CHAPTER 2

SOUTHERN CAPE ENVIRONMENTS

2.1 Introduction

The Quaternary comprises the Pleistocene (2.6 Ma-12 kyr) and Holocene (*c.* 12 kyr-present) epochs of the Cenozoic era and covers the last 2.6 million years (Ma) of the Earth's history up to the present. Globally the Quaternary is associated with northern hemisphere glaciations and fluctuating sea levels (*e.g.* Lambeck *et al.* 2002).

The interplay between these parameters is characteristic of the oscillating glacial-interglacial cycles which are in turn linked to changes in the dimensions affecting the Earth's orbit (Imbrie *et al.* 1984; Maslin & Christensen 2007). By altering the intensity of the seasons, these astronomical cycles facilitated the formation of glacial ice in the northern and southern hemispheres (Broecker & Denton 1990). The perturbations associated with these changes in global climate are reflected in oxygen isotope records (denoted as $\delta^{18}O$) derived from the remains of planktonic foraminifera found within marine sediment cores (Thompson & Goldstein 2006). The changing $\delta^{18}O$ composition of sea water which is determined from these cores is referred to by marine oxygen isotope stages (MIS). Warm periods generally correspond to odd numbered MIS whereas even numbers represent cold periods (Fig. 2.1).

In the context of this study, the climatic variations that occurred during the last 150 ka are most pertinent as this period covers the intermittent Middle Stone Age (MSA) occupation at Blombos Cave (BBC) (Figs 2.1, 2.2 & 2.3; also see Chapter 3 for details).

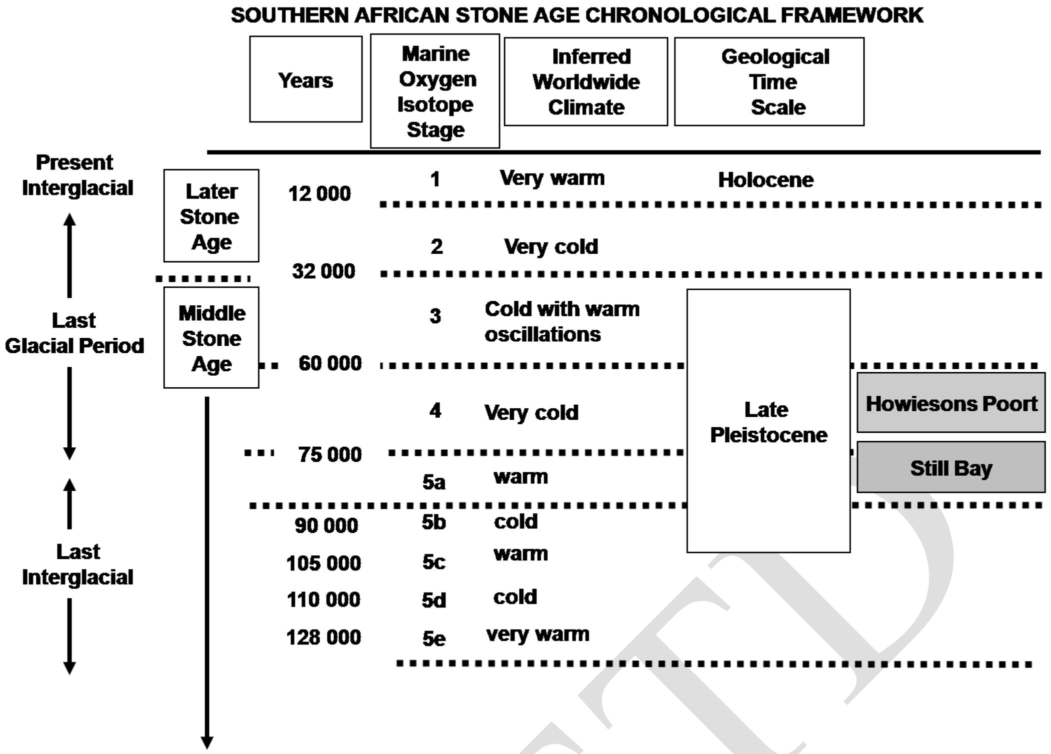


Figure 2.1 Global climatic changes corresponding to the South African Middle and Later Stone Age (image reproduced with permission from C. Henshilwood). The years and corresponding marine oxygen isotope stages are taken from Martinson *et al.* 1987 and the ages for the Howiesons Poort and Still Bay from Jacobs *et al.* 2008

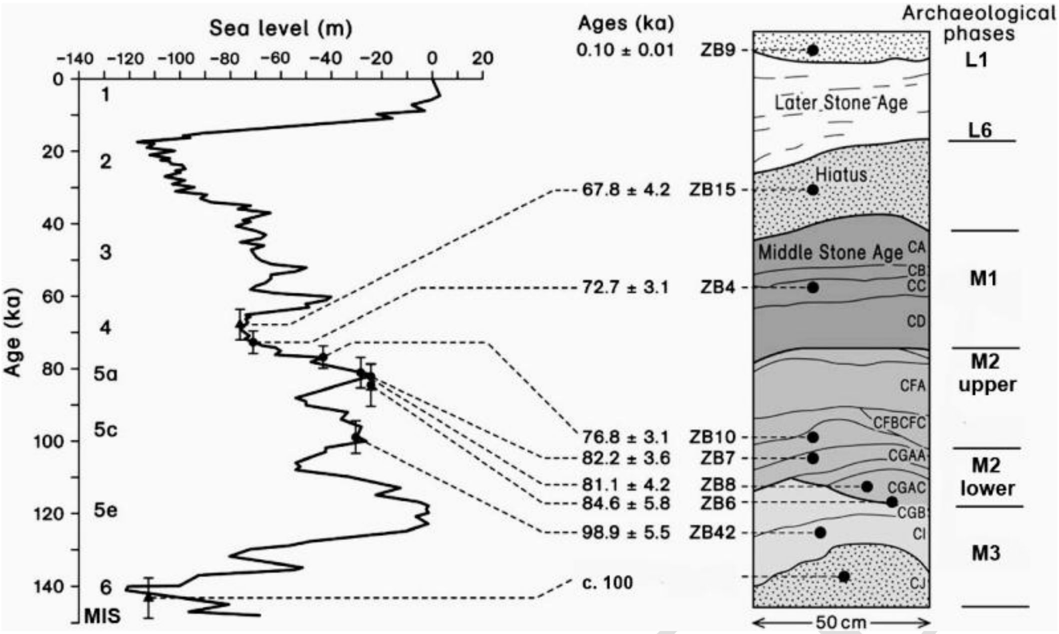


Figure 2.2 Dated Middle and Later Stone Age occupations at Blombos Cave. The LSA occupation phases L1 and L6 were dated by radiocarbon within the last 2 ka. The ages for the intermittent MSA occupations (denoted by the M1, M2 & M3 phases) were determined using OSL techniques and fall within the Last Glacial Period (Jacobs *et al.* 2006) (image reproduced with permission from C. Henshilwood; Jacobs *et al.* 2006)

Although southern Africa was not glaciated during the Quaternary, this period is marked by changes in vegetation and fauna, which are in part linked to variations in precipitation (*e.g.* Partridge 1993; Partridge *et al.* 1997; Meadows & Baxter 1999; Chase & Meadows 2007; Kristen *et al.* 2007).

The central focus of this study is to evaluate how climate change events affected the distribution and behaviour of palaeopopulations during their occupation at Blombos Cave (BBC) (see Chapter 3). In archaeological contexts a suite of radiometric techniques are used to date sections of a deposit and its associated material culture (*e.g.* charcoal, micromammal & macrofaunal bones, ostrich eggshell, shellfish, & rock art). These dating methods include, amongst others, radiocarbon, uranium series (U-series), optically stimulated luminescence (OSL), thermal luminescence (TL) and electron spin resonance (ESR) techniques.

The deposits at BBC have previously been dated using a number of procedures. Radiocarbon ages for example, were determined from the shell, charcoal and sheep bone in the Later Stone Age (LSA) levels (Henshilwood 1995, 2008a; Figs

2.2 & 2.3). However because of the 40 ka limit of the radiocarbon technique it could not be used to date the underlying Middle Stone Age (MSA) deposits at the site. Instead these MSA deposits which comprise three occupation phases (M1, M2 & M3) were dated using a combination of single and multiple quartz grain OSL techniques (Henshilwood 2008b; Henshilwood *et al.* 2002; Jacobs *et al.* 2003a, b, 2006). Burnt lithics from the M1 phase were also dated using the TL technique (Tribolo *et al.* 2005, 2006).

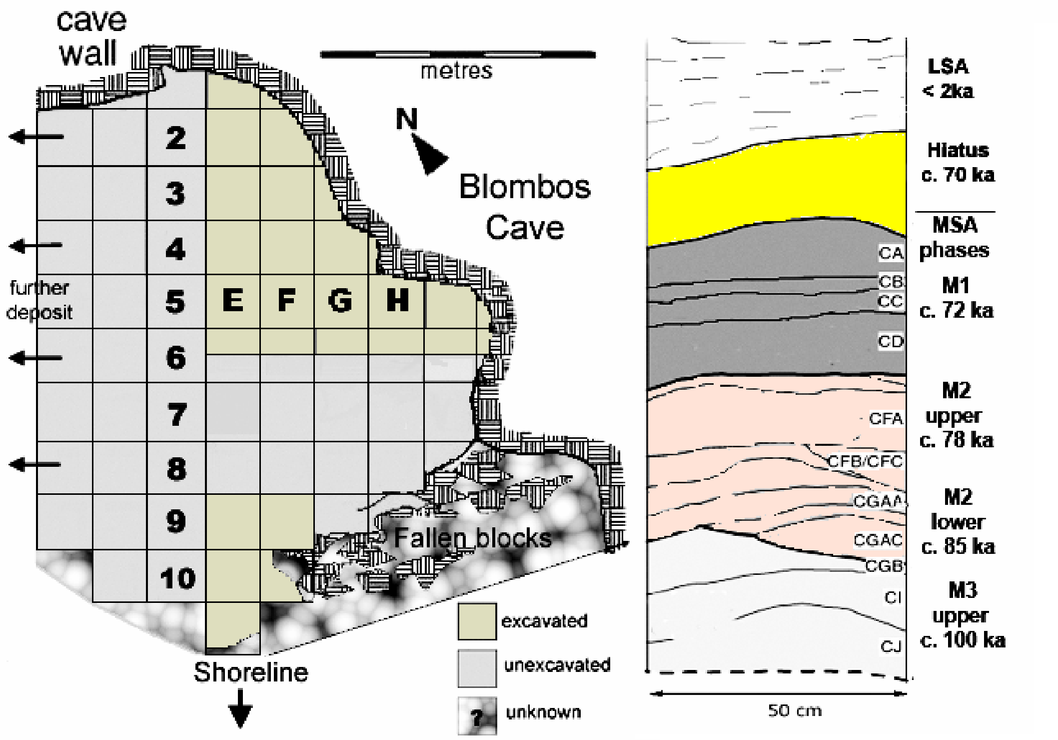


Figure 2.3 Stratigraphy of the archaeological deposits at Blombos Cave including the ages of the Middle Stone Age levels (image reproduced with permission from C. Henshilwood)

In this study U-series techniques were used to date the speleothem samples obtained within the De Hoop Nature Reserve (DHNR) (see Chapter 4). In turn, the corresponding stable isotope records obtained from these speleothems were correlated with the dated sediments at the nearby BBC (*e.g.* Jacobs *et al.* 2003a, b, 2006; Tribolo *et al.* 2005, 2006).

In South Africa U-series ages have only been determined from a few archaeological sites; Klasies River Mouth (*e.g.* Deacon & Geleijnse 1988; Vogel 2001; Wurz 2002), Boomplaas (Moffet & Deacon 1977; Deacon 1979), Wonderwerk Cave (Beaumont & Vogel 2006; Chazan *et al.* 2008) and Pinnacle Point (Marean *et al.* 2004, 2007; Bird *et al.* 2007; Koenig 2008; Bar-Matthews *et al.* 2008, 2010). The paucity of U-series ages for archaeological deposits is linked to a lack of suitable material for dating (discussed in Chapter 4) and the difficulty in relating the timing of speleothem growth to site occupation (Schwarcz 1992; St. Pierre *et al.* 2009).

Linking the behaviours of the occupants at BBC with specific climate regimes is far from straightforward. This is because of the paucity of suitable sites and the constraints associated with different dating methods, *e.g.* the 40 ka range of radiocarbon.

With regards to this study, it is important to understand the processes and identify the patterns related to the temporal fluxes in the southern Cape palaeoclimate. This chapter therefore presents the palaeoenvironmental evidence for the southern Cape during the last 150 kyr in two parts. The first section provides a background to the present-day environmental conditions in the De Hoop region and focuses on the local geology, climate and vegetation. The second part considers the palaeoenvironmental evidence associated with changes in sea level, climate and vegetation.

2.2 Geology of the De Hoop region

2.2.1 Brief introduction to formation of the southern Cape coast

The geological history of the southern Cape is closely tied to the formation of the Cape Fold Belt (CFB) Mountain range (King 1963; De Beer 1995; Fouché *et al.* 1992). This mountain range formed during two events; the first is associated with the Palaeozoic when the southern continents joined to form Gondwana between *c.*650 and 450 Ma (Lock 1978). The rifting and eventual disintegration of Gondwana by *c.*170 Ma marked the second episode in the orogeny of the CFB.

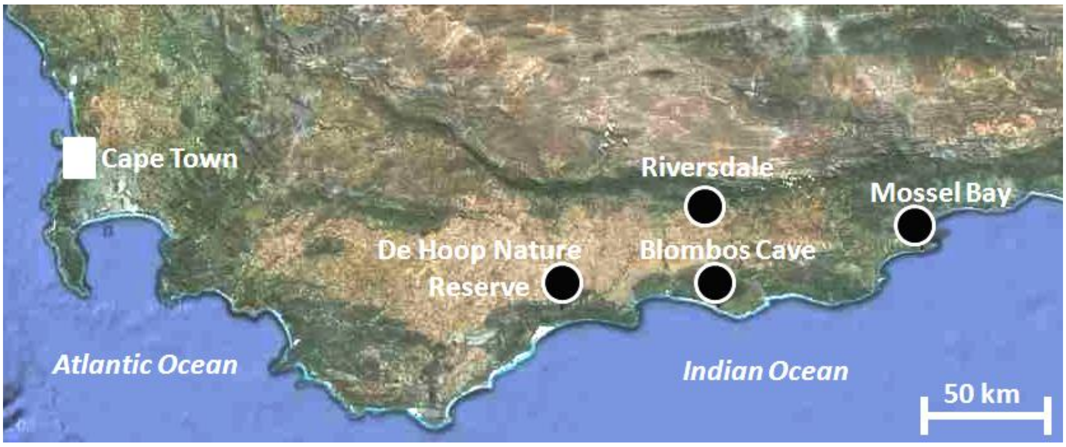
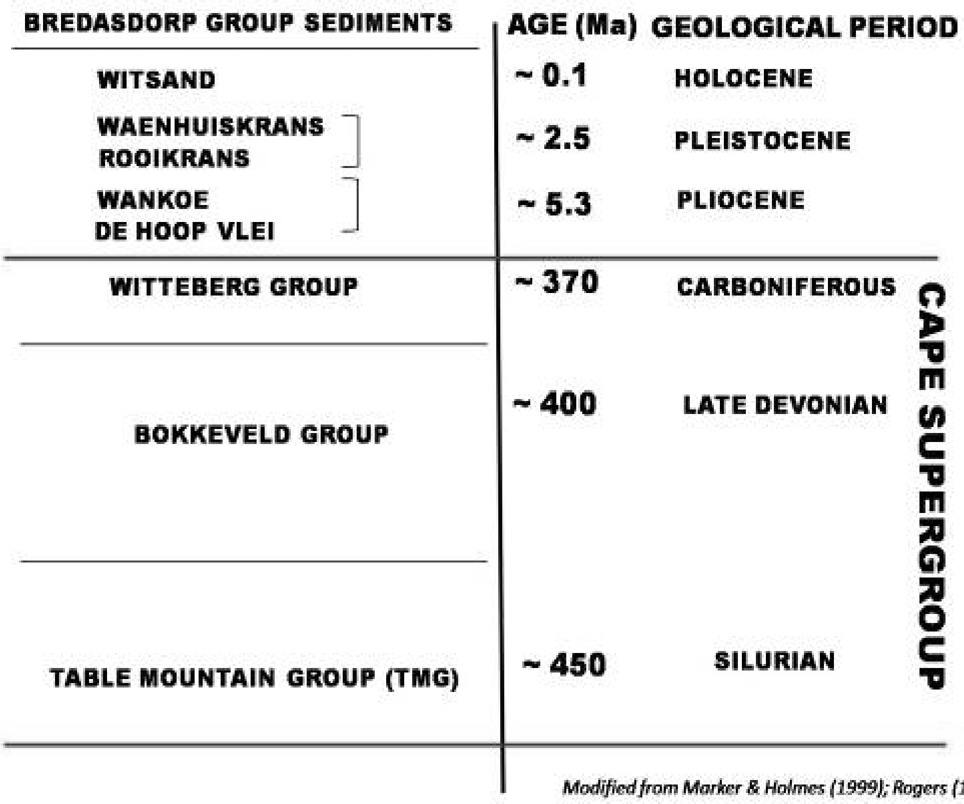


Figure 2.4 The southern Cape as defined in this study refers to the region between Cape Town and Mossel Bay and includes the De Hoop Nature Reserve and Blombos Cave

The Cape Supergroup sediments are one of the chief constituents of the CFB range and were deposited between 280 and 235 Ma (Compton 2004). The Cape Supergroup is ubiquitous across the Western Cape and comprises three main groups - the Table Mountain Group (TMG), the Bokkeveld Group and the Witteberg Group (De Beer 1995; Compton 2004; Fig. 2.5). These three groups of sediments form the basis for the underlying geology at De Hoop and Blombos Cave.



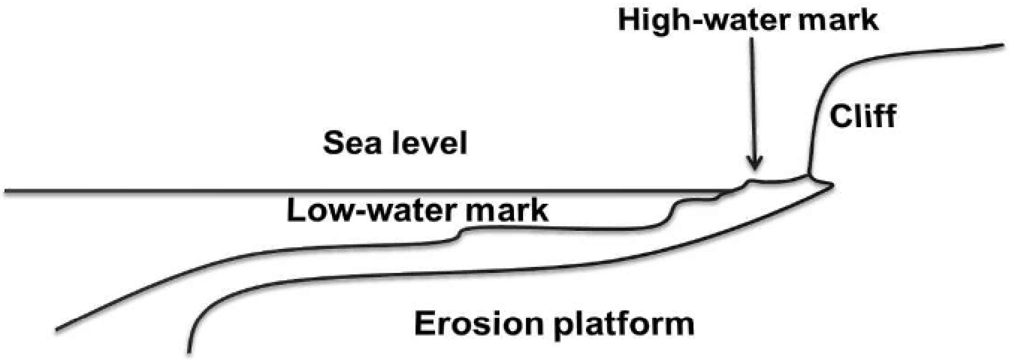
Modified from Marker & Holmes (1999); Rogers (1984)

Figure 2.5 Simplified stratigraphy of the main geological formations at De Hoop and Blombos Cave. Within the Cape Supergroup, the Table Mountain Group (TMG) forms the core of the Cape Fold Belt (CFB) and consists primarily of quartzitic sandstones. The TMG is overlain by the black shales, compact siltstone and olive-grey sandstones of the Bokkeveld sediments. These shales are in turn covered by the interbedded siltstone and sandstone of the Witteberg group. The Witteberg group is the youngest rocks of the Cape Supergroup. Coastal deposits of the Bredasdorp group, varying from Pliocene to Holocene age, are superimposed on the Cape Supergroup sediments (Marker & Holmes 1999)

In the southern Cape, the main ranges of the CFB (*viz.* Swartberg & Langeberg) comprise TMG sandstone and Witteberg quartzite (King 1963). Where these ranges terminate, the main bays of the region are formed (*viz.* St. Sebastian, Fish, Mossel, Plettenberg & St. Francis) (King 1963). The Witteberg (& Bokkeveld) are in turn overlain by the coastal deposits of the Bredasdorp Group (Marker & Holmes 2005; Holmes *et al.* 2007). The coastal limestones of the De Hoop region are typically covered by the lithified aeolian dune sands of the Wankoe and Waenhuiskrans formations (Holmes *et al.* 2007). It is from the De Hoop limestone caves that the speleothems used in this study were sampled (see Chapter 4).

The most conspicuous feature of the Cape south coast is the 5-10 km wide coastal platform, which is the product of sub-aerial erosion and regular submergence by water (Thwaites & Jacobs 1989; Marker & Holmes 2005) (Fig. 2.6). The formation of this coastal foreland was triggered by the late Mesozoic rifting during which the southern hemisphere supercontinent (*i.e.* Gondwana) separated into its constituent parts (Lock 1978; Marker & Holmes 2005).

By the early Cretaceous (*c.*145 Ma), the southern Cape coast was well established (Thwaites & Jacobs 1989). Although the region is thought to have been tectonically stable since its formation, it did experience another period of uplift and deformation (Marker & Holmes 2005; Holmes *et al.* 2007). This Miocene-Pliocene event distorted the coast and inland sections of the southern Cape by 600 m and 900 m in places (Partridge & Maud 1987).



Modified from Zeuner (1952) crediting Johnson (1938)

Figure 2.6 Key features of the southern Cape coastal platform. The coastal platform extends from the high-tide level to below the low-tide watermark. This geomorphic feature developed primarily because of erosion by ocean waves, windand subsequent weathering (chemical & mechanical) of exposed sea cliff rocks

Further deformation of the coastal platform is linked to the incision by the waters of the Keurbooms and Kaaimans rivers (King 1963). In the region between De Hoop and Blombos Cave however, the Goukou and Duiwenhoks rivers, emerging from the Langeberg cut into the area overlying the marine peneplain. In this section of the southern Cape, these two rivers etch out the coastal landscape along cracks in the Table Mountain quartzite (Rust 1998).

2.3 The southern Cape's present-day climate

2.3.1 Local climate

The southern Cape is the confluence for the interaction between the Indian and Atlantic Oceans and falls within a transitional zone between South Africa's winter and summer rainfall zones (Figs 2.8 & 2.9). The local climate is thus influenced by the prevailing winds (*viz.* the westerly winds & tropical easterlies) and the ocean currents (*viz.* the Agulhas & Benguela currents) (Partridge *et al.* 1997; Chase & Meadows 2007) (Fig. 2.7). The South Indian Anticyclone directs the Agulhas Current while the South Atlantic Anticyclone drives the Benguela Current (Tyson & Preston-Whyte 2000). In contrast to the southern Cape, the east and west coasts of South Africa are affected by the Agulhas and Benguela Currents, respectively (Ramsay & Cooper 2002). Although the southern Cape is not a major upwelling region it is still exposed to severe easterly wind reinforced thermoclines that develop over the Agulhas Bank (Schumann *et al.* 1995).

Variations in the interaction between these atmospheric and oceanic components produce corresponding changes in rainfall. The De Hoop region falls within South Africa's year-round rainfall zone (YRZ) and receives rainfall with peaks in August of *c.* 380 mm/pa and a mean annual temperature of 17.5 ^{o}C (Scott 1999) (Fig. 2.9). During the summer months (October to March), easterly winds prevail whereas in winter (June to August) the winds are mainly westerly and typically exceed speeds of 60 km/h (Scott 1999).

Image available from Tyson & Preston-Whyte 2000: 179

Figure 2.7 Main components of the atmospheric circulation which determine the weather and climate of South Africa. The westerly wave lows are generated by the westerly winds and are important features of the circulation in the coastal regions of South Africa. The anticyclones of the South Atlantic and South Indian Oceans represent high-pressure subtropical features which are associated with the tropical easterly winds (easterlies). The easterlies congregate at the Intertropical Convergence Zone (ITCZ) (0^{O} latitude) and generate the easterly waves that form in the easterly currents. The shifts in the easterly waves and lows produce summer rain over the interior regions of the country. Coastal lows typically form along the west coast and are facilitated by the southeast trade winds and the local Drakensberg (Berg) foehn wind (Tyson & Preston-Whyte 2000)

Image from http://www-das.uwoy.edu/~geerts/cwx/notes/chap11/Image13.gif

Figure 2.8 Main ocean currents affecting South Africa

Image from Chase & Meadows 2007

Figure 2.9 Extent of South Africa's three rainfall zones. The abbreviations WRZ, SRZ and YRZ refer to the winter-rainfall zone, summer rainfall zone and year-round rainfall zone, respectively

In the southern Cape, the easterlies (active from October to April) produce early summer coastal rain whereas the westerly troughs (active from June to August) bring heavy rains to the region (Tyson & Preston-Whyte 2000). Rainfall in this year-round zone varies between 250 and 380 mm in places with peak precipitation in winter (*viz.* August) (Scott 1999). Rainfall in the section of the year-round rainfall zone (YRZ) associated with De Hoop and BBC are currently influenced by the frequency of cold fronts of the westerlies, the intensity of tropical cyclones in the south Atlantic and local variations in land and sea temperatures (the latter is generated primarily in the Indian Ocean) (Scott 1999).

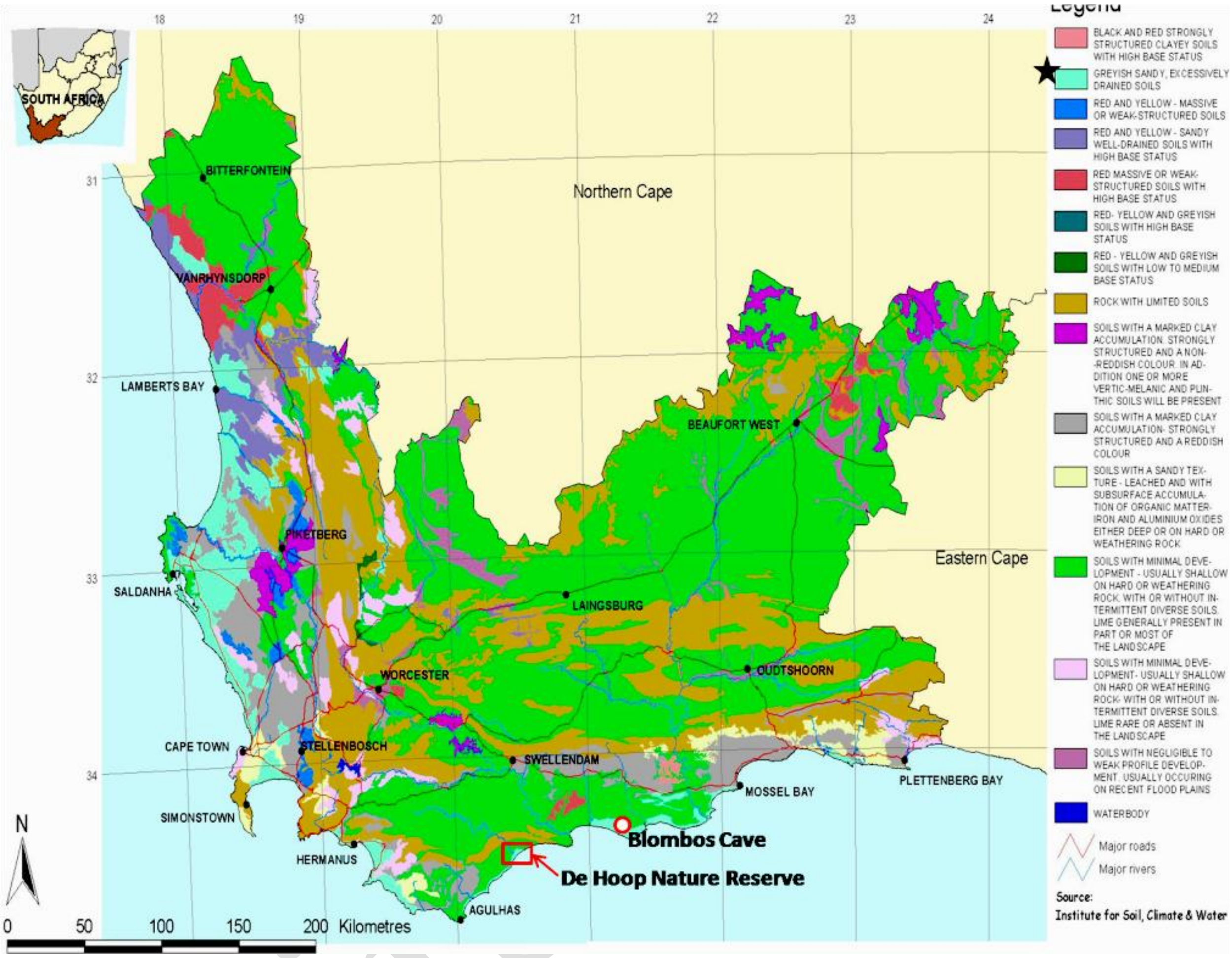
Differences in temperature, rainfall, topography and climate also facilitate the development of a mosaic of ecological habitats and communities. Five ecological habitats are contained within the De Hoop area and are characterised as the coastal plain, coastline, limestone hills, De Hoop Vlei and Potberg Mountains.

2.3.2 Extant vegetation

In the southern Cape, the extant vegetation is dominated by elements of the Cape Floristic Region (CFR), *viz.* fynbos and Renosterveld with other forms such as subtropical thicket, Afromontane forest and succulent Karoo types (Meadows & Baxter 1999). Fynbos occurs primarily in the southern and south-western regions of the Western Cape. This evergreen, sclerophyllous heath-like flora occurs on oligotrophic soils derived from the quartzitic Table Mountain Group sandstone (Cowling & Richardson 1995). It contains many endemic species and comprises *Restionaceae* (restios), *Ericaceae* (ericas) and *Proteaceae* (proteoid) growth forms (Cowling & Holmes 1992). The *Proteaceae*, *Ericaceae* and *Restionaceae* types of fynbos are all C_3 photosynthesising and occur on quartzitic soils.

The fynbos also contains arid-adapted succulents (CAM plants). On the Cape granites and shales of the Bokkeveld and Witteberg Groups grassy and *Asteraceous* fynbos that also contains some C_4 plants are found. Renosterveld also grows on these fertile shale derived soils and is dominated by *Elytropappus rhinoceroti* (Renosterbos) as well as grass and seasonal geophytes (Cowling *et al.* 1983; Low & Rebelo 1996). The calcretes and aeolianites of the coastal dunes also support Strandveld and subtropical thicket vegetation. This coastal vegetation comprises mainly C_4 and CAM plants although some C_3 photosynthesising shrubs are also present. The intermediate thicket vegetation occurs most often in pockets along South Africa's east coast. The isolated patches of coastal forest found in the southern Cape occur between Knysna and Plettenberg Bay and comprises evergreen trees (*e.g. Podocarpus falcatus*) and ferns (*e.g. Rumohra adiantiformis* & *Blechnum giganteum*) (Milton 1987).

Each of these vegetation types is adapted to a specific rainfall regime. Changes in the amount and seasonality of precipitation received in the areas where these plants occur therefore triggers corresponding episodes of vegetation succession and replacement (*e.g.* Cowling 1983). Renosterveld is particularly sensitive to rainfall seasonality and typically occurs in areas along the south coast receiving between *c.* 250 and 600 mm/pa (Low & Rebelo 1996). Rainfall exceeding the 600 mm/pa maximum promotes the development of dune *Asteraceous* fynbos, which occurs in areas where rainfall ranges from 600 to 800 mm/pa (Low & Rebelo 1996). The Succulent Karoo vegetation replaces both Renosterveld and fynbos when rainfall drops below 200 mm/pa. The Succulent Karoo is associated with areas with low winter rainfall and summer aridity. Elements of this biome occur on the south-east section of the Gouritz River, one of the major rivers along the southern Cape coast (Low & Rebelo 1996).



Source:
Institute for Soil, Climate & Water

Figure 2.10 Main soil types found in the De Hoop Nature Reserve and Blombos Cave (denoted by★) consists of excessively drained soils and greyish sands

Vegetation is broadly classified into C_3 and C_4 types where the C_3 and C_4 designation refers to the photosynthetic pathway used by the plants. In the Calvin-Benson cycle of C_3 photosynthesis CO_2 is fixed into a 3-carbon compound known as glyceraldehyde 3-phosphate (van der Merwe 1982). The ribulose bisphosphate (Rubisco) enzyme that has an affinity for the ^{12}C isotope drives this reaction. During the Hatch-Slack pathway of C_4 photosynthesis a 4-carbon compound called oxalacetate (OAA) is produced in the presence of phosphoenolpyruvate (PEP) (van der Merwe 1982). In contrast to C_3 plants the C_4 species do not discriminate between ^{12}C and ^{13}C forms of carbon. It is because of this difference in the isotopic form of CO_2 used during photosynthesis which makes stable carbon isotopes a useful palaeovegetation proxy (see Chapter 4 section 4.4). Grass comprises C_3 and C_4 types of which the latter is ubiquitous in the summer rainfall zone (SRZ) whereas C_3 forms are found primarily in the winter rainfall zone (WRZ) (Vogel *et al.* 1978).

2.4 Southern Cape palaeoenvironments

2.4.1 Eustatic and local sea level changes

Changes in sea level are broadly associated with tectonic process such as subsidence and uplift. Eustatic sea level variation provides useful information about changes in the extent of global ice sheets (*e.g.* Blunier & Brook 2001; Lambeck & Chappell 2001). This is because the ice sheets, which formed during the onset of northern hemisphere glaciations *c.* 3 Ma, caused concomitant changes in the global sea levels (Hvidberg 2000; Lambeck *et al.* 2002). Over the last glacial-interglacial cycle sea levels fluctuated up to 140 m and exceeded modern levels by +6-8 m during the last interglacial *c.* 125 ka (Lambeck *et al.* 2002). Sea levels subsequently dropped incrementally to a minimum by -130 m during the Last Glacial Maximum (LGM) *c.* 18 ka (Lambeck *et al.* 2002) (Fig. 2.11a).

Image from Ramsay & Cooper 2002: 87

Figure 2.11 (a) 200 kyr sea level curve for South Africa

Image from Fisher *et al.* 2010: 139

Figure 2.11 (b) Relative position of the southern Cape coastline within the last 200 kyr

In South Africa, sea levels have changed by *c.* 140 m during the last 2.5 Ma in response to periods of glacial advance and retreat (van Andel 1989). Along the South African east coast, for example interglacial sea levels correlating with MIS 5 and MIS 6/7 have been identified at Isipingo Beach and Sodwana Bay (Ramsay & Cooper 2002) (Fig. 2.11a). Corresponding uranium series ages of 128 ka and 117 ka are associated with sea levels of 3 m and 44 m below present. Using this data and proxy indicators which included aeolianites, beachrocks and estuarine molluscs Ramsay and Cooper (2002) produced a late Quaternary sea level curve for the entire country. Interpretations based on this curve suggest that during MIS 5c and 5e sea levels were +4 m above present-day levels whereas during the transition from MIS 4/3 sea levels were between 40 and 60 m lower.

Over the last 125 kyr different regions of the southern Cape coast were exposed or submerged with a last interglacial sea level of +4 m above present (Hendey & Volman 1986). Sea level highstands of +5.6 m, +8.5 m and +7.0 m were recently recorded at Cape Agulhas beach and the Swartvlei and Groot Brak estuaries, respectively (Carr *et al.* 2010). The OSL ages for these marine transgressions range between 118 and 125 ka and suggest that sea levels comparable to contemporary levels were reached during MIS 5 (Carr *et al.* 2010). This is supported by sedimentary evidence obtained from different localities along the coast. By the LGM however when sea level regression in the southern Cape mirrored the global decline the shore was *c.* 120 m lower than today (Fig. 2.11b).

Archaeologically, palaeo-sea levels are inferred primarily from the diversity and abundance of shellfish remains at a site. To illustrate, at PP13B which is situated some +15 m asl the MSA deposit called LC-MSA was dated stratigraphically from the upper, middle and lower sections using OSL techniques (Marean *et al.* 2007). The upper unit comprises three sub-units characterised by (1) a hard matrix of sand, silt and ash, (2) a layer of shellfish and dune sand and (3) dune in-fill. The shellfish and dune sand sub-units are dated at 120 ka and 90 ka, respectively (Marean *et al.* 2007). The OSL derived age for the LC-MSA middle section is 132 ka and a date of 164 ka corresponds to the lower section. A model-based reconstruction of the coastline indicates that the site was within close proximity (*c.* 5-10 km) to the sea during MIS 6 when the basal MSA occupation took place (Marean *et al.* 2007). This is concordant with the shellfish remains of *Perna perna* (brown mussels), *Turbo sarmaticus* (giant periwinkles) and *Scutellastra argenvillei* and *Patellidae* (limpets) found associated with LC-MSA upper (Marean *et al.* 2007).

At KRM on the Tsitsikamma coast the MSA sequence is sub-divided into units named MSA I through to MSA IV with the main site characterised by a series of caves and rock shelters called cave 1 and 1C and shelters 1A and 1B (Singer & Wymer 1982). The entire MSA sequence at the main site is dated between 120 ka and 60 ka (*e.g.* Wurz 2000). At cave 1, the deposit is characterised by a Holocene midden overlying the WS member. Beneath this member is the SAS member, which lies above the carbonised material of the RBS member (Deacon & Geleijnse 1988). The SAS and RBS members are dated, respectively, to *c.* 100 ka (Vogel 2001) and *c.* 85 ka (Bada & Deems 1975; Wurz 2000). MSA I occurs in the LBS and RBS members and MSA II occurs within the SAS member overlying MSA I and MSA III (Wurz 2000, 2002). The LBS member has a uranium series age of *c.* 110 ka and falls within the MIS 5e/d boundary (Vogel 2001). The MSA III stratigraphic sequence of cave 1A comprises the Upper member and a basal RF member (Deacon & Geleijnse 1988; Wurz 2000). The Howiesons Poort layers are sandwiched between the MSA II and III with several age estimates of *c.* 65 ka (Vogel 2001) and *c.* 70 ka (Deacon & Geleijnse 1988; Deacon 1989; Wurz *et al.* 2003). The marine molluscs identified from the LBS, RF and SAS members at the main site included many of the species identified at the PP13B site such as *P. perna* and *T. sarmaticus*. The presence of these species suggests a close proximity to the rocky shore and warmer seawater temperatures. The

KRM shellfish remains, which contained *Choromytilus meridionalis* (black mussels) and *Donax serra* (white mussels) implies cooler sea surface temperatures and sandy shore foraging, respectively (Thackeray 1988).

Many of these and other shellfish species decrease in relative abundance particularly in the MSA III and Howiesons Poort levels, which are dated to MIS 4 (Thackeray 1988, 2007; Jacobs *et al.* 2008). The sea level regression associated with this period could have consequently affected coastal foraging strategies as some sandy shore species such as *D. serra* became relatively more abundant than others (*e.g. P. perna*) (Thackeray 1988). The evidence for the KRM sea level regression appears to be concordant with the MIS 4/3 lower sea levels identified by Ramsay and Cooper (2002).

The MSA stratigraphic units at NBC on the Robberg Peninsula are dated from *c.* 120 ka to 50 ka but only the deposits from 18-24 ka contain low quantities of marine faunal remains. Although the apparent lack of shellfish remains in the NBC sequence prior to 10 ka is attributed to poor preservation, it has also been related to low LGM sea levels (Klein 1972). During the LGM (between *c.* 29 and 15 ka), the NBC site was reportedly more than 75 km from the coast (Klein 1972). This is concordant with a widely accepted view that people are not prone to moving and carrying shell material for long distances (> 10 km) (Erlandson 2001). Additionally, during periods of lower sea level many other sites such as Klasies River Mouth (KRM), Die Kelders (DK1) and Blombos Cave (BBC) would have been more than 10 km from the coast (van Andel 1989) (Fig. 2.12).

Figure 2.12 Present position of the archaeological sites mentioned in the text

2.4.2 Sedimentary evidence

Since sediment deposition is strongly influenced by prevailing sea level and the intensity of wave action against the coast, episodes of sea level change may be related to phases of sediment denudation and deposition.

Quartzite dominates the south coast lithology with sediments derived from fluvial, near-shore and aeolian sources (Rust 1998). Since the 1970s, intervals of dune formation and sedimentation recognised along the southern Cape coast have been linked to episodes of sea level change (*e.g.* Butzer & Helgren 1972). Subsequent research has since indentified multiple periods of dune accumulation which have also been related to the influence of the westerly winds (*e.g.* Carr *et al.* 2006a, b, 2007).

The southern Cape sedimentary record is broadly consistent and shows that sedimentation along the coast followed episodes of sea level transgression and regression correlated with MIS 5 and MIS 4/3. This is evident from studies on the cordon dunes, aeolianites and lunettes along the south coast sampled from the Wilderness, Hoë Walle, Soetendals Valley and the Agulhas Plain (Bateman *et al.* 2004; Carr *et al.* 2006a,b; 2007).

At the Wilderness OSL derived ages of 128 and 90 ka were obtained from the cordon dunes and correspond to MIS 5/4 with a break in deposition dated from 90 to 73 ka related to MIS 5a (Bateman *et al.* 2004). In a subsequent investigation on the

Wilderness barrier dunes (cordons) two depositional phases from 157-154 ka and 142-85 ka were indentified and correlated with MIS 5a,c and MIS 5e which are periods during which global sea levels declined between -20 and -30 m (Carr *et al.* 2007). Congruent OSL dates were recorded at Hoë Walle some 10 km west of Cape Agulhas where the aeolianite of MIS 5b age was dated to 88 ka (Bateman *et al.* 2004). In a related study at the Hoë Walle sea cliffs a palaeosol sample yielded an OSL age between 112 and 80 ka (Carr *et al.* 2007). These dates correspond to two episodes of high sea stands at +5 and +7 m. A depositional hiatus *c.* 118 ka was also identified and related to a -4 m sea level regression (Carr *et al.* 2007).

The archaeological proxy evidence from Blombos Cave (BBC) and Pinnacle Point (PP) supports the interpretation that sedimentation coincided with MIS 5. At BBC the cave entrance was blocked by dune sand dated to *c.* 70 ka (*e.g.* Henshilwood 2008b). A period of Middle Stone Age (MSA) occupation at the site occurred again *c.* 75 ka. Similarly, at the Pinnacle Point cave, PP9 the entrance was sealed by dune in-fill dated to 133 ka and a later period of aeolian deposition at 88 ka (Herries *et al.* 2008). An episode of MSA settlement at the site was recorded at *c.* 85 ka when the dune was partially eroded and the cave became accessible (Herries *et al.* 2008). At DK1, an electron-spin resonance (ESR) date (Avery *et al.* 1997) coupled with an analysis of the faunal remains (*e.g.* Klein & Cruz-Uribe 2000) has placed the MSA sequence at the site within MIS 4.

2.4.3 Vegetation proxy evidence

In the southern Cape vegetation proxy data is drawn from palynological and archaeological contexts, the latter of which includes terrestrial fauna and micromammal data. The south coast flora falls primarily within the Cape Floristic Region (CFR), which is associated with Gondwana, Eurasian and African lineages (Cowling & Holmes 1992; Linder 2005). The main Gondwanaland components are *Poacaeae* (grasses), *Iridaceae* (irises), *Podocarpus* (pines), *Proteaceae* (proteas) and *Restionaceae* (Cape reeds) with Eurasian elements such as *Rosaceae* (roses), *Ericaceae* (ericas) and *Boraginaceae* (Borages) being introduced by the Eocene

(Linder *et al.* 1992). Changes in the distribution of these vegetation types during oscillating glacial and interglacial cycles has been related to a number of factors operating at local and global scales. These include shifts in the orientation of the winter and summer rainfall gradients (Van Zinderen Bakker 1976; Cockcroft *et al.* 1987), fluxes in the ocean's thermohaline circulation (*e.g.* Peeters *et al.* 2004), declining atmospheric CO_2 concentrations (Ravelo *et al.* 2004) and variable growing season temperatures (Vogel *et al.* 1978; Pearcy & Ehleringer 1987).

MIS 5

Palaeovegetation proxies associated with MIS 5 are mainly from archaeological contexts. At Klasies River Mouth, a diversity index of the rodent microfauna was used as a vegetation indicator and vegetation comprising fynbos elements (*viz.* restios), grasses and geophytes was inferred from several species (Avery 1987). Most notably of these was the present-day fynbos endemics, *Otomys saundersiae* (Saunder's vlei rat), *Georychus capensis* (Cape molerat) and *Chlorotalpa duthieae* (Duthie's golden mole). Grassy component vegetation was inferred from *Amblysomus hottentotus* (Hottentots golden mole) with vegetation comprising geophytes suggested from *Cryptomys hottentotus* (common molerat) (Avery 1987; Thackeray 1987). The modern distribution of this species indicates that it is often found on geophyte-rich sandy soils (Lloyd 2000). The heterogeneous mix of vegetation containing fynbos elements, grass and geophytes is consistent with dune fynbos and lowland Renosterveld habitats.

Species such as *Otomys irroratus* (vlei rat) and *Rhabdomys pumilio* (striped mouse) were by contrast linked to more closed environments (Avery 1987). The dense, forested vegetation associated with the latter species falls within MIS 5a and 5c and similar taxa are observed in the present-day Afromontane forest in the area. Based on the microfaunal analysis it appears that within the vicinity of KRM the flora shifted between intervals of open and closed vegetation throughout MIS 5 (Avery 1987). The fauna identified in the M2 and M3 levels at Blombos Cave, to some extent, support this interpretation for forest-type vegetation during part of MIS 5. These levels are dated by luminescence techniques between 80 and 100 ka, respectively. The forest/woodland adapted species recovered within the levels include *Diceros bicornis* (black rhinoceros), *Syncerus caffer* (African buffalo), *Herpestes pulverulentus* (Cape grey mongoose) and *Genetta spp*. (genets) (see Chapter 3). This is broadly congruent with the $\delta^{13}C$ data obtained from the Crevice Cave stalagmite in Pinnacle Point, which suggests a strong C_3 vegetation component in the region by *c*. 90 ka (Bar-Matthews *et al*. 2010). Based on the current data it is also likely that C_3 dominated shrublands and fynbos elements were also present in the southern Cape during MIS 5 (see Chapter 5).

MIS 4/3

Relative to present-day conditions MIS 3 is characterised by large-scale cooling and insolation minima although it was substantially warmer compared to both MIS 2 and MIS 4 (Lambeck *et al*. 2002). During MIS 3 sea level was *c*. 30 to 60 km lower than present resulting in a concomitant displacement of the coastline by more than 10 km (Van Andel 1989; Mitchell 2008). Across South Africa temperatures were *c*. 2-3 ^{o}C lower than today (*e.g*. Partridge 1997). Although MIS 3 is associated with generally cooler climatic conditions this period did have oscillating warm and cold intervals. Cold and dry environmental conditions were for example inferred from the extralimital grazing ungulates in Die Kelders (DK1) correlated to MIS 3. Grazing species included *Equus capensis* (extinct Cape zebra/horse), *Connochaetes gnou* (Black wildebeest) and *Antidorcas marsupialis* (springbok) (Klein 1976; Klein & Cruz-Uribe 2000). The *A. marsupialis* and *C. gnou* in particular are distributed primarily across savanna and Karoo habitats. Their presence may be indicative of a glacial expansion of Karoo-type vegetation elements into the southern Cape (Cowling 1983) but as grazers their presence probably reflects an increase in grass abundance (Chase 2010).

Somewhat wetter and cooler conditions during part of the MIS 4 occupation at DK1 is however suggested based on the increasing size of *Bathyergus suillus* (Cape dune molerat) and the presence of *Redunca arundinum* (southern reedbuck) (Klein & Cruz-

Uribe 2000). This is broadly consistent with the south coast sedimentary evidence for MIS 4/3, which coincided with the MSA occupation at the site. The implication is that under glacial conditions DK1 provided a heterogeneous micro-climate that was suitable for human occupation.

MIS 2

Vegetation data corresponding to MIS 2 is more abundant and alternates between C_4 and C_3 dominance. Archaeological evidence associated with MIS 2 comes from Boomplaas (BP) and Nelson Bay Cave (NBC). At BP in the Cango Valley proxy evidence was based on an analysis of nine charcoal assemblages (Deacon 1979). The current vegetation is characterised by bush and shrubland however the wild olive *Olea* was prominent throughout the vicinity prior to 32 cal kBP (Deacon 1979; Scholtz 1986). Between 32 and 17 cal kBP when *Olea* became less common the C_3-photosynthesising *Asteraceae* (daisy) plant genera of *Euryops*, *Stoebe*, *Relhania* and *Elytropappus* became abundant in the BP deposits (Scholtz 1986).The prevalence of these fynbos/Renosterveld taxa implies cool, dry climatic conditions in the vicinity, which may be related to the glacial expansion of the WRZ (*e.g.* Chase & Meadows 2007).

Faunal remains from NBC corresponding to the Last Glacial Maximum (LGM) include larger grazers such as *Syncerus caffer* (Cape buffalo) and other cold-adapted, grazing animals (Klein 1972; Sealy 1996). The increased presence of these animals is thought to be indicative of a declining fynbos presence in the region during MIS 2 (Sealy 1996). Palaeotemperature data derived from the Cango Cave speleothem indicate that LGM temperatures in the southern Cape were 6 ^{o}C below modern values (Talma & Vogel 1992). The presence of grazing animals in the NBC deposit coupled with the palaeotemperature data implies that conditions during part of MIS 2 were sufficiently cool and moist enough to support C_3 vegetation.

MIS 1

A slightly different pattern from the LGM was inferred at NBC based on the stable carbon and nitrogen isotopic signature recovered from animal bones of Holocene age (Sealy 1996). The Holocene fauna from NBC comprises small browsers such as *Potamochoerus porcus* (bush pig) and *Tragelaphus scriptus* (bushbuck) (Klein 1972; Sealy 1996). The former species lived in areas with dune thicket vegetation and forested environments but no longer occurs in the southern Cape. The presence of both *P. porcus* and *T. scriptus* suggests warmer and moister conditions compared to MIS 2. Fossil pollen dominated by the riparian *Cliffortia* genus and the sedges of *Cyperaceae* was identified from sediment cores at Soetendalsvlei on the Agulhas Plain and are associated relatively moist conditions between 13.3 and 14.3 cal kBP (Carr *et al.* 2006a).

Data from the Norga peat core suggests that forest genera such as *Podocarpus*, *Olea* and *Cliffortia* were widely distributed between 4 and 2.6 cal kBP but declined progressively from 2.6-1.4 cal kBP (Scholtz 1986). A similar trend was observed in the stable carbon isotope data from the Cango Cave stalagmite corresponding to the period from 5-2 cal kBP (Talma & Vogel 1992). The Cango Cave data indicates a peak in the abundance of C_4 species, equating to *c.* 60% $C_{4,}$ by *c.* 2 cal kBP (Talma & Vogel 1992). This increase in the extent of C_4/CAM plants coincides with the decline in forest (C_3) pollen reported in the Norga peat core.

Faunal remains from the late Holocene levels (*c.* 1.8 cal kBP) at BBC, includes a number mammal and rodent species, such as *Oreotragus oreotragus* (klipspringer), *Raphicerus spp*. (Cape grysbok & Steenbok), *Mellivora capensis* (honey badger), *Tatera afra* (Cape gerbil) and *Acomys subspinosus* (spiny mouse), which are considered to be endemic to the present-day fynbos habitat.

2.4 Summary

In the southern Cape, changes in vegetation are linked to fluctuations in temperature, precipitation and sea levels. Based on archaeological and other palaeoproxy records it is evident that during at least the last 100 kyr patterns of vegetation change were not uniform and it is likely that microhabitats supporting mosaic plant and animal types existed. The proxy evidence presented in this chapter is summarised in Table 2.1. The extent to which these changing environmental conditions influenced the subsistence strategies and biogeography of Middle Stone Age people in the southern Cape, and specifically at Blombos Cave, is explored in the subsequent chapters of this dissertation.

Table 2.1 Summary of the inferred palaeoenvironment in the southern Cape from MIS 5 to MIS 1 (Data from Klein 1972; Deacon 1979; Avery 1987; Thackeray 1988, 2007; Scholtz 1986; Talma &Vogel 1992; Sealy 1996; Irving &Meadows 1997; Klein & Cruz-Uribe 2000; Jacobs *et al.* 2003a, b, 2006; Bateman *et al.* 2004; Carr *et al.* 2006a, b, 2010; Marean *et al.* 2007; Bar-Matthews *et al.* 2008, 2010; Henshilwood 2008a; Herries *et al.* 2008)

MIS	Time period	Sea level	Locality	Proxy indicators
5	*c.* 130-74 ka	Global sea level -40 m and -60 m lower during MIS 5b and by MIS 5a sea levels dropped between -20 m and -30 m		Sedimentary evidence from Cape Agulhas beach, Swartvlei and Groot Brak estuaries associated with multiple sea level highstands between +6 m and +8 m during the last 125 ka
			Blombos Cave	MSA occupation phase *c.* 75 ka
			Pinnacle Point	MSA habitation *c.* 85 ka after period of aeolian deposition at 88 ka Shellfish debris layer dated to 120 ka indicative of the site's proximity to the coast. Dune-in fill layer dated to 90 ka falls within MIS 5a
			Crevice Cave	C_3 vegetation along the south coast at transition from MIS 4 to MIS 5
			Wilderness	Dune cordon formation between 85 and 157 ka correlates with MIS 5e and 5b
			Hoë Walle	Aeolianite formation between 112 and 80 ka
			Klasies River Mouth	Rodent micro-fauna indicative of closed, forested vegetation during MIS 5a and 5c. Open, grassland vegetation with fynbos elements are also present in the area during MIS 5b
4	*c.* 73-63 ka	Global sea levels *c.* -75 m lower than today	Klasies River Mouth	Decrease in the abundance of shellfish related to MIS 4 sea level regression
			Blombos Cave	Aeolian dune sand fills the cave entrance *c.* 70 ka
			Die Kelders Cave	Moist climate with grassy vegetation inferred from

		Sea level between -40 m and -60 m at transition from MIS 4/3		extralimital grazers found in the MSA deposits dated to MIS 4
3	63-45 ka		Renosterkop and Soutpan, Agulhas Plain	Lunette accretion between *c.* 45 and 60 ka followed by wetter episodes in MIS 3 *cf.* MIS 4 Along the south coast there is a lack of active dunes dated to MIS 3
			Voëlvlei, Agulhas Plain	Mosaic vegetation comprising fynbos elements and Afromontane forest at transition from MIS 3 to MIS 2
2	45-12 ka	-120 m by the LGM	Boomplaas Cave, Cango Valley	> 32 cal kBP *Olea* prominent throughout the area Between 32 and 17 ka *Asteraceae* genera (*Euryops*, *Stoebe* & *Elytropappus*) more common
			Nelson Bay Cave, Robberg Peninsula	Grazing fauna in LGM deposits indicative of declining fynbos taxa
			Soetendalsvlei, Agulhas Plain	C_4 dominance *c.* 13.3-14.3 cal kBP
			Voëlvlei, Agulhas Plain	Lunette accretion between 13.1 and 2.6 ka
1	12 ka -		Nelson Bay Cave, Robberg Peninsula	Browsing fauna indicative of fynbos vegetation *c.* 12 ka shellfish appears in the deposit and grassland associated fauna disappears
			Norga, George	Fossil pollen of forest genera *Podocarpus*, *Olea* and *Cliffortia* between 4 and 2.6 cal kBP
			Cango Cave stalagmite	Increasing C_4 vegetation component between 5 and 2 ka

			Vankervelsvlei Blombos Cave	Peat bog formation between 3.2 and 7.1 cal kBP Browsing fauna indicative of fynbos scrub *c.* 1.8 cal kBP