Chapter 11
Paleoenvironments, Sea Levels, and Land Use in Namaqualand, South Africa, During MIS 6-2

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Abstract In order to expand on the potential range of early human experiences and adaptive strategies, it is first necessary to determine the paleoenvironmental signatures for a given region of study. In this paper we report on proxy terrestrial, marine, and sea level data in order to reconstruct past environments of Namaqualand, South Africa, during MIS 6-2. Although this semiarid southern extension of the Namib Desert is a prime area to investigate early modern human adaptive innovations, environmental and human history of Namaqualand has been largely neglected. We present environmental, chronological, and subsistence data from recent excavations at Spitzkloof Rockshelter A, and review equivalent data from other sites in the Succulent Karoo Biome. The presence of handaxes on the landscape point to a pre-MIS 6 presence in the region, but current evidence suggests that a more dedicated human occupation of the region likely began during MIS 5. Subsequent human dispersals into Namaqualand are recurrent but heavily pulsed and typically linked to humid stadial phases when sea levels were lower. We propose that the westward movement of the coastline potentially increased the carrying capacity of the region by promoting the colonization of grasses onto the coastal plain, attracting larger game. The mechanism driving this change can be attributed to either an increase in inland precipitation as the Benguela-cooled coastline moved west or reduced evapotranspiration due to lowered temperatures. The strongest evidence for this pattern is during MIS 2 when faunal and floral data indicate a cold but humid environment. Faunal species from Last Glacial Maximum (LGM) layers at Spitzkloof A and Apollo 11 include large ungulates such as *Equus capensis*, a moisture-loving species that disappears toward the end of MIS 2 (~14 ka) when conditions become more xeric.

Keywords Namaqualand • Late Pleistocene • Middle Stone Age • Paleoenvironments • Deserts • Hunter-gatherers • Climate change • Southern Africa

Introduction

Over the past two decades fossils of early *Homo sapiens* and genetics studies of modern populations have identified an African origin for our species at ~200 ka (cf. Cann et al. 1987; McDougall et al. 2008). Yet the sparse distribution of well-excavated sites across this vast continent means that we are still fleshing out the evolutionary processes within Africa that led ultimately to the complex, highly plastic forms of behavior typical of recent and living humans. Evidence from a handful of African Late Pleistocene sites provide glimpses of sociocultural, technological, and subsistence innovations that include geometric art forms (Henshilwood et al. 2002; Mackay and Welz 2008; Texier et al. 2010), personal ornamentation (Henshilwood et al. 2004; d'Errico et al. 2005; Bouzouggar et al. 2007), compound adhesive manufacture (Wadley et al. 2009), living and work space preparation (Wadley 2010; Wadley et al. 2011), fishing (Yellen et al. 1995; Henshilwood et al. 2001; Robbins et al. 2016), and shellfish exploitation (Klein et al. 2004; Avery et al. 2008; Marean 2010). These finds, although tantalizing, are material symptoms of underlying causes and processes that remain obscure. In order to begin understanding the deeper evolutionary currents responsible for behavioral complexity, however defined, the unevenness of datasets across the African continent must be corrected. This is especially true

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in Africa's more marginal biomes, which would have challenged humans to expand their behavioral repertoire (Dewar and Stewart 2012; Stewart et al. 2012, 2016).

When assessing the evolution of behavior it is imperative to first understand the ecological conditions of a particular region for a given time period in order to establish a baseline. This is important for interpreting the causes of specific behaviors or innovations as rooted in either social or environmental adaptations, or both. Environments change through time and so too will their attractiveness as a niche for subsistence resources, raw materials, or some unknown sociocultural relevance. In order to contribute to the accumulation of data from under-researched African regions we present data from the periods MIS 6-2 with focus on Namaqualand, South Africa. Namaqualand is a semiarid desert that is currently unpredictable and patchy in floral resources, and while rainfall arrives during the austral winter months, it is quite low at 50–250 mm per year (Desmet 2007).

In this paper we synthesize what we currently know about past environments of Namaqualand from MIS 6-2. Because this region has received very little research, it is necessary to include data from geographically disparate sites in order to develop a tentative yet meaningful picture (see Appendix A). We present paleoenvironmental, chronological and subsistence data from recent excavations at Spitzkloof Rockshelter A (hereafter Spitzkloof A). Spitzkloof A (28° 51.790 S, 17° 04.65270 E) is located in southern Africa's Succulent Karoo Biome, and more specifically in the hinterland or "Richtersveld" of northern Namaqualand. The site is situated 30 km south of the Orange River and 30 km east of the Atlantic Ocean (Fig. 11.1). Results from Spitzkloof A are offered alongside previously published data

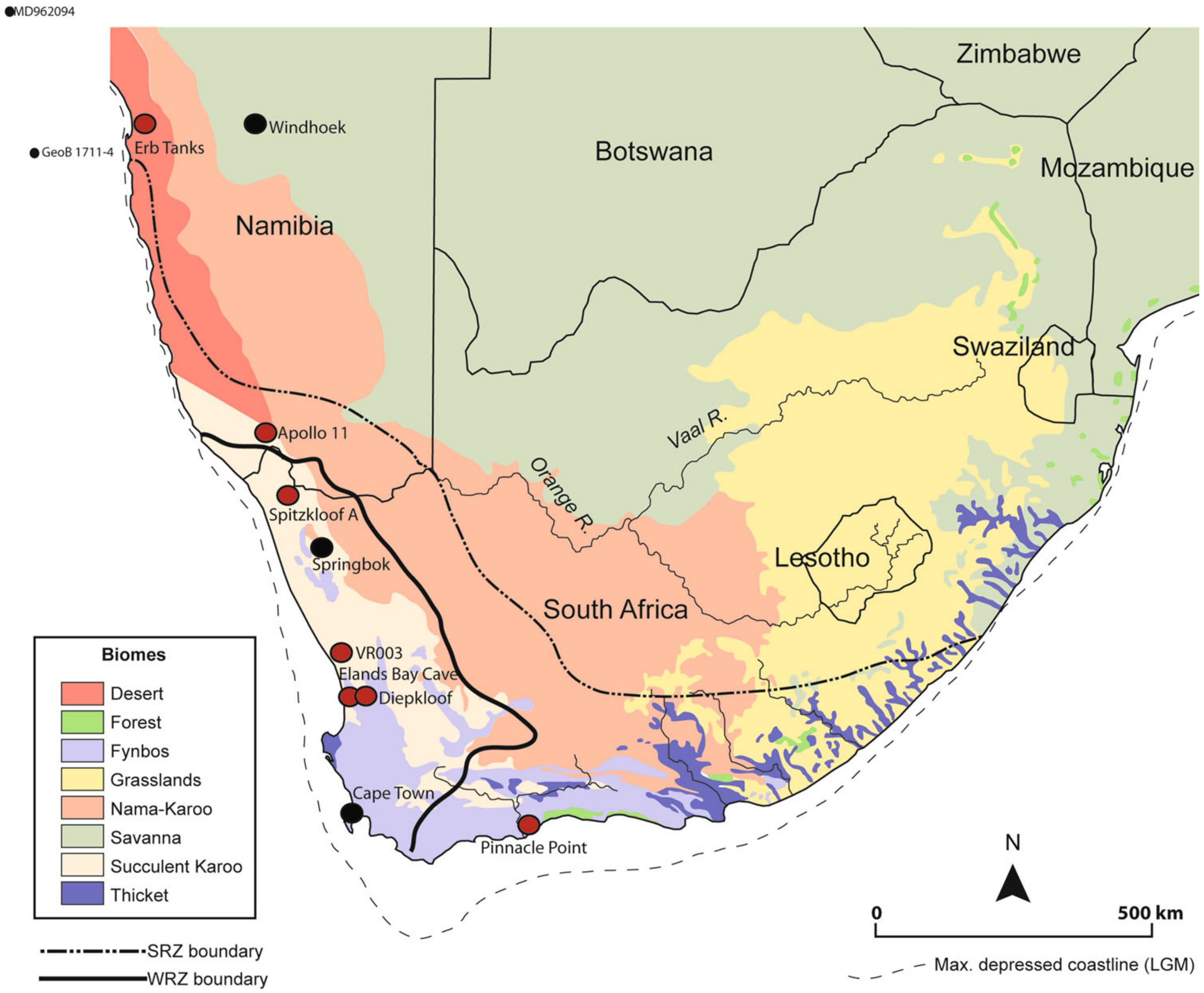

Fig. 11.1 Map of the study region identifying the biomes, archaological sites and marine cores referred to in the text. The winter rainfall zone (WRZ) and summer rainfall zone (SRZ) boundaries are indicated with the region between them receiving rainfall all year

from several other sites in the Succulent Karoo Biome with equivalent-aged deposits: Varsch River 003 (VR003) in southern Namaqualand, and the Namibian sites Apollo 11 Rockshelter and Erb Tanks.

In a study of the Holocene occupation of Namaqualand, Dewar (2008) notes that the region was inhabited during relatively cold humid phases including the Neoglacial (~4.2–1.4 ka) and the Little Ice Age (0.65–0.15 ka). Conversely, the region was occupied at a much lower density during warm and arid phases such as the Mid-Holocene Altithermal (7–4.2 ka) and Medieval Warm Epoch (~1.4–0.65 ka). Dewar concludes that water availability was the most likely factor driving settlement of the region. Here we test this hypothesis for the Pleistocene with the expectation that occupation will be linked to glacial and stadial phases, which were cold but more humid than current conditions (cf. Chase and Meadows 2007). The lowered sea levels that accompanied such phases may have played a particularly important role: with westward shifts of the arid coastline from its present position, precipitation could have reached larger areas of inland Namaqualand while the lowered temperatures could have increased the effectiveness of evapotranspiration.

Current Landscape

The Namaqualand coastal semidesert is the southern extension of the Namib Desert within the Succulent Karoo Biome. This region is demarcated by the Olifants River in the south (the boundary of the Fynbos Biome) while to the north it is defined by the Orange (Gariep) River (Fig. 11.1). The western edge is bounded by the Atlantic Ocean, while the eastern threshold borders the Bushmanland grasslands (Nama Karoo Biome) and is demarcated by the north–south-oriented Kamiesberg Mountains. These mountains range from 30 to 100 km inland and consist of granite gneiss that peak at 1,706 m above mean sea level (amsl). To the north, the Stinkfontein Mountain ranges consist of the Port Nolloth Group that unconformably overlies the Namaqua Metamorphic Group (Frimmel 2003) peaking at 1,377 m amsl. Numerous dry riverbeds crosscut the coastal plateau and flow very infrequently. The coastal plain or Sandveld consists of red Pleistocene sands that are overlain in areas with dynamic white aeolian sand of marine origin (Mucina et al. 2006). The Richtersveld includes the foothills and the Stinkfontein Mountains, with red Pleistocene fine-grained sand deposits and quartz gravel plains.

Namaqualand is within the Winter Rainfall Zone (WRZ), receiving >66% of its annual precipitation during the austral winter months. In the north, current mean annual rainfall is less than 50 mm with an increasing gradient to the south (up to 250 mm per annum) and east toward the mountains. The peaks of the Kamiesberg receive up to 400 mm per annum (Desmet 2007). The aridification of Namaqualand and the Namib Desert is caused by the interaction between cold sea surface temperatures and the westerly winds. Upwelling along the west coast in conjunction with the Benguela Current produces sea surface temperatures of between 11 and 17 °C (Eitel 2005). When humid southerly winds pass over the frigid sea, the air is cooled and cannot release precipitation until the winds have moved over the warm continent creating this west to east rain shadow gradient. Although rain is infrequent, when humidity ranges between 70 and 100% coastal fogs (known locally as "*Malmokkies*") form and can extend up to 90 km inland, providing an important source of hydration for flora and fauna. Although the official mean temperature for the entire Succulent Karoo Biome is 16.8 °C (Mucina et al. 2006), Namaqualand can exceed temperatures of 40 °C during the summer while winter minimums can fall to 7 °C and below. Very hot *Foehn* or "berg" winds can drive the daytime temperatures above 44 °C even in winter months.

The Succulent Karoo is one of eight terrestrial biomes in southern Africa, yet it has received relatively little archaeological attention compared to the productive Fynbos Biome of the Cape coastlands. Succulent Karoo vegetation is dominated by dwarf, succulent shrubs of which the Aizoaceae or "*Vygies*" are prominent as are Euphorbiaceae, Crassulaceae, and succulent members of Asteraceae, Iridaceae, and Hyacinthaceae (Mucina et al. 2006). Extravagant mass flowering of Asteraceae daisies occurs in spring. Grasses are rare and of C_3 type, while trees such as *Acacia karroo* are typically present along dry riverbanks. By necessity, flora and fauna are dry adapted species and occur in unpredictable and patchy distributions (Desmet 2007). The diversity of mammals and birds is very low compared to the rest of South Africa, but the region is a biodiversity hotspot for small reptiles and invertebrates.

Paleoenvironments, Sea Levels, and Settlement

According to Eitel (2005), the aridification of the Namib Desert and, by extension, Namaqualand, has its origin in the Miocene with the establishment of the Benguela Current. In 2007 Chase and Meadows synthesized the available paleoenvironmental proxy data to evaluate potential expansions of the WRZ using data from marine cores off the coast of Namibia, as well as terrestrial and other marine proxy data from South Africa's west coast. Their interpretation combined results from a wide range of datasets including pollen, aeolian, fluvial and lacustrine deposits, size and presence of mammals, and stable isotopes. They tested and seem to confirm an inverse relationship between temperature and humidity for the WRZ whereby glacial periods were humid and interglacials were dry. Scott et al. (2012) later revisited the well-dated terrestrial fossil pollen record and confirmed the inverse relationship between temperature and humidity.

Not only do glacial/interglacial periods reflect global temperatures they also affect the location of coastlines. The current South African shoreline was established ~9.0 ^{14}C kBP with small deviations during the Holocene. Throughout MIS 6-2, however, it fluctuated widely, ranging from +4 to −130 m amsl (Ramsey and Cooper 2002). Due to the gradual slope of the Southwest African Margin (continental shelf), even small changes in sea level will shift the location of the coastline. Cold glacial periods would have depressed sea levels exposing landmass that could be colonized by vegetation, while warm periods and concomitant sea level transgressions will have submerged land (cf. Compton 2011 for the southern coast). For example, a drop of 120 m would have extended the Namaqualand coastline westward by ~20 km. This could have impacted water availability in this semidesert by either: (a) exposing warm landmass shifting the rainfall shadow to the west and thereby increasing precipitation in regions that are today quite arid; or (b) evapotranspiration would have been less efficient in lowered temperatures. In either scenario increased water availability would have potentially supported a higher carrying capacity of flora and fauna.

Ramsey and Cooper (2002) evaluated the available sea level indicators for southern Africa in order to produce a well-constrained sea level curve from MIS 7-1. They rely largely on the dating of beachrock (aeolianite) using U-series and previously published dates from shoreline indicators primarily from the eastern Cape coast. In 2010, Fisher et al. developed a paleoscape model of changing sea level for the southern Cape coast at 1.5 ka intervals stretching back ~420 ka. They use integrated bathymetric datasets, GIS and a relative sea level curve (RSL) with ages extrapolated from oxygen isotope ratios from benthic foraminifera (the composite RSL constructed by Waelbroeck et al. 2002 correlates well with the localized geological data) to estimate the position of the coastline, and compared this predicted model with strontium isotope ratios from speleothems as an independent test of sea level. There are some incongruences between the two methods before 250 ka (MIS 7), but after this time they are more consistent. While this dataset was developed for the southern Cape, gross shifts in sea level will also affect the west coast and Namaqualand coastline. The Agulhas Bank of the southern Cape extends 300 km offshore, whereas the Southwest African Margin off Namaqualand reaches ~200 km offshore (Fig. 11.1). By contrast, the Eastern Cape continental shelf is very steep at only 3 km offshore (Fisher et al. 2010: Fig. 2). The Southwest African Margin is thus overall more similar in morphology to the Agulhas Bank than to the Eastern Cape, and we accordingly expect that offshore coastline movement in Namaqualand were more likely to be similar to Southern Cape values.

Pre-MIS 6 (>191 ka)

The Archaeology Contracts Office, a cultural resource management team based in Cape Town, has surveyed Namaqualand for over two decades (Dewar 2008; Dewar and Orton 2013; Halkett 2002, 2003, 2006a, b; Halkett and Dewar 2007; Halkett and Hart 1997, 1998; Halkett and Orton 2004, 2005a, b, 2007; Orton 2007, 2009; Orton and Halkett 2005, 2006; Webley 1992, 2002, 2009). Their extensive archaeological database (>1500 sites) makes clear that past populations used the landscape prior to MIS 6. For example, there are over 50 recorded Early Stone Age (ESA) open air sites identified by the presence of handaxes. The majority of these ESA sites reflect the quarrying of silcrete outcrops where thousands of artifacts were dropped. There is a ribbon of coarse silcrete outcrops along old marine terraces in northern Namaqualand (Roberts 2003) that extends across the Orange River into the Gemsbok region of Namibia (Corvinus 1983). The presence of large quartzite and quartz clasts at these silcrete quarry sites indicates that people must have transported these clasts to the marine terraces. There is no evidence for actual habitation sites although fossil bone has been found at one inland site near the town of Kleinsee (Orton personal communication), but few of these localities have been systematically sampled. All are situated within 5 km of the current coastline or along river valleys, the latter suggesting that early *Homo* followed corridors associated with fresh water or artifact deposits are covered with recent sands. Without proper chronological control, however, we cannot say whether artifacts that are currently near-coastal were deposited in a similar environmental setting, since sea levels have changed. No doubt many archaeological sites are currently submerged.

MIS 6 (191–130 ka)

Palaeoenvironmental datasets for the west coast of southern Africa that date to MIS 6 come from two marine cores (Fig. 11.1) off the southern and central coasts of Namibia: GeoB1711-4 and MD962094 (Shi et al. 2001; Stuut et al. 2002). The pollen from marine core GeoB177-4 identified high levels of Restionaceae, the evergreen family within the Fynbos Cape Floral Kingdom, in addition to a transitional desert/semidesert group Asteroideae, currently located near the Orange River (Shi et al. 2001). The term "desert/semidesert" is a poor descriptive though as it does not reflect the true water dependence of these families. The authors argue that the presence of these families is evidence for a northward expansion of the Cape floral elements during this stage and therefore reflects a humid signal. Stuut et al.'s (2002) study of grain size variations of terrigenous sediments from marine core MD962094 also suggests relatively humid conditions during MIS 6 based on a strong increase in the proportion of fluvial sediment deposits.

Sea levels during MIS 6 along the coast of Namaqualand are not yet well understood and thus for the time being we must rely on data from further afield. A U-series date from a sample of aeolianite located on the east coast of South Africa (182 ± 18 ^{230}Th/^{234}U ka: Pta-U430) was traced to a submerged beach rock facies at −3 m amsl (Ramsey and Cooper 2002). Strontium isotope ratios from Pinnacle Point on the southern Cape coast suggest two minor regression events at 189.7 and 173 ka. These events lead the paleoscape model that predicts low sea stands at 184.5 ka and 151 ka respectively (Fisher et al. 2010). While not yet resolved, both methods agree that there was a transgression at 167 ka to near modern coastal levels. Finally, a major drop in sea level is recorded until the end of MIS 6 with strontium isotope ratio data indicating a minimum sea level sometime between 155 and 150.5 ka, while the paleoscape model records two regressive peaks at 150.5 and 137 ka (Fisher et al. 2010).

There is currently no direct evidence for the occupation of Namaqualand during the penultimate glacial period. Surveys have identified over 90 Middle Stone Age (MSA) sites with large, heavily patinated blades, points and flakes as well as radial cores and Levallois reduction, but only a handful are diagnostic pieces and all relatively date to MIS 4 (see below). Site types include open air lithic scatters, quarries and food processing/habitation sites. There are two known rock shelters with MSA material on the surface with potentially very deep deposits: Spitzkloof (Dewar and Stewart 2012) and VR003 (Steele et al. 2012). There is also evidence for the reuse of the same silcrete outcrops that were exploited during the ESA, suggesting repeated use of the landscape (Dewar 2008; Dewar and Orton 2013).

MIS 5 (130–71 ka)

The transition to the Last Interglacial reflects a period of general aridification. Shi et al. (2001) record a sharp decline in Restionaceae and desert/semidesert pollen. These taxa were replaced by Kalahari dry forest, indicating an increased influence of the easterly trade winds and a reduced influence of the rain bearing westerlies. Only at the end of MIS 5 is there a slow return of the pollen spectra that signal humidity. Correspondingly, Stuut et al. (2002) note a drop in fluvial input during MIS 5e, with a return to moderate levels at MIS 5d followed by sharp increases in fluvial input during MIS 5c and 5a.

The paleoscape model and strontium isotope ratios from Pinnacle Point suggest that by 130 ka (MIS 5e) the coast had returned to near modern levels, with neither showing evidence for a major regression during MIS 5 (Fisher et al. 2010). Sea level data for the Last Interglacial in eastern South Africa is characterized by two sea level highstands at +4 m amsl separated by a −44 m lowstand. Based on two ionium dates of 110 ka and 98 ka at Klasies River Mouth, Hedley and Volman (1986) relate one of the +4 m amsl highstands to MIS 5c. At Sodwana Bay, U-series dated beachrock from a submerged shoreline at −44 m amsl yielded a date of 117 ± 7 ^{230}Th/^{234}U ka (Pta-U487). While Maud (1968), Hobday (1976), Cooper and Flores (1991) have identified two +4 m shoreline deposits in KwaZulu-Natal that are separated by the −44 m amsl unconformity, and suggest the other highstand was most likely deposited during MIS 5e (Ramsay and Cooper 2002). MIS 5c and 5a have been interpreted by Chappel and Shackleton (1986) to be close to the present sea level, which is supported by the paleoscape model with values ranging from +1.65 to +0.5 m amsl (Fisher et al. 2010: Table 1). The near modern sea level values remain until 72 ka where the strontium isotope data and paleoscape model agree that at there was a drop in sea level (Fisher et al. 2010).

The Last Interglacial has been proposed as the likely date for the small MSA assemblage from the near coastal rock shelter Boegoeberg 2 in Namaqualand. The corrected ^{14}C date on ostrich eggshell is 46,709–44,242 cal BP (44,200 ± 1200 ^{14}C BP, Pta-6956), but Klein et al. (1999) interpret the date as a minimum age and suggest that the occupation could be much older since the fauna implies true interglacial conditions; they propose substages 5e, 5b, or 5a. It is also possible that MSA processing sites located on the modern coastline date to this period, when sea level would have been similar. Processing sites are identified on the basis of the presence of large quantities of fossilized intertidal shellfish, tortoise and patinated lithics. This idea is perhaps reinforced by ethnographic research, which suggests that a typical daily foraging radius to the intertidal zones is likely to be no more than 8 and 10 km (Meehan 1982). Current evidence suggests that the sea level was further away ~45 ka (see below).

The oldest date in the greater Namib region associated with an archaeological deposit comes from Erb Tanks in central Namibia (McCall et al. 2011). An amino acid racemization date of 130 ka was recently obtained on ostrich eggshell from the very base of the shelter (McCall et al. 2011). Although this may be an indication that people were moving into the Namib Desert landscape when the sea levels were returning to near modern values, this date is a conspicuous outlier as noted by the authors. More dates are required to verify a human presence in early MIS 5. A more

Table 11.1 Number of specimens identified to species and their inferred diet (cf. Skinner and Chimimba 2005) for the Still Bay (SB), Howiesons Poort (HP) late MSA and Early LSA layers Apollo 11 (Vogelsang et al. 2010)

Species	Apollo 11 SB ∼70 ka	Apollo 11 HP ∼60 ka	Sptz A late MSA ∼52–51 ka	Apollo 11 late MSA III ∼43 ka	Apollo 11 Late MSA I ∼30 ka	Apollo 11 early LSA ∼25–14 ka	Diet
Bathyergus janetta	0	0	2	0	0	0	Browser
Raphicerus campestris	0	0	1	0	0	0	Browser
Oreotragus oreotragus	2	8	1	6	2	1	Browser
Silvicapra grimmia	0	0	1	0	0	0	Browser
Chersina angulata/Psammobates tentorius trimeni	2	1	41	1	1	0	Browser
Procavia sp.	3	2	0	4	11	10	Mixed
Lepus sp.	2	3	0	8	8	8	Mixed
Antidorcas marsupialis	2	1	1	3	1	0	Mixed
Phacocherus sp.	0	0	0	1	1	0	Grazer
Oryx gazella	0	0	2	0	0	0	Grazer
Equus zebra	2	5	0	4	5	3	Grazer
n	13	20	49	27	29	22	

These data are compared to the late MSA layers at Spitzkloof A (Dewar and Stewart 2012). *Note* In Vogelsang et al. (2010) the data are presented as relative abundance while this table presents the NISP

congruous date is 85 ka (also based on amino acid racemization) when paleoenvironmental indicators suggest that the region was returning to a more humid environment, although it is important to note that there is clearly evidence for vertical movement of ostrich eggshell at Erb Tanks (McCall et al. 2011). Unfortunately, there is no bone preserved from the MSA layers at Erb Tanks.

MIS 4 (71–57 ka)

Paleoenvironmental data for MIS 4 is restricted to marine proxies, a charcoal study, and faunal remains but nevertheless this period marks a distinct threshold reflecting a shift to a cooler and more humid environment. At 70 ka maximum sea surface temperatures (SST) dropped from interglacial temperatures of ∼22 to ∼20–19 °C, and maintained those lower values throughout both MIS 4 and 3 (Krist et al. 1999). There is an increase through time in Restionaceae and transitional desert/semidesert pollen taxa (cf. Asteroideae) at marine core GeoB1711-4 (Shi et al. 2001) while the coarse aeolian dust input increases dramatically (Stuut et al. 2002) suggesting increasing trade wind strength at the site of marine core MD962094. Charcoal analysis for the MIS 4 layers at Apollo 11 located 30 km north of the Orange River identify “a diverse array of woody vegetation reflecting an environment either very similar to or more favorable than today” (Vogelsang et al. 2010: 212). South of the study region, botanical remains from Diepkloof Rockshelter dating to ∼65–50 ka reflect afromontane taxa (Chase and Meadows 2007) indicating a humid late MIS 4/early MIS 3, although this is within the Fynbos biome that currently receives more rainfall than Namaqualand.

After the regression at 72 ka, the sea level remained low along the south coast until 60 ka at which point the strontium isotopes and paleoscape model identify a transgression event (Fisher et al. 2010). The curve developed by Ramsey and Cooper (2002) lacks data for this period.

The presence of Still Bay (SB) points 6 km inland from the town of Koignass (Dewar and Orton 2013) and the discovery of a Howiesons Poort (HP) segment near the Tweepad farm suggest that MSA people inhabited the northern coast of Namaqualand sometime between 74 and 60 ka (cf. Jacobs et al. 2008). In southern Namaqualand, two sites near the Varsche River indicate occupation during MIS 4: the open site STF001 has bifacial points while VR003 has both bifacial points and HP segments (Mackay et al. 2010; Steele et al. 2012). The faunal data from VR003 is presented in Steele et al. (2012), but it has not yet been directly dated. The authors identify one confidently *in situ* layer representing the HP layer from test pit II-04. The sample of identified remains consists of 58 elements, with the arid adapted browsers *Chersina angulata* (Angulate tortoise) dominating at 76% (Steele et al. 2012). The small species list makes identifying the environment tentative but the two herbivores identified to species, *Chersina angulata* and *Cryptomys hottentotus*, at least suggest that browse was available within a potentially arid region.

A more robust sample that includes both SB and HP is found at Apollo 11 with Optically Stimulated Luminescence (OSL) dating these techno-complexes at 71 ± 3 ka (AP6) and

63 ± 2 ka (AP4) respectively, with an intermediate pulse of occupation at 67 ± 3 ka (AP5) (Vogelsang et al. 2010). The faunal data from the recent excavation (Vogelsang et al. 2010: Table 6), although limited, are discussed here because Thackeray's (1977) analysis of the bones from the original excavations did not separate the SB from the HP layers. In the SB layers, of the 32 identified fauna, small mammals (size 1 and 2; cf. Brain 1981: up to 80 kg) dominate the assemblage at 59% with large mammals (>30 kg) at 25%. All species in the sample live on the landscape today with the important exception of the large grazing equid. Using the dietary preferences of the identified species there is a high proportion of mixed feeders, followed by browsers and grazers respectively (Table 11.1). Similar to the charcoal signal from the same deposits, the fauna suggests an early MIS 4 environment that was similar to today, but with more water available to support woody vegetation and grasses.

The HP layers at Apollo 11 produced a sample of 35 identified elements, similarly dominated by small mammals at 57% of the assemblage followed by large ungulates at 23% (Vogelsang et al. 2010: Table 7). Mirroring the SB sample, the identified species are present on the landscape today with the addition of the equid, indicating a nearly modern environment but with increased water availability. Noting the dietary preferences of the identified species (Table 11.1) there is an increased proportion of grazers and browsers at the expense of the mixed feeders. As this dataset is small and the mixed feeders could consume graze or browse, the most powerful inference from this table is the increase in the presence of grazers that do not live on the landscape today.

Erb Tanks has also produced two dates at ~65 ka and one at 60 ka although the occupation lacks SB and HP diagnostic tools (McCall et al. 2011). There is no faunal sample from Erb Tanks for this stage.

MIS 3 (57–29 ka)

During MIS 3, multi-proxy data indicates that the environment was fluctuating from arid to humid within a climatic regime that was cool overall. The charcoal identified from a settlement hiatus bracketed by OSL dates (AP3: 57.9 ± 2.6 ka and AP2: 42.9 ± 2.7 ka) at Apollo 11 consists of a single family Chenopodiaceae (*Salsola* type), which indicate xeric conditions (Vogelsang et al. 2010). By contrast, Restionaceae and desert/semidesert taxa within marine core GeoN1711-4 signals an increase in humidity beginning at 50 ka peaking at 32 ka (Shi et al. 2001). In marine core MD962094, the coarse aeolian dust input initially drops but then fluctuates dramatically (Stuut et al. 2002).

The fossil assemblage from the hyena den Boegoeberg 1 on the Namaqualand coast includes large water-dependent grazers, such as *Connochaetes taurinus* (blue wildebeest) and *Redunca arundimun* (southern reedbuck), suggesting a moist climate, while the large size of the hyena bones suggests a cool environment (Klein et al. 1999). The calibrated ^{14}C dates on ostrich eggshell are 45,500–36,000 cal BP (37,000 ± 5000 ^{14}C BP, GX-22191), 42,000–36,000 cal BP (35,000 ± 3000 ^{14}C BP, GX-21190) and 40,000–34,700 cal BP (33,000 ± 2600 ^{14}C BP, GX-21189), and are interpreted by Klein et al. (1999) as a minimum age and likely representative of late MIS 4 or early MIS 3. It is possible though that the Boegoeberg 1 dates are not representing an infinite date but rather record relatively cool and moist conditions in mid-MIS 3 as shown by the offshore pollen record. Further evidence for high humidity is found at Kannikwa near Port Nolloth in northern Namaqualand where a peat bed is dated at 32,000–31,000 cal BP (27,900 ± 310 ^{14}C BP, Beaumont 1986). Additional support for mid to late MIS 3 humidity is seen in a composite distribution of ^{14}C dated evidence for increased humidity from within the Namib Desert as a whole (Lancaster 2002), with a humid peak ending at the MIS 3/2 boundary at 37,000–31,000 cal BP (32,000–26,000 ^{14}C BP).

The Ramsay and Cooper (2002) curve indicates a drop in sea level in the eastern Cape based on wetland peats with depths of −52 m and −46 m dating from 50,000 to 47,000 cal BP (45,200 ^{14}C BP, Pta-4140) and 44,000–42,000 cal BP (39,000 ± 1500 ^{14}C BP, Pta-4142) respectively. The paleoscape and strontium isotope data (Fisher et al. 2010) also suggests a mid-MIS 3 drop in sea level at ~52 ka while the paleoscape data identifies two shallow transgressions at 40 ka and 30 ka that the strontium isotope ratios do not register (Fisher et al. 2010: 1389, Fig. 4). An offshore marine shell at a depth of −78.4 m amsl records a rapid drop in sea level with a calibrated ^{14}C date of 31,500–30,800 cal BP (27,800 ± 440 ^{14}C BP, Pta-1104), from the Orange River Mouth. This regression event essentially continues through to the Last Glacial Maximum (LGM) in MIS 2.

OSL dates from Apollo 11 indicate that it was occupied in several pulses during MIS 3: 58 ± 3 ka (AP9) and 57 ± 3 ka (AP3) from the base of the late MSA complex; 43 ± 3 ka (AP2) from the middle of the complex; and 30 ± 1.4 ka (AP11) at the top of the complex (Vogelsang et al. 2010). Radiocarbon dates add mid to late occupational pulses occurring at ~37,000 cal BP, and ~32,000–29,000 cal BP (Vogelsang et al. 2010).

While there is no faunal data for the earliest MIS 3 occupation, Vogelsang et al. (2010: Table 6) present the identified remains for the ~43 ka pulse (Late MSA III) and the ~30 ka pulse (Late MSA I). The species list from these occupations mirrors the results from MIS 4 with the addition of a second grazing species (*Phacochoerus sp.*) supporting a more humid signal within an arid zone (Table 11.1).

Table 11.2 Radiocarbon ages of ostrich eggshell from Spitzkloof A, Namaqualand, South Africa

Lab no.	Context	Date in ^{14}C BP	Calibrated dates in cal BP
UBA-17609	Layer Nick	14,350 ± 10	17,274–17,093
UBA-17610	Layer Nick	14,400 ± 70	17,391–17,134
UBA-17611	Layer Nadja	15,200 ± 50	18,304–18,108
UBA-17612	Layer Jaird	16,250 ± 60	19,457–19,237
UBA-17613	Layer Dave	19,550 ± 60	23,415–23,132
UBA-17614	Layer Mark	19,750 ± 80	23,671–23,393
UBA-17615	Layer Julie	19,550 ± 60	23,415–23,132
UBA-17616	Layer Brian	>59,250	N/A
UBA-17617	Layer Brian	52,150 ± 800	N/A
UBA-17618	Layer Brian	51,150 ± 850	N/A

The ^{14}C dates were run at the ^{14}Chrono Centre at Queens University Belfast. Dates are calibrated using the software Calib 7.0 and the calibration curve Shcal13.14c for the southern hemisphere (Hogg et al. 2013). Note that the geological layers Dave, Mark, and Julie represent a single chronological layer. *Note* Experiments have shown that fossil ostrich eggshell is typically 180 ± 120 years too old (Vogel et al. 2001) and so 180 yr was subtracted before calibration

Radiocarbon dates measured on ostrich eggshell from layer Brian at Spitzkloof A returned ages of 52,150 ± 800 ^{14}C BP and 51,150 ± 850 ^{14}C BP (Table 11.2). A third date is likely infinite at >59,250 ^{14}C BP. The presence of gypsum nodules from this layer indicates climatic conditions ranging from arid to semiarid (Dregne 1976; Middleton 2003), but with enough moisture to have put the gypsum in solution (Dewar and Stewart 2012). The fauna from this occupation pulse consists of 810 identified specimens representing a minimum of fourteen different species that are all found on the landscape today (Dewar and Stewart 2012). Small mammals dominate the assemblage at 37% followed by tortoises at 35%. The identified species consists primarily of browsers (Table 11.1) but the presence of the *Oryx gazella* suggests that there was some grass available. Overall the species list suggests the environment at ~52–51 ka was very similar to MIS 4. Erb Tanks was occupied at 45 ka but fauna and other environmental indicators are absent (McCall et al. 2011).

MIS 2 (29–14 ka)

Increased or more effective precipitation during early MIS 2 (~28–20 ka) is recorded in Namibia from calcified reed beds and lacustrine deposits at Koichab Pan (Lancaster 1984), Narabeb (Teller and Lancaster 1986), Khommabes (Teller and Lancaster 1985) and Gobabeb (Vogel and Visser 1981). Charcoals from the Late Pleistocene layers at Apollo 11 are dominated by *Olea*, a woody species that lives in dry riverbeds of the central highlands (Vogelsang et al. 2010). This species is not found near Apollo 11 today. *Olea europaea* ssp *africana* is a frost and drought tolerant species that at first glance could signal a cool and arid landscape. Alternatively, *Olea* pollen from a hyrax midden in the Brandberg (Dâures Massif, Namibia) co-occurring with *Stoebe* type, dwarf shrubland taxa, *Artemeisia* and fern pollen dating to the LGM (~21 ka) has been interpreted by Scott et al. (2004) as indicating a cool moist signal. Although the authors do caution that this may not necessarily reflect increased precipitation but rather a drop in average temperature reducing evaporation, which would also render rainfall more effective (Scott et al. 2004).

The marine core data also support a wet early MIS 2. Shi et al. (2001) record the highest percentages of Restionaceae pollen in core GeoB1711-4 at ~24 ka, declining until ~19 ka and then finally dropping off to negligible values at ~14 ka (*contra* Scott et al. 2004 who did not find Restionaceae in the Brandberg). Fluvial sediments at MD962094 and trade wind proxy data from GeoN1711-4, MD962094, and GeoB1706 mimic the marine core pollen data with high values at the onset of MIS 2 that steadily decrease through time (Stuut et al. 2002).

Further south at Elands Bay Cave, the LGM layers (~25–21.5 ka) are marked by maximum values of pollen from woodland taxa and the lowest xeric karroid and Strandveld pollen values (Meadows and Baxter 1999). Charcoal studies from the same deposits substantiate this pattern of increased humidity with the presence of afromontane species such as *Celtis Africana* and *Grewia occidentalis*, which are intolerant of drought. Pollen from rock hyrax middens in the Cederberg Mountains suggest a shift at ~16 ka from a glacial vegetation consisting of *Stoebe/Elytropappus* shrubs and fynbos elements (Ericaceae and Proteaceae) to a Holocene vegetation signal with a mosaic of fynbos, thicket, and succulent vegetation (Scott and Woodborne 2007a, b). The authors interpret this shift as a result of increasing temperatures and reduced precipitation (although there is marked variability within the LGM).

Local data comes from the Eksteenfontein spring 18 km northeast of Spitzkloof A (Scott et al. 1995, 2012) where *Stoebe/Elytropappus* pollen samples indicate the region was still fairly cool from ~15.2 to 13.6 ka, but warming by ~12.5 ka. Scott et al. (2012) suggest that this period also reflects reduced moisture from a cold dry fynbos to a more modern arid environment.

In Durban Bay (Eastern Cape) a wetland peat located at −22 m amsl produced a calibrated date of 30,000–28,000 cal BP (24,950 ± 950 ^{14}C BP, GaK-1390) (King 1972 in Ramsey and Cooper 2002). By 20,000 cal BP (16,990 ± 160 ^{14}C BP, Pta-182) the sea had dropped to a maximum of −130 m amsl based on a dated *Pecten sp.* shell from Cape St. Francis (Vogel and Marais 1971), while submerged material ranging from −100 to −90 m amsl dating to ~13 ka indicates a slow post-LGM transgression.

The paleoscape model and strontium isotopes also identify a shallow transgression at the MIS 3/2 boundary while the paleoscape model confirms a rapid drop in sea level beginning in early MIS 2 with a peak ~20 ka. Unexpectedly, the LGM peak is not captured by the strontium isotope data (Fisher et al. 2010). A marine shell near the mouth of the Orange River mouth indicates that at 18,900–18,000 cal BP the Namaqualand coastline was located −87.2 m amsl (Vogel and Visser 1981).

There are two pulses of occupation at Spitzkloof A during MIS 2 (Table 11.2). The first pulse is identified from three ostrich eggshell ^{14}C dates at ~23,500–23,000 cal BP. A second pulse is registered by four ^{14}C dates ranging from ~19,000 to 17,000 cal BP, bracketing the period when the coastline would have been near-maximum distance away. Preliminary analysis of the fauna from the ~23,000 cal BP layers suggests an increase in the diversity of species with the addition of grazing equids and alcelaphines, a third species of tortoise *Homopus signatus signatus* and even a fish vertebra. While these few elements represent a small sample together they indicate a likely increase in fresh water availability.

The lithic scatter AK2006-001G along the coast of Namaqualand, though undated has artifacts typical of Late Pleistocene microlithic assemblages that occur between ~20 and ~9.5 ka in South Africa, Lesotho and Swaziland (Orton 2008). Orton (2008) argues that AK2006-001G was likely deposited between 17,000 and 11,000 BP (~20,500–13,000 cal BP). At Apollo 11, ^{14}C dates identify occupation at ~25,000 cal BP, ~22,000 cal BP, and 17,000–15,000 cal BP. Thackeray's (1977) "mean ungulate body mass index" analysis at Apollo 11 correlates positively with rainfall and was high during MIS 2, suggesting that both primary productivity and carrying capacity were higher than present day. The presence of *Equus capensis* at Apollo 11 until ~14 ka has been interpreted as evidence for humid conditions until latest MIS 2 when xeric conditions then dominated (Thackeray 1979). Erb Tanks also has punctuated dates at 25, 20, 15 and 12 ka (McCall et al. 2011) that are similar to Spitzkloof A and Apollo 11.

Synthesizing the Data: When Did People Occupy Namaqualand?

Pre-MIS 6 (>191 ka)

Current evidence for the occupation of Namaqualand before MIS 6 comes from the presence of handaxes along the marine terrace and inland river valleys. All we can say is that populations were using the landscape to some degree and provisioning themselves with quartzite, quartz and silcrete raw materials at quarry sites. When these individuals were present, what the environment was like and where the coastline lay are currently unknown and the foci of future research.

MIS 6 (191–130 ka)

Palaeoenvironmental proxy data from marine cores off the coast of Namibia indicate that the penultimate glacial period grew more humid through time based on the presence of flora that require higher water availability than are present in Namibia today and the high input of fluvial sediments. The Southern Cape and by proxy the Namaqualand coastline experienced flux during the first half of MIS 6 but the later half of this stage experienced a lowered sea level during the penultimate glacial maximum. This indicates that during much of MIS 6, the Namaqualand shoreline would have been much further west than it is today which has two implications: (1) the exposed coastal plain had the potential to increase carrying capacity, especially as precipitation would have been more effective through a shifting rain shadow or less efficient evapotranspiration; and (2) any coastal or near-coastal sites deposited during MIS 6 are now likely to be submerged. This hypothesis will be tested when more precise datasets are available for this stage. While it seems that MIS 6 would be a good time to occupy Namaqualand, to date there are no known sites but hopefully continued survey along inland river terraces will change this.

MIS 5 (130–71 ka)

Namaqualand experienced fluctuations in both temperature and humidity during MIS 5. The aridity that ushered in this stage became moderate during MIS 5d, but pollen and fluvial inputs signaling increasing humidity only occur later during MIS 5c and 5a.

Overall the sea level was near modern values for much of this stage. Two minor sea level highstands likely occurred during MIS 5e and 5c with a return to modern sea level by MIS 5a. While a major regression event is registered on the Eastern Cape at ~117 ka, there is no evidence for a substantial drop in sea level from the Pinnacle Point/Aghulas Bank data until the end of this stage at 72 ka. It thus remains unclear whether the Namaqualand coastline experienced the ~117 ka event. Direct measurement of the Southwestern African Margin can answer this question and a paleoscape model for this stretch of the continental shelf is currently being generated.

There is currently no directly dated evidence for human occupation of Namaqualand during MIS 5. However, the shellfish processing sites with fossilized material and heavily patinated lithics may date to this stage since they are unlikely to have been deposited beyond an 8–10 km foraging radius of the intertidal zone (cf. Meehan 1982). This is also the isotope stage during which Klein et al. (1999) infer human occupation at Boegoeberg 2, specifically during MIS 5e, 5b or 5a. Erb Tanks in Namibia has produced two dates at either end of MIS 5, but there is a strong possibility that the earlier date is erroneous. The later date of 85 ka, which is associated with evidence of increasing humidity, represents the earliest firmly dated evidence for occupation of the greater Namib region, at least for the time being. Of interest is the close correspondence between this age and that recently obtained date (~83 ka) for the earliest sustained human presence in the Maloti-Drakensberg, another challenging environment (Stewart et al. 2012, 2016).

MIS 4 (71–57 ka)

Paleoenvironmental data from the marine cores and charcoal from Apollo 11 reflect a shift to a cooler more humid environment starting at ~70 ka. Just before this, the paleoscape model and strontium isotope ratios predict a corresponding regression in sea level and thus a westerly expansion of the coastal plain, opening up the landscape to flora and fauna. The end of this stage is marked by a transgression event straddling the MIS 4/3 boundary that would have drowned this newly expanded coastal plain. Although, the fauna from Apollo 11 seem to suggest little change in species through this 14 ka and thus reflects a relatively muted environmental change, while the presence of woody vegetation and grasses suggests that it was more humid than today. Interestingly, the faunal remains from Varsch River 003 in southern Namaqualand suggest the end of MIS 4 was potentially semiarid and provided enough browse to attract tortoises. A Namaqualand-specific paleoscape model and larger datasets of faunal material are required to test these patterns. SB points and HP segments are found in a range of localities across the study region including open air sites and shelters, although compared to other southern Africa landscapes we know very little about these techno-complexes in Namaqualand. The increased number of sites and site types from this stage suggests a more consistent use of the landscape than was seen during MIS 5.

MIS 3 (57–29 ka)

Multi-proxy data from MIS 3 indicate that it was a stage in flux. Apollo 11 was occupied at ~58 ka when the shoreline was relatively close to modern values and the fauna indicates a modern-like environment but with the addition of equids. By 57 ka, Apollo 11 was abandoned and the charcoal sample reflects aridity until ~43 ka. Contradictorily the marine offshore pollen suggests increased and more effective precipitation by 50 ka peaking at 32 ka, while the fauna at Boegoeberg 1 potentially also indicate a wet and cool period from 45.5 to 35 ka. Data from both the eastern and southern coasts identify a low sea stand at ~52–50 ka, when Spitzkloof A was occupied and cemented gypsum deposits indicate an arid environment with enough moisture to put the gypsum into solution. The fauna from this layer is dominated by arid adapted browsing species yet the presence of gemsbok indicates the availability of some grass. The occupation of Erb Tanks (~45 ka) and Apollo 11 (43, 37 and 30 ka) also correlates with low or lowering sea levels and the presence of additional grazing species at Apollo 11 indicates a potential for more effective precipitation. Overall we see occupation of the greater region during both low and high sea stands and contradictory signals for humidity especially for early to mid-MIS 3.

For now, the most parsimonious answer is that this was a period of fluctuating environmental conditions and thus conflicting proxy signals and intermittent occupation of the region, particularly during early MIS 3. Only with the colder and potentially more humid conditions of late MIS 3 do occupational pulses become more frequent.

MIS 2 (29–14 ka)

Globally, MIS 2 exposed humans to one of the coldest and driest environments of the Pleistocene – the LGM. Yet most proxy data suggests that Namaqualand likely enjoyed some periods of increased water availability, with xeric conditions only recorded during latest MIS 2. LGM flora and fauna from

Apollo 11 suggest a cold but humid environment with increased primary productivity and carrying capacity, although the charcoal signal is complicated. The environment deteriorates by 14 ka with the introduction of more xeric conditions and the extinction of *Equus capensis*. Flora and fauna from the Spitzkloof region, including the Eksteenfontein spring produce a cool/humid signal until it changes at ~13 ka, a pattern supported by the marine core proxies. From 30 to 20 ka sea levels potentially dropped to a −130 m amsl, while a submerged marine shell near the Orange River Mouth records a lowstand of −87.2 m a.m.s.l at ~19–18.5 ka.

Occupations at Spitzkloof A, Apollo 11 and Erb Tanks are pulsed from ~22 to 13 ka but are more frequent than any previous stage. During this interval sea level would have been at its lowest with the coastline up to ~20 km further west than present day, opening up a vast tract of land available to be colonized by flora and fauna. Preliminary evidence that the flora and fauna did take advantage of the coastal plain is the presence of grazing ungulates at Apollo 11 and Spitzkloof A and a high "mean ungulate body-mass index" that correlates positively with precipitation.

Conclusion

The paleoenvironmental and settlement signals we possess for Namaqualand are currently patchy at best, primarily due to the dearth of large research projects in the region. This is currently being redressed through our ongoing excavations at Spitzkloof A and B in northern Namaqualand (Dewar and Stewart 2012) and the Varsche River project in southern Namaqualand (Mackay et al. 2010; Steele et al. 2012). Environments during MIS 6-2 have been preliminarily reconstructed based on proxy data from distant marine and terrestrial sources. The resulting picture tentatively supports the very broad correlation in the WRZ of glacials and stadials as phases of humidity, while interglacials were more arid (cf. Chase and Meadows 2007). One cautionary note is that the limited data for Namaqualand does not reflect particularly strong differences between glacial and interglacial periods and so continued fine-grained research in the region is required to verify the pattern. Currently the proxies used to identify past conditions remain imperfectly aligned, as best shown by the time lag between the sea level curves and the contradictory signals in MIS 3, but future work will hopefully address these issues.

As sea level is linked to global temperatures, glacial period shorelines are for the most part submerged. The majority of archaeological reconstructions of glacial periods will therefore have to reflect inland settlement and subsistence strategies. If human occupation of Namaqualand is linked to the availability of water (cf. Dewar 2008), as we suspect, then we would expect to see increased visibility of populations on the landscape during humid periods when the ocean is regressing and the potential for increased carrying capacity is highest. The current number of dated sites is too small to confidently verify this assertion but so far the majority of occupation pulses do seem to correlate with expanded coastlines. Although tentative, we certainly do have evidence for the occupation of Namaqualand during humid periods (from MIS 4-2). Particularly informative are sites dating to MIS 3, a period that is poorly known in South Africa, especially from the far better studied southern Cape coastline. So far the data indicates that Namaqualand was more often occupied when it was generally cooler and more humid than it is today, conditions that at times could have supported grasslands and thus large game. However of equal interest is that people were present when the region was not as "easy", during MIS 5 and parts of MIS 3 for example. Future research will expand our datasets to hopefully provide much more detailed understandings of when humans occupied different parts of Namaqualand, why humans were drawn or pushed into the region, and the environmental conditions that prevailed both when people were there and, importantly, absent. For example, the rare grasses in Namaqualand today are of the C_3 type, while those of neighboring Bushmanland are C_4. We can thus use stable isotope analysis to test whether environmental changes simply increased the availability of local species or were more complex and involved shifting rainfall zones with a concomitant westward expansion of Bushmanland grasses. Most crucially, improving our knowledge of the adaptive strategies involved in colonizing and mastering such shifting environments is essential for illuminating the processes underlying modern human behavioral evolution.

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Appendix A

The proxy data presented in this study, the associated dates, implications and sources of the data. The dates are presented as they were in their published form while the calibrated dates column reflects calculations for this study.

Marine isotope stage 6: Glacial 191–130 ka	Data	Signal	Date	Calibrated dates at 1σ (for this study) cal BP[b]	Implication	References
	Pollen[a]	High percentage of *Restionaceae* and desert/semi-desert taxa			Humid	Shi et al. (2001)
	Terrigenous sediments[a]	Grain size suggests increase in proportion of fluvial sediment deposits			Humid	Stuut et al. (2002)
Southern Cape sea level	Strontium isotopes	Slight increase in $^{87}Sr/^{86}Sr$	189.7 ka		Minor regression	Fisher et al. (2010)
Southern Cape sea level	Paleoscape model: Bathymetry and GIS[a]	>30 km from modern coastline	184.5 ka		Minor regression	Fisher et al. (2010)
Eastern Cape sea level	Uranium series dating of aeolianite	Beachrock at −3 m amsl	182,000 ± 18,000 (Pta-U430)		Minor transgression	Ramsey and Cooper (2002)
Southern Cape sea level	Strontium isotopes	Slight increase in $^{87}Sr/^{86}Sr$	173 ka		Minor regression	Fisher et al. (2010)
Southern Cape sea level	Paleoscape model: Bathymetry and GIS[a]	~4.81 km from modern coastline	167 ka		Minor transgression	Fisher et al. (2010)
Southern Cape sea level	Strontium isotopes	Slight decrease in $^{87}Sr/^{86}Sr$	167 ka		Minor transgression	Fisher et al. (2010)
Southern Cape sea level	Strontium isotopes	Peak high ratio of $^{87}Sr/^{86}Sr$ at ~152 ka	Between 155 and 150.5 ka		Major regression	Fisher et al. (2010)
Southern Cape sea level	Paleoscape model: Bathymetry and GIS[a]	Maxima peak/~91.11 km from modern coastline	150.5 ka		Major regression peak	Fisher et al. (2010)
Southern Cape sea level	Paleoscape model: Bathymetry and GIS[a]	Maxima peak/~96.51 km from modern coastline	137 ka		Major regression peak	Fisher et al. (2010)

Marine isotope stage 5: Last Interglacial 130–71 ka	Data	Signal	Date	Calibrated dates at 1σ (for this study) cal BP[b]	Implication	References
	Pollen[a]	Sharp decline of *Restionaceae* and desert/semi-desert taxa, replaced by Kalahari dry forest taxa, but they rebound at the end of this stage			Arid with an increase in humidity by MIS 5a	Shi et al. (2001)
	Terrigenous sediments[a]	Drop in fluvial input at stage MIS 5e, moderate at MIS 5d, sharp increases during MIS 5c and MIS 5a			Arid with slowly increasing humidity and humid peaks at MIS 5c and 5a	Stuut et al. (2002)
Southern Cape sea level	Paleoscape model: Bathymetry and GIS[a]	Minima/~1 km from modern coastline	~130 ka		Major transgression	Fisher et al. (2010)
Southern Cape sea level	Strontium isotopes	Decrease in $^{87}Sr/^{86}Sr$ to near modern values	~130 ka		Major transgression	Fisher et al. (2010)
	Shellfish	Boegoeberg 2: shellfish suggests coastline is near modern location	MIS5e, b or a?			Klein et al. (1999)
Eastern Cape sea level	Inferred date	+4 m amsl highstand	MIS5e?		Minor transgression	Ramsey and Cooper (2002)
Eastern Cape sea level	Uranium series date of aeolianite	−44 m amsl lowstand	117,00 ± 7,000 (Pta-U487)		Regression	Ramsey and Cooper (2002)
Eastern Cape sea level	Ionium dates from Klasies River Mouth	+4 m amsl highstand	110 ka and 98 ka		Minor transgression	Hendley and Volman (1986), Ramsey and Cooper (2002)

(continued)

Marine isotope stage 5: Last Interglacial 130–71 ka	Data	Signal	Date	Calibrated dates at 1σ (for this study) cal BP[b]	Implication	References
	Amino acid racemization date	Erb Tanks	85 ka		Presence of people in the landscape	McCall et al. (2011)
Southern Cape sea level	Paleoscape model: Bathymetry and GIS[a]	Peak/15.56 km from modern coastline	~72.5 ka		Regression	Fisher et al. (2010)
Southern Cape sea level	Strontium isotopes	Slight increase in ^{87}Sr/^{86}Sr	~72 ka		Regression	Fisher et al. (2010)
Marine isotope stage 4: Glacial 71–57 ka	**Data**	**Signal**	**Date**	**Calibrated dates at 1σ (for this study) cal BP[b]**	**Implication**	**References**
	Pollen[a]	Steady increase in *Restionaceae* and desert/semi-desert taxa			Increasing humidity	Shi et al. (2001)
	Terrigenous sediments[a]	Peak input of aeolian dust and trade winds, but winds reduce before the end of the stage			Increasing humidity	Stuut et al. (2002)
	OSL date and fauna	Apollo 11: Still Bay points and arid adapted species + equids (grazers)	70.7 ± 2.6 ka (AP6)		Presence of people on the landscape in a modern-like environment with grass available: more humid?	Vogelsang et al. (2010)
	Relative dating	Namaqualand coast: Still Bay artefacts	~70 ka		Presence of people on the landscape	Dewar (2008)
	Relative dating	VR3: Still Bay artefacts	~70 ka		Presence of people on the landscape	Steele et al. (2012)
	Relative dating	STF001: Still Bay points	~70 ka		Presence of people on the landscape	Mackay et al. (2010)
	OSL date	Apollo 11	66.9 ± 2.6 (AP5)		Presence of people on the landscape	Vogelsang et al. (2010)
	Amino acid racemization date on eggshell	Erb Tanks	65 ka		Presence of people on the landscape	McCall et al. (2011)
	OSL date and fauna	Apollo 11: Howieson's Poort and arid adapted species + equids (grazers)	63.2 ± 2.3 ka (AP4)		Presence of people on a modern-like landscape but more humid with grass available?	Vogelsang et al. (2010)
	Amino acid racemization date on eggshell	Erb Tanks	60 ka		Presence of people on the landscape	McCall et al. (2011)
Southern Cape sea level	Strontium isotopes	Decreasing ^{87}Sr/^{86}Sr for a short period	~60 ka		Transgression	Fisher et al. (2010)

(continued)

Marine isotope stage 4: Glacial 71–57 ka	Data	Signal	Date	Calibrated dates at 1σ (for this study) cal BP[b]	Implication	References
Southern Cape sea level	Paleoscape model: Bathymetry and GIS[a]	Shoreline steadily returns to near modern values for a short period	~60 ka		Transgression	Fisher et al. (2010)
	Relative dating	Namaqualand coast: Howieson's Poort	~60 ka		Presence of people on the landscape	Dewar (2008)
	Relative dating and fauna	VR3: Howieson's Poort and browsing tortoises dominate	~60 ka		Presence of people on an arid landscape with browse available	Steele et al. (2012)
	Charcoal	Apollo 11: Diverse array of woody vegetation similar to modern environment or more favorable	58 ± 3 ka (AP9)		Semiarid and or slightly more humid	Vogelsang et al. (2010)

Marine isotope stage 3: Stadial 57–29 ka	Data	Signal	Date	Calibrated dates at 1σ cal BP (for this study)[b]	Implication	References
	OSL and Charcoal	Apollo 11: Single species of Xeric taxa *Chenopodiaceae* during occupation hiatus	Between 57.9 ± 2.6 ka (AP3) and 42.9 ± 2.7 ka (AP2)		Arid	Vogelsang et al. (2010)
	Pollen[a]	Decreasing but fluctuating levels of *Restionaceae* and desert/semi-desert species	~57–50 ka		Drying?	Shi et al. (2001)
Southern Cape sea level	Paleoscape model: Bathymetry and GIS[a]	Coastline shifts to ~18 km from the modern shore	~57–40 ka		Slight regression	Fisher et al. (2010)
Southern Cape sea level	Strontium isotopes	Slight decrease in $^{87}Sr/^{86}Sr$ ratios	~55 ka		Slight transgression	Fisher et al. (2010)
	Pollen[a]	Increasing proportion of *Restionaceae* and desert/semi-desert taxa with a peak at 32 ka	50–29 ka		Increasing humidity	Shi et al. (2001)
Southern Cape sea level		Steady increase in $^{87}Sr/^{86}Sr$	~55–27 ka		Regression	Fisher et al. (2010)
	Terrigenous sediments[a]	Rapidly fluctuating aeolian dust input and trade winds			Instability?	Stuut et al. (2002)
	^{14}C on Ostrich eggshell, fauna and gypsum	SptzA arid adapted species, primarily browsers but Gemsbok suggests some grass. Gypsum crystals present	~52–51 ka		People on the landscape in a (semiarid) modern-like environment but with increased humidity	Dewar and Stewart (2012, this volume): Table 11.1
Eastern Cape sea level	^{14}C dated Wetland Peats	−52 m amsl lowstand	45,200 ± 2,000 ^{14}C BP (Pta-4140)	49,968–47,070	Regression	Ramsey and Cooper (2002)
	^{14}C on ostrich eggshell and fauna	Boegoeberg1: Large hyenas and water-dependent grazing species	37,220 ± 5,010 ^{14}C BP (GX-22191)	45,433–36,161	Cool/humid with grass	Klein et al. (1999)
Eastern Cape sea level	^{14}C dated wetland Peats	−46 m amsl lowstand	39,100 ± 1,530 ^{14}C BP (Pta-4142)	44,286–41,875	Regression	Ramsey and Cooper (2002)
	Amino acid racemization dates on eggshell	Erb Tanks	45 ka		Presence of people on the landscape	McCall et al. (2011)
	OSL	Apollo 11	43 ± 3 ka (AP2)		Presence of people on the landscape	Vogelsang et al. (2010)
	^{14}C on ostrich eggshell and fauna	Boegoeberg1: Large hyenas and water-dependent grazing species	34,990 ± 3,110 ^{14}C BP (GX-21190)	42,061–36,101	Cool/humid with grass	Klein et al. (1999)
	^{14}C on ostrich eggshell and fauna	Boegoeberg1: Large hyenas and water-dependent grazing species	33,230 ± 2,630 ^{14}C BP (GX-21189)	40,118–34,755	Cool/humid with grass	Klein et al. (1999)

(continued)

Marine isotope stage 3: Stadial 57–29 ka	Data	Signal	Date	Calibrated dates at 1σ cal BP (for this study)[b]	Implication	References
Southern Cape sea level	Paleoscape model: Bathymetry and GIS[a]	Slight shift to ~10 km from modern shoreline	~40 ka		Shallow transgression	Fisher et al. (2010)
	Calibrated ^{14}C dates	Apollo 11 occupational pulses	~37 cal BP		Presence of people on the landscape	Vogelsang et al. (2010)
Southern Cape sea level	Paleoscape model: Bathymetry and GIS[a]	Coastline moves to ~25 km from modern shore	~32 ka		Slight regression	Fisher et al. (2010)
	Calibrated ^{14}C dates	Apollo 11 occupational pulses	~32–29 calBP		Presence of people on the landscape	Vogelsang et al. (2010)
	^{14}C dated peat bed	Peat bed at Kannikwa near Port Nolloth	27,900 ± 310 ^{14}C BP	31,998–31,269	High humidity	Beaumont (1986)
Orange River Mouth sea level	^{14}C marine shell	−78.4 m amsl lowstand	27,800 ± 440 ^{14}C BP (Pta-1104)	30,881–31,506[d]	Regression	Vogel and Visser (1981)
	OSL and fauna	Apollo 11: arid adapted species + equids and warthog (grazers)	30 ± 1.4 ka (AP11)		Landscape is slightly more humid than today. Some grass available?	Vogelsang et al. (2010)
Southern Cape sea level	Paleoscape model: Bathymetry and GIS[a]	Shore returns a few km to ~22 km from modern coast	~30 ka		Shallow transgression	Fisher et al. (2010)
Marine isotope stage 2: Last Glacial Maximum 29–14 ka	Data	Signal	Date	Calibrated dates at 1σ cal BP (for this study)[b]	Implication	References
Eastern Cape sea level	Durban Bay: ^{14}C dated Wetland Peats	−22 m amsl stand	24,950 ± 950 ^{14}C BP (GaK-1390)	29,949–27,997	Transgression	Ramsey and Cooper (2002)
	Pollen and charcoal	Elands Bay Cave: Woodland taxa peak and xeric taxa minimum + drought-intolerant species	20.5–17.8 ^{14}C kBP	~25,098–24,314 to 21,904–21,110[c]	High humidity	Meadows and Baxter (1999)
	Pollen[a]	Peak percentage of *Restionaceae*	~24 ka		High humidity	Shi et al. (2001)
	Terrigenous sediments and trade wind proxies[a]	Peak fluvial activity and trade winds	~24 ka		High humidity	Stuut et al. (2002)
	^{14}C Hyrax dung Pollen	*Olea, Stoebe* type, *Artemesia,* and fern pollen co-occurring with dwarf shrubs	17,000 ± 190 ^{14}C BP (Pta-8902)	20,739–20,248	Cool and moist or increased evapotranspiration	Scott et al. (2004)
Southern Cape sea level	^{14}C *Pecten sp.* shell	−130 m amsl maximum	16,990 ± 160 ^{14}C yrs BP (Pta-182)	20,044–19,605[d]	Last Glacial Maximum peak	Vogel and Marais (1971)
	Pollen[a]	*Restionaceae* percentages declining	~19–14 ka		Declining humidity	Shi et al. (2001)
	Terrigenous sediments and trade wind proxies[a]	Fluvial activity and trade wind curves declining	~19–14 ka		High humidity declining through time	Stuut et al. (2002)
Orange River Mouth sea level	^{14}C marine shell	−87.2 m amsl lowstand	16,100 ± 160 ^{14}C BP (Pta-1105)	18,982–18,611[d]	Regression	Vogel and Visser (1981)
	Pollen	Cederberg Mountains: increasing fynbos, thicket and succulent vegetation	13,000 ± 130 ^{14}C BP (Pta-5896) to 11,390 ± 100 ^{14}C BP (Pta-6041)	15,695–15,289 to 13,281–13,100	Increasing temperatures and reduced precipitation	Scott and Woodborne (2007a, b)
	Pollen	Eksteenfontein spring: *Stoebe/Elytopappus* indicate cool temperatures and increase of Karoo-like environment	15.2–13.6 calBP (extrapolated dates)		Cool and humid replaced by aridity	Scott et al. (1995)

[a] Dates were extrapolated using the oxygen isotope curve

[b] This study calibrated ^{14}C dates using the software Calib 7.0 and the Shcal13.14c calibration curve (Hogg et al. 2013; Reimer et al. 2013)

[c] No error provided, dates were calibrated with an approximate error of ±300 yrs

[d] Marine shell was calibrated using the calibration curve Marine13.14c with a ΔR value of 146 ± 85 (Dewar et al. 2012; Reimer et al. 2013)

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