromorpha arborensens* provide evidence for forest. The growth form of *Heteromorpha arborescens* is highly variably depending upon growth location and conditions. It can grow as a very large forest tree although it also grows as a shrub on the Highveld (L. Wadley pers. comm.). *Buxus* species are smaller, often forming part of the understorey vegetation in forest (Pooley 1997). The C*eltis* species cannot be distinguished at present, however, all *Celtis* species can be found in forest (van Wyk & van Wyk 1997). *Heteromorpha arborescens* occurs from the coast up to 2000 m and throughout eastern South Africa (Pooley 1997). This deciduous tree often grows at the margins of evergreen forest, but can also occur in a range of habitats from closed ravines to open and rocky hillsides (Coates Palgrave 2002).

6.2.2.15. OMOD Summary and Environmental Interpretation

Taxa found in OMOD indicate that the cave occupants may have exploited two types of vegetation habitat. Identifications of *Acacia* spp., *Albizia* spp., cf. *Burkea africana*, cf. *Afzelia* sp., *Erythrina* spp. and *Mystroxylon* sp. suggest that a relatively open vegetation type existed near the cave. In addition, the presence of *Buxus* sp., *Celtis* sp., *H. arborescens*, and some *Erythrina* spp. indicate that wood was brought to the cave from a forest environment. The identification of *Celtis* sp., is consistent with well developed forest. This would certainly be evident if the specimen was *Celtis milbraedii*, which is found in climax forest in KwaZulu-Natal (Pooley 1997). This

taxon has been identified in the seed assemblage from this layer and it provides support for the suggestion of a well-developed forest near the cave. This layer contains a combination of evergreen and deciduous taxa.

The riverine component of the OMOD assemblage is less prominent than in previous layers (Fig. 6.10). *Erica* spp. are less well represented and they are the only taxa present in this layer that are dependent upon the presence of water although some of the forest taxa, such as *Erythrina* and *Mystroxylon* are frequently noted at the fringes of the forest, near rivers. Previously it has been suggested that *Erica* species provide an indication of cooler environments. In this layer there are many taxa which imply that the environment was warm. It is therefore unlikely that the *Erica* identifications alone could be used as an indication of cooler environments because this association is not supported by any other taxa identified in the sample. The *Erica* spp. identifications confirm the presence of the river.

6.2.2.16. Layer MOD: The Assemblage

Layer MOD has recently been dated to about 50 000 years ago (Z. Jacobs pers. comm.). All the charcoal fragments analysed from MOD were identifiable. Preservation of charcoal was noticeably better than in other layers. There were more fragments from the larger size classes, >15 mm, and fewer specimens showed signs of micro-scale damage, such as fractures along rays. One hundred and eight fragments of the total were identified to family, genus or species and six Charcoal Types were defined. Twenty different families are represented, and within these, 13 genera have been identified (Table 6.8). The Charcoal Types contained one fragment each, making further identifications difficult. Some of the identified taxa are only represented by one or two specimens but many of these had been identified in other layers analysed, which enabled identification here. These identifications include; *Nuxia* sp., *Diospyros* sp., *Rapanea melanophloeos*, *Erica* spp., *Curtisia dentata*, *Bridelia* sp., *Mystroxylon* cf. *aethiopicum* and *Cunonia capensis*. *Pappea capensis* and *Macaranga* cf. *capensis* are new identifications and are only present in MOD.

Other better represented genera include; *Acacia* spp., *Albizia* spp., *Drypetes* sp., and the suggested identification of *Sapium/Spirostachys*. Family identifications are diverse and many of the families present in this layer have been recorded in RSp and OMOD. Identifications include, Flacourtiaceae, Rhamnaceae, Proteaceae, Sterculiaceae, Euphorbiaceae, Tilliaceae, Lamiaceae, Oleaceae, Anacardiaceae, Rutacaea, Sapotaceae, all Fabaceae sub-families, one Anacardiaceae type and another Anacardiaceae/Burseraceae identification for which the wood anatomy is not distinct enough to distinguish to family level.

6.2.2.17. Contemporary Distribution of Taxa and Environment Data

Macaranga and *Bridelia*, from the Euphorbiaceae family, contain two and four species in southern Africa respectively. Of the two *Macaranga* species one is confined to high altitude regions of Eastern Zimbabwe (Coates Palgrave 2002) while the other more probable identification, *M. capensis*, grows in forest at low altitudes (Pooley 1997). In KwaZulu-Natal it is a deciduous tree (Pooley 1997) often occurring on stream banks (Coates Palgrave 2002). The *Bridelia* identification is more difficult to refine. There are two species in modern KwaZulu-Natal and one further north in the Limpopo and Zimbabwe (Coates Palgrave 2002). The two Natal taxa, *B. cathartica* and *B. micrantha* grow in riverine fringe forests (Pooley 1997). *B. micrantha* grows next to the Tongati River today.

Identifications of *Diospyros* and *Nuxia* are labelled cf. indicating they are suggested rather than secure identifications. *Diospyros* species occur across a range of habitats and many can be found in KwaZulu-Natal today (van Wyk & van Wyk 1997). *Nuxia*, with only two species present in southern Africa, provides more information. Both *N. congesta* and *N. floribunda* grow in evergreen forest. An identification of *N. floribunda* would indicate a mild environment with plenty of water (Coates Palgrave 2002) while *N. congesta* may suggest a drier, rocky, bushveld habitat (Coates Palgrave 2002). The unique characteristics in the wood anatomy of each of these, and within the Buddlejaceae family, needs to be better documented before this

identification can be resolved. *Pappea capensis* is widely distributed across southern Africa (Fig. 6.7). It occurs in wooded grassland, bushveld and riverine fringes (Coates Palgrave 2002; Pooley 1997) and therefore its presence does not assist in refining the environmental interpretation.

6.2.2.18. MOD Summary and Environmental Interpretation

Evergreen and deciduous components are present in the charcoal identifications from MOD. The majority of the trees are half-hardy, meaning they can withstand some frost. The data indicate that there may have been some forest near the cave. The extent or complexity of the forest cannot be determined from these identifications although the data provide little evidence for the forest being different from the forest community surviving in the area today. It also seems likely that what is now the Tongati River was flowing during this period, supported by the identifications of trees preferring riverine habitats, such as *Erica*, *Bridelia* and *Macaranga*. Although the majority of the data indicate a riverine forest vegetation type there are components that are often found in drier, savanna bushveld conditions. *Pappea capensis* represents a species that can occur in both riverine and drier bushveld environments. *Albizia* and *Acacia* suggest the presence of a drier environment although species from these genera are found in the immediate vicinity of the cave today and can occur in a wide range of environments in southern Africa.

6.2.2.19. Layer Bu: The Assemblage

Bu is one of the final MSA layers at Sibudu cave with an OSL date of 35.2 ?1.8 ka (Wadley and Jacobs 2004). This deposit has been excavated from quadrants towards the back of the cave and is not present in the witness trench. Charcoal was analysed from squares D2 and E2.

Nine families are present in the charcoal assemblage and eight of these were identified further. *Brachylaena* sp., *Acacia* spp., *Erica* spp., and *Kirkia* spp. are present. Species identifications include *Clerodendrum glabrum*, *Xylothecca*

kraussiana, Mystroxylon cf. *aethiopicum* and cf. *Phoenix reclinata*. Many of the specimens from Bu were grouped as Charcoal Types and 23 of these are represented by one fragment only (Table 6.9). Charcoal from Bu was fairly well preserved and therefore this high percentage of Charcoal Types is likely to be indicative of a true change in the assemblage, which may be related to a change in the environment, rather than an indication of poor preservation. Some specimens were also identified as taxa from Sapotaceae, Rubiaceae, Fabaceae and the sub-family Papilionoideae, as well as Rubiaceae/Apocynaceae and Anacardiaceae/Burseraceae families.

6.2.2.20. Contemporary Distribution of Taxa and Environment Data

The combination of taxa within this layer is different from that observed in other layers. *Xylothecca kraussiana* and *Clerodendrum glabrum* are often present in coastal vegetation such as dune forest, coastal thicket and bushveld, although they are also recorded inland within southern Africa (Pooley 1997)

Arecaceae, the Palm family, contains a range of palms that are widespread across southern Africa. Wood anatomical structures observed in the specimen from this layer indicate that the most likely identification is cf. *Phoenix reclinata* however this cannot be confirmed until more comparative material has been obtained. This species occurs along rivers, in open low-lying grassland regions (Coates Palgrave 2002), and near the coast in subtropical parts of southern Africa, although it does not grow in dune vegetation (Grant & Thomas 1998). It can be found growing near the cave today and frequently occurs in other regions of KwaZulu-Natal. The presence of *Phoenix reclinata* in conjunction with *Xylothecca kraussiana* and *Clerodendrum glabrum* is interesting because they are often found in similar environments, both close to the coast and inland.

Brachylaena spp. may provide more specific environmental niche data, however this depends upon which species are present in this layer. *Brachylaena discolor*, which was discussed in detail in the description of the HP layers, is representative of

evergreen coastal vegetation. In Bu there is more than one taxon present in the charcoal assemblage and many of the specimens have anatomical characteristics that are similar to those documented for *B. rotundata.* *B. rotundata* is deciduous and has a restricted distribution in northern South Africa (Fig. 6.8). It grows in bushveld and open woodland often in dry, rocky lacalities and on small hills (Coates Palgrave 2002).

The Fabaceae identifications from Bu have been divided into two sub-families, Mimosoideae and Papilionoideae. The Mimosoideae specimens are further defined as *Acacia* spp. As mentioned previously the information provided by these identifications is limited because *Acacia* spp. are widespread and numerous within southern Africa. Although they are present in a diverse range of environments within each of these they preferentially grow in open locations. There are a few exceptions to this such as *A. schweinfurthii* (which is a scrambler) and *A. xanthophloea* (the fever tree). Papilionoideae is also a large sub-family of Fabaceae containing taxa that occur in many regions of southern Africa. The specimen from this layer contains anatomical characteristics, such as storied rays and parenchyma, found in many Papilionoideae taxa; however, it has not been possible to identify it beyond family. This is partly a limitation of the reference collection available while also being a reflection of the difficulties associated with making identifications in this group.

It is interesting to note the presence of *Kirkia* sp. in this layer. The taxon was also identified in the samples from RSp and HP. *Kirkia acuminata* is a deciduous tree that is found in a variety of bushveld habitats (Grant & Thomas 2000) and woodland at medium to low altitudes (Coates Palgrave 2002). In contrast, *Kirkia wilmsii* grows at higher altitudes on mountain slopes and rocky hills (Coates Palgrave 2002). The presence of either of these species would provide evidence for a drier environment than is present in KwaZulu-Natal today. Their specific distributions are discussed in the context of the HP sample (see above).

6.2.2.21. Bu Summary and Environmental Interpretation

The charcoal specimens from this layer are a combination of evergreen and deciduous taxa. Some of the taxa are widespread in southern Africa while others are confined to small areas or they grow within limited niches. The majority of taxa identified in this sample are present either in the modern cave region or nearby in KwaZulu-Natal. *Kirkia* provides an exception to this and for this reason its presence may be pivotal to the interpretation of the combination of taxa present in this layer. The *Brachylaena* identifications may also be significant to the interpretation, however this cannot be determined without secure species identifications.

The identifications can be interpreted in a number of different ways. Firstly, it is possible that the *Kirkia* taxon is an outlier within this layer. It may have been brought from a nearby, but distinct vegetation environment. Secondly, it can be assumed that *Kirkia* was present in the same vegetation region as the other taxa within the deposit. In making this assumption it is implied that the environment may have been significantly different. Although all the identifications may not be observed in combination in KwaZulu-Natal today many of them are found in the Limpopo, and Mpumalanga provinces. The regions in which they occur are, on the whole, drier than KwaZulu-Natal, however within these dry regions there are wetter niches, such as along rivers that contain many of the taxa present in this layer.

6.3. Summary

Charcoal is preserved throughout the MSA deposits, however, preservation and charcoal quantities vary within and between stratigraphically distinct layers. Charcoal is analysed from eight layers, spanning a period of between 30-35 000 years. The oldest layers, from the HP, are about 62 000 years old (Z. Jacobs pers. comm.) and the youngest layer analysed, Bu, is dated to 35.2 ?1.8 ka (OSL) (Wadley & Jacobs 2004). There are fewer charcoal fragments in the HP layers, however, the

preservation of these fragments is good. In some of the later layers, in particular Eb and RSp, internal structures of the charcoal are less well preserved. Preservation is very good in MOD and specimens are classed as identifiable, with taxonomic identifications or as Charcoal Types.

Each layer analysed contains evergreen and deciduous taxa and, in total, more evergreen than deciduous taxa are identified. In layers OMOD and RSp the deciduous taxon presence is more prominent than in other layers. Indicators of forest, riverine and bushveld vegetation are present throughout the layers, however, as with the deciduous and evergreen indications the prominence of the three different communities varies between layers. More bushveld taxa are present in the younger layer and more of the riverine and forest taxa are noted in older layers. In addition, although the communities are present throughout the samples they are represented by different taxa suggesting changes in the types of vegetation community from which the cave occupants collected. These differences are interpreted as evidence for changes in the vegetation environment that may be a result of larger scale climatic changes.

It is important to note that vegetation indicating the presence of the river persists throughout the layers analysed. Its presence is not unexpected and these taxa provide a constant background of identifications over which other vegetation types appear and perhaps disappear through time. There is evidence to suggest that the composition of the riverine community also changed a little through time. The presence of the river vegetation is likely to have obscured some of the more subtle vegetation and climatic shifts because it may have acted as an oasis providing a constant source for wood for the cave occupants.

There are also some taxa that are present throughout the assemblages, such as *Ziziphus mucronata* and *Rapanea melanophloeos*, which may suggest some continuity in the vegetation surrounding the cave. Both of these plants are fairly

versatile and *Z. mucronata* in particular is widespread in southern Africa and therefore it is difficult to assess the evidence for continuity because these taxa would probably have been able to adapt to changes in vegetation and climate. Another taxon, *Leucosidea sericea*, does not grow near the coast naturally, although it can survive along the coast if introduced (C. Scott pers. comm.). Its presence and the presence of taxa from northern South Africa are interpreted as evidence for a southwards shift in vegetation belts. This may have been the result of a change in climate, lowering of sea level or both.

Some layers contain taxa that are currently not found in the Sibudu Cave vicinity. Of these, some only grow in northern South Africa today in regions that receive significantly less rainfall than the Sibudu region does. Identifications of *Kirkia* sp. and *Ximenia* sp. were unexpected. Both taxa are found in drier habitats than the Cave region experiences today and they are often found in savanna bushveld or woodland vegetation.

Four distinct groups of layers can be defined on the basis of their dates and taxon compositions. The oldest sample analysed from the HP layers suggests the presence of an evergreen forest. The area may have received quite high rainfall or have had high moisture availability, through the soils, the presence of the river or humidity levels. There is contrasting evidence for a drier environment in the HP layers. The region may have been warmer, receiving more sunlight than the sheltered and shaded forest region. This combination of taxa is not found in modern KwaZulu-Natal although can be found further north in Limpopo Province. The vegetation in the HP may be similar to extant forest and bushveld communities in northern KwaZulu-Natal today.

The second group that can be defined includes layers Eb, SPCA and BSp. SPCA and BSp are stratigraphically sequential, and Eb is slightly lower in the stratigraphy (Fig. 3.3), however, they all lie within a sequence of layers dated to between about 60 000

years ago and 56.7 ±2.3 ka. Each of these layers contain evidence for a variety of vegetation communities, including forest and riverine vegetation and to a lesser extent drier, bushveld vegetation. These layers contain strong evidence for riverine vegetation. The presence of *Leucosidea sericea* and *Erica* spp. may indicate the area experienced cooler climatic conditions during this occupation phase.

The third group includes layers RSp, OMOD and MOD. These layers date to 53.4 ±3.2 ka (OSL), 51.8 ±2.1 ka (OSL) (Wadley & Jacobs 2004) and about 50 000 years ago (Z. Jacobs pers. comm.) respectively and they contain significantly more taxa from drier and warmer communities than the previous group of layers do. The forest and riverine vegetation indicators are still present and within these there are evergreen taxa, but deciduous taxa are better represented. Deciduous species include a range of Fabaceae taxa as well as *Kirkia* sp. and *Ximenia* sp.

Bu, one of the final MSA layers, makes the fourth group. This layer contains some taxa that can currently be found near the cave in the remnant forest vegetation. The trend of increased numbers of Fabaceae taxa does not continue into Bu. Instead there are more forest taxa and there are several new identifications that are consistent with riverine forest vegetation. The number of *Erica* sp. fragments have reduced but this may be a result of different fragmentation rather then a true reduction in the assemblage or the environment. There are some similarities between the range of taxa present in Bu and those identified in the HP layers. For example, *Kirkia* sp. and *Brachylaena* spp. are present in both layers. Other taxa, such as *Podocarpus* sp., are not been present in the Bu sample.

In the following chapter evidence is presented from the quantitative analysis, while continuing to draw upon the qualitative data presented above.

CHAPTER 7. QUANTITATIVE ANALYSIS RESULTS AND PRELIMINARY INTERPRETATION

7.1. Introduction

In this chapter the results of the quantitative analyses are presented. Factor analysis results are given both before and after rotation of the data matrix. Reference is made to taxon distributions, vegetation niche data and modern cultural uses to aid interpretation of the identified factors. Several explanations for each factor are provided and summary statistics are used to produce indices for factors defined after the rotation was applied. The final quantitative test used is a correspondence analysis. This test was used as a complimentary analysis method to verify the results of the factor analysis. The outcome of this test is discussed and interpreted. Comparison to the factor analysis is reserved for Chapter 8. The following discussion is concluded with a summary in which I discuss some of the major trends in the data that have become apparent during identification, analysis and interpretation.

7.2. Quantitative Analysis

7.2.1. Factor Analysis

Factor analysis results are presented both before and after applying an orthogonal varimax rotation. The analysis identified seven factors that influence the charcoal assemblage (Table 7.1). Three of these factors account for 71% of variability within the data and over half of the variability can be explained by the first two factors. These two factors are most important in determining the composition of the data set.

Factor loadings for the variables included in the analysis are discussed for the first three factors before and after rotation to establish the major influences upon the data, whether environmental or cultural. The dichotomous relationships between variables in the remaining factors are likely to be attributable to very small influences upon the assemblage composition and are therefore not considered further. All variables with factor loadings less than 0.3 and greater than -0.3 are not influential in defining the factors and those values have been removed from the results table (Table 7.2). The taxa have been ordered (Table 7.3 – 7.8) from largest to smallest within the highest and lowest factor loading categories.

7.2.1.1. Results Prior to Rotation

Of the nine important variables with high positive factor loadings in F1, six belong to the encompassing Fabaceae family (Table 7.3). Genera and species identifications included in each variable are listed in Appendix F. As the occurrence of *Afzelia*, *Burkea* and other Caesalpinioideae taxa as well as *Albizia* spp. and *Acacia* spp. from the Mimosoideae sub-family increases, there is a corresponding decrease in the occurrence of *Ptaeroxylon obliquum*, *Ochna* spp., *Leucosidea sericea*, *Morella pilulifera*, *Podocarpus* spp. and *Erica* spp. This factor is most influential in determining the composition of the data. F1 includes some of the most commonly occurring taxa, but it does not included taxa such as *Rapanea melanophloeos* that are present in small numbers throughout the samples.

In F2 some of the taxa that were previously assigned low loadings in F1 have been separated and placed at opposing ends of this factor (Table 7.4). This indicates that although they are underlain by a common determinant, F1, they are also influenced by an additional factor, which affects these variables in a different way resulting in the dichotomy observed in F2. Celastraceae, *Podocarpus* spp., *Ochna* spp., and *Brachylaena* spp. in this factor are observed to increase, while *Morella pilulifera*, *Leucosidea sericea* and *Erica* spp. decrease. This second factor is not exclusively composed of taxa with negative factor loadings from F1. Other influential taxa are

Rapanea and *Celtis*, which are grouped with *Morella*, *Leucosidea* and *Erica* in F2. At the positive end of the factor there are also additional taxa including *Kirkia* sp., Sterculiaceae, Proteaceae and *Buxus* sp. None of the variables with high loadings in F1 display significant factor loadings in F2 suggesting that they have little influence upon this factor.

In the third factor, F3, there is repetition of variables assigned significant loadings in previous factors (Table 7.5). Disregarding Olacaceae, all variables in the data are included in F1 or F2. Olacaceae (*Ximenia* sp.) has the largest negative factor loading and its occurrence is therefore highly influential upon F3. To interpret the factor it will be important to consider the environmental requirements and cultural uses of *Ximenia* sp. that may influence its occurrence in relation to other taxa in the assemblage. The *Ximenia* sp. is grouped with *Kirkia* sp., as well as taxa from Proteaceae and Rutaceae. At the positive end of the factor the Fabaceae family, and more specifically the Papilionoideae sub-family as well as *Ficus* sp., *Celtis* sp., *Buxus* sp. and taxa from Sterculiaceae, are noted.

7.2.1.2. Interpretation Prior to Rotation

Variables assigned positive factor loadings in F1 tend to be found growing in open savanna environments (Table 6.1), although some of these families such as the Mimosoideae, contain taxa that are able to grow in a wide range of habitats. Distributions and environmental niche data were examined for each taxon. The majority of taxa assigned positive loadings grow in the summer rainfall region of southern Africa in areas with low winter rainfall values. Families with negative loadings contain taxa that grow along the coast and often as far south as the Eastern Cape. Some of these taxa are able to grow in a range of habitats in the winter rainfall region of the Cape. Many of the identified taxa have a moisture requirement and grow in riverine forest (although not exclusively).

F1 may also be explained by changes in selection of firewood. Some taxa at opposing ends of the factor are recorded as good fuelwoods. This factor recognises that layers with a dominance of *Erica* spp. are distinct from layers where *Acacia* spp. are dominant. There is some overlap in the occurrence of these taxa; however, the factor analysis has noted the general trend that as one increases in percentage frequency the other decreases. It has also recognised that the occurrence of *Podocarpus* is, with the exception of RSp, distinct from the occurrence of *Acacia* spp. *Erica* spp. and *Acacia* spp. are used as fuelwood by modern societies in South Africa. Although *Podocarpus* is not noted as fuelwood, it is possible that it was used in the absence of other better fuelwood types, or it is possible that *Podocarpus* does in fact burn well but it is not used today and therefore it is not recorded as a fuelwood in the literature.

F2 identified some overlap with variables important in F1. Since many of the taxa that are polarised in this factor can be found together and grow in similar environments it is difficult to interpret the result with any great certainty. Rather than being dependent on one of the climatic variables considered here it is likely that another perhaps more discrete agent is influencing the composition of this factor. This factor identifies differences in the occurrence of *Podocarpus* spp. and *Erica* spp. in the data set. The previous factor grouped these taxa. *Erica caffra,* which is the dominant *Erica* species, and *Podocarpus* species grow along the edges of steams and rivers and therefore proximity to rivers is unlikely to be the influential factor. Many of the taxa grouped with *Podocarpus* grow within forest vegetation, whereas, at the opposite end of the factor many of the identifications grow at the forest margins. This is not exclusively the case, however, because there are taxa such as *Kirkia* that are grouped with the forest taxa. *Podocarpus* and *Kirkia* are not necessarily contradictory identifications but, although they may grow in close proximity, they are not specifically found within the same vegetation niche.

The third factor, F3, contains taxa from a range of environments and the *Ximenia* sp. identification was noted as important in this factor. *Ximenia americana* and *Ximenia caffra* are able to grow in the warm dry regions of northern South Africa in Limpopo and Mpumalanga provinces. *X. americana* and *X. caffra* are bushveld species (Coates Palgrave 2002) and are often found in the same regions as *Acacia, Kirkia* and *Albizia* species. *X. caffra* has a slightly wider distribution and also grows in coastal bushveld in KwaZulu-Natal. Both species are used for various medicinal tasks and the fruits of these trees are edible. The wood is not recorded as fuelwood although this does not preclude its use as such.

Ximenia is grouped with *Kirkia* sp., Proteaceae and Rutaceae. Proteaceae contains a wide range of *Protea* species and *Faurea* species. Distinguishing between genera on the basis of wood anatomy may be possible but the anatomical structures of specimens in these samples were not distinct enough to do so. Many *Protea* and *Faurea* species grow in warm bushveld regions although different species are also dominant plants of the Cape Fynbos vegetation. Identifications from the large Rutaceae family include *Calodendrum capense* and *Vepris* sp. *C. capense* is often found in wooded ravines and it has a fairly wide distribution from sea-level to 2000 m a.m.s.l. (Pooley 1997). *Vepris* is a large genus and it is therefore difficult to confine the identification or to suggest specific environmental requirements. At the opposite end of the factor *Celtis* and *Buxus* species are indicators of forest vegetation but other taxa come from a wide range of environments. This factor does not appear to be influenced by a clear environmental factor.

7.2.1.3. Results After Rotation

One of the most striking differences between the rotated and unrotated factor results is that fewer variables are assigned significant factor loading values after rotation and this is particularly noticeable in RF1. This is one effect of rotating the data matrix using a varimax rotation. The rotation makes the differences between the variances greater, which has the effect of placing more families within the “cut off” area (less

than 0.3 and greater than –0.3), so that fewer families are assigned significant factor loadings. Only families that are most influential upon the factor remain and it is therefore often easier to interpret the results after a rotation has been applied.

The first factor after rotation (RF1) remains in essence similar to F1 before rotation although some differences are apparent. The first is that the positive and negative loadings have been reversed. In RF1 the highest positive loadings are assigned to Ericaceae and Myricaceae while the lowest negative loadings are assigned to Papilionoideae, Fabaceae, Celastraceae, Mimosoideae *Acacia* spp., *Brachylaena* spp. and *Kirkia* sp. variables (Table 7.6). The opposite was true prior to rotation. Secondly, RF1 is not dominated by the Fabaceae variable or subfamilies within Fabaceae whereas F1 was dominated by these taxa. In RF1 Celastraceae, *Brachylaena* spp. and *Kirkia* sp. are also important.

The second factor RF2 contains some variables such as Papilionoideae, *Morella pilulifera* and *Erica* that are also important in RF1 suggesting the first two rotated factors are not completely independent of one another with regards to their influence - whether environmental or cultural - upon the vegetation brought to the cave. In RF2 the *Brachylaena* spp. have been grouped with *Erica* spp. and *Morella pilulifera* (Table 7.7). Previously, in RF1, *Brachylaena* spp. were placed with the group of variables containing Fabaceae and Papilionoideae. The shift in placement between these factors indicates that the *Brachylaena* spp. variable may be pivotal to the interpretation of the first two factors.

Many of the variables in RF3 are also included in RF1 and RF2. At the positive end of RF3 six variables have significant loadings, whereas at the negative end there are only two variables included in the factor (Table 7.8). This suggests that variables at the positive end of the factor are more important in determining this factor than those at the negative end. The positive end of the factor includes Ochnaceae, *Ptaeroxylon obliquum*, *Podocarpus* spp., *Buxus* spp., Celastraceae, Sterculiaceae and Proteaceae

while at the negative end of the factor the sub-families Papilionoideae and Mimosoideae *Acacia* spp., which belong to the larger Fabaceae family, are influential (Table 7.8). This factor is interesting because it recognises the co-occurrence of *Podocarpus* spp. with Ochnaceae taxa and *Buxus* spp. but it does not isolate the co-occurrence of *Kirkia* spp. and *Podocarpus* spp. which is evident in the data (Fig. 6.10).

7.2.1.4. Interpretation After Rotation

Families placed at opposite ends of RF1 have been correlated with environmental data and habitat requirements. In RF1 positive loadings were assigned to taxa that tend to occur in cooler regions of southern Africa when compared to the taxa exhibiting negative loadings. The distribution maps show that many of the taxa with positive loadings are able to grow at higher altitudes than those with negative loadings. It is possible that this factor is governed by temperature. Another possible explanation for the dichotomy observed in RF1 is moisture requirements of the plants. Taxa influential at the positive end of the factor, including *Morella pilulifera*, *Erica* spp., *Rapanea melanophloeos*, and *Leucosidea sericea* require moisture and are often found near rivers, whereas those at the negative end do not depend upon access to water and are able to withstand long winter droughts.

Some variables with the lowest loadings in RF2 are noted as being able to withstand frost conditions (Table 6.1). Those with highest temperature values and highest factor loadings tend to occur in areas where frost is infrequent. The combination of temperature, distribution data and environmental tendencies indicates that this factor may be dependent upon the niches in which these taxa grow. In addition anthropogenic influences may be responsible for the composition of this factor, as suggested in the interpretation of F1 (prior to rotation). RF2 also recognises a dichotomy between the Mimosoideae group of variables and the Ericaceae variables. As mentioned in Chapter 4, taxa from both families are frequently used as fuelwood by modern societies.

The most influential variable in RF2 is the Asteraceae family (*Brachylaena* spp.) and interpreting their presence may be critical for interpreting this factor. Two possible species in the data set include; *B. discolor* and *B. rotundata* although there are a number of other possible species that are not represented in the reference collection and cannot be excluded with confidence. The majority of specimens display anatomical characteristics most similar to *B. discolor*. This plant is recorded as frost resistant although it rarely grows far from the coast unless along rivers (such as the Tongati).

Interpreting RF3 is quite difficult because there are limited data available for the negative end of this factor. At the positive end of RF3 climate data are available for six of the seven variables whereas as at the negative end data are available for one variable (Mimosoideae *Acacia*). Many *Acacia* species grow in warm dry parts of southern Africa and they are predominantly found in the summer rainfall region of the sub-continent. This taxonomic grouping is very large and there are some *Acacia* species that have different habitat tendencies. On the whole they are distributed in the relatively wetter eastern parts of southern Africa although there are some species that occur in the drier western provinces.

Environmental niche data, described in Chapter 6, for the variables in RF3 show that taxa with the highest positive loadings can all be found in relatively damp forest conditions, often as understorey vegetation. Some of the taxa with positive loadings are able to grow in cooler mountainous areas as well as in forests along the coast to the south of Durban. Forests in KwaZulu-Natal receive high annual precipitation, often in excess of 900 mm (Acocks 1988). This factor appears to be governed by habitat tendencies of the taxa. Habitats of taxa included in this factor range from forest (which in this instance is cool and wet) to a more open woodland habitat (which are warmer and drier). Most importantly, this Factor recognises a distinction

between the occurrence of *Podocarpus* and its suite of forest taxa and the other forest taxa that are recorded in other layers analysed.

As discussed above, there is over-lap of variables that are identified as significant across each of these factors, indicating that some taxa are influential in more than one factor. There are other taxa such as Celtidaceae and Olacaceae that are not important in any of the first three factors after the rotation has been applied. Whether taxa are considered influential or not is dependent upon where the arbitrary "cut off" is placed (in this instance 0.3 and –0.3). In descriptive statistical procedures such as this the number factors that are included in the interpretation and the placement of the cut off is at the discretion of the researcher. The overlap of taxa makes defining the factors difficult and as shown above there are a number of different ways the results can be interpreted.

7.2.1.5. Summary Statistics

The rotated factor loadings are used to produce factor scores (RFS1-3) and summary statistics (SSRF1-3) for each factor. The values are plotted on a scale from 0-100 to obtain an index for each factor.

RF1 can be attributed to changes in temperature or to changes in the moisture requirements of taxa in the factor. First it is assumed that changes in temperature affected the local vegetation and thus changes in the composition of the archaeological assemblage, producing the dichotomy observed in RF1. Values closest to 0 (Fig. 7.1) represent warmer periods while values closer to 100 indicate the colder periods. This was determined by analysing the presence/absence of taxa in the layers with highest and lowest index values. For example, SPCA has taxa that yielded positive factor loadings, such as Ericaceae and Rosaceae. These taxa tend to be distributed in cooler environments than taxa at the opposing end of the factor. Taxa yielding negative factor loadings were associated with higher temperatures. Taxa from the warmer temperature grouping occur within layers that have low SSRF1

values. Bu was assigned the lowest value. The plot of the SSRF1 values shows that temperatures were coldest during the occupation period associated with the archaeological layers SPCA and Eb. BSp also has a relatively higher SSRF1 value than is observed for the other layers. The warmest periods (lowest SSRF1 values) have been assigned to Bu and HP. OMOD, MOD and RSp all display fairly similar values and are grouped closer to the warmer end of the index.

If RF1 is determined by the moisture requirements of plants the lowest index values represent periods with taxa from dry environments dominant and higher values are associated with taxa with higher moisture requirements. It is likely that these changes in the taxon representation are related to changes in climate and vegetation not just to changes in wood selection strategies. In this scenario the SSRF1 index indicates that drier conditions prevailed during occupation periods associated with the HP layers, RSp, OMOD, MOD and Bu. This does not correlate with the qualitative descriptions given for HP or for Bu although it does correlate to the descriptions given for RSp, OMOD and MOD in Chapter 6. During SPCA, Eb and BSp there are more taxa that have higher moisture requirements. Bu and the HP layers provide unexpected indices. This may be because these samples do not contain taxa that are influential in RF1, or that it is incorrect to interpret this factor as indicating a change in available moisture. *Podocarpus*, a taxon that is generally found in regions with high moisture availability, is present in the HP layers and it is therefore probable that this interpretation is incorrect and that temperature is a more likely determinant for this factor. Implications of this observation are considered further in Chapter 8.

Perhaps the most likely determinant for RF2 is available moisture (Fig. 7.2). Influential taxa at the negative end of this factor are found near rivers and in regions with high moisture availability. The index can be interpreted as an indication of the presence of riverine taxa as the dominant component of the assemblage verses taxa that are able to survive without rivers. The dichotomy does not indicate the absence of the river during some occupation periods but rather that riverine taxa were less

prominent in the assemblage and this may indicate that the river was reduced in size or that it did not flow perennially.

RF2, which was initially interpreted as an indication of the numbers of frost resistant taxa shows that during occupations associated with SPCA and Eb more plants that are frost resistant were brought to the cave than during occupations associated with OMOD, RSp and MOD. Values obtained for HP, BSp and Bu are grouped towards the "frost resistant" end of the index. It can therefore be suggested that there may have been more frost resistant plants in the vegetation environment during this occupation, indicating a change in environment, or that this pattern was obtained by chance.

It is harder to interpret the indices if the factor is attributed to wood selection. In this instance, the taxa at opposing ends of the factor (*Acacia* spp. and *Erica* spp.) are good fuelwoods. Opposing ends of the index, 0 and 100, must therefore be interpreted as representing the selection of good fuelwoods. It is possible to suggest that one end (where *Erica* spp. are dominant) is represented by taxa used for kindling while the other end contains taxa that are used for prolonged burning. This is not a conventional way of interpreting the indices and it is perhaps inappropriate to use this analytical method. Other taxa present in this factor, such as Asteraceae (*Brachylaena* spp.), Euphorbiaceae 1, Sterculiaceae and Lamiaceae variables do not support the interpretation of this factor as an indication of fuelwood collecting strategies. These families contain many taxa that are not specifically collected by modern communities for use as fuelwood today.

The dichotomy of variables observed in the third factor is closely related to the niches in which these taxa occur preferentially with forest taxa separated from taxa from less forested and more open woodland vegetation (Fig. 7.3). The SSF3 plot shows that the most forested environments were evident during the HP occupation. RSp, OMOD, and MOD have SSF3 values that are clustered at the woodland end of the

index. This was expected because *Acacia* spp. are prominent in these layers. Bu, SPCA and BSp also have values closer to this end of the index. These occupation periods contain many taxa that are associated with more open savannah environments. Forest taxa are however present in all layers and the HP layers also contain some taxa that can grow in less forested, dry environments. The SSF3 plots highlight the differences between the HP assemblage and the other seven assemblages.

Summary Statistics results show that Bu and the HP charcoal assemblages were accumulated during warm and wet phases, whereas MOD, OMOD and RSp were most likely accumulated during a period of warm yet drier climatic conditions. BSp, SPCA and Eb have some taxa that are indicative of cooler conditions and the summary statistics results suggest that conditions were relatively dry. Although cooler conditions may have been evident during the Last Glacial it is unlikely that these were ever extreme. The continuing presence of riverine vegetation community components as well as some bushveld taxa provide evidence to support this suggestion.

7.2.2 Correspondence Analysis

Results of a Correspondence Analysis test using absolute fragment numbers are given. The graph (Fig. 7.4) shows that axis 1 explains 27.35% of variability in the data, while axis 2 explains 23.54%. Together 50.89% of variations in the data are explained by axis 1 and 2. The influence of the first two axis upon the composition of the data set is roughly equal. A third axis, which explains 16.01% of variability, was also noted; however, only the first two axis are discussed here.

On axis 1 two clear clusters can be defined while three clusters are present on axis 2. Axis 1 groups HP and Bu (Fig 7.4), which lie on the positive side of the axis and separates them from all the other MSA layers, which are placed on the negative side of the axis between values of 0 and -1. On axis 2 the first group contains MOD,

which has been isolated from other layers. The second and third groupings consist of SPCA, BSp, Eb, Bu and HP on the negative side of the axis and OMOD and RSp of the positive side (Fig 7.4).

Patterns in the distribution of layers on the first and second axis cannot strictly be related to the depth of the deposits or time because their distributions along the axis do not correlate with these influences. It is interesting to note, however, that with the exception of Bu, axis 2 separates the oldest layers (on the negative axis) from the younger layers analysed (on the positive side) (Fig 7.4). This indicates that the Bu charcoal assemblage has more similarities to the older layers than to the younger layers. Many of the taxa found in Bu are also found in the HP layers, Eb, SPCA and BSp. On axis 1 Bu and the HP layers are isolated from Eb, SPCA and BSp (Fig. 7.4), suggesting that they are equally different from these layers. Their location does not necessarily suggest that they are similar to each other although there are some taxa present in Bu that are also present in the HP layers. The HP layers and Bu contain *Brachylaena* sp., and *Kirkia* sp. There are also many different taxa, such as *Podocarpus* spp., *Ochna* sp. and cf. *Phoenix reclinata*. The younger layers, RSp, OMOD and MOD are grouped on the first axis and they do contain many of the same taxa such as *Acacia* spp., *Albizia* spp., *Mystroxylon* cf. *aethiopicum* and *Ziziphus mucronata*. On the second axis MOD is assigned the highest positive value. This suggests that either MOD contains some taxa that are not found in either of the other two layers or that OMOD and RSp have been drawn towards the Eb, SPCA and BSp group because of shared taxa. The second scenario appears to be more accurate than the first.

Distributions of taxa along axis 1 and 2 were analysed to determine whether a common underlying factor such as a change in climate or a change in cultural selection was apparent. On axis 1 the occurrence of *Podocarpus* spp. has been isolated from most of the other taxa. On axis 2 there appears to be a distinction between taxa from moist forest communities (on the negative side of the axis) and

those from drier woodland savanna communities (on the positive side). There are some exceptions to this, such as the *Kirkia* sp., which is found on the negative side of axis 2 and *Cunonia capensis* a moist forest taxon that is placed on the positive side of F2.

It has already been shown in the qualitative analysis (Chapter 6) that there are some taxa co-occurring in the charcoal samples, such as *Kirkia* and *Podocarpus*, that may at first appear to have come from distinctly different vegetation communities. It is necessary, however, to consider that the wood in the assemblage may not represent one vegetation community as it may have been collected from several communities that were exploited for wood resources by the cave occupants. It is therefore important to consider the composition of vegetation types that are found in close proximity as well as individual vegetation types. The taxa that appear to be anomalous in their placing on the second axis may be an indication of the combination of vegetation communities that are represented through the charcoal assemblages from Sibudu Cave.

7.3. Summary

In assessing sampling size adequacy it was found that richness values for each layer were not significantly different and therefore the weak positive correlation observed between sample size and richness could not be used when discussing the effectiveness of the sampling employed. For this reason richness values were also not used for developing a discussion concerning taxon diversity within each layer. In the interpretation I have however referred to families, such as Fabaceae, being better represented in some layers (such as MOD and Bu) than they are in others (for example Eb and BSp). These observations are only made when supported by other identifications within the layer.

Results and interpretation are given both before and after a varimax rotation was applied to the data. The following summarises the main findings. Fewer families are influential in the factors after the rotation was applied. On the whole the analysis recognises the same families as influential before and after rotation. This is particularly noticeable for F1 and RF1. The type and distribution of taxa in the layers suggest that the environment may have been subject to changes in temperature and available moister. It is also apparent that the assemblage composition is influenced by cultural selection. The analysis identifies that temperature and/or cultural selection are most influential in determining the spread of taxa in the assemblage. When converted into an index using summary statistics SSRF1 shows that the region was probably cooler during occupations associated with layers Eb and SPCA and was warmer during the occupation associated with HP, RSp, OMOD, MOD and Bu. BSp lies in the middle of the index suggesting intermediate conditions between the warmer and cooler phases. The use of warmer (in this instance) does not imply conditions were warmer than they are today, but rather that conditions were warmer than the coldest phases of the last glacial. It is unlikely that climatic conditions were warmer than they are currently during any of the occupation phases analysed from the MSA. It is also important to note that although there are indications of slightly cooler conditions there is no evidence to suggest that conditions were ever extreme during the occupations analysed.

RF2 is interpreted as recognising the influence of available moisture upon the taxa in the environment and the assemblage. I use the term "available moisture" because this factor is not governed purely by quantity of precipitation but rather increases and decreases of the amount of moisture a plant can exploit, whether through changes in humidity, soil moisture or precipitation. Available moisture is a complex environmental factor that is influenced by changes in temperature, the location of a plant within the vegetation community (such as next to a river, in the forest, or on the forest fringes), slope aspect and vegetation type (whether forest, woodland or bushveld for example). The Summary Statistic index for RF2 shows that on the

whole the assemblage is composed of taxa that thrive in moist conditions and it is possible to deduce that there was relatively high water availability in the region throughout the occupation of Sibudu Cave. Layers RSp, OMOD and in particular MOD, provide evidence for periods of reduced moisture availability.

RF3 is interpreted as indicating changes in the type of forest vegetation present. While forest taxa are identified in all the layers analysed, the factor analysis recognises a difference between the HP layers and the other seven layers. The main difference between these groups is the occurrence of *Podocarpus* spp. RF3 groups *Podocarpus* species with some of the other forest taxa and separates them from the woodland savanna community species. The Summary Statistics index shows that during the HP occupation forest is the major component of the charcoal assemblage and yet during the post-HP occupation forest taxa are less prominent in the assemblage. It is not possible to interpret this factor as a clear distinction between forest and woodland taxa because when the values assigned to each layer in the Summary Statistic index are compared to the actual contents of the layers, this distinction is certainly not clear.

The Correspondence Analysis highlights two factors that are important in determining the composition of the charcoal assemblage. The first axis separates Bu and the HP layers from all other layers, showing that the assemblages in these layers are distinctly different from the assemblages in other layers. This analysis determines that although there are similarities between the sample from the HP layers and the assemblage in Bu, these similarities are not greater than the differences that are apparent.

The second axis differentiates between the older layers which are dominated by forest and riverine taxa, and the younger layers, dominated by woodland taxa. Bu is again noted as an exception and is placed with the older layers. In this instance this can be interpreted as showing that Bu contains more similar taxa to the oldest layers than it

does the youngest layers. Neither axis is determined by a singular climatic component, such as temperature and neither axis is clearly related to wood collecting strategies although they have both been influenced by the occurrence of wood types brought to the site.

CHAPTER 8. DISCUSSION

8.1. Introduction

Preliminary interpretations of the charcoal data have been given in Chapters 6 and 7. In the discussion that follows I draw together the interpretations from each analysis technique to present evidence for changes in vegetation and palaeoenvironments during the Last Glacial. This discussion is also used to establish whether the qualitative and quantitative procedures provide compatible results or whether the techniques used highlighted different or even contradictory features in the data. Charcoal analysis is rarely used as an environmental proxy on its own and for this reason I compare the results of this analysis with data from the other environmental proxies (presented in Chapter 3) studied at Sibudu Cave. The Sibudu Cave charcoal data are then compared with data from sites in the summer and winter rainfall regions of South Africa to establish the similarities and differences between the two regions during the Last Glacial. I then place the evidence from Sibudu Cave in the context of global climatic changes to broaden this discussion further.

8.2. Sibudu Cave Charcoal Assemblage

Charcoal samples were extracted from eight assemblages spanning the extent of the MSA excavations (at the end of 2003) at Sibudu Cave. During the 2003 excavation and lithic analysis it was established that the MSA deposits contain HP and post-HP lithic assemblages dating from about 62 000 years ago to 33 000 years ago (Wadley and Jacobs 2004). HP charcoal was sampled from three layers although these samples were analysed as one sample of equal size to the samples from other layers.

The majority of the samples were taken from the post-HP sequence. Within this sequence the samples were divided into three major chronological groups to distinguish the final MSA, termed the late post-HP layers, from the early and middle post-HP layers. Layers Eb, SPCA and BSp lie within the early post-HP grouping. These units are all dated to between 60-55 000 years ago. The middle post-HP group incorporates RSp, OMOD and MOD, which date to between 55-50 000 years ago (Z. Jacobs pers. comm.). The late post-HP group includes layer Bu and this layer has a date of 35 000 years ago (Z. Jacobs pers. comm.). The late post-HP is found only in the east of the excavation grid, whereas the early and middle post-HP are found across the entire excavation grid.

Preservation of wood charcoal and charred botanical remains, such as seeds, grass corms and thorns, is very good in most of the MSA layers. Large quantities of charred wood are present, particularly in the upper MSA layers. Although there is less wood preserved in the lower layers, preservation of internal structures is good and for most specimens classification to at least family level or Charcoal Type was possible. Layers Eb and RSp displayed the poorest preservation. In RSp there were many specimens which had fractured along the ray cells. These fractures probably developed during charring and subsequently sediment grains became incorporated into the fissures causing further damage to the rays and other structures normally exposed in radial tangential sections. Rays were most affected but in some specimens the clarity of vessels and vessel pits was also compromised because the sediment grains worked their way into the vessels damaging and obscuring the vessel structures. It was necessary to analyse several views of the radial tangential section on a single specimen to acquire sufficient detail of anatomical structures that would allow for classification. These fractures could often be observed without using a microscope and it was therefore possible, prior to fracturing, to select areas of the specimen that had been least affected and to obtain the best radial tangential section possible. Unfortunately some specimens were highly damaged and identification was not possible. The specimens in MOD and OMOD were significantly better preserved.

In these layers fragments were large and both internal and external structures were better preserved than they were in the charcoal analysed from other MSA layers. Often some of the bark and phloem were still present around the xylem. The level of preservation, particularly of internal structures, was very influential in determining the number of identifications that could be made as well as the level of identification possible. The scope of the reference collection also influenced identification and this is discussed below.

As discussed in Chapters 4 and 5 preservation is determined by a series of processes. First, the temperature, duration of exposure to fire and the amount of oxygen present will determine whether a fragment is burnt completely or charred. It is possible that burning wood in high temperature fires causes fractures, as observed in specimens from RSp, to develop. Some of the fragments have a glassy appearance and the anatomical structures appear to have fused, for example Charcoal Type 95. This may also be a result of exposure to hot or prolonged fire. Secondly, at Sibudu Cave time may influence charcoal preservation. There is more charcoal in the upper than the lower MSA layers. This may be a result of sediment compaction causing specimens in the deepest layers to fragment and become incorporated into the sediment matrix. However, preservation of bone appears to improve in the older layers and it is therefore unlikely that increased sediment compaction and charcoal fragmentation have caused the decrease in the quantity of charcoal. One must be cautious not to over-interpret changes in charcoal quantities through time because time resolution of layers may not be directly comparable both in terms of the duration of accumulation and also the duration and/or frequency of site occupation. As a further complication it is also possible that less wood was burnt during the older MSA occupations at the site. The type of wood provides a third factor which appears to affect preservation and possibly fragmentation. During identification, features that may be taxon specific were noted. It appeared that structures in one taxon subjected to fire, for example Charcoal Type 95, were more likely to fuse than the same structures in another taxon, for example Charcoal Type 91, from the same layer and presumably similar

conditions of deposition. Woody species often contain gums and resins which affect their specific density and hardness. It would be valuable to determine whether these attributes have a direct effect upon preservation and whether preservation traits are species specific or whether there is significant variability within a taxon. It may also be possible to establish which are the most likely taxa to preserve in the archaeological record. This information could be used to help establish a direction for developing the reference collection. The results of such a study could also assist with charcoal identification and also with gaining a better understanding of the site formation processes and anthropogenic activities at the site.

Using the results of qualitative and quantitative analyses, evidence for changes in palaeoenvironment and for changes in wood selection are discussed for each period.

8.2.1. Howiesons Poort (HP)

The HP at Sibudu Cave is different from all post-HP layers analysed not just for its distinct lithic assemblage but also its charcoal assemblage. Differences observed between the HP and the post-HP layers may be a result of archaeological sampling bias, distinctly different vegetation types caused by changes in the climate, or different wood selection behaviour during the HP occupation that led to the distinct combination of taxa present. I present the evidence from the HP charcoal assemblage in light of each of these suggestions.

8.2.1.1. Sampling

One m^2 grid unit (B6) of HP deposit was available for analysis. It is possible that the current HP charcoal sample includes branches that have been sampled repeatedly and that analysis of charcoal from an additional 1 m^2 would reveal the presence of other taxa. Whether an additional excavation unit would significantly alter the sample

composition remains to be tested. Unit B5 was excavated in 2004 and the charcoal from this square will be analysed as part of a future project.

8.2.1.2. Palaeoenvironmental interpretations

HP Layers (GS, GR and GR2 62 000 years ago) - There is strong evidence during the HP occupation for a vegetation type that is different from that of today. The combination of HP taxa is not evident in the modern vegetation around the cave and it has not been documented in literature sources, such as Acocks (1988), Low & Rebelo (1998) or Rutherford & Westfall (1994). One of the most notable differences between the HP identifications and the modern vegetation is the presence of *Podocarpus* species. These are present in two post-HP layers (SPCA and RSp); however, the suite of taxa in the HP layers is not evident in either of these assemblages. The co-occurrence of *Kirkia* sp. and *Podocarpus* spp. is particularly interesting because *Podocarpus* grows in moist forest and riverine forest conditions whereas *Kirkia* thrives in woodland vegetation types in regions that are significantly drier than the modern Sibudu Cave region. The presence of both species was initially assumed to indicate contradictory conditions, but both have been recorded in the Waterberg in close proximity although not strictly within the same vegetation niche. Other taxa identified in the HP layers, for example *Buxus* spp., *Ptaeroxylon obliquum* and *Brachylaena sp.*, provide strong evidence for mesic forest vegetation that probably grew in warm conditions. The factor analysis interpretation suggests the taxa in the HP layers display some similarities to, as well as differences from, taxa found in other layers, although none of these layers contain the exact combination of taxa found in the HP layers. This is particularly apparent in the RF3 Summary Statistics index, which places the HP layers at the opposite end of the index from all other layers. The index was interpreted as recognising differences between moist forest taxa and taxa found in other forest types (perhaps drier forests). Beyond the forest there must have been a significantly drier vegetation community to support the *Kirkia* and possibly the *Ochna* sp. (although this would only be the case if *O. pulchra*

was present, because some *Ochna* species, such as *O. arborea*, are found in forests in KwaZulu-Natal). Correspondence analysis also suggests that the charcoal assemblage from the HP layers is significantly different from the assemblages in most other layers although some similarities between Bu and the HP layers have been recognised on the first and second axis of the correspondence analysis. On the second axis HP layers were grouped with the early post-HP layers, which also contain many forest taxa and relatively fewer bushveld taxa than the middle and late post-HP layers.

There are several taxa identified in the HP layers, such as the Apocynaceae/Rubiaceae, that are absent from other layers analysed. The Apocynaceae/Rubiaceae specimens have distinct anatomical characters allowing for easy identification to this taxonomic level. This specific taxon has not been observed in any other layers although other taxa from the Apocynaceae and Rubiaceae families have been identified.

To summarise, the palaeoenvironmental data from the HP layers suggest conditions that were warm and moist. The assemblage is dominated by evergreen forest taxa. *Podocarpus* may have been a large component of the forest. Deciduous components in the assemblage represent a different vegetation type. There may have been a significantly drier woodland community beyond the immediate forest vegetation surrounding the cave and along the river.

8.2.1.3. Evidence for culturally influenced wood selection

The HP occupations do not contain good fuelwoods, with the exceptions of *Buxus* sp. and *Ptaeroxylon obliquum*. It was initially hypothesised (Chapter 1) that good fuelwoods were likely to be present in higher frequencies than poor fuelwoods if wood had been selected, rather than indiscriminately collected, and if wood was predominantly brought to the cave for use in fires. This hypothesis was made using the assumption that good fuelwoods would have originally made up a large

component of the fire and thus a large component of the charcoal assemblages. *Podocarpus* is not noted in the literature as a good fuelwood and therefore its presence in large quantities could be interpreted either as an indication of a lack of wood selection, or an indication that wood was brought to the site for other purposes. It was suggested (Chapter 7) that *Podocarpus* may burn well, although it is not currently used or recorded as fuelwood in the literature. If selection of wood for fire was not important during this phase of occupation then a tree in close proximity to the site or a taxon that is abundant in the vegetation may become over represented in the charcoal assemblage. Bundles of branches collected from the forest floor would be likely to contain *Podocarpus* in large quantities if it was growing close to the site along the valley sides as a prominent component of the forest vegetation. It is evident that people travelled to acquire good lithic raw material in all the MSA occupation phases. Assuming the sample analysed provides a true representation of the assemblage, the presence of *Podocarpus*, the absence of other good fuelwoods and the evidence that people at Sibudu Cave travelled for other resources, supports the suggestion of either a change in wood collecting behaviour or a notable change in vegetation.

There are two reasons why wood may have been indiscriminately collected rather than selected. First, it is possible that the cave occupants lacked knowledge of wood properties and therefore wood selection was not important. Second, the assemblages could have accumulated during short occupation periods and emphasis was not placed upon acquiring good fuelwood. HP lithic assemblages contain a combination of tools that are unusual in most MSA assemblages. Backed blades and segments are more frequent in the HP and there are higher proportions of blades than in other MSA industries at the site. In HP assemblages there is generally an absence of points that are common in pre- and post-HP assemblages. It is thought that many of the HP backed tools were hafted. If this is so one would expect that the people manufacturing the tools and the hafts were aware of wood properties. The exact function of these tools is not fully understood at present and it is beyond the scope of

this research to review the literature. The topic was introduced to show that during the time that the "traditional" MSA lithics were being manufactured, good fuelwoods were routinely selected (see discussion of post-HP). In contrast, during the HP, which has a lithic industry that has frequently been considered evidence for the development of complex social behaviours, good fuelwoods were not used. I would suggest that lithic raw material selection throughout the MSA at Sibudu Cave indicates an awareness of raw material resources and it is therefore difficult to concede that for some tasks (lithic manufacture) the occupants were aware of resources and yet for others (fuelwood collection, haft manufacture) they were not. It appears more likely that *Podocarpus* was fulfilling another purpose; that it does, in fact, burn well, or that the selection of this wood was driven by cultural or environmental factors that are not yet understood.

There is some evidence from hearths in the HP layers to support the suggestion of short occupations, although the evidence is not conclusive. Hearths in these layers are small and relatively more confined than they are in other occupation periods. There are also fewer hearths in the HP squares excavated thus far than there are in any equivalent area of post-HP layers. This suggests that fires were constructed less frequently in the HP, perhaps indicating shorter occupations. The upper section of the HP deposit built up very quickly. There are three dates for the sequence and all are around 62 000 years ago (Z. Jacobs pers. comm.). Dense lithic concentrations in the HP layers do not lend support to the suggestion of short occupations. Sediment analyses may help resolve the issue.

It is also possible that *Podocarpus* was brought to the site to fulfil purposes other than fuel. *Podocarpus* wood is often used as timber for decorative furniture by modern societies. The wood is soft and it is generally used with harder wood providing the supporting structures of the furniture. Although there is no evidence for structures, such as huts, during the MSA at Sibudu Cave it is possible that *Podocarpus* wood was used to make objects. It is also a resinous wood and the resin could have been

used in the hafting process as part of the mastic used to attach the stone tools to the shaft of the haft. Residue analysis being carried out (M. Lombard pers. comm.) may confirm this suggestion. Branches brought to the site with resin may subsequently have been incorporated in the fire either accidentally or deliberately.

There are several other wood types in the assemblages that are recorded as fuelwoods. For example, *Ptaeroxylon obliquum* and *Buxus* species are present in small quantities in the HP layers and in some of the younger layers. Both taxa burn readily and provide excellent tinder.

8.2.2. Post-Howiesons Poort (post-HP)

8.2.2.1. Sampling

The post-HP is a long and complex series of deposits comprising the majority of the MSA excavations undertaken at Sibudu Cave. The post-HP sequence dates from about 60-33 000 years ago (Wadley & Jacobs 2004; Z. Jacobs pers. comm.). There are a number of trends in the lithic assemblages that distinguish the post-HP from the HP. The post-HP does not contain segments or backed blades. Instead there are unifacially-retouched points and scrapers that are standard in the MSA in southern Africa. Hornfels and dolerite are dominant, while quartzite and quartz lithics are present in smaller frequencies. An increase in quartz was noted towards the early post-HP (G. Cochrane pers. comm.). The late post-HP layers contain hollow-based points that are not present in the other MSA assemblages.

8.2.2.2. Palaeoenvironmental interpretations

Early post-HP (Layers YA1-BSp 60-55 000 years ago) - Charcoal was analysed from Eb, SPCA and BSp within this series of layers. The charcoal assemblages from each of these layers display sufficient similarities to be grouped together. Taxa found in all of these layers include *Morella pilulifera, Acacia* spp., *Erica* spp., *Rapanea melanophloeos* and *Ziziphus mucronata*. There are also several identified taxa that

are common to two rather than three of the layers in this group and similarities can be noted amongst taxa that have been identified to family level.

The majority of taxa identified in these layers are from forest and riverine forest communities. There are some bushveld taxa, such as the *Ziziphus mucronata* and *Acacia* spp. that are able to grow in both bushveld and forest vegetation. *Ximenia* sp. is the only true bushveld taxon found in the early post-HP layers. This taxon grows in northern South Africa in dry regions and in vegetation that is more open than the forest vegetation in which the majority of the taxa are found. Evidence for riverine vegetation is strong. It was anticipated that the river would have been present throughout the MSA occupation of Sibudu Cave and therefore riverine vegetation elements were not unexpected. Some of the identified taxa were, however, not anticipated. *Leucosidea sericea*, for example, does not naturally occur near the coast (Fig. 6.2) and at its closest (at Eshowe in northern KwaZulu-Natal) it is approximately 30 km from the modern shoreline. To the south at Pietermaritzburg it is approximately 70 km from the coast. Its presence may lend support to the identifications of the other taxa from further north in South Africa and together these taxa suggest a different environment from that of today. *Leucosidea sericea* may be an indication of cooler climates and its presence may indicate that the lowered sea level of the Last Glacial affected vegetation distribution. *Leucosidea sericea* is a pioneer species that could have taken advantage of changes in climate caused by a marine regression during the colder stadial OIS 4. Between 60-55 000 years ago the sea level would have been approximately 50-60 m below its current level (Ramsay 1996) and such a drop would have exposed between about 2-10 km of currently submerged land off the coast at Durban and to the north of Durban. Although this was not a large regression it would place the shoreline up to 25 km from the cave, whereas it is currently only about 15 km from the cave. The more distant shoreline may have caused a drop in humidity enabling the growth of dry community taxa, such as *Ximenia* sp. The lowered sea level would certainly have reduced the effect of sea mist, if not eliminating it as a factor altogether.

Erica spp. are first noted in the early post-HP layers. *Erica caffra* is a component of riverine vegetation. This taxon is not found in the modern vegetation surrounding the cave, but it is found nearby to the south in KwaZulu-Natal and, unlike *Leucosidea sericea,* it does grow near the coast. Both taxa are particularly common in the Drakensberg along rivers. Other taxa present in the early post-HP, such as *Rapanea melanophloeos*, *Calodendrum capense, Podocarpus* spp., *Ptaeroxylon inerme* and *Morella pilulifera,* are also found in the Drakensberg foothills. The identification of *Leucosidea sericea* on its own may be interpreted as an indication of cooler winter conditions because it grows in regions such as the Drakensberg and Gauteng that receive frost in the winter months. It is possible that the vegetation was similar to the vegetation in the foothills of the Drakensberg. The suite of taxa in Eb and SPCA are particularly similar to the Drakensberg taxa. Layer BSp does contain some of these, but it also has some different taxa that may indicate that it is a transition phase between the early and the middle post-HP layers.

In the qualitative analysis the differences between BSp, and Eb and SPCA were recognised and then confirmed by the results of the factor analysis. In the first and second factors (RF1 and RF2), layers Eb and SPCA were assigned similar summary statistics values. BSp was assigned a different value and it was placed in the middle of the summary statistics indices. This suggests that there are more similarities in temperature and moisture between Eb and SPCA than there are between either of these layers and BSp. It further suggests that taxa identified in BSp display similarities to taxa in the middle post-HP, or that temperature and moisture were intermediate between the two periods.

To explain further the differences and isolation of the BSp suite of taxa from those of the other two layers I have examined the taxon occurrences in each of the three layers. *Leucosidea sericea* and *Nuxia* sp. are the only taxa present in both Eb and SPCA that are absent in BSp. *Acacia* spp. are present in BSp and continue into the middle post-HP layers; however, a few *Acacia* spp. were also noted in Eb. These

changes in the assemblage probably contributed to the division of BSp from the other layers in the summary statistics. The factor analysis recognised a decrease in the abundance of *Erica* spp. in BSp. This makes the assemblage appear more similar to the assemblages in the middle post-HP layers, in which *Erica* spp. are less abundant. There are, however, very few taxa that are present in both BSp (from the early post-HP) and RSp (from the middle post-HP). Those that are present across these layers are taxa that are present in most if not all other layers analysed. Interpretations that rely upon increases or decreases in taxon occurrence must be treated with caution unless other changes in the assemblage that support the interpretation are apparent. In this instance the decrease in *Erica* spp. appears to be supported by an increase in bushveld taxa and a change in the forest taxa present – from cool, moist forests to warm, possibly drier vegetation types.

The factor analysis does, however, suggest some similarities in the three layers, Eb, SPCA and BSp, by assigning them similar summary statistics values in the third rotated factor. This places the layers at the same end of the indices, suggesting that there are similarities in the forest taxa that are present.

The correspondence analysis also implies similarities in Eb, SPCA and BSp by grouping these layers on both the first and second axis. The analysis separated these layers from the younger layers. On the first and second axis in the correspondence analysis no significant difference was noted between BSp and the other early post-HP layers. Differences between the early post-HP group and the middle post-HP layers are more marked than differences within the early post-HP layers.

To summarise, many of the taxa present are currently found in forest communities in KwaZulu-Natal and more specifically in the foothills of the Drakensberg Mountains. Evergreen taxa are prominent and there is strong evidence for the presence of the river. There were some taxa from drier environments, probably open woodland communities, but these are not numerous and are not represented throughout the

layers. Plotting the first (temperature) and second (moisture) rotated factors against each other shows that the region experienced cooler conditions (although possibly only in the winter months) than at present and the region would have been fairly moist, although not necessarily more so than it is today.

Middle post-HP (Layers RSp-MOD 55-50 000 years ago) - RSp, OMOD and MOD lie within the period 55-50 000 years ago. These layers, grouped as the middle post-HP, have been differentiated from the early post-HP using the charcoal assemblage contents. The middle post-HP layers contain more deciduous taxa than the early post-HP layers do. Many of these are from the Fabaceae family. *Acacia* species are present throughout and in addition there are more environment specific indicators such as the *Albizia* spp., *Burkea africana* and *Afzelia quanzensis*. All of these taxa are found in bushveld habitats. Other bushveld species present in the middle post-HP layers include *Kirkia* sp., *Ximenia* sp. and *Pappea capensis*. *Pappea capensis*, which was identified in MOD, is found in similar vegetation habitats to the *Ximenia* sp. and *Kirkia* sp. that occur in RSp. *Pappea capensis* is, however, widespread in South Africa and is not as environment specific as the other taxa. These identifications indicate a significantly drier climate than is currently in effect in this part of KwaZulu-Natal. Forest taxa are present although they are less prominent than they were in the preceding period. Of the forest taxa present, many are able to grow in a range of forest types and their modern distributions are not restricted to KwaZulu-Natal. There are also some generalist taxa, such as the *Bridelia* and *Drypetes*, which could provide evidence for forest similar to today's forest although they could equally provide evidence for a different type of forest or even for bushveld. *Bridelia* and *Drypetes* have only been identified to genera and to provide more detailed vegetation descriptions species identifications would be required.

The factor analysis grouped these middle post-HP layers towards the warm and dry ends of the summary statistics indices for RF1 and RF2, respectively. In each of the statistical analyses, RSp and OMOD were placed closer to each other than they were

to MOD. The taxa identified in MOD and its placement in the statistical tests may suggest it is transitional between the middle and late post-HP periods.

Late post-HP (Layers Ore2-Co 49-33 000 years ago) - Taxa identified in Bu, which is dated to about 35 000 years ago (Z. Jacobs pers. comm.), provide evidence for vegetation similar to that in the region today. Many of the identified taxa such as the *Brachylaena*, *Phoenix*, and *Acacia* are present in the modern vegetation. Each analysis technique has shown that the suite of identifications in Bu differs from the taxa in the other post-HP layers. The quantitative analyses recognised similarities between the Bu and HP layers. In the factor analysis both the HP layers and Bu were assigned values that place them at the warm end of the temperature index. Although there are similarities between Bu and the HP layers there are also differences. For example, no *Podocarpus* species were identified in layer Bu.

In Bu *Erica* spp. are the only taxa that could indicate cooler climatic conditions. Most of the taxa are from forest and/or bushveld vegetation communities. Bu was assigned a low summary statistic value in RF2 placing it at the moist end of the index. In the qualitative analysis it was noted that many of the taxa are found together in wetter niches, along rivers and in ravines in drier regions such as Limpopo or Mpumalanga. Taxa such as the *Phoenix* and *Erica* indicate the presence of the river. High moisture availability noted by the factor analysis and summary statistics could be interpreted as the moisture availability of a specific niche from which these taxa were collected rather than for the region as a whole. Modern environmental data show that many of the taxa in Bu are wide ranging and the data could be interpreted in a few ways. A large number of Charcoal Types was defined for the Bu assemblage and many of these are not present in other layers analysed. Taxa from Bu may therefore represent a significantly different vegetation environment that is not well represented by the current reference material.

8.2.2.3. Evidence for culturally influenced wood selection

The post-HP layers contain several taxa that are good fuelwoods. Most striking is the dominance of *Acacia* spp. and *Erica* spp. (when percentage frequencies are measured). Both taxa are present throughout the early, middle and late post-HP sequence. *Acacia* is one of the most commonly used indigenous fuelwoods amongst modern societies in southern Africa whether in urban or rural contexts. This is partly because the genus is ubiquitous in South Africa but also because *Acacia* species are an efficient wood because they produce good coals and thus sustained fire. *Acacia* species burn at even temperatures and do not produce noxious fumes that would cause irritation to the eyes or contamination of food. The presence of *Acacia* species in the assemblage suggests that fuelwoods were selected with burning properties in mind. It is also possible that *Acacia* species were present near the cave in relatively large quantities and that dead wood, ideal for burning, was abundant. *Erica* species also burn well but these taxa do not produce sustained fire. In modern communities *Erica* spp. are used as kindling. The plants are small with small branches and the wood burns quickly, making them an ideal source of tinder for starting a fire.

The co-occurrence of *Acacia* and *Erica* suggest that these taxa were used during the same occupations and possibly in combination in fires constructed throughout the post-HP. Percentage frequencies reveal a different pattern. During the early post-HP, *Erica* spp. are dominant in the assemblages and *Acacia* spp. are less well represented. Subsequently there is an increase in the occurrence of *Acacia* spp. fragments and a corresponding decrease of *Erica* specimens. The decrease in *Erica* spp. occurs during early post-HP layers and into the middle post-HP. The increase in *Acacia* spp. is most marked in the middle post-HP layers. The factor analysis recognised this pattern as one of the major underlying trends in the data set. It is interesting to note that *Leucosidea sericea* is present when *Acacia* spp. are not as abundant. *L. sericea* is also a good fuelwood which burns slowly.

It is possible to speculate, on the basis of percentage frequencies, that MSA people changed their wood-collecting behaviour through time. In the earliest post-HP occupations they relied upon small taxa and probably burnt wood for short periods, while in the later occupations they gathered fuelwood that would have allowed fire to be sustained for longer periods. The perceived change in taxon use could be attributed to a development in awareness of fuelwood properties or a change in the requirements that determined fuel selection. Factors determining selection may include climatic conditions, the purpose of the fire or even group size. If, however, change in frequencies of *Acacia* spp. and *Erica* spp. were determined by cultural selection alone one could speculate that the background taxa would have remained similar through time. There are some taxa present in all assemblages analysed, but as the previous discussion has shown there are many changes in taxon representation and, importantly, some of these are environmental indicators.

Fragmentation must also be considered as a possible explanation for the changes in percentage frequency of *Acacia* and *Erica* species. It is currently not fully understood whether fragmentation is haphazard or whether it is to some extent dependent upon wood types. Experiments are being conducted to establish better the taphonomic factors affecting charcoal assemblages (Austin 2004). The increase in *Acacia* and decrease in *Erica* could be a random pattern that is the result of fragmentation of branches subjected to fire. It does, however, seem improbable that fragmentation would produce the trend observed in the data. This pattern continues through several layers and does not appear random. The presence/absence data of other taxa in the assemblage lends support to the environmental interpretations that have been proposed.

Spirostachys africana, which is usually avoided as a fuelwood, may be present in the assemblage. This cannot be confirmed with the available reference material because *Sapium integerrimum* has very similar wood anatomy. If *Spirostachys* is present it is surprising, because it produces noxious fumes when burnt. It is unlikely that it was

knowingly collected or that it was collected in large quantities. It may have been gathered accidentally in bundles of wood collected from the ground. There are very few specimens identified as *Sapium/Spirostachys*, suggesting it wasn't a large component of the wood types brought to the site.

The remaining taxa are an assortment of plants that are mainly trees, although there are a few shrubs in the assemblage. It was not anticipated that shrubby taxa would be prominent in the assemblage. The palm tree identification was also unexpected. First, it was assumed that palm tree wood was unlikely to survive as charcoal because it is very soft and, secondly, that it was unlikely to be brought to the site for fuel because its soft loose structure makes it an unfavourable fuelwood. It is possible that the plant was brought to the site for another, unknown, purpose (for example, making rope) or that it was been incorporated accidentally in the firewood.

Medicinal uses of identified taxa were documented; however, these data have not been used to interpret this assemblage. It is possible that people used plants for medicinal purposes in the MSA but without concrete evidence for such use of plants there is no basis for using the data when discussing the MSA charcoal assemblage. The data may be useful in the future for interpreting the Iron Age charcoal assemblage from Sibudu Cave.

8.3. Palaeoenvironmental Proxies from the Middle Stone Age at Sibudu Cave

8.3.1. Charcoal and Botanical Remains

In this section I compare the data from the charcoal analysis with data from the analysis of charred seeds from Sibudu Cave. Limited data available from pollen and phytolith studies are also drawn upon. All MSA seeds (with the exception of the HP layers) from across all excavated squares were included in the analysis (Wadley

2004). The seeds thus provide data for the sequence from 60-33 000 years ago whereas the charcoal provides views upon sections of the sequence between 62-35 000 years ago. The records for pollen and phytoliths are significantly more patchy than either the seed or charcoal sequences.

Six taxa are common to both the seed and charcoal assemblages between 60 and 35 000 years ago. Of these, two are found to occur in the same layers. *Acacia* seeds and charcoal occur in layers Su2-Mi, BSp2-BSp and YSp-RSp. *Acacia* spp. were also identified in the pollen in layers B/G 2, BP and Or. An *Ochna* sp. was identified in the charcoal in Eb and in the HP layers. *Ochna* seeds have also been identified and it has been suggested that either *O. pulchra* or *O. arborea* are likely species (Wadley 2004). Seeds from these species have very similar anatomical traits and it may not be possible to distinguish them. Other shared seed and charcoal identifications include *Celtis* spp., *Phoenix reclinata, Ziziphus mucronata* and *Sideroxylon inerme*. The charcoal and seed assemblages contain *Celtis* cf. *africana*, whereas *C. mildbraedii* was only identified in the seeds. *Phoenix reclinata* is a secure seed identification, but the charcoal identification is only a suggestion at present because palm taxa need to be better documented in the reference collection before the identification can be verified. *Phoenix* was also identified in the phytolith assemblage. The seed and phytolith specimens are both from RSp, whereas the charcoal specimen is from Bu. *Ziziphus mucronata* is present throughout the sequence of deposits in either the seeds or charcoal. The identification of *Z. mucronata* throughout the MSA sequence can be interpreted in two ways. Either it provides evidence for continuity in the vegetation through time or it is only present throughout because it is been able to withstand climatic change and resulting changes in vegetation. The second suggestion seems more likely because there are changes in the other taxa through time. In addition, *Ziziphus mucronata* is widespread in southern Africa and grows in various habitats and in diverse climatic conditions. *Sideroxylon inerme* is present in most of the post-HP sequence between 60-50 000 years ago. This tree is evergreen but can grow in a range of niches including coastal dune forest, coastal woodland or dry woodland.

The occurrence of *Ziziphus mucronata* and *Sideroxylon inerme* throughout these layers does not negate the evidence for environmental change.

By combining the charcoal and seed data detailed description of the vegetation can be obtained. The seed identifications include some small understorey taxa such as *Rhoicissus rhomboidea* and *Asparagus* sp. that are not present in the charcoal assemblage. These taxa may have been collected and used as tinder; however, this is not apparent from the charcoal assemblage. The seeds were found in the early and middle post-HP layers. The early post-HP charcoal assemblages are dominated by forest taxa. Their identification supports the charcoal evidence and suggests that the forest was well developed, with canopy species, forest margin species and understorey components. *Buxus* species, which are also understorey forest components, are preserved in the charcoal.

8.3.1.1. Early post-HP

The earliest layers between YA and BSp contain large quantities of *Erythroxylum* seeds. This period encompasses the layers I have grouped as the early post-HP. Wood specimens of *Erythroxylum emarginatum* were collected once it had been identified in the seed assemblage. Although SEM images of this taxon have not yet been taken, the wood has been charred and the anatomical characters have been viewed using incident light microscopy. *Erythroxylum emarginatum* is not present in the charcoal sampled from any of the layers. Its presence in the seeds contributes to the evidence for forest vegetation. The Drakensberg taxa, so prominent in the charcoal assemblage in layers Eb and SPCA, are not evident in the seed assemblage. Many of the seeds are found in the modern vegetation and do not provide distinct evidence for a change in vegetation.

In Wadley's (2004) second grouping, BSp2-BSp, there are strong indications for forest vegetation in both the seeds and the charcoal. This community may have been similar to the current forest vegetation around the cave or to other vegetation types

nearby in the KwaZulu-Natal region. Many of the taxa found in these layers can be found in the Hawaan forest, north of Durban. The Hawaan forest is relatively dry although it is within approximately one kilometre of the shoreline. Bushveld taxa are not common in either the seed or charcoal assemblage from BSp2-BSp. The *Acacia* identifications may suggest the presence of woodland or bushveld near the forest; however, some *Acacia* species are able to grow at forest margins and near rivers. Other possible bushveld identifications include *Sideroxylon inerme, Manilkara* sp. and *Ziziphus mucronata*; however, these taxa are also able to grow in forest vegetation.

8.3.1.2. Middle post-HP

Seed assemblages from layers YSp-BL display a similar trend to the charcoal assemblages from layer RSp. Deciduous taxa are more common while evergreen forest and riverine fringe forest vegetation are still present. As in the charcoal many of the deciduous taxa are found in the modern vegetation. The seed assemblage does not contain many taxa from northern South Africa. One exception to this is the *Ochna* identification. If it is *O. pulchra* it provides similar environmental evidence to the *Kirkia* sp. and *Ximenia* sp. present in the charcoal.

OMOD and MOD seeds provide a distinctly different signature from the charcoal because evergreen taxa are dominant in the seeds while deciduous taxa are common in the charcoal. The suggestion of evidence for a wet phase (Wadley 2004) cannot be supported by the charcoal data, which contain many more bushveld and dry vegetation community taxa than is found in the previous layers or in the seeds.

8.3.1.3. Late post-HP

Seed data for the late post-HP differ from the data provided by the charcoal for this period. In the seed analysis (Wadley 2004) it was suggested that there was strong evidence for dry vegetation, although the factor analysis on charcoal recognised the presence of taxa from moist niches. Unfortunately the data from both assemblages

are limited. Charcoal specimens currently grouped as Charcoal Types may reveal a different image of the palaeoenvironment once identified.

8.3.2. Botanical Remains and Fauna

Plug (2004) gives detail on several macromammalian species that are not present in the modern Sibudu Cave area and that have not been recorded either archaeologically or historically in KwaZulu-Natal. These are all common in regions with more grassland and in drier savannah. Plug (2004) likens the faunal assemblage to the fauna of the eastern lowveld and describes the assemblage as a Kruger Park type fauna. In this region conditions are significantly drier than in KwaZulu-Natal today. Many of the taxa in the fauna are also present in Limpopo and east into Mpumalanga. She further suggests that the current continental fauna could have been present in the Sibudu Cave region if shifts in vegetation, caused by a lowering of sea level, had occurred.

Animals can provide some evidence for the ambient vegetation and climate but they are adaptable and often widespread rather than niche specific. Giraffe is one taxon that is fairly habitat specific. Its presence suggests that *Acacia* thornveld/woodland must have been present in the cave vicinity. This is verified in both the charcoal and seed assemblages. The tortoise was recognised as an indicator of warm and drier conditions than the region receives today. *Kirkia* sp. in the charcoal and the possible identification of *Ochna pulchra* in the seeds support this suggestion.

Macrofauna are generally not very habitat specific; however, shifts in animal dispersal would, to some extent, correlate with the shifts in vegetation. Ideally independent isotopic signatures are required to obtain more specific detail on climatic conditions. Bone is being analysed (J. Smith pers. comm.) to acquire an isotopic sequence. In addition, microfauna may provide some niche specific information and assist in developing a fuller image of the past vegetation and climatic conditions around Sibudu Cave. It was anticipated that many of the taxa present in the seed

assemblage would also be present in the MSA charcoal. It can be hypothesised that the differences between the assemblages are due to differences in the agencies of accumulation and also the different purposes for which wood and fruits are collected. Seeds in the archaeological assemblage may be from more diverse environments than the charcoal because a range of accumulating agents could have deposited them in the cave.

8.4. The Contribution of Sibudu Cave data to Understanding Palaeoenvironments in southern Africa during the Last Glacial

In the following discussion I assess whether the Sibudu Cave data correspond with palaeoenvironmental data for other regions in South Africa. There is limited palaeoenvironmental data for southern KwaZulu-Natal in which Sibudu Cave lies and therefore I examine the broad climatic trends rather than changes in vegetation type that may be very specific to the region or even to the site's immediate surrounds. In general, evidence from Sibudu Cave corroborates well with data from other sites in the summer rainfall region of South Africa. Discrepancies in data sets may point towards evidence for localised climatic changes or to interpretations that are based upon localised vegetation rather than climatic conditions as a whole.

8.4.1. Oxygen Isotope Stage 4 (OIS 4)

Border Cave and Rose Cottage Cave micromammalian and charcoal data respectively suggest that conditions were drier with increased grassland vegetation in the east (Border Cave) and more scrub taxa (Avery 1992) and *Protea* west of Lesotho (Rose Cottage Cave) (A. Esterhuysen pers. comm.). At Rose Cottage Cave it may have been cooler than it is currently. This suggestion is based on the decreased diversity of taxa observed in the charcoal assemblage in the pre-HP layers (A. Esterhuysen pers.

comm.). Sediment profiles at Voordrag and possibly the Port Durnford Formation (if the date of 70 000 years ago is accepted) provide evidence for moister environments.

Sibudu Cave charcoal is yet to be analysed from the pre-HP and from the older HP layers (excavated in 2004). It is hoped that the assemblages from these layers will provide data for palaeoenvironments during OIS 4. The oldest layers analysed thus far have a date of 61 000 BP and lie on the boundary between OIS 4 and OIS 3.

The Port Durnford sequence and Sibudu Cave charcoal assemblage contain evidence for *Podocarpus* species and both sequences have been interpreted as indicating moister climatic conditions. In other sites dry conditions are evident at this stage of the Last Glacial. At Voordrag, for example, the accumulation of colluvium at about 50 000 years ago suggest conditions were drier. Although the taxa from the HP layers of the Sibudu Cave sequence have been interpreted as evidence for moister conditions, there is also evidence, such as the *Kirkia* sp., for a drier community. It is therefore suggested that the vegetation requiring higher moisture levels may be localised within a region that, on the whole, has relatively dry climatic conditions. A moister climate would be indicated in the charcoal assemblage if wood was collected from valley forests, because this habitat is more likely to support taxa with greater moisture requirements than an exposed, well-drained, habitat. Oasis-like environmental conditions may mask the overall climatic conditions. This observation can be used to emphasise the need for a combination of proxies to develop a detailed view of the past vegetation and climate.

The pre-HP layers at Sibudu Cave will probably provide further evidence for conditions during OIS 4. OIS 4 is currently not as well represented as OIS 3 by data from Sibudu Cave or other sites in southern Africa. Seeds and fauna from the HP and pre-HP will also assist the current interpretation, which is based only upon the charcoal. The combined data sets may reveal, for example, whether the moister

conditions are a result of bias in the charcoal assemblage towards a moister niche, or whether wetter conditions were present in the region as a whole.

During OIS 4 the winter rainfall region is characterised by moist conditions rather than the dry conditions evident in some areas of the summer rainfall. The moist conditions indicated during the HP occupation at Sibudu Cave, may suggest conditions were more similar to conditions in the winter rainfall region. The presence of *Kirkia*, however, does not support this suggestion and if conditions were similar to the winter rainfall region, one would not expect the warm signature the Factor Analysis provides for the HP assemblage.

8.4.2. Oxygen Isotope Stage 3 (OIS 3)

This period is better documented with more sequences from archaeological sites as well as non-archaeological sites such as Voordrag and the Tswaing Crater. In the summer rainfall region there is strong evidence for a drier climate. Temperature appears to have varied more than moisture although at some sites moister periods are evident within the generally dry regime. The HP occupation at Rose Cottage Cave ends in OIS 3 and at this time conditions were a little warmer following a possible drought phase that straddles the OIS 3/4 boundary. By 59 000 years ago and continuing into the post-HP assemblage, forest taxa were present in the charcoal assemblage from Rose Cottage Cave (A. Esterhuysen pers. comm.). At Border Cave temperatures were constant throughout OIS 3 and the microfauna assemblage indicates that the region was significantly drier becoming drier still towards the LGM (Avery 1995). At Voordrag conditions were generally drier between 56 000 and the LGM but there was a wet and cool phase prior to 31 000 years ago during which time sclerophyllous fynbos vegetation was prominent (Botha 1996). This vegetation type is generally confined to the southwest of South Africa or to the higher altitudes of the Drakensberg Mountains. Its occurrence at Voordrag suggests a significant shift of vegetation belts (Botha 1996) as temperatures dropped towards the LGM. This phase may coincide with layer Bu at Sibudu Cave as well as other late post-HP layers that

have not yet been analysed. Layer Bu has been described as warm and wet rather than cool and wet as was found at Voordrag. It was suggested that the high proportion of unidentified Charcoal Types in the charcoal assemblage was an indication of a significantly different vegetation community. The identified taxa suggest an environment similar to today; however, once the Charcoal Types have been identified this interpretation may need to be altered. The vegetation evident at Voordrag and the palaeoclimatic interpretation provides clues for the type of vegetation that may have been present at Sibudu Cave and thus the plants that need to be collected in the future for developing the reference collection. If, as Botha (1996) suggests, there was a 1000 m drop in vegetation belts by the time of the LGM, layer P4L (at Voordrag), which is slightly older than the LGM, probably records the early effects of this shift. Presumably vegetation around Sibudu Cave would also have contained more taxa that are currently found further inland and at higher altitudes.

By examining a simplified vegetation map of southern Africa (Fig. 8.1) it is possible to predict the effects of a lowered sea level and an altitudinal shift in vegetation. It is possible that Sibudu Cave would have lain at the edge of the "Undifferentiated bushveld and woodland" and the "Afromontane and inland forest (with grassland/fynbos)", rather than in the "Coastal grassland (associated with forest/bushveld)" (van Wyk & van Wyk 1997). Predicting shifts in vegetation is more complicated than merely projecting a lowered vegetation belt because factors such as the underlying geology, river systems, slope aspect and prevailing winds would have influenced vegetation distribution and must be taken into account. It is important to gather more data from Sibudu Cave and other nearby sites within the summer rainfall region to establish the extent and complexity of the shift in vegetation belts proposed by Botha (1996).

Tswaing Crater and Wonderkrater show that conditions were generally cooler than they are today and within OIS 3 there were a few warmer phases either side of a cooler phase. During the warmer episodes towards the end of OIS 3 savannah

vegetation was prominent, whereas during the cooler phase forest developed. This may indicate that the region was wetter and this period may be concurrent with the cool, moist phase at Voordrag (discussed above). Absolute dates for Tswaing Crater and Wonderkrater would assist in correlating these climatic fluctuations.

8.4.3. Correlations between temperature and moisture records and the Sibudu Cave summary statistics indices

In other palaeoenvironmental studies temperature and moisture indices from Summary Statistics were compared with temperature and rainfall records that show evidence for globally forced climate patterns (Thackeray 1992; 2002; Thackeray & Avery 1990). These indices can help establish whether the patterns observed in the archaeologically derived palaeoenvironmental proxies provide evidence for global or local climate changes. The Sibudu Cave charcoal indices for RF1 (temperature) and RF2 (moisture) have been correlated with the Vostok ice core temperature record (Fig. 8.2) and the Tswaing Crater rainfall proxy record (Fig. 8.3), respectively. The technique is used to look for broad consistencies between the data rather than to correlate absolute changes in temperature or moisture. The rainfall record has been used although the Sibudu Cave index was interpreted as being influenced by moisture availability and the index was probably dependent upon a series of factors in addition to rainfall.

Sibudu Cave charcoal data indicate warm temperatures associated with the HP occupation at about 61 000 years ago. On the Vostok core index temperatures remained cold between 70-60 000 years ago. This discrepancy may indicate that the effects of the cold stadial were not very marked in South Africa or that the warm indicator for the HP is anomalous. It will be easier to interpret this when the pre-HP layers have been analysed. Charcoal assemblages from mid and late post-HP show that there was a slight temperature amelioration in the early part of OIS 3. Summary statistics suggest that during the accumulation of layer Bu conditions were warmest. Warmer conditions (when compared with OIS 4 or the LGM) also prevailed at the

beginning of OIS 3 in the Vostok ice record and there were several subsequent fluctuations in temperature (Fig. 8.2). Layer Bu may fall into one of the peaks in temperature fluctuation.

The moisture availability index was plotted against the Tswaing Crater proxy rainfall record (Fig. 8.3). The Tswaing Crater records appear to provide contradictory evidence to the evidence from Sibudu Cave; that is, when rainfall is highest at about 50 000 years ago at Tswaing Crater, the Sibudu Cave data provide evidence for the driest period. The driest rainfall period at Tswaing Crater correlates with the period at Sibudu Cave when taxa dependent upon moisture are most prominent in the assemblage. The driest phase at Tswaing is thought to date to 61 000 years ago, correlating (by date) with the HP layers from Sibudu Cave. The indication from Sibudu Cave is for moister conditions at this time.

Clarke *et al*. (2003) have correlated the Tswaing dry phase with the development of the colluvium at Voordrag (P on Fig. 2.7), which is dated to 56.5 ±5.2 ka (Clarke *et al*. 2003). This appears to be a large discrepancy in time. If the same procedure was followed for the Sibudu Cave data, the HP layers and/or the early post-HP layers from Sibudu, could also be correlated with these dry phases. Charcoal from layer BSp and the HP layers at Sibudu Cave have a similar age to the dry phases observed at Voordrag and Tswaing, respectively, but the summary statistics indices for these layers suggest intermediate moisture and high moisture availability. Evidence for the drying phase is strongest during Eb and SPCA at Sibudu Cave.

8.5. Summary

It is clear from the discussion presented above that the Sibudu Cave charcoal record appears to display evidence for changes in vegetation that were, to some extent, a product of more widespread changes in climate. For example, the drying trend

observed at the boundary between OIS 4 and OIS 3 appears to be relatively widespread. It is also apparent that the charcoal assemblage records evidence for localised changes such as the indication of high moisture availability during the HP occupation. Some of the apparent discrepancies may indicate that the vegetation across southern Africa responded to global climatic shifts in a variety of ways. There are several possible explanations for the apparent discrepancies in the data. First, palaeoenvironments may have varied sufficiently across southern Africa to produce different climatic signatures. Secondly, it is possible that the proxies used are recording evidence for microclimate rather than globally affected climatic changes. Thirdly, the discrepancies may be a product of the resolution of the absolute dates available. Secure absolute dates for this period of the Last Glacial are a result of relatively recent advances in dating techniques. Sibudu Cave and Voordrag are among the first to benefit from the application of these new techniques. As more accurate dates become available for previously studied sites and new palaeoenvironmental studies are undertaken in South Africa, especially in regions where there are relatively few records for the Last Glacial, gaps in the evidence will be filled and explanations for the temporal and spatial discrepancies discussed here should become apparent.

CHAPTER 9. CONCLUSIONS & FUTURE RESEARCH

9.1. Introduction

The primary aim of this research, outlined in Chapter 1, was to identify and characterise evidence for environmental change using the charcoal assemblage from Middle Stone Aga (MSA) layers in Sibudu Cave. Research was undertaken with the awareness that charcoals from archaeological contexts are essentially a result of human activities and therefore provide a biased view of palaeovegetation and palaeoclimate. Sibudu Cave provided an excellent opportunity to assess the nature of environmental data that can be obtained using charcoal assemblages from MSA contexts. The site contains MSA deposits that have been dated between about 62 000 and 33 000 years ago (Wadley & Jacobs 2004; Z. Jacobs pers. comm.), and occupation was therefore within the Last Glacial.

9.2. Global climates during the Last Interglacial/Glacial cycle

Global evidence suggests that the height of the Last Interglacial was at about 125 000 years ago. Climatic conditions were similar to or a little warmer than current conditions in many parts of the world and sea levels were also at about the same level or a little higher than they are today. Between 125 000 and 75 000 years ago conditions became gradually cooler towards the onset of the Last Glacial at about 75 000 years ago. During this cooling period several fluctuations in sea level, with high stands at 100 000 and 80 000 years ago (Shackleton & Opdyke 1973), have been recorded suggesting climatic fluctuations significant enough to affect continental ice

sheets. The beginning of the Last Glacial at 75 000 years ago is marked by a significant cooling period coinciding with the expansion of continental ice sheets and a global sea level regression. After 60 000 years ago there was a warmer phase during which time sea levels rose again, although not as high as they are today. This warmer interstadial, Oxygen Isotope Stage (OIS 3), lasted about 30 000 years. In the northern hemisphere there is evidence for brief warming and cooling episodes (Lowe & Walker 1997) within the interstadial but conditions remained glacial. By 30 000 years ago conditions began deteriorating towards the Last Glacial Maximum (LGM) at about 20 000 years ago, when sea levels were significantly lower and conditions became cooler and drier.

9.3. Evidence for changes in climate during the Last Interglacial/Glacial cycle in South Africa

Palaeoenvironmental proxies from archaeological and non-archaeological site contexts indicate that the effects of global climatic changes during the Last Interglacial/Glacial cycle were felt to varying extents across South Africa. There is evidence for changes in shoreline between the Last Interglacial, when sea levels were higher than they currently are, and the LGM, when sea levels were significantly lower. Palaeoshorelines that lie offshore, east of Richards Bay (Ramsay 1996), preserve evidence for shorelines lower than the modern shorelines. During the Last Glacial these lowered sea levels would have resulted in changes in the coastal profile around the subcontinent, with wide expanses of currently submerged land exposed in the Cape to the west of Port Elizabeth. Along the Transkei coast the continental shelf is steeper and the coastal profile would have altered very little, whereas further north the continental shelf becomes wider and less steep, although it is not as shallow here as it is in the Cape. Fluctuations in sea level would have had varying impacts upon

the geomorphology, vegetation, and distribution of fauna and the occupants of a region due to variations in the onshore and offshore topography around South Africa.

Prior to the Last Glacial the winter rainfall region may have been wet with bushy vegetation present in many areas. Sites with deposits from the Last Interglacial are rare but those that do have deposits from this period contain evidence for fauna and climatic conditions that are similar to today. The oldest deposits at Boomplaas may date to about 80 000 years ago and in these layers the suite of fauna is more similar to fauna recorded historically in the region than it is to the younger MSA deposits at the site.

Data from many sites in the winter rainfall region indicate that during the Last Glacial conditions were colder and wetter, with more extensive grassland habitats, than during the Last Interglacial or today. Grasslands were probably prominent on the coastal plain that would have been exposed as a result of the marine regression. Faunal assemblages are dominated by grazing ungulates. Evidence for wetter conditions is supported by larger molerat body sizes, while Saunders's vlei rat provides support for cooler conditions. There is evidence for some variation within this pattern; however, this may be due to microclimatic changes influencing the composition of the archaeological assemblages rather than providing evidence for more broadly felt climatic fluctuations. Towards the end of the Last Glacial, conditions became cooler and drier than they had been previously. This is evident from a lack of woody taxa and the increased prominence of shrubland, such as at Boomplaas at 32 000 years ago. The occurrences of Saunders's vlei rat, which increases during the LGM, and forest shrew, which decreases at the same time, suggest conditions became progressively cooler and drier. The first cold stadial (OIS 4) of the Last Glacial, between 75 and 60 000 years ago, was characterised by cool and moist conditions, whereas the second cold stadial of the Last Glacial (OIS 2 encompassing the LGM) appears to have been cooler and drier, indicating more extreme conditions in many regions.

Proxies from Elands Bay Cave in the Western Cape provide slightly anomalous environmental evidence. Charcoal identifications have been interpreted as indicators of wetter conditions. The region may have been subject to perennial rainfall rather than the winter rainfall it receives today. Faunas present in the archaeological assemblage suggest it was cooler than at present. The implications from Elands Bay Cave are that the Western Cape may have been subject to a different climatic regime from the rest of the winter rainfall region. To summarise, the majority of sites in the Cape region experienced cooler conditions but eastern areas became significantly drier, while the west received more rainfall.

Summarising palaeoenvironments of the summer rainfall region is more complicated. The area is significantly larger than the winter rainfall region and includes a diverse range of vegetation biomes through which the archaeological sites are widely dispersed. One of the main limitations of analysing data from this region is establishing whether the changes observed in the vegetation or fauna are localised or whether they are the result of climatic changes that are felt across the whole region. The reactions of vegetation within diverse biomes and their associated faunas to changes in climate may vary. For example, a forest such as the forest near Sibudu Cave will survive a dry phase because it is focussed on the river. Extremely dry regions with little vegetation will also not be affected dramatically by a dry phase because the existing vegetation is adapted to these conditions. The intermediate woodland and grassland savanna vegetation types are more likely to be affected and a dry phase may result in a reduction of tree vegetation cover and an increase in shrubs. Broad trends, many of which appear to be the result of widespread climatic changes, are summarised below.

In northern KwaZulu-Natal, at Border Cave and Voordrag, there is evidence for drier grassland environments during OIS 4. The Howiesons Poort (HP) occupation at Border Cave was between 60 and 80 000 years ago (Grün & Beaumont 2001) and

during this time grassland vegetation developed, temperatures and both seasonal and annual rainfall decreased, and the Summer Aridity Index (SAI) increased. At Voordrag, dry conditions (indicated by colluvium accumulation) are recorded as pulses 100-95 000, and at 56 000 and 31-28 000 years ago (Clarke *et al.* 2003). At Rose Cottage Cave the pre-HP occupation contains a limited charcoal assemblage indicating cooler and drier conditions (A. Esterhuysen pers. comm.) and thus provides supporting data for cool, dry conditions during OIS 4. The HP lithic industries at Rose Cottage Cave and Border Cave coincide with these dry, cool conditions. Layers associated with post-HP lithic industries at these sites indicate that a slightly warmer period followed. At Rose Cottage Cave the area may have become a little moister because there is evidence for forest vegetation, while at Border Cave drier environments are evident by 40 000 years ago. Tswaing and Wonderkrater support the evidence for slightly warmer conditions during OIS 3, although at Tswaing a cooler phase is evident prior to 40 000 years ago during which time *Podocarpus* forest was able to develop (Scott 1999). Secure absolute dates are not yet available for these deposits and therefore their exact placement in the Last Glacial remains uncertain. In general, conditions at both sites were dry and in particular the region would have been significantly warmer during OIS 3 than during the subsequent LGM.

Although there is a general pattern of dry conditions during the Last Glacial there are several sites that provide evidence of wetter episodes that vary geographically and temporally. These wetter phases may be relatively localised and may not be a result of global changes in climate. Wetter conditions are recorded at Port Durnford at about 70 000 years ago (although the date for this site remains uncertain) and at Voordrag at 42 000, 40 000 and 36 000 years ago. Conditions were also cool, enabling fynbos elements to move into the Voordrag region in northern KwaZulu-Natal from the higher altitudes of the Drakensberg.

Conditions during the Last Glacial in both the winter and summer rainfall regions were generally cooler than they are today, with wetter conditions that gradually became drier in the Cape, and drier conditions with wetter phases in the east and northern parts of South Africa. On the basis of this evidence it was hypothesised that the Sibudu Cave region would also have experienced climatic conditions that were different from those in the region today and that these should have affected the vegetation in the site vicinity and the woody taxa available for the site occupants to collect. Sibudu Cave was ideal for a palaeoenvironmental reconstruction because a range of environmental proxies were being studied by other researchers and the charcoal interpretations could be assessed against the results of these other environmental indicators. In addition, some of these proxies are less influenced by human activities than archaeological charcoal assemblages, and the range of proxies provide information on different aspects of the palaeoenvironment. All these sources of data could be drawn together to present a broader image of the palaeoenvironment including vegetation, fauna and climate.

9.4. Evidence for climate change using palaeoenvironmental proxies from Sibudu Cave

9.4.1. Macrofauna, seeds, phytoliths and pollen

These environmental proxies suggest that conditions were dry by the beginning of OIS 3. These conditions continued throughout the post-HP occupation of the site. The faunal assemblage contains giraffe and tortoise, which indicate the presence of savanna grassland vegetation. This in turn suggests significantly drier climatic conditions than the area receives today. This is confirmed by *Acacia* sp. that were identified in the seed, phytolith and pollen assemblages. The possibility that *Ochna pulchra* was in the area also supports the evidence for a drier than present vegetation. Several animals that are not currently or historically recorded in the Sibudu Cave

region are present in the archaeological assemblage. Blue wildebeest, sable/roan, impala and waterbuck, which are more commonly found in northern KwaZulu-Natal, are present in the MSA layers. The suite of animals in the macrofaunal assemblage is similar to the fauna found in the Kruger National Park in the eastern Lowveld of South Africa. In this area conditions are warm and less humid than in KwaZulu-Natal where Sibudu Cave is located. The seed assemblages from the site do not contradict this interpretation, but rather contribute to the image of the past vegetation and climate. Evergreen taxa are common in the seeds. Many of these are from forest vegetation communities and some are understorey components suggesting that the forest was well developed. Many of the taxa are present in the modern vegetation and it is therefore likely that this forest was similar to today's forest. The seed assemblages may provide evidence for a drying trend in the MSA layers above RSp. More deciduous seeds are present in these younger layers (with the exception of OMOD), but these are also present in the modern vegetation community and may not necessarily imply vegetation change.

9.4.2. Charcoal

The Sibudu Cave charcoal analysis shows that during the HP occupation the region experienced high moisture availability. This was shown both in the descriptive analysis and in the statistical analyses of the HP layers. A temperature index produced using summary statistics suggests that conditions were warm. It is difficult to compare this temperature indication with modern temperatures for the region because the index is based on the charcoal assemblage for which there is no modern equivalent. However, using the taxa present it is possible to suggest that conditions were warm and wet, although the region was probably not warmer than it is today. *Podocarpus* spp. and *Buxus* sp. provide evidence for mesic forest vegetation, while *Kirkia* sp. indicates the presence of a warmer, dry vegetation community beyond the forest.

During the early post-HP occupation (about 60-55 000 years ago) there was a change in the charcoal assemblage that has been interpreted as a change in environmental conditions in the site vicinity. Modern distributions of the taxa present and the summary statistics suggest that conditions were drier and cooler than during the HP occupation. There is strong evidence for a riverine forest community (*Erica* spp., *Leucosidea sericea*, *Rapanea melanophloeos* and *Bridelia* spp.) and there are some taxa that are currently only found further inland in regions that can be seasonally cold (*Leucosidea sericea*). Some of the taxa can be found in the foothills of the Drakensberg. This may suggest that a significant shift in vegetation zones occurred at the end of OIS 4 and the beginning of OIS 3. Such a shift may have resulted from changes in sea level. A lowered sea level would not have dramatically changed the profile of this stretch of coast because of the relatively steep offshore topography; however, it may have been sufficient to reduce the ameliorating influence of the coast upon the area and thus changes in vegetation may have occurred.

The middle post-HP layers (55-50 000 years ago) contain more bushveld and savanna taxa than the previous layers. This suggests that conditions were drier and the vegetation was perhaps more open than it was during the accumulation of the assemblages associated with previous occupations. This drying trend appears to be consistent with the changes observed at Border Cave, where grassland also increased during this time.

The late post-HP occupation was analysed through one layer (Bu) only and therefore the interpretation of the final MSA occupation of Sibudu Cave is necessarily limited. Many of the identified taxa in this layer are found in the region around the site today. This suggests that the climate and vegetation may have been similar to the current conditions. Riverine forest taxa dominate the Bu sample. The *Kirkia* sp. identification may be interpreted as evidence for a drier community that is not in existence today. The summary statistics placed layer Bu at the warm and moist ends of the temperature and moisture indices. In addition, both the factor analysis

(summary statistics) and the correspondence analysis group layer Bu with the HP layers. It is concluded that this is because there are some taxa that are common between these layers. There are perhaps more taxa common to Bu and the HP layers than there are between these layers and any other layers analysed thus far. There are, however, many taxa that are not common to Bu and the HP layers. For example, *Podocarpus* spp. and the Rubiaceae/Apocynaceae identifications, common in the HP layers, are absent from Bu. In addition, Bu contains many Charcoal Types that are currently unidentified and most of these are only present in Bu. It will be necessary to analyse charcoal from other HP layers and from the late post-HP layers to establish whether the similarities initially recognised are real.

The charcoal analysis also revealed an interesting pattern that can be explained in several ways. *Erica* spp. and *Acacia* spp. were commonly identified taxa in all post-HP layers. The analysis revealed that while *Erica* spp. decreased through time (oldest to youngest), *Acacia* spp. increased through time. This observation is based on percentage frequencies of these taxa; however, it is possible to speculate on several scenarios that could have produced this pattern. The suite of taxa in the charcoal assemblages from middle post-HP layers suggest an overall increase in bushveld taxa. In particular, taxa from the Fabaceae family become more prominent. There is a corresponding, but less marked, decrease in the occurrence of riverine and forest taxa. This combined pattern of percentage frequency and species occurrence could be a result of a change in wood collecting behaviour (driven by social choice, change in collecting location, or a change in the purpose for which wood is collected). It could also be indicative of a real change in the vegetation around the cave (driven by changes in climate) or it could be a result of sampling bias. It is difficult to eliminate any of these suggestions at present and it is possible that the results of further charcoal studies will assist by filling gaps and either strengthening or refuting this apparent trend.

9.5. Summary

In Chapter 1 it was hypothesised that wood incorporated into the Sibudu Cave MSA assemblage was predominantly collected for fuel and that the assemblages would therefore be biased towards good fuelwoods. Direct evidence for wood-using activities at the site are limited to fuel burning in hearths. There is some secondary evidence for haft manufacture; however, it is difficult to establish whether taxa in the charcoal assemblage are remnants of these activities. It was assumed that whether wood was considered a good source of fuel or not was based primarily upon the physical properties of the wood rather than upon social constructs that are not visible through the MSA archaeological assemblage. It was further assumed that woods documented to be good fuel today would have been collected, if available, in the past. Several woods that are currently used for fuel are present in the Sibudu Cave charcoal assemblage. These include *Erica* spp., *Acacia* spp., *Leucosidea sericea, Ptaeroxylon obliquum*, and *Buxus* sp. The HP layers are anomalous because good fuelwoods are not prominent components of their assemblages. In all other layers analysed fuelwoods are prominent or even dominant. The most prominent taxa in the HP layers are *Podocarpus* spp. and a Rubiaceae/Apocynaceae taxon. These may have been collected (or selected) for fuel; equally, they may have been brought to the site inadvertently or they may have been selected to fulfil another purpose. The assumption appears to be accurate for most layers; however, there are many taxa in the samples that are not considered good fuelwoods. In addition, the relatively high diversity of taxa in each layer suggests that wood selection may not have been as important during the MSA as was originally anticipated.

The second hypothesis made in Chapter 1 concerned the extent to which the archaeological charcoal would resemble the vegetation environment around the cave. It was acknowledged that direct comparisons between the percentage frequencies of taxa in the sample (or even the assemblage) and taxa in the environment cannot be made. It was, however, assumed that the majority of taxa would have been collected

from the near vicinity of the site. The taxa present suggest that several vegetation habitats, including forest and savanna, were exploited for wood collecting. There is no strong evidence that special woods were collected from distant sources. In each layer analysed the suite of taxa can either be found growing together in communities today or in habitats that are found in close association (as in the case of the *Kirkia* sp. and the *Podocarpus* spp.). Some taxa that today are not present in the region and that only grow in northern South Africa were identified. Rather than suggesting evidence for (absurdly) long distance transport, these taxa, when placed in the context of all the other charcoal identifications and environmental proxies, were interpreted as evidence for climate and vegetation change in the area.

The third hypothesis is closely linked to the second. In this scenario I suggested that changes in the charcoal assemblage should provide evidence for environmental and climatic change. To some extent this is true. There are changes in the combinations of taxa present that must be related to climatic change. For instance, *Leucosidea sericea* is not currently found in the area. In the early post-HP layers, its association with other taxa currently found in the Drakensberg foothills implies that conditions may have been more seasonal than at present, with frost in winter. Clear differences between taxa in the HP layers and all other post-HP layers have also been interpreted as evidence for environmental change. This study has identified instances when differences in the charcoal assemblages might be a result of behavioural changes (such as the fluctuations in the occurrence of *Acacia* spp. and *Erica* spp.) rather than climatic changes. It was suggested that percentage frequencies could not be used as evidence for changes in vegetation and these taxa provide a good example of problems that might arise. It is sometimes difficult to decipher the causes of changes observed in the charcoal assemblage and there may be instances where this is not possible using charcoal data alone.

9.6. Directions for Future Research

Several areas of research that are under-represented in palaeoenvironmental studies in South Africa were noted during this project. It became clear during the literature search that data for the LGM and younger sequences exceed the quantities of data available from sites dating to the Last Interglacial/Glacial cycle. This is, to some extent, a result of better preservation and higher dating resolution in the younger stratigraphic layers of sites than the older contexts. Recent development of new, more accurate, techniques for dating archaeological contexts (particularly for deposits beyond the limit of 14C dating) have improved the potential for palaeoenvironmental interpretations for sites with deposits from the Last Interglacial/Glacial cycle. These techniques, such as single grain Optically Stimulated Luminescence dating, should also facilitate comparisons of data from different sites. It is now necessary to ensure that the palaeoenvironmental data, published prior to the acquisition of the new dates, are reassessed and perhaps even reinterpreted in light of the new dates available. For many sites in South Africa this has yet to be done.

Results of the Sibudu Cave research and other palaeoenvironmental studies have shown that palaeovegetation and climatic conditions during the Last Glacial were not homogeneous across South Africa or within the summer rainfall region. It appears more likely that global climatic shifts after the Last Interglacial manifest in various ways and to differing extents across South Africa. These studies also show that by using a range of different proxies from different sites it is difficult to reach consensus on the changes that have occurred and the extent of these (whether changes in climate or vegetation). A review of the available palaeoenvironmental data (including a discussion of dates that should be used and those that need to be reassessed) for sites across South Africa is required. This should be a collaborative effort carried out by specialists to ensure that the interpretations of proxy data are accurate. Such a collaborative review could be used to identify gaps in the existing palaeoenvironmental records and potential avenues for future research.

The current research has highlighted several areas for further exploration through charcoal analysis. The HP layers, for example, provided evidence for a distinctly different charcoal assemblage from the assemblages in other layers. As it is currently uncertain whether these differences are a result of changes in climate and vegetation, changes in wood use or wood collecting behaviour, or whether they are a result of sampling bias, it would be valuable to analyse HP charcoal from other excavation units to establish whether the pattern is present throughout. Pre-HP charcoal may also assist in establishing whether this trend continues into the older layers or whether it is confined to the HP layers. Analysing charcoal from pre-HP, HP and post-HP assemblages from other archaeological sites in southern Africa will be necessary to ascertain whether the pattern is confined to the Sibudu Cave assemblage or whether it is apparent in other charcoal assemblages, and thus whether it is a widespread environmental change or a localised occurrence. There is limited data currently available from Rose Cottage Cave and further charcoal analysis could be carried out on the MSA assemblage from that site. Many sites in southern Africa do not contain pre-HP, HP and post-HP deposits; however, by analysing charcoal from sites that are in close proximity it will be possible to piece together information for an area. Using charcoal assemblages alone it may not be possible to determine if the pattern is a result of changes in environmental conditions or whether it is culturally driven. It may be necessary to use evidence from other proxies. Isotopic analysis of bone and even charcoal may help resolve this by providing a view on the environmental changes that is not biased by human selection processes.

This project has highlighted the need for a well documented, and comprehensive, reference collection. There are a large number of Charcoal Types that cannot currently be identified and it is probable that many of these are absent from the comparative collection. It has already been suggested that there may be shrubs within the assemblage and therefore shrub taxa provide an obvious area for expansion of the collection. It is also possible that the assemblage contains young branches.

Identifying these may not be possible because of their heterogeneous wood anatomy. It is important to explore this further because a dominance of young branches in an assemblage would indicate a different collecting strategy from an assemblage in which mature wood specimens are dominant. Expanding the reference collection is a long term project and it is intended that the collection should be made available, through publication, to other researchers in South Africa and elsewhere. The importance of clearly documenting wood anatomical characters has already been discussed in Chapter 4 and this should be an integral part of expanding and publishing the reference database. It is hoped that this work will lead to charcoal analysis becoming a more routine part of post-excavation analysis. A well documented reference collection for South Africa will ultimately allow the emphasis of charcoal research to be placed on interpreting the assemblages rather than the process of charcoal identification.

REFERENCES

Acocks, J.P.H. (1988). *Veld Types of South Africa,* 3rd edn. Memoirs of the Botanical Survey of South Africa 57.

Aitken, M.J. (1997). *Science-based dating in Archaeology*. London, Longman.

Allaby, M. ed. (1998). *Dictionary of Plant Sciences*. Oxford, Oxford University Press.

Archer, F. (1990). Planning with people – Ethnobotany and African uses of plants in Namaqualand (South Africa). *Mitteilungen aus dem Institute für Allgemeine Botanik Hamburg* 23b: 959-972.

Austin, P.H. (2004). Towards a better understanding of wood charcoal taphonomy: an experimental approach. Abstract vol. III International Meeting of Anthracology pp.2.

Avery, D.M. (1982a). Micromammals as palaeoenvironmental indicators and an interpretation of the late Quaternary in the southern Cape Province, South Africa. *Annals of the South African Museum* 85: 183-374.

Avery, D.M. (1982b). The micromammalian fauna from Border Cave, Kwazulu, South Africa. *Journal of Archaeological Science* 9:187-204.

Avery, D.M. (1987). Late Pleistocene coastal environment of the Southern Cape Province of South Africa: micromammals from Klasies River Mouth. *Journal of Archaeological Science* 14: 405-421.

Avery, D.M. (1992). The environment of early modern humans at Border Cave, South Africa: micromammalian *Palaeogeograph,y Palaeoclimatolog,y Palaeoecology* 91: 71-87.

Avery, D.M. (1995). Physical environment and site choice in South Africa. *Journal of Archaeological Science* 22: 343-353.

Bada, J.L. & Deems, L. (1975). Accuracy of dates beyond the C-14 dating limit using aspartic acid racemization reaction. *Nature* 255: 218-219.

Badal Garcia, E. (1992). L'anthracologie préhistorique: à propos certains problèms méthodologiques. In J.-L. Vernet, ed. Les chabons de bois, les anciens écosystèms et le rôle de l'homme. Colloque organise à Montpellier du 10 an 13 septembre 1991. *Bulletin de la Société Botanique de France* 139, *Actualités Botaniques* 2/3/4: 167-189.

Barefoot, A.C. & Hankins, F.W. (1982). *Identification of Modern and Tertiary Woods*. Oxford, Clarendon Press.

Bé, A.W.H. & Duplessy, J.C. (1976). Subtropical convergence fluctuations and Quaternary climates in the middle latitudes of the Indian Ocean. *Science* 194: 419-421.

Beaumont, P.B. (1980). On the age of Border Cave hominids 1-5. *Palaeontologia Africana* 23: 21-33.

Binford, L.R. (1984). *Faunal Remains from Klasies River Mouth*. Orlando, Academic Press.

Botha, G.A. (1996). The Geology and Palaeopedology of the Late Quaternary Colluvial Sediments in KwaZulu/Natal. *Council for Geoscience Memoir* 83.

Botha, G.A. (1997). *Maputaland Field Guide and Abstracts*, INQUA Commission on the Quaternary Shorelines, Africa Subcommision, Council for Geoscience, Pietermaritzburg.

Botha, G.A., de Villiers, J.M., & Vogel, J.C. (1990). Cyclicity of erosion, colluvial sedimentation and palaeosol formation in Quaternary hillslope deposits from northern Natal, South Africa. *Palaeoecology of Africa and the surrounding islands* 21: 195-210.

Botha, G.A., Scott, L., Vogel, J.C. & von Brunn, V. (1992). Palaeosols and palaeoenvironments during the Late Pleistocene Hypothermal in northern Natal. *South African Journal of Science* 88 (Sept/Oct): 508-512.

Broecker, W.S., Thurber, D.L., Goddard, J., Ku, T-L., Matthews, R.K. & Mesolella, K.J. (1968). Milankovitch hypothesis supported by precise dating of coral reefs and deep-sea sediments. *Science* 159: 297-300.

Butzer, K.W. (1984). Late Quaternary environments in South Africa. In J.C. Vogel, ed. *Late Cenozoic Palaeoclimates of the southern Hemisphere*. Balkema, Rotterdam 235-264.

Cain, C.R. (2004). Notched, flaked and ground bone artefacts from Middle Stone Age and Iron Age layers of Sibudu Cave, KwaZulu-Natal, South Africa. *South African Journal of Science* 100: 195-197.

Cain, C.R. (in press). Using burned animal bone to look at Middle Stone Age occupation and behaviour. *Journal of Archaeological Science.*

Carlquist, S. (1975). *Ecological Strategies of Xylem Evolution. Berkley*, University of California Press.

Carrión, J.S., Brink, J.S., Scott, L., & Binneman, J.N.F. (2000). Palynology and palaeoenvironment of Pleistocene hyaena coprolites from an open-air site at Oyster Bay, Eastern Cape coast, South Africa. *South Africa Journal of Science* 96: 449-453.

Cartwright, C. & Parkington, J. (1997). The wood charcoal assemblage from Elands Bay Cave, southwestern Cape: principles, procedures and preliminary interpretation. *South African Archaeological Bulletin* 52: 59-72.

Chappell, J. & Shackleton, N.J. (1986). Oxygen isotopes and sea level. *Nature* 324(13): 137-140.

Clarke, M.L., Vogel, J.C., Botha, G.A. & Wintle, A.G. (2003). Late Quaternary hillslope evolution recorded in eastern South African colluvial badlands. *Palaeogeography, Palaeoclimatology, Palaeoecology* 197: 199-212.

Coates Palgrave, K. (revised and updated by Coates Palgrave, M.) (2002). Trees of Southern Africa. Cape Town, Struik Publishers.

Cochrane, G.W.G. (2003a). The Role of Diversity in the Evolution of Symbolic Behaviour: Insights from South African Lithic Assemblages. Vol. 1 & 2. Unpublished PhD thesis. The University of the Witwatersrand, South Africa.

Cochrane, G.W.G. (2003b). Artefact attribute richness and sample size adequacy. *Journal of Archaeological Science* 30(7): 837-848.

Cooper, J.A.G. (1990). Late Pleistocene Marine embayments of Zululand, South Africa. *Palaeoecology of Africa and the surrounding islands* 21: 49-59.

Cowling, R.M., Cartwright, C.R., Parkington, J.E. & Allsopp, J.C. (1999). Fossil wood charcoal assemblages from Elands Bay Cave, South Africa: implications for Late Quaternary vegetation and climates in the winter-rainfall fynbos biome. *Journal of Biogeography* 26: 367-378.

Deacon, H.J. (1995). Two late Pleistocene-Holocene archaeological depositories from the southern Cape, South Africa. *South African Archaeological Bulletin* 50: 121-131.

Deacon, H.J. & Geleijnse, V.B. (1988). The stratigraphy and sedimentology of the main site sequence, Klasies River, South Africa. *South African Archaeological Bulletin* 42: 5-14.

Deacon, H.J., Deacon, J., Scholtz, A., Thackeray, J.F., Brink, J.S. & Vogel, J.C. (1984). Correlation of palaeoenvironmental data from the Late Pleistocene and Holocene deposits at Boomplaas cave, southern Cape. In J.C. Vogel ed. *Late Cainozoic Palaeoclimates of the Southern Hemisphere*. 339-352. Rotterdam, Balkema.

Deacon, H.J., Scholtz, A. & Daitz, D. (1983). Fossil Charcoals as a source of palaeoecological information in the fynbos region. In H.J. Deacon, Q.B. Hendey and J.J.N. Lambrechts eds. *Fynbos palaeoecology: A preliminary synthesis*. South African National Scientific Programmes Report 75 (Dec): 174-182. Pretoria, CSIR.

Deacon, H.J. & Wurz, S. (1996). Klasies River main site, cave 2: a Howiesons Poort occurrence. In G. Pwiti and R. Soper eds. *Aspects of African Archaeology*. 213-218. Harare, University of Zimbabwe Publications.

Deacon, J. & Lancaster, N. (1988). *Late Quaternary Palaeoenvironments of Southern Africa*. Oxford, Clarendon Press.

Desch, H.E. & Dinwoodie, J.M. (1981). *Timber: its structure, properties and utilisation.* London, The Macmillan Press.

Dimbleby, G.W. (1967). *Plants in Archaeology*. London, John Baker.

Dincauze, D.F. (2000). *Environmental Archaeology: principles and practice*. Cambridge, Cambridge University Press.

Dowson, T.A. (1988). Shifting vegatation zones in the Holocene and later Pleistocene: Preliminary charcoal evidence from Jubilee Shelter, Magaliesberg, southern Transvaal. In K. Heine ed. *Palaeoecology of Africa and the surrounding islands* 19: 233-239.

du Toit, A.L. (1954). *Geology of South Africa*. Edinburgh, Oliver and Boyd.

Eichhorn, B. (2002). Anthrakologische Untersuchungen zur Vegetationgeshichte des Kaokolandes, Nordwest-Namibia. Inaugural-Dissertation zur Erlangung des Doktorgrades der Metematisch-Naturwissenschaftlichen Fakultät der Universität zu Köln.

Ellery, W., Bill, C., McKensie, A, Murphy, M. & Tooley, J. (2000). Sustainable use of natural hardwood resources in the Thukela Biosphere Reserve. The Town and Regional Planning Commision Suplementary Report 53.

Emilliani, C. (1955). Pleistocene temperatures. *Journal of Geology* 63: 538-575.

Esterhuysen, A.B. (1996). Palaeoenvironmental Reconstructions from the Pleistocene to Present: an analysis of archaeological charcoal from sites in the eastern Free State and Lesotho. Unpublished MA Thesis. The University of the Witwatersrand, South Africa.

Esterhuysen, A.B. & Mitchell, P.J. (1996). Palaeoenvironmental and archaeological implications of charcoal assemblage from Holocene sites in western Lesotho, southern Africa. *Palaeoecology of Africa and the surrounding islands* 24: 203-232.

Feathers, J.K. (2002). Luminescence dating in less than ideal conditions: case studies from Klasies River Main Site and Duinefontein, South Africa. *Journal of Archaeological Science* 29: 177-194.

Feathers, J.K. & Bush D.A. (2000). Luminescence dating of Middle Stone Age Deposits at Die Kelders. *Journal of Human Evolution* 38: 91-119.

February, E.C. (2000). Archaeological charcoal and dendrochronology to reconstruct past environments of southern Africa. *South African Journal of Science* 96 (March): 111-116.

Figueiral, I. (1992). Methodes en anthracology: etude de sites du Bronze final et de l'age du fer du nord-ouest du Portugal. In J.-L. Vernet, ed. Les chabons de bois, les anciens écosystèms et le rôle de l'homme. Colloque organise à Montpellier du 10 an 13 septembre 1991. *Bulletin de la Société Botanique de France* 139, *Actualités Botaniques* 2/3/4: 191-204.

Flemming, B. W. (1976). Rocky Bank – evidence for a wave-cut platform. *Annals of the South African Museum* 71: 33-48.

Ford, R.I. (1988). Commentary: Little Things Mean a Lot – Quantification and Qualification in Paleoethnobotany. In C.A. Hastorf and V.S. Popper eds. *Current Paleoethnobotany: analytical methods and cultural interpretations of archaeological plant remains* 215-222.

Goldberg, P. (2000). Micromorphology and site formation at Die Kelders Cave I, South Africa. *Journal of Human Evolution* 38: 43-90

Goodwin, H. & Tansley, A.G. (1942). Prehistoric charcoals as evidence of former vegetation, soil and climate. *Journal of Ecology* 29(1): 117-126.

Grant, R. & Thomas, V. (1998). *Sappi Tree Spotting KwaZulu-Natal, Coast and Midlands: Tree identification made easy*. Johannesburg, Jacana Education.

Grant, R. & Thomas, V. (2000). *Sappi Tree Spotting Bushveld including Pilanesberg and Magaliesberg: Tree identification made easy*. Johannesburg, Jacana Education.

Grant, R. & Thomas, V. (2004). *Sappi Tree Spotting KwaZulu-Natal and Eastern Cape: Tree identification made easy*. Johannesburg, Jacana Media.

Grün, R. & Beaumont, P. (2001). Border Cave revisited: a revised ESR chronology. *Journal of Human Evolution* 40: 467-482.

Grün, R., Beaumont, P.B. & Stringer, C.B. (1990b). ESR dating evidence for early modern humans at Border Cave in South Africa. *Nature* 344: 537-539.

Grün, R., Shacklton, N.J. & Deacon, H.J. (1990a). Electron-spin-resonance dating of tooth enamel from Klasies River Mouth Cave. *Current Anthropology* 31: 427-432.

Hadac, E. & Hasek, M. (1949). Remnants of woods from the prehistoric fire-places in Bohemia. *Studia Botanica Cechoslovaca* 10(4): 136-148.

Harper, P.T. (1994). The Middle Stone Age sequences at Rose Cottage Cave: a search for continuity and discontinuity. Unpublished MA Thesis. The University of the Witwatersrand, South Africa.

Heinz, C & Thiébault, S. (1998). Characterization and palaeoecological significance of archaeological charcoal assemblages during the late and post-glacial phases in southern France. *Quaternary Research.* 50: 56-68.

Henshilwood, C.S., Sealy, J.C., Yates, R., Cruz-Uribe, K., Goldberg, P., Grine, F.E., Klein, R.G., Poggenpoel, C., van Niekerk, K. & Watts, I. (2001). Blombos Cave, Southern Cape, South Africa: Preliminary Report on the 1992-1999 Excavations of the Middle Stone Age Levels. *Journal of Archaeological Science* 28: 421-448.

Hutchings, A., Scott, A.H., Lewis, G. & Cunningham, A.B. (1996). *Zulu Medicinal Plants – An Inventory*. Pietermaritzburg, University of Natal Press.

IAWA Committee (1989). List of microscopic features for hardwood identification. *International Association of Wood Anatomists (IAWA) Bulletin new series* 10: 221-332.

Ilic, J. (1991) *CSIRO Atlas of Hardwoods*. Melbourne, Crawford House Press in association with CSIRO.

Jacobs, Z., Duller, G.A.T. & Wintle, A.G. (2003a) Optical dating of dune sand from Blombos Cave, South Africa: II - single grain data. *Journal of Human Evolution* 44: 613-625.

Jacobs, Z., Wintle, A.G. & Duller, G.A.T. (2003b) Optical dating of dune sand from Blombos Cave, South Africa: I - multiple grain data. *Journal of Human Evolution* 44: 599-612.

Jane, F.W. (revised by Wilson, K. & White, D.J.B.) (1970). *The Structure of Wood*. London, Adam and Charles Black.

Killick, D.J.B. (1990). *A field guide to the flora of the Natal Drakensberg*. Johannesburg, J. Ball.

Klein, R.G. (1976). The mammalian fauna of the Klasies River Mouth sites, southern Cape Province, South Africa. *South African Archaeological Bulletin* 31: 75-98.

Klein, R.G. (1978). A preliminary report on the larger mammals from Boomplaas Stone Age cave site, Cango Valley, Oudtshoorn District, South Africa. *South African Archaeological Bulletin* 33: 66-75.

Klein, R.G. & Cruz-Uribe, K. (1996). Size Variation in the rock hyrax (*Procavia capensis*) and late Quaternary climatic changes in South Africa. *Quaternary Research* 46: 193-207

Klein, R.G. & Cruz-Uribe, K. (2000). Middle and Later Stone Age large mammal and tortoise remains from Die Kelders Cave 1, Western Cape Province, South Africa. *Journal of Human Evolution* 38: 169-195.

Kromhout, C.P. (1975). 'n Sleutel vir die mikroskopiese uitkenning van die vernaamste inheemse houtsoorte van Suid-Afrika. *Department of Forestry Bulletin* 50: 1-140.

Leney, L. & Casteel, R.W. (1975). Simplified Procedure for Examining Charcoal Specimens for Identification. *Journal of Archaeological Science* 2: 153-159.

Lenhof, L. (1995). The Marine Geology of Walker Bay off Hermanus, SW Cape, South Africa. Unpublished MA Thesis, University of Cape Town, South Africa.

Liengme, C.A. (1983). A study of wood use for fuel and building in an area of Gazankulu. *Bothalia* 14(2): 245-257.

Lombard, M. (2002). Evidence for hunting and hafting at Sibudu Cave during the Middle Stone Age. *The Digging Stick* 19(3): 1-3.

Lombard, M., Parsons, I. & van der Ryst, M.M. (2004). Middle Stone Age lithic point experimentation for macro-fracture and residue analysis: the processes and preliminary results with reference to Sibudu Cave points. *South African Journal of Science* 100: 159-166.

Low, A.B. & Rebelo, A.G., eds. (1996). *Vegetation of South Africa, Lesotho and Swaziland (Map)*. Pretoria, Department of Environmental Affairs and Tourism.

Low, A.B. & Rebelo, A.G., eds. (1998). *Vegetation of South Africa, Lesotho and Swaziland*. Pretoria, Department of Environmental Affairs and Tourism.

Lowe, J.J. & Walker, M.J.C. (1997). *Reconstructing Quaternary Environments*. London, Longman.

Marean, C.W., Abe, Y., Frey, C.J. & Randall R.C. (2000a). Zooarchaeological and taphonomic analysis of the Die Kelders Cave 1 Layers 10 and 11 Middle Stone Age larger mammal fauna. *Journal of Human Evolution* 38: 197-233.

Marean, C.W., Goldberg, P., Avery, G., Grine, F.E. & Klein R.G. (2000b). Middle Stone Age stratigraphy and excavations at Die Kelders Cave 1 (Western Cape Province, South Africa): the 1992, 1993, and 1995 field seasons. *Journal of Human Evolution* 38: 7-42.

Maud, R.R. (2000). Estuarine Deposits. In T.C. Partridge & R.R. Maud, eds. *The Cenozoic of Southern Africa*. Oxford monographs on geology and geophysics no. 40: 162-172. New York, Oxford University Press.

Maud, R.R. & Botha G.A. (2000). Deposits of the South Eastern and Southern Coasts. In T.C. Partridge and R.R. Maud, eds. *The Cenozoic of Southern Africa*. Oxford monographs on geology and geophysics no. 40: 19-32. New York, Oxford University Press.

Metcalfe, C. R. & Chalk L. (1950a). *Anatomy of the Dicotyledons* Vol. 1. Oxford, Clarendon Press.

Metcalfe, C. R. & Chalk L. (1950b). *Anatomy of the Dicotyledons* Vol. 2. Oxford, Clarendon Press.

Miksicek, C.H. (1987). Formation Processes of the Archaeobotanical Record. *Advances in Archaeological Method and Theory* 10: 211-247.

Moll, E. (1992). *Trees of Natal*. Cape Town, University of Cape Town Press.

Moll, E.J. & White, F. (1978). The Indian Ocean coastal belt. In M.J.A. Werger ed. *Biogeography and Ecology of southern Africa*, 561-598. The Hague, W. Junk.

Mudekwe, J. (1997). Assessing the effect of tree size on the production of harvestable deadwood for fuelwood. Unpublished MSc thesis. University of the Witwatersrand.

Neumann, K. (1999). Charcoal from West African Savanna Sites. Questions of Identification and Interpretation. In M. Van der Veen ed. *The Exploitation of Plant Resources in Ancient Africa*. New York, Kluwer Academic / Plenum Publishers.

Neumann, K., Kahlheber, S. & Uebel, D. (1998). Remains of woody plants from Saouga, a medieval west African village. *Vegetation History and Archaeobotany* 7: 57-77.

Neumann, K., Schoch, W., Détienne, P., & Schweingruber, F.H. (2000). *Woods of the Sahara and the Sahel*. Bern, Haupt.

Nicholson, P. H. (1981). Fire and the Australian Aborigine – an enigma. In A.M. Gill, R.H. Groves and L.R. Noble, eds. *Fire and the Australian Biota* 55-76. Canberra, Australian Academy of Science.

Olsen, S.L. & Shipman, P. (1988). Surface modification on bone: trampling vs butchery. *Journal of Archaeological Science* 15: 535-553.

Orme, A.R. (1976). Late Pleistocene channels and Flandrian sediments beneath Natal estuaries: a synthesis. *Annals of the South African Museum* 71: 77-85.

Orton, C. (2000). *Sampling in Archaeology*. Cambridge Manuals in Archaeology. Cambridge, Cambridge University Press.

Oschadleus, H.D., Vogel, J.C. & Scott, L. (1996). Radiometric date for the Port Durnford peat and development of yellow-wood forest along the South African east coast. *South African Journal of Science* 92: 43-45.

Parkington, J. (1990). A Critique of the Consensus View on the Age of the Howieson's Poort Assemblages in South Africa. In P. Mellars ed. *The Emergence of Modern Humans: An Archaeological Perspective*, Edinburgh, Edinburgh University Press.

Parkington, J., Cartwright, C., Cowling, R.M., Baxter, A. & Meadows, M. (2000). Palaeovegetation at the last glacial maximum in the western Cape, South Africa: wood charcoal and pollen evidence from Elands Bay Cave. *South African Journal of Science* 96: 543-546.

Partridge, T.C., Demenocal, P.B., Lorentz, S.A., Paiker, M.J. & Vogel, J.C. (1997). Orbital forcing of climate over South Africa: a 200 000-year rainfall record from the Pretoria Saltpan. *Quaternary Science Reviews* 16: 1125-1133.

Piqué, R. & Barceló, J. A. (2002). Firewood management and vegetation changes: a statistical analysis of charcoal remains from Holocene sites in the north-east Iberian Peninsula. In S. Thiébault, ed. *Charcoal Analysis: Methodological Approaches Palaeoecological Results and Wood Uses*. Proceedings of the Second International Meeting of Anthracology, Paris, September 2000. BAR International Series 1063: 1-7

Plug, I. (2004). Resource exploitation: animal use during the Middle Stone Age at Sibudu Cave, KwaZulu-Natal. *South African Journal of Science* 100: 151-158.

Plug, I. & Engela, R. (1992). The macrofaunal remains from recent excavations at Rose Cottage Cave, Orange Free State. *South African Archaeological Bulletin* 47: 16-25.

Pooley, E. (1997). *The Complete Field Guide to Trees of Natal, Zululand and Transkei*. Durban, Natal Flora Publications Trust.

Popper, V.S. & Hastorf, C.A. (1988). Introduction. In C.A. Hastorf and V.S. Popper eds. *Current Paleoethnobotany: analytical methods and interpretations of archaeological plant remains.* 1-16. Chicago and London, University of Chicago Press.

Prell, W.L. & Hutson, W.H. (1979). Zonal temperature anomaly maps of Indian Ocean surface waters: modern and Ice Age pattern. *Science* 206: 454-456.

Prell, W.L., Hutson, W.H. & Williams, D. F. (1979). The subtropical convergence and late Quaternary circulation in the southern Indian Ocean. *Marine Micropaleontology* 4: 225-234.

Prior, J & Alvin, K.L. (1983). Structural changes on charring woods of *Dichrostachys* and *Salix* from southern Africa. *International Association of Wood Anatomists (IAWA) Bulletin new series* 4: 197-206.

Prior, J & Alvin, K.L. (1986). Structural changes on charring woods of *Dichrostachys* and *Salix* from southern Africa: the effect of moisture content. *International Association of Wood Anatomists (IAWA) Bulletin new series* 7: 243-250.

Prior, J. & Gasson, P.E. (1990). Comparative wood anatomy of afromontane and bushveld species from Swaziland, southern Africa. *International Association of Wood Anatomists (IAWA) Bulletin new series* 11(4):319-336.

Prior, J. & J. Tuohy (1987). Fuel for Africa's fires. *New Scientist* 115: 48-51.

Ramsay, P.J. (1996). Quaternary marine geology of the Sodwana Bay continental shelf, northern KwaZulu-Natal. *Bulletin of the Geological Survey of South Africa* 117.

Reitz, E.J. & Wing, E.S. (2000). *Zooarchaeology*. Cambridge Manuals in Archaeology. Cambridge Cambridge University Press.

Renaut, R. & Bamford, M.K. (2003). Results of preliminary palynological analysis of samples from Sibudu Cave, KwaZulu-Natal. Unpublished Report. Bernard Price Institute for Palaeontological Research.

Rossen, J. & J. Olsen (1985). The controlled carbonization and archaeological analysis of SE U.S. Wood Charcoals. *Journal of Field Archaeology* 12: 445-456.

Rutherford, M.C. & Westfall, R.H. (1994). Biomes of southern Africa: an objective categorisation. *Memoirs of the Botanical Survey of South Africa* 63.

Salisbury, E.J. & Jane, F.W. (1941). Charcoals from Maiden Castle and their significance in relation to the vegetation and climatic conditions in prehistoric times. *Journal of Ecology* 28: 310-325.

SANBI (2004). National Herbarium Pretoria Computerized Information System (PRECIS), Pretoria, South African National Biodiversity Institute.

Schick, K.D. & Toth, N. (1993). *Making Silent Stones Speak*. New York, Simon and Schuster.

Schiegl, S., Stockhammer, P., Scott, C. & Wadley, L. (2004). A mineralogical and phytolith study of the Middle Stone Age hearths in Sibudu Cave, KwaZulu-Natal, South Africa. *South African Journal of Science* 100: 185-194.

Schoch,W., Heller, I., Schweingruber, F.H., Kienast, F. (2004). Wood anatomy of central European Species. Online version: www.woodanatomy.ch

Scholtz, A. (1986). Palynological and palaeobotanical studies in the southern Cape. Unpublished MA thesis, University of Stellenbosch.

Scholtz, A. (1990). Wood anatomy records rainfall and climate. *South African Water Bulletin* Maart: 16-19.

Schumann, D., Kirsten, G. & Oliver, E.G.H. (1992). *Ericas of South Africa*. Vlaeberg, Fernwood Press.

Schwarcz, H.P. & Rink, W.J. (2000). ESR dating of Die Kelders Cave I site, South Africa. *Journal of Human Evolution* 38: 121-128.

Scott, L. (1999). Vegetation history and climate in the Savanna biome South Africa since 190,000ka: a comparison of pollen data from the Tswaing Crater (the Pretoria Saltpan) and Wonderkrater. *Quaternary International* 57/58: 215-223.

Scott, L., Anderson, H.M. & Anderson, J.M. (1997). Vegetation History. In R.M. Cowling, D.M. Richardson & S.M. Pierce eds. Vegetation of Southern Africa. Cambridge, Cambridge University Press.

Scott, L., Cooremans, B. & Maud, R.R. (1992). Preliminary palynological evaluation of the Port Durnford Formation at Port Durnford, Natal, South Africa. *South African Journal of Science* 88: 470-483.

Scott, M.H. (1927). Notes on the characteristics and minute structure of thirty woods indigenous to South Africa. *South African Journal of Science* 24: 298-317.

Shackleton, C.M. (1993). Fuelwood harvesting and sustainable utilisation in a communal grazing land and protected area of the eastern Transvaal lowveld. *Biological Conservation* 63: 247-254.

Shackleton, C.M. & Prins, F. (1992). Charcoal Analysis and the "Principle of Least Effort" – A Conceptual Model. *Journal of Archaeological Science* 19: 631-637.

Shackleton, C.M. & Prins, F. (1993). Charcoal yields from dry wood samples of ten savanna trees. *South African Archaeological Bulletin* 48: 42-44.

Shackleton, N.J. (1967). Oxygen Isotope analyses and Pleistocene temperatures re-assessed. *Nature* 215:15-17.

Shackleton, N.J. & Opdyke N.D. (1973). Oxygen isotope and palaeomagnetic stratigraphy of equatorial Pacific core V28-238: Oxygen isotope temperatures and ice volumes on a 10^5 and 10^6 Year Scale. *Quaternary Research* 3: 39-55.

Singer, R. & Wymer, J. (1982). *The Middle Stone Age at Klasies River Mouth in South Africa.* Chicago, Chicago University Press.

Smart, T.L. & Hoffman, E.S. (1988). Environmental Interpretation of Archaeological Charcoal. In C.A. Hastorf and V.S. Popper, eds. *Current Paleoethnobotany: analytical methods and cultural interpretation of archaeological plant remains* 167-205. Chicago, Chicago University Press.

Smithers, R.H.N. (1983). *The Mammals of the Southern African Subregion.* Pretoria, University of Pretoria.

Styles, D. (2001). A preliminary report on trees, larger woody shrubs and suffrutices in Krantzkloof, Durban. Unpublished manuscript.

Talma, A.S. & Vogel, J.C. (1992). Late Quaternary palaeotemperatures derived from a speleothem from Cango Caves, Cape Province, South Africa. *Quaternary Research* 37: 203-213.

Tankard, A.J. (1976). Cenozoic sea-level changes: a discussion. *Annals of the South African Museum* 71: 1-17.

Tankard, A.J. & Schweitzer F.R. (1974). The geology of Die Kelders Cave and environs: a palaeoenvironmental study. *South African Journal of Science* 70: 365-369.

Thackeray, A.I. (1989). Changing fashions in the Middle Stone Age: The stone artefact sequence from Klasies River main site, South Africa. *African Archaeological Review* 7: 33-57.

Thackeray, A.I. (1992) The Middle Stone Age South of the Limpopo River. *Journal of World Prehistory* 6(4): 385-439.

Thackeray, A.I. & Kelley, A.J. (1988). A technological and typological analysis of Middle Stone Age assemblages antecedent to the Howiesons Poort at Klasies River main site. *South African Archaeological Bulletin* 43: 15-26.

Thackeray, J.F. (1987). Late Quaternary environmental changes inferred from small mammalian fauna, southern Africa. *Climate Change* 10: 285-305.

Thackeray, J.F. (1992). Chronology of Late Pleistocene deposits associated with *Homo sapiens* at Klasies River Mouth, South Africa. *Palaeoecology of Africa and the surrounding islands* 23: 177-191.

Thackeray, J.F. (2002) Palaeoenvironmental change and re-assessment of the age of Late Pleistocene deposits at Die Kelders cave, South Africa. *Journal of Human Evolution* 43: 749-753.

Thackeray, J.F. & Avery, D.M. (1990). A comparison between temperature indices for Late Pleistocene sequences at Klasies River and Border Cave, South Africa. *Palaeoecology of Africa and the Surrounding Islands* 21: 311-315.

Tusenius, M.L. (1986). The Study of Charcoal from some Southern African Archaeological Contexts. Unpublished MA Thesis. University of Stellenbosch, South Africa.

van der Veen, M. & Fieller, N. (1982). Sampling Seeds. *Journal of Archaeological Science* 9: 287-298.

van Wyk, B.-E. & Gericke, N. (2000). *Peoples Plants: a guide to useful plants of southern Africa*. Pretoria, Briza publications.

van Wyk, B. & van Wyk, P (1997). *Field Guide to Trees of Southern Africa*. Cape Town, Struik Publishers.

Veeh, H.H. & Chappell, J. (1970). Astonomical theory of climate change:support from New Guinea. *Science* 167: 862-865.

Verhoeven, R.L. & van der Schijff H.P. (1974). Anatomical Aspects of Combretaceae in South Africa. *Phytomorphology* 24: 158-164.

Villa, P., Delanges, A., & Wadley, L. (in press). A late Middle Stone Age artifact assemblage from Sibudu (KwaZulu-Natal). Understanding the transition to the Later

Stone Age in South Africa. In F. d'Errico and L Backwell, eds. *From Tools to Symbols. From early himinids to modern humans.*

Vogel, J.C. (1983). Isotopic evidence for climates and vegetation of southern Africa. *Bothalia* 14: 391-394.

Vogelsang, R. (1996). Continuation des recherches archéologiques au nord du Burkina Faso: campagne de 1995. *Nyame Akuma* 46: 6-10.

von Maydell, H.J. (1983). Arbre et arbustes du Sahels. Leurs caratéristiques et leurs utilisation. *Eschborn, Deutsche Gesellschaft für Technische Zusammenarbeit.*

Wadley, L. (1979). Big Elephant Shelter and its role in the Holocene Prehistory of central south west Africa. *Cimbebasia* (B) 3(1): 1-76.

Wadley, L. (2001). Preliminary report on excavations at Sibudu Cave, KwaZulu-Natal. *Southern African Humanities* 13: 1-17.

Wadley, L. (2004). Vegetation changes between 61 500 and 26 000 years ago: the evidence from seeds in Sibudu Cave, KwaZulu-Natal. *South African Journal of Science* 100: 167-173.

Wadley, L., Esterhuysen, E., & Jeannerat C. (1992). Vegetation Changes in the eastern Orange Free State: the Holocene and later Pleistocene evidence from charcoal studies at Rose Cottage Cave. *South African Journal of Science* 88: 558-563.

Wadley, L. & Jacobs, Z. (2004). Sibudu Cave, KwaZulu-Natal: Background to the excavations of Middle Stone Age and Iron Age occupations. South African Journal of Science 100: 145-150.

Wadley, L., Williamson, B. & Lombard, M. (2003). Ochre in hafting in Middle Stone Age southern Africa: a practical role. *Antiquity* 78 (103): 661-676.

Wagner, G.E. (1988). Comparability among Recovery Techniques. In C.A. Hastorf and V.S. Popper eds. *Current Paleoethnobotany: analytical methods and cultural interpretation of archaeological plant remains* 17-35.

Webley, L.E. (1978). The history and archaeology of pastoralist and hunter-gatherer settlement in the north-western Cape. Unpublished MA Thesis. University of Stellenbosch, South Africa.

Wells C.R. (2003). Behavioural ecology during the Middle Stone Age at Sibudu Cave, KwaZulu-Natal, South Africa: a faunal perspective. Unpublished MSc Thesis. The University of the Witwatersrand, South Africa.

Wheeler, E.A., Pearson, R.G., LaPasha, C.A., Zack, T. & Hatley W. (1986). *Computer-Aided Wood Identification.* Agricultural Research Service, North Carolina State University

White, F. (1978). The afromontane region. In M.J.A. Werger, ed. *Biogeography and Ecology of Southern Africa*. The Hague, W. Junk.

Williams, D.F., Moore, W.S. & Fillon R.S. (1981). Role of glacial Arctic Ocean ice sheets in Pleistocene oxygen isotope and sea-level records. *Earth and Planetary Science Letters* 56: 157-166.

Williams, M., Dunkerley, D., De Deckker, P., Kershaw, P. & Chappell J. (1998). *Quaternary environments.* London, Edward Arnold.

Williamson, B. S. (2004). Middle Stone Age tool function from residue analysis at Sibudu Cave. South African Journal of Science *100: 174-178.*

Wood, W.R. & Johnson, D.L. (1978). A survey of disturbance processes in archaeological site formation. *Advances in Archaeological Method and Theory* 1: 315-381.

Wright, J.A. (1964). Gully pattern and development in wave-cut bedrock shelves north of the Orange River mouth. *Transactions of the Royal Society of South Africa* 67: 163-171.

Wurz, S. (1999). The Howiesons Poort at Klasies River, South Africa. *South African Archaeological Bulletin* 54: 38-50.

Wurz, S. (2002). Variability in the Middle Stone Age Lithic Sequence, 115,000-60,000 Years Ago at Klasies River, South Africa. *Journal of Archaeological Science* 29: 1001-1015.

Zhiv, D.I. (1975). *Geological-Geophysical Atlas of the Indian Ocean.* International Indian Ocean Expedition Series. Moscow, Academy of Sciences of the USSR.