HISTORY AND SELECTION IN THE LATE PLEISTOCENE ARCHAEOLOGY OF THE WESTERN CAPE, SOUTH AFRICA

Volume 1

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I hereby declare that the work contained in this thesis is entirely my own except where the work of others has been acknowledged. This thesis has not previously been submitted in any form for any other degree at this or any other university.

Alex Mackay

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ABSTRACT

This thesis examines late Pleistocene changes in stone artefact technologies at five sites in the Western Cape province of South Africa. Previous approaches to late Pleistocene technological change in the region are demonstrated to have been affected by uncritically accepted ideas derived from foundational works. In particular, culture history and cultural evolutionism are shown to have influenced the ways in which archaeological materials have been presented and interpreted. As a consequence of these schools of thought, the nature, causes and significance of technological change in the period under consideration remain poorly understood.

With reference to Dual Inheritance Theory, Optimal Foraging Theory and theory related to the organization of technology, the thesis argues that the technological changes witnessed at the five sites examined reflect a sequence of adaptations to spatial and temporal variation in the distribution of critical resources. These adaptations include variance in population mobility and in the dispersal of individuals and groups across the study area. Data related to mobility and dispersal suggest that at certain points in the late Pleistocene the study area was occupied by at least two distinct groups, with different tendencies in implement manufacture.

Technological variation is found to be a regular facet of the sequences considered, though the intensity of variation appears to increase during periods of major environmental change. Culture-historic units such as the Howiesons Poort and Still Bay are shown to be points in an on-going and fluid process of adaptation. Moreover, these units are shown to be complex and internally variable, rather than discrete and static entities. Arguments to the effect that technological systems such as those represented by the Howiesons Poort and Still Bay are inherently advantageous over other late Pleistocene technologies are inconsistent with the evidence presented. Instead it is suggested that these and other technological systems were subject to regular turnover as part of the adaptive process. In considering these changes, the thesis also provides an explanation for the disappearance of prepared core systems from the study area, and, by extension, for the end of the Middle Stone Age.

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This thesis is dedicated to my family, who have seen me stay at university damn near into middle age with only a bare minimum of pointed remarks, and whose support along the way has been boundless. I suppose I should now get a job. Or something like that ...

1

INTRODUCTION

1.1 INTRODUCTION

This thesis is underpinned by two aims. The first and most important is to fill a spatial gap in our understanding of the late Pleistocene archaeology of southern Africa. This aim is met by presenting new information about sequences of stone artefacts recovered from a series of sites occupied intermittently through the period from ~120 ka[1] to ~20 ka. The second aim is to provide an explanation for why the changes observed take the forms they do. Though approaches which seek to explain, rather than simply to describe, changes in stone artefact technology have become increasingly frequent over the last 30 years, they remain uncommon in studies of the late Pleistocene archaeology of southern Africa. (The reasons for this are considered in Chapter 3).

The difficulty that arises when attempting to explain changes in stone artefacts is that few if any of us have ever had to live for prolonged periods with stone artefacts as a critical component of our technological interaction with the subsistence environment. Thus, familiar though the concept of cutting-edge tools may be, we have only a very limited relational basis on which to understand the factors which affect past human decisions about what kinds of artefacts to make, and when and how to make them. Because of this, our explanations of changes need to be built on robust theoretical platforms.

For the purposes of this thesis, three bodies of theory are employed – Dual Inheritance Theory, Optimal Foraging Theory, and theory relating to the organization of technology. The perspective taken is that the stone artefacts manufactured at any particular point in space and time will reflect the inter-related processes of history and selection. History is

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[1] Throughout this thesis, 'ka' is used to signify 'thousand years ago'. 'Kyr' is used to refer to intervals of time in thousands of years. All radiocarbon dates will be given as calibrated years before present (cal yr BP) except where otherwise specified.

viewed here as a through-time process composed of contingency and variability. In this context, contingency refers to the transmission of information, both ideational and genetic, from one generation to the next (and within generations in the case of ideas). Variability refers to the tendency of that information to change within and between episodes of transmission as a result of a variety of processes. It is contingency which gives consistency to history, and which makes cultural studies possible; it is variability, on the other hand, which makes cultural studies worthwhile.

At the same time, the transmission of information through time and across space is not an undifferentiated process. Some ideas, like some genes, will be more successful in one context than another. Selection thus provides what we might think of as horizontal pressure on the vertical flow of history, constantly rechannelling and reshaping historical information. Combined, an appreciation of historical and selective processes allows us to begin to understand why things happen the way they do.

In this thesis, history, and particularly historical contingency, is important for explaining not only archaeological data, but also approaches to archaeology – why, that is, we do archaeology the way we do, and how this shapes the way we see the archaeological record. In the same way an artefact maker is not entirely free of the traditions into which she/he is born, we as archaeologists are not free from the interests and approaches of our forebears. In the case of southern Africa, the history of these interests and approaches is a particularly fascinating one, and consideration of it helps to explain at least some of the major issues with which we find ourselves confronted.

The thesis begins with a review of the archaeology of southern Africa from 220 ka to 20 ka (Chapter 2) as it is presently known. Necessarily, within the constraints of a dissertation such a review cannot be exhaustive, and readers are directed to the more fulsome summaries offered by Mitchell (2002) and Deacon and Deacon (1999). The review has multiple objectives, though the primary one is to provide a context within which to place the new information to be presented. A secondary objective is to highlight the information gap that this study will in part fill.

Chapter 3 presents a brief history of southern African archaeology, with an emphasis on late Pleistocene studies. Two schools of thought – culture evolutionism and culture history

– are argued to have been of particular importance to past and present archaeological work. The limitations and effects of these schools of thought are critically assessed, and the need for new, more theoretically informed approaches is highlighted.

The theoretical approaches to be employed in this thesis are presented in Chapter 4. The chapter begins by briefly stating the case for using evolution as a principle for the understanding the structure of archaeological material. Subsequently, the focus is on providing means for analyzing the historical processes of variation and transmission, and for modeling optimal subsistence, settlement and technological responses to environmental variation. Dual Inheritance Theory (DIT), as described by Boyd and Richerson (1985, 2005; also Bettinger 1991), is used to provide a platform for historical analysis. Insights from Optimal Foraging Theory (OFT) are used to model variance in subsistence and settlement systems under different conditions.

The final facet of the theoretical approach is derived from the loosely-aligned body of work often referred to as the organization of technology (cf., Nelson 1991). It is suggested that technological systems have costs and benefits that vary with the organization of settlement and subsistence, and with the constraints of the environment within which they area deployed. As with OFT, the objective here is to model what are likely to have been the most effective technological strategies given a variety of conditions.

Chapter 5 introduces the study area. This includes discussion of the configuration of relevant resources in the area, and how these may have changed through time in response to broad-scale environmental variation. Previous archaeological research in the area, which has generally been focused on the Holocene, is briefly discussed as a background against which late Pleistocene patterns can be compared and contrasted. Chapter 5 also introduces the five sites – Diepkloof, Elands Bay Cave, Klein Kliphuis, Klipfonteinrand and Hollow Rock Shelter – which form the basis of the thesis.

In Chapter 6, the environmental and site sequence information presented in Chapter 5 are combined with the theoretical platform developed in Chapter 4 to generate hypotheses about expected changes to settlement, subsistence and technology in the study area through the late Pleistocene. Hypotheses are important because, as Bettinger (1991: 164) notes, without hypotheses, DIT, OFT and the organization of technology amount to little more than just-so stories. The purpose of such hypotheses is not to make correct statements about the past of an area, but to make explicit, theoretically-grounded, and testable statements about the past. In addition to the favoured hypotheses developed here, three alternative hypotheses, derived from recent work in southern Africa but reconfigured so as to be testable against the available data, are also presented.

The aspects of technological change to be considered and their relationship to the hypotheses are discussed in the Methods chapter, Chapter 7. The results of analysis are presented in Chapter 8. In Chapter 9, the results from Chapter 8 are considered in terms of the hypotheses.

The conclusion to the thesis (Chapter 10) summaries the results and presents a discussion of changing technological and land use systems in the study area through the period from 120 ka to 20 ka. The implications of the results for broader regional issues are considered, with reference to the results of other research as presented in Chapter 2. The thesis concludes with some reflections on the archaeology and archaeological history of southern Africa, and its relationship with wider issues in human prehistory.

A brief note on terms and issues

Most of the material with which this thesis deals might be described as belonging to the Middle Stone Age, or MSA. The MSA is one of three Ages in a scheme devised by A.J.H Goodwin (Goodwin and van Riet Lowe 1929) to organize southern African archaeological finds. Goodwin’s three-age scheme of Earlier, Middle and Later Stone Ages was developed as a local equivalent of the European Lower, Middle and Upper Palaeolithic and has often been viewed in this way since. Consequently the scheme comes laden with considerable conceptual baggage, which is outlined in more detail in Chapter 3.

The objective of this thesis is to explore and explain technological and other behavioural changes through the late Pleistocene in terms of history and selection. History, as noted above, is a fluid process. Though it is always necessary for the purposes of analysis to divide and categorise data into units, the perspective taken here is that the units used must be appropriate to the specific aims and objectives of analysis. Thus what is important in a unit is not its objective reality, but its utility. Goodwin’s three age scheme, which partitions the late Pleistocene into the MSA and LSA, is not considered useful for the purposes of this thesis. This issue is discussed at greater length in Chapter 4.

In a similar vein, the argument about behavioural modernity (cf., Henshilwood and Marean 2003; Klein 1989, 1995; McBrearty and Brooks 2000) has been central to much recent work on the late Pleistocene of southern Africa. Consequently, a degree of correlation has developed between studies of southern Africa's late Pleistocene and engagement with the 'modernity' debate. With this comes some expectation of continuity in that relationship.

Modernity is not, however, considered at any great length in this thesis. There are several reasons for this. The first is that the thesis deals primarily with stone artefacts, and the relationship between stone artefacts and behavioural modernity is a fraught one at best. While the forms of certain artefacts, most notably bifacial points and backed artefacts, are often taken to be directly relevant to the question of when humans became behaviourally 'modern' (eg., Foley and Lahr 2003; Mellars 2006a,b; Minichillo 2005; Moore *et al*. In Press), such inferences are problematic. Both bifacial points and backed artefacts have Middle Pleistocene antiquity in central Africa (Barham 2002; Barham and Smart 1996; Beaumont and Vogel 2006; Clark and Brown 2001) and occur early in the MSA in southern Africa (cf., Beaumont and Vogel 2006; Kuman *et al*. 2005, yet their first appearance is rarely heralded to mark the appearance of modern behaviour. As importantly, a number of later Pleistocene and Holocene archaeological records are bereft of such implement forms but it is not argued that the authors of these records were in any way non-modern (Brumm and Moore 2005; Mackay and Welz 2008). The importance of any given type of implement in respect to the modernity debate seems to hinge largely on whether or not it is associated with the European Upper Palaeolithic (McBrearty and Brooks 2000). Why the Upper Palaeolithic should be accepted as the arbiter of whether or not a technology reflects behavioural modernity is unclear. Perhaps more critically, it is not obvious that an archaeological signature of modern behaviour actually exists, and it is thus open to question whether or not the concept of 'modernity' has any meaning with relation to archaeology generally, or to stone artefacts specifically (Kusimba 2005; Mackay and Welz 2008).

As noted above, the subjects with which any work deals must be relevant to its aims. The issue of behavioural modernity is not central to the aims of this thesis, and it is thus central neither to the organization the thesis nor to its discussion. Some possible implications for the debate arising from the results of the thesis are, however, considered in the conclusions.

2

ASPECTS OF THE LATE PLEISTOCENE ARCHAEOLOGY AND ENVIRONMENTS OF SOUTHERN AFRICA

2.1 INTRODUCTION

This chapter provides a summary of current knowledge about the archaeology and environments of southern Africa during the late Pleistocene. Though the focus of this thesis is on archaeological changes in the Western Cape specifically, data from the sub-continent more broadly are presented. There are several reasons for this. Primarily, at present there is insufficient published information about the pre-Holocene occupation of the Western Cape for the review to focus on this region alone. It is in part this information gap which this thesis is designed to fill. Understanding of the broader context is also necessary to appreciate the significance of the results to be presented. At another level, many of the processes previously argued to have influenced archaeological signatures in southern Africa are considered to have operated at the sub-continental, rather than local or regional scales. Assessing the validity of these claims requires an understanding of the wider archaeological pattern. The temporal span of the summary also exceeds that with which the thesis is directly concerned. Archaeological and environmental data covering the range from 220 ka to 20 ka are presented. The earlier parts of this period are discussed relatively briefly, with a stronger focus on the period post-dating 120 ka.

As discussed in the following section *Temporal organisation of data*, the review is divided into three temporal blocks, and each block is sub-divided into three sections. The first section deals with patterns in occupation and stone artefact technology. The second deals with faunal data, though in many cases, only a few well-preserved and well-published assemblages are available for consideration. The third section deals with current knowledge concerning environmental changes.

2.1.1 Temporal organisation of data

One of the objectives of this thesis is to understand the meaning of changes in technological organisation in southern Africa through time. This aim is complicated to an extent by the general lack of chronometric control over the majority of known archaeological assemblages. Most of the time period with which this thesis is concerned lies beyond the range of ^{14}C dating, and as such has been beyond the effective limits of chronometry until the last 15-20 years. Consequently, only recently excavated sites tend to be dated, and in many cases, those sites have produced only a few dates. Although concerted dating programs, such as that pursued recently by Jacobs and colleagues (Jacobs *et al.* 2008a), have improved this situation, even such thorough work has tended to target certain periods of interest, rather than entire sequences.

Thus, when faced with a decision about how to structure a review of past archaeological work, three options present themselves. The first is to forgo discussion of archaeological materials which are undated, and concentrate only on dated material. The second option is to forgo time as an organising principle, and group materials instead by similarities in their composition. The former of these options would involve ignoring too much data and would thus negate the value of the review. The latter option would make it largely impossible to integrate archaeological data with other streams of information, such as palaeoecology.

The third option, and that selected here, involves using dated materials to infer the ages of undated materials, based on the assumption that compositional similarities between assemblages broadly imply comparability of ages. Relative stratigraphic positioning provides one independent, if loose, check on this assumption, while the demonstrated tendency for similar materials to date to similar ages provides a degree of confidence in the assumption’s general validity. Nevertheless, this approach remains far from ideal, and its application has consequences for interpretations of archaeological sequences that need further consideration. This is provided in Chapter 3, in the section on *Culture history in southern African archaeology*. Similarly, the bracketing dates used for temporal blocks should be considered somewhat ‘fuzzy’. In placing the Howiesons Poort within a temporal block from *80-60 ka* it is not implied that all Howiesons Poort-like assemblages necessarily antedate 60 ka, but rather that the bulk of such assemblages in the preponderance of sites appear to antedate this time.

Having decided on a means of organising archaeological data, it remains to settle on a scheme with which to divide time. The most obvious option is the Oxygen Isotope Stage (OIS) system, which would allow archaeological data to be 'built into' an existing environmental framework. The primary problem with such an approach is in the assumption that archaeologically-meaningful changes will necessarily cohere with global-scale climate variation. This seems unreasonably presumptive, and runs the risk of being proscriptive – forming archaeological units in terms of environmental units will almost certainly create the impression that the latter is a determinant of the former. While such a relationship may well exist, and indeed, consideration of this issue is important later in this thesis, it seems preferable to start without assuming that it does.

With these points in mind, the review considers the archaeology of southern African from ~220 ka to ~20 ka in terms of three temporal blocks; 220-80 ka, 80-60 ka, 60-20 ka. These blocks are relatively arbitrary, though breaks generally correlate with significant assemblage changes. At the same time, these blocks should not be misunderstood as being intended to be behaviourally meaningful in the sense of the units created by Volman (1981), Singer and Wymer (1982), or others (Minichillo 2005; Wurz 2002). This is not an attempt to provide a new framework, but only to provide a general structure within which to discuss the available data.

2.1.2 Volman's scheme

Tom Volman's (1981) PhD thesis is the most wide-ranging and thorough work on the stone artefact technologies of late Pleistocene[2] southern Africa yet produced. Volman analysed in detail artefacts from eight sites, and provides a summary discussion of more than 80 others both in southern Africa and beyond. The objective of his thesis was primarily to provide a framework within which to place the burgeoning number of assemblages collected from southern African sites, particularly those in the southern Cape region. The result was a four-

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[2] Volman's was a study of 'Middle Stone Age' rather than 'late Pleistocene' technologies per se. In effect, however, the temporal coverage is little different from that of this thesis.

part scheme based on gross morphological similarities between artefacts in different sites. At the time in which Volman was writing there was no effective chronometry capable of dealing with the ages of the materials with which he was working. Studies of geomorphology, site formation and mammalian species representation provided some general clues to the age of finds, but, out of necessity, Volman worked from the premise that like artefacts would be of like ages. Thus, each of the units described was believed to represent a block of time.

Though chronometry has greatly developed since the 1980's, the majority of Volman's sites remain undated. This is particularly true of apparently older assemblages. Moreover, few have subsequently been reanalyzed. Thus, Volman's thesis remains a key reference text. Importantly, as the accounts given of different assemblages could not be comprehensive within the constraints of his thesis, it is difficult to divorce the data presented from the scheme they were used to develop. That is, the data discussed from many sites are only those relevant to the formulation of the scheme. In consequence, making use of Volman's assemblage descriptions necessitates, to some extent, employing his scheme as well. For these reasons, a brief introduction to Volman's scheme is presented here. Volman's groupings are presented in chronological order from oldest to youngest. All quotes in the following are from Volman (1981), pages 249-257.

Early MSA 1

The oldest unit in the scheme, MSA 1 is characterized by assemblages with "very few formal tools", "relatively short, broad flakes" and "a very low incidence of multiple faceted butts". With regard to materials used in artefact manufacture, Volman states: "at Elands Bay and Peers Cave [these] are overwhelmingly quartzite … at Melkbosstrand and Duinefontein 2 flaked stone is mostly medium quality silcrete".

Early MSA 2

The second oldest unit in the scheme is MSA 2, which Volman sub-divided into 2a and 2b. MSA 2a is characterized by rare formal tools, of which denticulates are the most common category. Scrapers and bifacial points are also noted, but unifacial points appear to be absent. Flakes are "long and narrow … and the proportion of multiple faceted butts is relatively high". "Raw materials in these assemblages are almost entirely quartzite".

MSA 2b is differentiated from 2a by a "higher incidence of retouch" and a "greater diversity of retouched pieces". Unifacial points were noted in all 2b samples examined, and bifacial points were observed in all but one sample. Denticulates, the most common retouched artefact form in MSA 2a assemblages, were rare or absent from most samples, though "denticulate endscrapers" were present in all but one site. In addition, "[e]very site provided rare backed pieces which would not be out of place in Howieson's Poort assemblages". Faceted butts remained common, but less so than in MSA 2a, with an increase in the proportions of 'plain' and 'simple' butts. Similarly, while materials in most sites remained quartzite-dominated, the proportion of non-quartzite pieces was generally greater than in MSA 2a.

Howiesons Poort

Howiesons Poort samples are differentiated from those of other MSA units by the prevalence of backed pieces, including "segments, trapezoids and other backed and/or truncated forms", in the retouch sample. The occurrence of other implement types is more highly variable. Unifacial and bifacial points are noted in one site, but are generally absent from others, as are denticulates. Scrapers of various forms appear to occur in most sites, though their prevalence is not discussed. The proportion of faceted butts is variable. Material prevalence is generally distinct from other MSA units, with fine-grained rocks such as silcrete far more prevalent.

Late MSA

Volman described the Late MSA as a "convenient label for all those southern Cape MSA assemblages which lack characteristic Howieson's Poort formal tools and which either overlie Howieson's Poort assemblages or appear to be younger than both Howieson's Poort and early MSA assemblage on other grounds". Consequently, the unit is heterogeneous. The defining features of assemblages in this unit are the "emphasis on denticulate-like modification of edges … and their rare unifacial points". Scrapers and "a few large backed flakes" are also noted. Quartzite is the dominant material is some sites but some "sequences demonstrate considerable variability in raw material proportions through time".

In the following sections of this chapter, the units MSA 1, MSA 2a and MSA 2b will be used to help group assemblages. Volman's definition of Howiesons Poort remains broadly current, though there have been additions and amendments (discussed below). The 'heterogeneity' in Volman's final unit, which is broadly equivalent with the temporal block '60-20 ka', has been considerably fleshed out, to the extent that the unit as he defines it is not a particularly useful way of understanding what is, in the scheme of late Pleistocene technological change, a critical period. In general, the reductive nature of Volman's scheme gave it a limited capacity to deal with the variability which is becoming increasingly apparent. Finally, it should be noted that Volman's scheme does not include the 'Still Bay', a unit which has existed for more than a century but which has recently been revived to great effect and greater attention. These later units (Still Bay, Howiesons Poort, late MSA) are also now considerably better dated than the earlier units, making the coarse typological framework less necessary. The utility of Volman's work lies largely in the organisation of material from earlier (pre-80 ka) periods.

2.1.3 Spatial organisation of data

Spatially, patterns in southern African archaeology and environments will be discussed in terms of current rainfall seasonality zones, with occasional reference made to a simple division of coast/coastal plain, montane, and interior settings. Three rainfall zones are identified based on the time of year when the majority (> 66%) of rain presently falls (Figure 2.1; cf., Chase and Meadows 2007). The winter rainfall zone (WRZ), receives the most of its rain from April to September and is largely restricted to the south west of southern Africa. Conversely, the summer rainfall zone (SRZ), which dominates much of the east, south east and interior of the continent, receives the majority of its rain between October and March. Lying at the interface of these two zones is the year-round rainfall zone (YRZ), which receives significant input throughout the year.

It should be noted that other researchers have favoured spatial schemes based on vegetation biomes (e.g., Mitchell 2002, 2008; Wadley 1993; cf., Mucina and Rutherford 2006), and that this clearly provides a more complex and nuanced means of approaching spatial patterns in the region. At present, however, the total sample of sites occupied 220-20 ka relative to the number of biomes (n=9) renders this approach relatively cumbersome. Specifically, several biomes are represented by only a few sites, and these commonly provide a discontinuous record through most of the period of interest. Biome boundaries were also variable in the past, and while this is also true of rainfall seasonality patterns, there are limited grounds for predicting the ways in which biome boundaries will be reorganized under different conditions, particularly in the general absence of terrestrial vegetation records. It may also be that some present biomes have no past analogue, and vice versa. Thus, though the biome-based approach is almost certainly more meaningful in many ways, the rainfall-zone approach is a sufficiently useful heuristic device for the purposes of this thesis.

2.1.4 Proxy indicators and environmental controls

Each temporal block incorporates a summary of environmental changes. Complicating these summaries is the general paucity of good terrestrial archives and the fragmentary nature of those archives which do exist. The result is that the environmental sections suffer from a heavy reliance on proxy indicators derived from marine cores, and modeling based on rainfall controls and their relationship with global- and regional-scale climate changes.

Temperature and rainfall provide key controls over biomass (cf., Kelly 1995), and are thus of relevance to past patterns of occupation. Temperature changes are inferred using a combination of terrestrial records and Antarctic ice cores. Because of the good resolution of data it provides for the study period, the Epica Dome C ice core will be used to assess southern hemisphere temperature fluctuations in the majority of cases. Detailed, long-duration terrestrial rainfall records are sparse outside of the SRZ, however, rainfall is generally expected to have responded to global temperature changes (and concomitant variance in Antarctic ice volume) and sea surface temperatures (SST’s) (Chase and Meadows 2007; Nicholson and Flohn 1980; Tyson and Preston-Whyte 2000).

In the WRZ, precipitation derives chiefly from frontal systems embedded in the westerly storm tracks, which blow south of the African continental mass during summer, but which migrate north in the colder months (Chase and Meadows 2007). With an expansion of

Antarctic ice under globally cooler conditions, the westerlies are expected to have been forced further north, resulting in an increase in the geographical extent of the WRZ, and the duration and impact of its rainy season. Conversely, warmer temperatures are likely to have induced decreases in rainfall in the WRZ. Changes in obliquity increase or diminish seasonal temperature variance and may have acted in concert with temperature changes to influence the timing, length and relative dominance of rainfall systems and seasons.

Rainfall in the SRZ is determined by a different set of controls. Primarily, rains in south eastern and interior southern Africa derive from summer monsoonal activity, which is dependent on the formation of robust convection cells in the Indian Ocean. These cells result from high SSTs, and their formation is likely to have been impaired under generally cooler conditions (Reason and Mulenga 1999). Globally-cold conditions are also expected to have weakened inter-hemispheric thermal contrast, which would in turn limit seasonal displacement of the Inter-Tropical Convergence Zone (ITCZ) (Nicholson and Flohn 1980). Exaggerated seasonal displacement of the ITCZ during interglacials is expected to have resulted in increased moisture delivery to the SRZ, while its restricted range of movements during glacial periods, coupled with a weakening of the global hydrologic cycle, is likely to have increased aridification of the area (Nicholson and Flohn 1980).

Indian Ocean SST's and displacement of the ITCZ provide two guides to precipitation changes in the SRZ. An additional control on rainfall in the SRZ is precessional forcing. The Tswaing archive suggests that monsoon strength generally responded positively to Milankovich-scale insolation peaks for most of the last 200 ka (Partridge *et al.* 1997), however, this effect may be limited to periods of high orbital eccentricity (Brian Chase, pers comm. 2009). The collapse of the southern hemisphere monsoon in South Africa and Australia under low eccentricity during the Last Glacial Maximum occurred despite precessional forcing (Chase and Meadows 2007; Nicholson and Flohn 1980; Wyrwoll *et al.* 2007). Changes in obliquity are also likely to have influenced rainfall patterns, with diminished seasonal variance and potential increases in TTTs occurring during obliquity minima (cf., Tuenter *et al.* 2005), as well as increasing hemispheric temperature gradients and more expansive sea-ice resulting in an increased influence of westerly systems (Chase and Meadows 2007).

Combined, the available conceptual models and archives provide a very generalized means of predicting environmental responses to climate changes in different parts of southern Africa. Wherever possible, terrestrial archives are used as the primary basis for environmental discussion. In their absence, however, the environmental sections of the various temporal blocks rely on coarse conceptual models. In that regard, it should be noted that for much of southern Africa through much of the late Pleistocene, the environmental record is simply too poorly understood to make definitive statements.

2.2 SOUTH AFRICAN ARCHAEOLOGY 220-20 ka

2.2.1 Archaeology and environments 220-80 ka

Patterns in stone artefact technology and occupation

Some time between 280 ka and 200 ka, the production of handaxes appears largely to have ceased in southern Africa, marking the end of the Earlier Stone Age (ESA) (Beaumont and Vogel 2006; Grün and Beaumont 2001; Klein *et al.* 1999; Kuman *et al.* 1999; Sheppard and Kleindienst 1996). The absence of handaxes, in combination with the presence of prepared cores and the production of predominantly convergent flakes, form the defining criteria of the following Middle Stone Age (MSA) (cf., Goodwin and Van Riet Lowe 1929: 98)[3]. In southern Africa the transition from ESA to MSA is marked by industries – the Fauresmith and Sangoan – which include elements of the technological systems symptomatic of both Ages. The key identifying feature of these industries is the presence of large bifacially worked tools, in some ways intermediate between handaxes and bifacial points. Dates place the end of the Fauresmith between 220 ka and 174 ka, though the more recent date is contested (Beaumont and Vogel 2006[4]; Szabo and Butzer 1979). While no Sangoan assemblages have been directly dated, the Lupemban of central Africa, which shares a number of its technological features, along with the addition of occasional backed pieces,

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[3] Due to its reliance on the absence of handaxes, Minichillo (2005: 29) has referred to this as a largely "negative" definition. Identifications of the MSA with the presence of Levallois technology (e.g., Tryon *et al.* 2006) perhaps provide a more positive means of identification.

[4] Chazan *et al.* (2008) have recently disputed the characterization of material associated with this date as Fauresmith.

has been dated by U-series to between 230 ka and 300 ka at Twin Rivers Kopje (Barham 2002; Barham and Smart 1996; Clark and Brown 2001).

Sites from this early period in southern Africa are few, and the Fauresmith and Sangoan remain somewhat enigmatic. Dates from the open air site of Florisbad suggest that less transitional, more strongly MSA technologies may have been present as early as ~280 ka (Grün *et al.* 1996; Kuman *et al.* 1999). Dates exceeding 200 ka for MSA material have also been returned from the sites of Wonderwerk (dated by U-series to ~220 ka – Beaumont and Vogel 2006) and Border Cave (dated by ESR to ~227 ka – Grün and Beaumont 2001). The identity of the hominids responsible for these pre-200 ka assemblages remains largely unclear – the hominid associated with the date of ~280 ka at Florisbad bears affinities to modern *H. sapiens,* but is suggested by Kuman *et al.* (1999) to be more safely assigned to *H. helmei*.

Assemblages from units dating < 279 ka and > 157 ka (units N, O and P) at Florisbad are relatively small, with little retouch, and with rotated cores as the dominant nucleus form. At Wonderwerk, Beaumont and Vogel (2006: 221) describe the stone artefact assemblages from layers dated 220-70 ka as including "prepared cores, blades, and Levallois, unifacial and bifacial points", but provide little additional information, while the early MSA layers (5WA, 6BS) at Border Cave are assigned by Grün and Beaumont (2001; see also Mitchell 2002: 84; Watts 2002) to MSA 1 in Volman's (1981) scheme.

While MSA 1 has generally been characterized as a prolonged period of little archaeological innovation or interest, recent data have begun to suggest the existence of periods of considerable variability. Units M-G at Florisbad, generally associated with a date of 157 ± 21 ka, include an unusually high percentage of retouched forms, dominated by side-scrapers, as well as elongate flakes referred to as blades (Kuman *et al.* 1999). Similarly, layers dated 164 ± 12 ka at Pinnacle Point cave 13b include apparent evidence of bladelet production (Marean *et al.* 2007).

The OIS 5e high sea stand around 120 ka marks a significant point in the archaeology of the region, both for taphonomic and behavioural reasons. At this time, several rich archaeological repositories along the south coast, such as Klasies River Main site and

Nelson Bay Cave, are likely to have suffered the loss of substantial volumes of sediment, and thus their assemblages reflect only post-120 ka accumulation (Hendey and Volman 1986). Other sites, such as Ysterfontein, may only have been formed during the high stand (Avery *et al.* 2008; Klein *et al.* 2004). It is also around this time that sufficient evidence exists to suggest that *H. sapiens* had become the dominant, if not the only extant hominid species in southern Africa, though with significant morphological variation within the small available sample (Churchill *et al.* 1996; H. Deacon 1995; Grün and Beaumont 2001; Jacobs *et al.* 2006; Miller *et al.* 1999; Rightmire and Deacon 1991; Thackeray 1992). Genetic evidence suggests that the stabilization of indigenous (Khoisan) populations in southern Africa occurred some time before 140 ka (Behar *et al.* 2008; Tishtkoff *et al*. 2009).

Volman (1981) classified the earliest, and thus post-high stand, assemblages from Klasies River (members LBS and RBS) and Nelson Bay Cave (NBC – layers 9 and 10) as MSA 2a. Wurz (2002) has since redescribed the LBS member in terms of the reduction of cores to produce of points and blades, rather than in terms of the rare retouched elements. To the three south coast expressions of the MSA 2a noted by Volman (Klasies River, Nelson Bay Cave and Herolds Bay Cave), Wurz adds Die Kelders; Peers Cave (probably the basal units from Peers original excavation (cf., Peers 1927, 1929) rather than the later excavation by Anthony (1967)); the Namibian sites Apollo 11 (layer H? (Watts 2002)), Bremen 1C and 2b, and AAR1 (unspecified layers); unspecified layers from Cave of Hearths and Florisbad (presumably Unit F, dated 121 ± 6 ka, though the assemblage has been argued to contain small elongate flakes referred to as bladelets (Kuman *et al.* 1999)); and unspecified layers of Border Cave (presumably 4BS, 4WA, and 5BS, which have been dated by amino acid racemisation to >100ka (Miller at al 1999; Mitchell 2002: 83; Watts 2002)). The inclusion of Die Kelders in the list seems problematic. Wurz gives bracketing dates for MSA 2a at between ~115 ka and ~100 ka, while the entire Die Kelders MSA may have been deposited rapidly some time between 70 ka and 60 ka (Feathers and Bush 2000; Schwartz and Rink 2000). Figure 2.2 presents the locations of MSA 2a sites with Die Kelders excluded.

Following MSA 2a is MSA 2b (Volman 1981) which Wurz (2002) suggests be renamed the Mossel Bay industry (Wurz 2002). Wurz's selection of the term Mossel Bay is based on Goodwin's characterization of a sample from Mossel Bay Cave (1930; also Goodwin and Malan 1935). Complicating this usage is the fact that Goodwin (1931) applied the term

"Mossel Bay Variation" to both pre- and post-Howiesons Poort layers at the name site. Keller's (1968) reanalysis of Goodwin and Malan's 1932 sample appears to confirm Goodwin's suggestion, with unifacial and bifacial points, scrapers, burins and obliquely truncated blades all identified.

These issues aside Wurz (2002: 1008) describes the dominant core form in the Klasies sample as "unipolar convergent Levallois … directed at the production of Levallois-like points". While Wurz suggests that few pieces were retouched, Volman suggests retouch to have been considerably more common in MSA 2b than in MSA 2a contexts. This contention is supported by Thackeray's (1989) analysis of the 1984 Deacon re-excavation of Klasies River, in which an effective doubling of retouch prevalence (1% to 2%) is noted from MSA 2a to MSA 2b. According to both Thackeray and Wurz the dominant retouch forms at Klasies River were notched and denticulate pieces. Volman (1981) notes the presence of unifacial and bifacial points in the MSA 2b samples from Nelson Bay Cave and Paardeberg, while Wurz (2002: 1009) notes that the "few unifacial and bifacial pieces of the [Singer and Wymer excavation at Klasies River] sample came from the top levels of the MSA II and the base of the overlying Howiesons Poort'.

In addition to the occurrences at Klasies River, Nelson Bay Cave and Paardeberg, Volman assigned spits 7-9 from Klipfonteinrand to the MSA 2b. To this list, Wurz (2002) adds Hollow Rock Shelter (potentially layers Sand IIIa and IIIb as suggested by Watts (2002), but undescribed by the excavator, Evans (1994)); Peers Cave (unspecified layers); Blombos Cave (presumably the ~99 ka unit M3, but possibly also the ~77-85 ka unit M2 (cf., Henshilwood *et al.* 2001a; Jacobs *et al.* 2006)); Die Kelders; Apollo 11 (Layer G? (Watts 2002)); Pockenbank; AAR1 (unspecified layers); Tiras 5; Cave of Hearths (unspecified layers); Florisbad (unspecified layers); Border Cave (unspecified layers); Sehonghong, Moshebi's Shelter and Rose Cottage Cave; and Uhmlatuzana (layer 28? Kaplan 1990)). Watts (2002) suggests the addition of Bushman Rock Shelter (layers 31-19) and Olieboompoort (Bed 2). The assemblage from the Atlantic coast site of Ysterfontein may also be ascribed to MSA 2b, based on the prevalence of denticulate pieces, and the absence of other typical markers (Avery *et al.* 2008). The distribution of these sites is presented in Figure 2.3.

Wurz provides bracketing dates for the MSA 2b/Mossel Bay of between ~100 ka and ~80 ka, which appears broadly acceptable for most sites. This range may suit the inclusion of Ysterfontein, though the dating of this site remains contentious. Avery *et al.* (2008) suggest a probable range from 110-80 ka, though they leave open the possibility that the assemblages was deposited during OIS 4. The inclusion of Die Kelders in the MSA 2b unit, however, again seems questionable. Equally, unit M3 from Blombos, which has been dated to ~99 ka though which may extend to ~140 ka, falls at the temporal interface of MSA 2a and MSA 2b (Henshilwood 2001a; Jacobs *et al.* 2006). Assigning M3 to either unit is complicated by the dominance of silcrete (63%) and quartz (20%) over quartzite (16%) in artefact manufacture (Henshilwood *et al.* 2001b: 428). Quartzite is the dominant material in all other MSA 2a and 2b-assigned south coast YRZ sites. Bifacial points are absent from the large sample (n=16 736) in this unit, with notched and denticulate pieces the dominant retouch form. Given the poverty of denticulate retouch noted for MSA 2b (Volman 1981: 253) M3 might be assigned to MSA 2a. On the other hand, core reduction strategies in this unit are described as being geared "predominantly for the production of flakes rather than flake-blades" (Henshilwood *et al.* 2001a: 428) – a finding more consistent with Wurz's Mossel Bay unit. In a similar vein, Soressi (unpublished report cited in D'Errico and Henshilwood 2007) is reported to have suggested that the M3 assemblage is unlike MSA 2a as identified by Volman. Given these complications, it may be most reasonable not to attempt to shoehorn the assemblage into any of these categories.

Fauna

Comparatively few well-described faunal assemblages are available from early (pre-120 ka) contexts. The Florisbad fauna is one exception, though as carnivores appear to have been the primary accumulating agent, this assemblage is better considered under the section on *Environments* (Brink 1988). A small sample of mammalian fauna is preserved in the early MSA layers at Border Cave, and this is dominated by medium and large bovids, though with some smaller bovids and a reasonable proportion of lagomorphs (Klein 1977). Better preservation occurs in the LC-MSA unit at Pinnacle Point cave 13b[5], dated to ~164 ka. At the time of occupation, PP13b was coastally situated, and as such the faunal assemblage is strongly influenced by coastal subsistence opportunities. Perhaps the main contribution of

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[5] Unit M3 at Blombos conceivably includes fauna from >120 ka, given the bracketing date of ~140 ka from underlying archaeologically sterile sediments. However, based on Figure 17 from Jacobs *et al.* (2006) ~99 ka seems to be a representative date for the archaeologically-active component of the unit.

the LC-MSA fauna is its demonstration that concerted exploitation of sessile marine fauna was a facet of human behaviour before OIS 5. At present, however, PP13b does not appear to provide evidence for exploitation of marine resources other than shellfish.

Fauna from MSA 2a and MSA 2b are best represented by the large samples from Klasies River. Unfortunately the Klasies sample is compromised by sampling techniques and on site sorting (cf., Deacon 2001; Turner 1989). Keeping this issue in mind, the MSA 2a sample from Klasies River is dominated by medium and large bovids, with smaller bovids less well represented. Also common in these lower layers are Cape fur seal and dassie (*procavia capensis*). Other small mammalian species are comparatively poorly represented (Klein 1976).

Beyond Klasies, faunal samples that may be attributable to MSA 2a include those from Ysterfontein and the M3 unit at Blombos. The Yserfontein fauna include a variety of lagomorphs and other small mammals, as well as small and large bovids, seals, reptiles and an abundance of shellfish (Klein *et al.* 2004). Proportions of terrestrial fauna, however, are as yet unpublished. The M3 unit at Blombos also contains an abundance of shellfish, though with few terrestrial fauna. Like the ~164 ka layers at PP13b, neither sample contains significant evidence of fish.

The MSA 2b sample from Klasies displays a conspicuous increase in assemblage diversity, but overall sample size is also larger. While medium to large bovids continue to dominate as they had in MSA 2a, there is a far better representation of small mammals such as mongoose, caracal, otter and baboon, all of which had been rare or absent in the preceding unit. Cape fur seal and dassie, however, continued to be well represented (Klein 1976). While fish were absent from this unit, they were present in the lower layers of Blombos Cave M2, along with shellfish. Henshilwood *et al.* (2001a) indicate that the fish were probably trapped or speared in nearby inlets.

Environments

Terrestrial records covering OIS 7-5 are relatively poor, with most information limited to the rainfall record of the Twsaing crater (Partridge *et al.* 1997), and a series of proxy markers in marine cores located off the west, south and south east coasts (e.g., Be and

Duplessy 1976; Chen *et al.* 2002; Pahnke and Sachs 2006; Shi *et al.* 2001; Stuut *et al.* 2002; van Campo 1990). These are supplemented by sporadic terrestrial archives, which, while notably better represented towards the end of OIS 5, are generally poorly dated and poorly resolved.

The cessation of handaxe production and the onset of more typically levallois modes of reduction appear to have occurred under interglacial conditions associated with OIS 7. Sea levels through most of OIS 7 were relatively high, though perhaps still somewhat lower than present (Ramsay and Cooper 2002; Thompson and Goldstein 2006), and temperatures were probably slightly cooler (Jouzel *et al.* 2007; Petit *et al.* 1999). The Twsaing Crater archive extends back only as far as the termination of OIS 7, with exceptionally low rainfall inferred ~200 ka, followed by relatively wet conditions at the OIS 7/6 interface. Aeolian deposition in the YRZ during OIS 7, and again at the OIS 7/6 and 6/5 boundaries may suggest periods of aridity, however, significant question marks remain over the factors driving aeolian activity, and thus over the meaning of aeolianite formation in this area (Bateman at al 2004; Carr *et al.* 2007; Chase and Thomas 2006). The most notable faunal record from OIS 7 comes from Florisbad, which suggests that “modern sub-Saharan savanna” conditions were in place in the southern African interior as early as ~250 ka (Brink 1988). Faunal and pollen analysis from Florisbad suggest that the initial phases of occupation occurred in the context of a relatively wet and highly productive environment (Brink 1988; Kuman *et al.* 1999; Van Zinderen Bakker 1989).

Subsequent occupation at Florisbad (157 ± 21 ka), and also Pinnacle Point (164 ± 12 ka) and possibly Blombos unit M3 (Jacobs *et al.* 2006) occurred under glacial conditions associated with OIS 6. Sea levels through most of this period were considerably lower than present (Thompson and Goldstein 2006), though the occupation of Pinnacle Point correlates with a brief high stand, reflected in the presence of shellfish in the site (Marean *et al.* 2007).

Expansion of Antarctic ice sheets in OIS 6 would theoretically have resulted in northward migration of the westerlies and an expansion of the WRZ. Marine records provide some support for this suggestion. Pollen from the coast of Namibia documents cool moist conditions through OIS 6 (Shi *et al.* 2001), while sediment outflow suggests increased fluvial activity (Stuut *et al.* 2002). In the interior SRZ, the ~157 ka occupation at Florisbad is broadly contemporaneous with a considerable spike in rainfall, though the Twsaing record indicates rainfall generally at or above present levels in the SRZ for most of OIS 6 (Partridge *et al.* 1997).

The period from 140 ka to 120 ka was one of rapidly rising sea levels, culminating in the OIS 5e high stand (Shackleton 1987; Marean *et al.* 2007). From the cessation of 5e through to the late Holocene, sea levels were constantly below present levels. Holocene sea level rise has thus necessarily resulted in considerable attrition of archaeological sites from OIS 5, OIS 4, OIS 3 and OIS 2.

In the WRZ, the decrease in ice volume post-120 ka appears to have resulted in reduced winter rainfall and attendant fluvial activity in the WRZ (Stuut *et al.* 2002). The degree to which this induced aridification of the WRZ and YRZ, is however, not entirely clear (Chase and Meadows 2007). Increases in south easterly winds may have offset winter rainfall reductions through increased summer rainfall input (Little *et al.* 1997). The presence of red-knobbed coot in the faunal assemblage at Ysterfontein, which OSL ages place 130-110 ka, implies that standing fresh water was available close to site, which it presently is not, and leaves open the question of moisture levels in the WRZ in early OIS 5 (Avery *et al.* 2008), though it remains possible that the Ysterfontein assemblage dates to a later part of OIS 5. Similarly, the undated faunal assemblage from Boegeberg, which conceivably relates to this period, suggests relatively moist conditions (Klein *et al.* 1999). The Ysterfontein fauna also imply significantly more grasses and broad-leafed browse in the area than at present. In contrast, the Klasies River fauna imply a mosaic of forest, grass and fynbos shrubs similar to that pertaining from the late Holocene to present (Klein 1976)

In the SRZ, marine cores from the south east Indian Ocean indicate warm SSTs from 130-110 ka, with a gradual decline thereafter (van Campo *et al.* 1990). This is consistent with the Tswaing archive, which documents significantly greater-than-present rainfall in the SRZ 120-110 ka under the influence of precessional forcing. The record from early occupation layers at Border Cave suggests a preponderance of moist dense vegetation, with a moderate presence of woodland species and a paucity of grasslands prior to the OIS 5c/5b interface (Avery 1992).

From 120 ka through to 80 ka, sea surface temperatures in both the south east Atlantic and south west Indian Ocean decreased, with relatively low SSTs also implied by the marine fauna at Blombos (Be and Duplessy 1976; van Campo 1990; Chen *et al.* 2002; Henshilwood *et al.* 2001a). Rises in sea level through this period resulted in drowning of much of the Agulhas plain, and limited the exposed shelf area off the east and west coasts to ~10 km or less in most places. Stuut *et al.* (2002) record increased fluvial output in the WRZ at this time, while the Twsaing record indicates rainfall around present levels centred on 105 ka, followed by a significant peak from ~100-85 ka. This increase is coincident with an expansion of grasslands, inferred from micromammals at Border Cave (Avery 1992). Faunal patterns from Klasies River in the YRZ are taken to suggest conditions as wet as, or wetter than present in layers presumed to date to around 100 ka (Avery 1987; Klein 1974). Rainfall may also have been relatively evenly distributed throughout the year (Avery 1987).

The transition from MSA 2a to MSA 2b thus appears to have occurred in the context of increasingly cool, wet conditions across much of southern Africa, though the hypothetical temporal interface of the two units coincides broadly with a period of near-glacial cold and a southern hemisphere summer insolation minimum (Chase and Meadows 2007; Jouzel *et al.* 2007; Petit *et al.* 1999). Macro- and micromammal patterns at Klasies reflect a change from more open to more closed forested environments across this transition (Avery 1987; Klein 1974, 1976), while the micromammals at Border Cave in the SRZ are interpreted by Avery (1992) to infer the opposite.

2.2.2 Archaeology and environments 80-60 ka

Patterns in stone artefact technology and occupation

Starting soon after 80 ka, significant changes appear in a number of assemblages in southern Africa. Most notable among these is the appearance of large numbers of apparently soft-hammer worked bifacial points, variously described as foliate, lanceolate, or “double-pointed” (Henshilwood *et al.* 2001a; Villa *et al.* 2009; Wadley 2007). These points are generally used as the *fossile directeur* of the Still Bay industry, one of the original MSA industries identified by Goodwin and Van Riet Lowe (1929). It was initially believed that the distribution of Still Bay sites was limited to the southern Cape region (broadly comparable to the YRZ and southern WRZ) (Goodwin and Van Riet Lowe 1929; Henshilwood *et al.* 2001a), but recent results from the eastern coast SRZ site of Sibudu have been used to argue for a wider distribution (Wadley 2007). Figure 2.4 presents the current distribution of known Still Bay sites in southern Africa.

The recent rejuvenation of the Still Bay as an archaeological entity is remarkable, given that 35 years ago Sampson (1974), noting the near total absence of well-controlled samples, suggested that there were probably insufficient grounds for its formal classification as an industry (see also Deacon 1979). Though several purportedly Still Bay shelter contexts had been identified (e.g., Peers Cave, Dale Rose Parlour, and Tunnel Cave), most were coarsely excavated and poorly documented (Malan 1955; Minichillo 2005; Volman 1981; Wurz 2002). Perhaps of greater influence was the absence of Still Bay units from the deep sequences at Klasies River, Nelson Bay Cave and Border Cave, which were thought at the time of their excavation to provide relatively complete coverage of the MSA (Minichillo 2005). The rejuvenation of the industry has largely been the result of excavations at Hollow Rock Shelter and Blombos Cave.

The 1993 excavation of the small shelter site Hollow Rock Shelter in the Cederberg Mountains of the WRZ produced the first well-controlled, well-documented Still Bay assemblage for nearly forty years (cf., Evans 1994). The 13 sq metres excavated into the shallow deposit at the site returned a sample of 40 bifacial points, in addition to a smaller sample of scrapers, unifacial points, denticulates and rare backed artefacts. The upper four layers of the site contained bifacial points, however, only in the uppermost two were these implements the dominant form. In the lower layers, scrapers and denticulates dominated the implement sample. Changes in bifacial point prevalence at Hollow Rock Shelter correlate with changes in material frequency. The lower two layers are dominated by quartzite, with comparatively minor input from quartz, hornfels, silcrete and chert. In the upper two layers, while quartzite remained the most common material, the relative prevalence of the non-quartzite rocks approximately doubled. Both hornfels and silcrete are considered to be non-local to the site (Evans 1994), though the definition of non-local in use here is unclear. Evans (1994) has suggested that the lower layers at Hollow Rock Shelter may be assigned to MSA 2b, though the lack of abrupt change between these two groupings makes this assignation appear both arbitrary and unnecessary. Presently, the age of the Still Bay at Hollow Rock Shelter is unknown.

Larger, ongoing, and now well-dated excavations at Blombos Cave have provided probably the best-resolved Still Bay occurrence so far known. The MSA component of the Blombos sequence has been divided by the excavators into three primary units – M1, M2 and M3 – with M1 further subdivided into M1a and M1b. As noted above, the unit M3 can be ascribed to either MSA 2a or MSA 2b, without really cohering well with either. Perhaps the defining aspect of the unit with regard to the Blombos sequence is the absence of bifacial points. The subdivided unit M1 is ascribed by the excavators to the Still Bay-proper, with the status of the intervening layer M2 somewhat unclear. In several regards, M2 bears comparison with the lower two layers at Hollow Rock Shelter. Bracketed by dates of 84.6 ± 5.8 ka and 76.8 ± 3.1 ka, M2, like the lower units at Hollow Rock Shelter, contains only a few bifacial points (n=21) in comparison with more than three hundred in the overlying unit (cf., Villa *et al.* 2009). M2 is also distinguished from the overlying and underlying units by differences in material prevalence; in this case by the predominance of quartz (50.7%) over silcrete and quartzite.

Another defining feature of M2 is the large number of bone points. McCall (2007) has characterised M2 as a transitional layer between MSA 2b (to which he assigns unit M3) and the Still Bay. This assertion is based largely on the perceived complementarity of bifacial and bone points, and continuities in material selection from M2 through to M1a. While possibly true, detailed trends are difficult to detect in the unit-based system in which the data are presented, though Henshilwood *et al.* (2001a) imply that potentially significant within-unit changes do indeed exist. Minichillo (2005: 26) has suggested assigning M2 its own industry-level term – the Blombos sub-stage. No data for other potentially transitional pre-Still Bay contexts (e.g., Sibudu or Diepkloof) are as yet available.

The overlying unit at Blombos, M1 (a and b), contains the overwhelming bulk of the bifacial points in the assemblage. Reduction of these pieces appears to have involved the use of soft organic or possibly soft-stone hammers (Henshilwood *et al.* 2001a; Villa *et al.* 2009). Small numbers of unifacial points are also present in this unit, as are scrapers and denticulates. In total, retouched artefacts account for 1.1% of the artefact total in unit M1.

With regard to materials used in artefact manufacture, M1 is dominated by silcrete (71.6%). While long considered a non-local material at Klasies River and other south coast sites (cf., Singer and Wymer 1982; Ambrose and Lorenz 1990), recent work by Minichillo (2006) has provided grounds for thinking that silcrete can be sourced from the cobble beds located in close proximity to many such sites, albeit in much lower frequencies than quartzite.

There are notable similarities and differences between the Still Bay-ascribed assemblages at Blombos / Hollow Rock Shelter and those from the SRZ site of Sibudu Cave. While layers RGS and RGS2 at Sibudu do contain bifacial points, the number of such finds, both in absolute terms and as a percentage of the assemblage total, is comparatively small. Based on data in Henshilwood *et al.* (2001a) bifacial points account for ~0.6% of the assemblage total. At Sibudu this value is 0.26%. In addition, 6.2% (2 of 30) of bifacial points at Sibudu are complete. At Blombos, this value is ~20% (based on data in Wadley 2007; Villa *et al.* 2009 and excluding Villa *et al.*'s phase 1 points). The high breakage rate at Sibudu may relate to the absence of bifacial point manufacture on site suggested by Wadley (2007). In contrast, the excavators at both Blombos and Hollow Rock Shelter have argued for on site manufacture.

The majority of the bifacially flaked pieces at Sibudu are made from dolerite, available within the immediate vicinity of the site. Nevertheless, the proportion of dolerite to materials not available within 10 km (including hornfels, quartz and quartzite) is lower in points than in the general artefactual population. Like Blombos and Hollow Rock Shelter, the Still Bay assemblage from Sibudu Cave includes some unifacial points. In addition, as at Hollow Rock Shelter, small numbers of backed pieces (n=4) are also present. Wadley (2007) makes clear that these are integral to RGS and RGS2 and not intrusive from overlying Howiesons Poort-ascribed layers.

Overall, retouch at Sibudu accounts for 0.6% of the assemblage total – about half that at Blombos, and approximately a quarter of the retouch rate observed in the upper layers at Hollow Rock Shelter and the MSA 2b from the Deacon's 1984 excavation at Klasies River (Thackeray 1989). Both Wadley (2007) and Henshilwood *et al.* (2001a) also note that the Still Bay layers at Sibudu and Blombos contain very few cores.

Jacobs *et al.* (2008a) have recently provided a single age estimate for the Still Bay at Sibudu, placing it at 70.5 ± 2 ka. Quasi-concurrent ages are also provided for the Still Bay at Diepkloof, the sequence from which is described later in this thesis. Jacobs *et al.* use this concurrence to argue for a brief and simultaneous duration for Still Bay occurrences across southern Africa. It is unclear, however, how the dates from Blombos (which range from 76.8 ± 3.1 ka to 72.7 ± 3.1 ka) are reconciled with this hypothesis. Moreover, recent thermoluminesence (TL) dating of the Diepkloof sequence provides ages as great as 129 ± 11 ka for the Still Bay component.

The conditions under which the Still Bay ended, and the nature of the occupation and technological systems which followed are issues of enduring interest. One of the first excavated Still Bay contexts, that at Peers Cave, suggested that the bifacial point-rich layers[6] were directly overlain by an industry largely bereft of points, the retouched component of which was dominated by backed pieces, and which the excavators, following Stapleton and Hewitt (1927, 1928), termed Howiesons Poort (Peers 1929). Subsequent attempts to clarify the relationship between these two industries – Still Bay and Howiesons Poort – have been hampered by a marked trend for sites to contain expressions of either, but rarely of both industries. While large repositories such as Klasies River, Nelson Bay Cave and Border Cave all have well developed Howiesons Poort expressions, none include an identified Still Bay component, though bifacial points do occur in the lowermost Howiesons Poort units at Klasies River and Nelson Bay Cave (Volman 1981; Wurz 2002). Equally, Boomplaas, Howiesons Poort Shelter, Klein Kliphuis, Montagu Cave, Rose Cottage Cave, Sehonghong, and numerous other sites have Howiesons Poort but no Still Bay (Carter *et al*. 1988; Deacon 1979; Keller 1973; Mackay 2006; Stapleton and Hewitt 1927, 1928; Wadley and Harper 1989). Of the well known Still Bay occurrences, both Blombos and Hollow Rock Shelter appear to have been abandoned at the end of the Still Bay, with Blombos not being reoccupied until the Holocene and Hollow Rock Shelter showing no evidence of subsequent occupation.

Based on these discontinuities and a review of recent dates, Jacobs *et al.* (2008a; also D'Errico and Henshilwood 2007) have suggested an elapse of 7-10 kyr between the two

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[6] The Peer's termed these layers at Peers Cave "finer Still Bay", in contrast to the unifacial point-rich "coarser Still Bay" which overlay the Howiesons Poort.

industries. In contrast, McCall (2007, 2006; also Lombard 2005a) has suggested that aspects of the Howiesons Poort can be perceived in the later Still Bay (M1a) at Blombos, and that the latter arose rapidly after the former with little or no elapse of time. Muted support for this proposition comes from the sequences at Klasies River and Nelson Bay Cave. Further complicating the argument for significant temporal separation is the lack of an obvious industry either overlying the Howiesons Poort or underlying the Still Bay which might reflect the intervening period of occupation.

One possibility relates to the sequence from Die Kelders, which, although large, was apparently rapidly deposited some time between 70 ka and 60 ka (Feathers and Bush 2000; Schwarcz and Rink 2000). The Die Kelders sequence is ascribed to neither the Still Bay nor the Howiesons Poort, lacking bifacial points entirely and containing only a few amorphous backed artefacts from a massive sample (n > 500 000; cf., Avery *et al.* 1997; Thackeray 2000). The dominant retouch forms at Die Kelders are notched and denticulate artefacts. Several of the layers are silcrete-rich (Thackeray 2000), which, while often taken as a feature of the Howiesons Poort on the south coast, is also a feature of the Still Bay at Blombos. The majority of layers reported by Thackeray, however, are dominated by quartz and quartzite. Minichillo (2005) has suggested including the Die Kelders sequences as a separate MSA sub-stage, positioned temporally between the Still Bay and Howiesons Poort and centred on a date of 70ka.

Two sites – Sibudu and Diepkloof – are of particular importance to the relationship between the Still Bay and Howiesons Poort. These are the only two stratified contexts excavated since Peers Cave to contain both industries (Rigaud *et al.* 2006; Wadley 2007). While insufficient data are presently available from Sibudu to address the issue of this relationship, Rigaud *et al.* (2006) provide a preliminary division of the Diepkloof sequence into 6 “complexes”. Two of these, complexes 4 and 5, are ascribed to the Howiesons Poort. Underlying complex 5 is the Still Bay-ascribed complex 6. On this basis, Diepkloof does not appear to provide evidence for a significant intervening industry between the Howiesons Poort and the Still Bay. A more detailed consideration of the Diepkloof sequence will form part of the results of this thesis.

While there may or may not be an intervening industry or hiatus lying between the two, has at least been confirmed that the Howiesons Poort is temporally more recent than the Still Bay, as it was originally believed to have been (Malan 1949a). The Howiesons Poort is defined by characteristic backed pieces, most specifically, by forms variously referred to as crescents, segments or lunates (Lombard 2005a; Thackeray 1992). While these implements are also diagnostic of some later industries, most notably those from the LSA, the Howiesons Poort examples tend to be unusually large, commonly exceeding 25mm (Lombard 2005a; Thackeray 1992). In some sites, such as Apollo XI, Howiesons Poort Shelter, Montagu Cave, Peers Cave (Peers excavation layer 4), Rose Cottage Cave, and Uhmlatuzana, Howiesons Poort assemblages also contain small numbers of unifacial, bifacial and/or denticulate points, while in others (e.g., Klasies River, Nelson Bay Cave, Klipfonteinrand and Boomplaas) such pieces are largely or entirely absent. Volman (1981: 254) also notes that well-resolved Howiesons Poort expressions are generally poor in denticulates and scrapers.

Beyond retouched implements, the Howiesons Poort is commonly associated with increases in the prevalence of blades. Wurz (2002) notes that blades in the Howiesons Poort are considerably smaller than those produced in earlier parts of the MSA. While it was initially suggested that the canted orientation of these blades to the platform inferred the use of indirect percussion (Wurz 1997), more recent studies have suggested that artefact production/reduction in the Howiesons Poort, like the Still Bay, involved the use of soft stone or organic hammer reduction (Rigaud *et al.* 2006; Soriano *et al.* 2007). Complicating the use of blade prevalence as a marker of the Howiesons Poort is considerable inter-observer variability in the identification of such pieces (Mackay 2006).

Howiesons Poort expressions in the WRZ and YRZ, such as Klasies River, Nelson Bay Cave, Diepkloof, and Klein Kliphuis are notable for striking increases in the frequencies of silcrete. Singer and Wymer (1982) initially described silcrete as a non-local material, but as mentioned earlier, it may equally be possible that at some of these sites silcrete was available within a few kilometers (Minichillo 2006). At some SRZ sites, for example, Rose Cottage Cave and Sibudu, the no significant changes in material prevalence accompany the other Howiesons Poort markers (Villa *et al.* 2005; Soriano *et al.* 2007).

Figure 2.5 presents the distribution of identified Howiesons Poort expressions across southern Africa. Immediately obvious is the contrast with the limited distribution of Still Bay assemblages. Howiesons Poort occurrences are common to almost all contexts across the region. Included as Howiesons Poort in this figure are assemblages characterized as epi-Pietersburg (e.g., Beaumont *et al.* 1978), though the relationship between these two industries is not entirely clear.

As well as being broadly distributed, Howiesons Poort assemblages are often associated with conspicuous increases in assemblage size, and/or artefact density. Howiesons Poort artefacts account for approximately 46% of all artefacts from the Klasies River caves and shelters, while at Nelson Bay Cave, this figure is ~90%. At Apollo XI, Jacobs *et al.* (2008a: Supporting Online Material) note that the Howiesons Poort-assigned units produced both the largest and most dense assemblage of the various MSA units identified. A similar pattern is noted at Umhlatuzana, where the three most artefact-rich layers in the sequence all occur in the Howiesons Poort. At the nearby site of Sibudu, Wadley and Jacobs (2006) suggest a higher density of artefacts in Howiesons Poort than in other contexts.

Perhaps because of the large size of many Howiesons Poort assemblages it is occasionally possible to discern a degree of within-industry variation. Volman (1981: 255) for example suggests that older Howiesons Poort layers in southern Cape sites tend to contain higher frequencies of fine-grained rocks than more recent layers. Numbers of non-retouched artefacts through the Cave 1A sequence at Klasies River display a distinct bimodality (Figure 2.6). Proportions of fine silcrete and quartz display a complementary distribution across those modes, the former being prevalent early in the Howiesons Poort and the latter being prevalent in more recent Howiesons Poort layers (Figures 2.7). At Nelson Bay Cave, silcrete and quartz are both most prevalent in early Howiesons Poort layers, with quartzite dominant thereafter (cf., Volman 1981).

While the composition of the very earliest Howiesons Poort assemblages and the nature of the industry’s emergence remain unclear, improved resolution is increasingly available concerning the cessation of the technological features of the industry. Most notably, Soriano *et al.*’s (2007) avoidance of the strict Howiesons Poort / post-Howiesons Poort dichotomy has allowed identification of trends which indicate that the end of the

Howiesons Poort at Rose Cottage Cave involved the gradual disappearance of a variety of technical features, including backed pieces, but also the production of soft hammer blades.

As an early expression of blade-and-backed artefact industries which are globally prevalent in the last 20 ka, the Howiesons Poort has attracted considerable interest. Though earlier examples of such industries are known elsewhere (e.g., Gopher *et al.* 2005), perceptions of the precocity of the industry have resulted in its being unusually extensively-, if not as yet well-dated. Dates for the Howiesons Poort at various sites range between ~80 ka and ~50 ka (Parkington 1999; Parkington *et al.* 2006; Grün and Beaumont 2001; Vogel 2001; Lombard 2005a; Tribolo *et al.* 2005; Valladas *et al.* 2005). Following early chronometric studies it was considered likely that the Howiesons Poort would turn out to be broadly coincident with OIS 4 (e.g., Ambrose and Lorenz 1990), yet despite increasing numbers of dates, clear consensus has yet to be reached.

More recently some researchers have begun to argue for a later age range for the Howiesons Poort, centred on the OIS 4 / OIS 3 boundary. This assessment is based primarily on thermo-luminescence dates from Klasies River and Rose Cottage Cave (e.g., D'Errico and Henshilwood 2007; Tribolo *et al.* 2005; Valladas *et al*. 2005). Tribolo *et al.* (2005) and Soriano *et al.* (2007) give TL age ranges for the Howiesons Poort at Klasies River and Rose Cottage Cave as, respectively, 62 ± 7 ka – 50 ± 4 ka and 60 ± 4.6 ka – 41.7 ± 3.7 ka. In contrast, OSL ages for the latter site provide a range of 66 ± 4 ka – 57 ± 3 ka (Soriano *et al.* 2007). Similarly OSL ages from Sibudu place the commencement of the post-Howiesons Poort between 57.6 ± 2.1 ka and 59.6 ± 2.3 ka suggesting that the industry ended with the commencement of OIS 3 (Jacobs *et al.* 2008b). Herries (2006) palaeomagnetic data support the Sibudu dating, suggesting that the end of the Howiesons Poort coincided with the transition to warmer conditions, inferred to have been the onset of OIS 3. Taking a different view again, the recent redating program conducted by Jacobs *et al.* (2008a) has been used to suggest a brief (~5 kyr) and synchronous duration for the Howiesons Poort across the sub-continent, centred on 62 ka.

Fauna

In general, few Still Bay-assigned faunal assemblages have been published. Though good preservation is reported at Sibudu and Diepkloof, reports on the fauna have yet to be forthcoming, while preservation at HRS was poor. Consequently, Blombos provides the only faunal sample available for consideration here, a fact complicated by its coastal setting, and thus specific hunting/foraging context. Further affecting the utility of inferences drawn from the Blombos fauna is the relatively small sample of non-marine animals in the data so far published. These issues aside, the M1 and M2 faunal assemblages, like that from M3, are dominated by shellfish, attesting to a continued coastally-adapted foraging pattern, with Turban shell the most common species. The warm water adapted brown mussel (*Perna perna*), largely absent from M3, is comparatively common in the upper MSA units, perhaps indicating minor ocean warming. As with M3, M1 and M2 contain numerous fish remains, which have been used to suggest similarities in fish procurement practices between MSA and LSA people (D'Errico and Henshilwood 2007).

Of the non-marine fauna, dassie are prevalent in M1 and M2, though somewhat less common than in M3. The obverse pattern pertains in dune mole rat, which increases in prevalence from M3 to M1/M2. The other notable change in terrestrial fauna is the increase in small, large-medium, and large bovid representation, most notably in M1. The most common bovids in the sample are "solitary, highly territorial small browsers" such as grysbok and steenbok (Henshilwood *et al.* 2001a: 438). In total, small bovids account for ~60% of the bovid NISP at Blombos. Tortoises remain common in these units, though their size drops considerably. Henshilwood *et al.* ascribe this change to potential increases in human populations.

Initial faunal interpretations of the Howiesons Poort were heavily reliant on the biased Klasies River sample. Based on analysis of this material Klein (1976) inferred relatively few changes in species abundance from MSA 2 to the Howiesons Poort, though higher proportions of certain large bovids (e.g., Cape buffalo and quagga) were noted. While Avery (1987) was able to use these data to infer increases in assemblage diversity, more significant has been the observation that selective sampling and the use of coarse screens is likely to have led to a general under-representation of small fauna (Deacon 2001: 11; note also Turner 1989).

Few other Howiesons Poort faunal assemblages have been characterized, due in large part to poor preservation. The recently published, very well preserved assemblage from

Howiesons Poort and more recent layers at Sibudu, however, provides a significant and much needed addition (Clark and Plug 2008). The Sibudu fauna suggest a marked emphasis in the Howiesons Poort on small animals, particularly small (class I) bovids such as blue duiker, as well as dassie, Gambian giant rat, and various species of monkey (mainly vervet and Syke's monkey). While small-medium (class II and III) bovids are also well-represented in the Sibudu Howiesons Poort, between them they account for less than 30% of the overall assemblage total and less than 40% of the bovid total, with medium-large (class IV and V) bovids contributing only a further 2.1% to the bovid NISP. Combining all bovids from class II to V only accounts for 29.5% of the total NISP, while Blue Duiker alone accounts for 33.6%. In the absence of clear environmental explanations for the pattern (see following section), Clark and Plug (2008) suggest that the increased focus on small mammals in the Howiesons Poort reflects increased diet breadth and an overall intensification of resource extraction.

Environments

The period from 80-70 ka was one marked by highly variable but generally declining global temperatures, and dramatically falling sea levels (Jouzel *et al.* 2007; Petit *et al.* 1999; Pillans *et al.* 1998). The ~40m sea level decrease from 82-72 ka probably resulted in increases of exposed coastal shelf of 5-25 km on the east and west coasts, and 5-40km south of the YRZ. Theoretically, this cooling would have produced increases in rainfall in the WRZ, a proposition supported by marine cores, which imply humid and windy conditions (Shi *et al.* 2001; Stuut *et al.* 2002). Dune molerats from layers dated 82-73 ka in the YRZ site of Blombos also appear to indicate relatively wet conditions, while the presence of springbok, and, less securely, black wildebeest, are suggestive of an environment grassier than present (Henshilwood *et al.* 2001a).

In the SRZ, 80 ka marks the termination of a relatively wet phase, but more notably, the cessation of high amplitude variation in rainfall. From 80 ka to the present, Tswaing indicates wetter-than-present conditions only once (~50 ka), and rainfall at present levels on only two occasions (~70 ka, ~30 ka). For the remainder of OIS 4 and OIS 3, conditions in the eastern interior of southern Africa appear to have been relatively dry (though with rainfall still exceeding 500 mm/yr). Beaumont and Vogel (2006: 224) suggest a reduction in precipitation of ~60% in the interior lasting from 73-12 ka, arguing that the area "was uninhabited at times when temperatures fell below those prevailing during MIS 5.1", but provide no discussion of the basis for this argument. SSTs derived from Indian Ocean cores appear to imply relatively cool seas through most of OIS 4 (Be and Duplessy 1976; van Campo *et al.* 1990).

The period from 70-60 ka is one of the coldest of the last few glacial/interglacial cycles (Jouzel *et al.* 2007; Petit *et al.* 1999). If we assume both that there was a hiatus between the Still Bay and the Howiesons Poort from 70-65 ka, and, further, that the assemblage from Die Kelders dates to the intervening period, then it would appear that the hiatus coincided with a time of unusually cold and wet conditions. Thackeray (1987), for example, has suggested that temperatures during the formation of the Die Kelders assemblage were considerably colder than those during the deposition of the Howiesons Poort layers at Klasies River. Fauna from Die Kelders also indicate wet, cool conditions, including the formation of a marsh or marshy environments in the local area (Henshilwood *et al.* 2001a; Klein and Cruz-Uribe 2000). In addition, the presence of grazers such as springbok, quagga and black wildebeest are taken to imply generally grassy vegetation quite unlike the present fynbos (Klein and Cruz-Uribe 2000).

Regardless of the precise temporal placement of the Die Kelders fauna, the bulk of OIS 4, including the period dated 70-60 ka appears to have been wet and grassy in the WRZ and YRZ (Avery 1987; Chase and Meadows 2007; Klein 1974, 1976; Klein and Cruz-Uribe 2000). Cool conditions with a preponderance of C3 grasses are also observed in the phytolith record from Sunnyside 1, located in the upland interior of the SRZ. In contrast, fauna from the coastal plain SRZ site of Sibudu appear to suggest closed or semi-closed habitats in association with the Howiesons Poort, though with some more open habitats also having occurred in the vicinity of the site (Allott 2006; Clark and Plug 2008). The Tswaing crater indicates that these changes in vegetation composition occurred against a backdrop of lower-than-present rainfall, while southern hemisphere summer insolation fell to a minimum in broad concert with the end of the Howiesons Poort (Chase and Meadows 2007).

2.2.3 Archaeological changes 60-20 ka

Patterns in stone artefact technology and occupation

The period from 60-20 ka is perhaps one of the most interesting, archaeologically, in southern Africa. It is also one of the most-neglected (Mitchell 2008). Environmentally, this period includes the transitions from OIS 4 to OIS 3, and from OIS 3 to OIS 2. Archaeologically, the period sees the end of the Howiesons Poort, and its replacement by a heterogeneous but broadly linked suite of assemblages, often subsumed under the rubric of 'post-Howiesons Poort'. Perhaps more significantly, by the end of this period, those prepared core reduction systems which are used to define the MSA appear to have been abandoned, heralding the beginning of the LSA.

As Volman (1981) suggests, the assemblages labelled as late MSA are relatively heterogeneous. As the term post-Howiesons Poort suggests, these assemblages are grouped as much by their poverty of Howiesons Poort markers and stratigraphic relationship to the Howiesons Poort, as by any distinctive features they may share. In part the apparent heterogeneity of the grouping may relate to its extensive duration. While the beginning and end dates for the unit have changed considerably, Volman's (1981) initial estimate of 40 kyr years remains broadly accurate, in some geographical locations at least (Wadley 2005). Nevertheless, 40 kyr is no more than the duration of MSA 2 and considerably shorter than the presumed duration of MSA 1, and thus elements of the variance within the post-Howiesons Poort MSA necessarily derive either from the significantly increased number and size of samples, or from genuine increases in technological variation, or possibly a combination of both. The influence of sample size should not be discounted, given recent suggestions of considerable as-yet unidentified variation within early MSA contexts (e.g., Kuman *et al.* 1999; Marean *et al.* 2007).

The most general identifying features of post-Howiesons Poort MSA assemblages are the presence of unifacial points and increases in the prevalence of scrapers, with bifacial points noted in some contexts, particularly late in the post-Howiesons Poort. The absence of key Howiesons Poort markers, specifically large numbers of segments, is also a necessary identifying feature, given the persistence of unifacial points and scrapers in low frequencies in several Howiesons Poort occurrences. Another, albeit poorly defined, marker of these industries are “knives” (also called “straight sidescrapers” (Wadley 2005)) – large parallel-sided flakes with marginal retouch. These various retouched artefacts – unifacial and bifacial points, scrapers, and knives – are observed in sites in a variety of contexts, including the WRZ sites of Peers Cave, Diepkloof and Klein Kliphuis; the YRZ site Klasies River; and the SRZ sites of Ntloana Tsoana, Rose Cottage Cave, Sehonghong. Shongweni, Sibebe, Sibudu and Umhlatuzana (Cochrane 2006; Davies 1975; Kaplan 1990; Mackay 2006; Mitchell 2002; Mitchell and Steinberg 1992; Peers 1929; Price-Williams 1981; Rigaud *et al.* 2006; Singer and Wymer 1982; Villa *et al.* 2005; Volman 1981; Wadley 2005).

Material changes also accompany changes in retouch type at several, but notably not all sites. At Diepkloof, Klasies River and Klein Kliphius, the prevalence of silcrete decreases, with attendant increases in the prevalence of quartzite (Mackay 2006; Singer and Wymer 1982; Rigaud *et al.* 2006). At Umhlatuzana, the transition from Howiesons Poort to late MSA is marked by a dramatic shift from quartz dominance to a prevalence of hornfels, while at Sehonghong and Ntloana Tsoana CCS prevalence decreases in the initial post-Howiesons Poort before increasing again before the end of the MSA. At Sibudu, the immediate post- Howiesons Poort involved an apparently sudden and short-lived change from dolerite / hornfels to quartz and quartzite (Cochrane 2006), while material prevalence patterns in the later post- Howiesons Poort units are not dissimilar from those in the Howiesons Poort (Soriano *et al.* 2007). Similarly, at Rose Cottage Cave, major changes in material are not an obvious identifying feature of the post-Howiesons Poort (Villa *et al.* 2005).

Several researchers have suggested sub-dividing the post-Howiesons Poort into different groupings – an approach which seems meritorious given the unit’s extended duration and heterogeneity. Complicating this approach are question marks over the comparability of different post- Howiesons Poort units between different sites and across southern Africa more generally. For example, Singer and Wymer (1982) suggest sub-division of the Klasies post-Howiesons Poort into MSA III and MSA IV, while at Sibudu, Wadley (2005; Wadley and Jacobs 2006) differentiates “post-Howiesons Poort”, “late MSA” and “final MSA” units. Volman (1981) describes the difference between Klasies MSA III and MSA IV in terms of a change in core prevalence from radial to single platform cores. At Sibudu, the post-Howiesons Poort is identified by a preponderance of quartz and a lack of backed pieces; the late MSA by unifacial points and a preponderance of dolerite and hornfels; and the final MSA by the presence of both unifacial and bifacial points, as well as small numbers of backed artefacts. Late and final MSA comparable to those at Sibudu may also occur in the undated sequence from the WRZ site of Klein Kliphuis (Mackay 2006), though the available data derive from a coarse and poorly resolved excavation.

The bifacial points in the final MSA at Sibudu incorporate a type referred to as "hollow-based" points – an apparently time-restricted form also observed at the nearby site of Umhlatuzana (Kaplan 1990). Complicating comparisons between Umhlatuzana and Sibudu is Kaplan's identification of only two post-Howiesons Poort units – the earlier one being called "late MSA" and the later "MSA/LSA transition". The former unit contains large numbers of unifacial points, and comparatively fewer bifacial points and scrapers. Backed pieces are absent. In the latter unit, segments are present, along with large numbers of unifacial and bifacial points, and smaller numbers of scrapers and hollow based points. There is also considerable patterning within the "MSA/LSA transition" unit at Umhlatuzana; the frequencies of unifacial, bifacial and hollow based points all peak in the lowest three of the five layers in the unit, while segments peak in the upper three.

Transitional MSA/LSA units have also been suggested for the sites of Rose Cottage Cave, Sehonghong and Sunnyside 1, all of which are located in the montane regions of the SRZ. These sites appear to lack the hollow based points observed at Sibudu and Umhlatuzana, and identification of the transitional nature of the assemblages at Rose Cottage Cave and Sehonghong hinges largely on the persistence of MSA-ascribed implement types (almost exclusively knives) and increases in the prevalence of bladelets – perceived as a precursor to the succeeding, bladelet dominated Robberg industry (Clark 1999; Mitchell 1994). Beaumont (1978) has alternatively suggested that layers dated > 35 ka at Border Cave be classified as 'early LSA' on the basis of bladelets and the presence of OES beads. As Mitchell (2008, 1988; also Kaplan 1990) points out, however, these layers also contain prepared cores, part of the basic definition of the MSA, and might thus be better considered comparable to the transitional units at Rose Cottage Cave and Sehonghong.

The exclusion of Border Cave from the list of early LSA assemblages is significant. It is commonly suggested that LSA technological systems began to appear in southern Africa around 40 ka (Klein 1989; McBrearty and Brooks 2000). Without the evidence from Border Cave, however, the only dated sites with LSA assemblages > 25 ka in the region are Heuningneskrans, Kathu Pan and Cave James, all located in the interior SRZ. Heuningneskrans has a ^{14}C age of 29 480 ± 600 cal yr BP (Pta-101) from a non-basal LSA unit (Vogel and Beaumont 1972). Extrapolating from a constant rate of accumulation, Vogel and Beaumont (1972) suggest a basal date of around 32 ka, though this is necessarily speculative. Wadley (1993) reports an age of '31 000' years for the same site, though it is without an associated error range, and its context and method of determination are unclear. Kathu pan has a series of ^{14}C ages from 31 600 ± 700 cal yr BP (I-13040) to 36 600 ± 1200 cal yr BP (Pta-3591) for purportedly LSA material, however, details of the assemblage are not available (cf., Mitchell 2002: 114). The Cave James assemblage dates to > 29 ka (Wadley 1988). Assemblages at both sites are dominated by bipolar reduction of quartz and a paucity of retouched implements.

Other than these sites, almost all firm evidence for LSA technology dates to 25 ka or younger. Figure 2.8 displays the available dates and technological systems against the Epica Dome C Antarctic temperature curve for the period 60-16 ka. The results suggest an early MSA/LSA transition in the SRZ interior (~30-45 ka), a transition elsewhere in terminal OIS 3 (~25-30 ka), and the onset of the LSA proper around the peak of the last glacial (~24 ka). Repositioning the transition in this way is important insofar as it implicates climatic drivers that are precluded when the transition is presumed to have occurred somewhere in the middle of OIS 3.

Leaving aside for a moment the issue of post-Howiesons Poort units and the MSA/LSA transition, and turning to the distribution of post-Howiesons Poort occurrences more broadly, Figure 2.9 details the location of post-Howiesons Poort assemblages in southern Africa[7]. The figure suggests that, like the Howiesons Poort, post-Howiesons Poort sites are broadly distributed across most of southern Africa. Indeed, in total, sites in this age range

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[7] Figure 2.9 largely follows Mitchell (2008) except where ages and/or unit affinities could not be confirmed with available documents. Also excluded is the uppermost MSA unit at Florisbad: ^{14}C dates for the unit are from the 1950's and almost certainly too young (21455±779 cal yr BP). The most recent excavators of the site suggest that the relevant "samples are too small to characterize the industry" (Kuman *et al.* 1999: 1423).

are more common than those of the Howiesons Poort, though it should be noted that the duration is considerably longer. This general distribution, however, masks significant patterning, which becomes apparent when finite ^{14}C dates are used as a simple parameter. While the termination of the Howiesons Poort occurs beyond the ^{14}C range in the vast majority of known cases, evidence of MSA sites pertaining to the last 40 ka appears, on the basis of the limited available sample, to be spatially restricted. In the SRZ, apparently finite ^{14}C dates for post-Howiesons Poort assemblages have been recorded from numerous sites, including Heuningneskrans, Melikane, Rose Cottage Cave, Sibudu, Sidebe, Strathalan B, Sehonghong, Shongweni and Umhlatuzana (Clark 1999; Davies 1975; Kaplan 1990; Mitchell 1996; Opperman and Hydenrych 1990; Price-Williams 1981; Vogel and Beaumont 1971). In addition, Driekoppen has two TL ages within the last 40 ka (Wallsmith 1990), while Sunnyside 1 has an OSL age of 30.5 ± 1.4 ka (Henderson *et al.* 2006). Many of these sites also have ^{14}C dates for MSA assemblages < 30 ka. In the WRZ and YRZ, though the available, dated sample is considerably smaller, only two YRZ sites, Boomplaas and Apollo XI, have returned convincing, finite[8] dates for the post-Howiesons Poort, and those from Boomplaas exceed 30 ka (Deacon 1979; Wendt 1976). The assemblages from Apollo XI dating 40-20 ka are also relatively sparse compared with those underlying them (Volman 1981). Figure 2.10 presents data on the distribution of all sites finite ^{14}C ages >20,000 cal yr BP.

Assemblages from the other dated post-Howiesons Poort contexts in the WRZ/YRZ, Diepkloof and Klasies River, antedate 40 ka (Parkington *et al.* 2006; Singer and Wymer 1982). In addition, the well dated sequence at Elands Bay Cave has calibrated ^{14}C dates > 40 ka and < 25 ka, but none in between (Parkington 1990), while Klipfonteinrand and Nelson Bay Cave, though occupied in the Howiesons Poort, appear to have been abandoned from the end of the Howiesons Poort until after 20 ka. When Eland Bay Cave and Nelson Bay Cave are reoccupied, the dominant technological systems resemble those of Heuningneskrans, Cave James and other early LSA sites, being bipolar-dominated, poor in morphologically regular retouched flakes, and, importantly, bereft of any MSA markers

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[8] Lewis (2008) in a summary of radiocarbon age patterns in the eastern and western Capes includes WRZ dates in the range 40-20 ka from Klasies River and Howiesons Poort Shelter (HPS). The finite KRM dates in this range are either out of sequence or derive from units which underlie infinite dates, or which also have infinite dates. The Howiesons Poort Shelter dates are anomalous in the context of the broader Howiesons Poort pattern, and can be compared with early ^{14}C dates from Diepkloof, which subsequent redating has demonstrated to be significantly inaccurate. On these bases, the finite dates from KRM and HPS are rejected.

(Mitchell 2002; Parkington In Prep). The lack of 40-25 ka dates may explain the absence of transitional MSA/LSA assemblages in this area.

The contrast inferred here should not be misconstrued, however, as being between *continuous* occupation in the SRZ and occupational hiatuses in the WRZ and YRZ, 60-25 ka. Jacobs *et al.* (2008b) have recently argued that occupation in the SRZ is better understood as being ‘pulsed’ – that is, comprised of a series of punctuated occupational episodes. At Sibudu the timing of these pulses is seen to coincide with warming phases observed in the Antarctic ice record, bracketed at 38.6 ± 1.9 ka (final MSA); 47.7 ± 1.4 ka (late MSA); and 58.5 ± 1.4 ka (post-Howiesons Poort). Jacobs *et al.* note coincidence between these pulses and periods of occupation at Border Cave (cf., Grün *et al.* 2003; Millard 2006), though the comparison is complicated by the lack of technological similarity between like-dated assemblages at the two sites (Wadley 2005). It is also worth noting that patterns of occupational pulsing have been suggested for the terminal Pleistocene / early Holocene at a continental scale, albeit with temporal complementarity rather than coincidence between the SRZ and WRZ/YRZ (Mitchell *et al.* 1998).

Distinguishing pre- and post-40 ka occupation also has implications for the interpretation of genetic data. Behar *et al.* (2008) have suggested that, while little introgression of non-Khoisan lineages into southern Africa occurred from 140-40 ka, the period 40-30 ka saw the introduction of several new lineages into the Khoisan group, as well as the appearance of Khoisan lineages in groups outside of southern Africa. Behar *et al.* associate these changes with the advent of the LSA, but, as has been noted here, the dates are considerably too early for the majority of LSA, and even transitional MSA/LSA assemblages. An alternative explanation, and one consistent with the archaeological data, is that the period 40-30 ka was one of occupational disruption. Data from the SRZ suggest episodic occupation, while data from the WRZ and YRZ suggest very thin occupation and possible abandonment. It may be that these occupational discontinuities encouraged both the emigration of some indigenous southern African groups into other parts of Africa, and the immigration of central and east African groups into potentially depopulated areas of the south.

Fauna

Despite the reasonably large number of sites within this temporal bracket, robust faunal samples are limited, as they are for the Howiesons Poort, with poor preservation the major factor (e.g., Klein 1977; Plug and Engela 1992). Furthermore, and as noted above, data from the Klasies River sample appear to have been compromised by sieving and selection. The discussion of post-Howiesons Poort MSA fauna is thus heavily reliant on the sample from Sibudu, while the brief discussion of early post-MSA fauna is based on finds from NBC and Boomplaas.

At Sibudu, Clark and Plug (2008) note considerable differences between the Howiesons Poort and post-Howiesons Poort faunal patterns. While Howiesons Poort predation appears to have focused on relatively small package items such as class I bovids and a diverse array of other small fauna. The post-Howiesons Poort fauna in contrast are largely dominated by bovids of size class II and above (those with live weights exceeding 23 kg). In the Howiesons Poort, such bovids combined account for < 40% of the total NISP of identifiable fragments. In the earlier of Clark and Plug's two post-Howiesons Poort units (post-Howiesons Poort 'MSA 2') this figure rises to > 80%, with the largest single rise being in class II bovids (24-84 kg; Howiesons Poort = 19.1% NISP, post-Howiesons Poort MSA 2 = 36.6% 3NISP), which also comprise the largest single category of fauna. In the later post-Howiesons Poort MSA unit, 'MSA 1', the overall contribution of class II-V bovids again increases, to a total of 95%. The dominant grouping in MSA 1 is class III bovids (85-295 kg), which account for 56.3% of the NISP total.

Faunal data from early OIS 2 (30-20 ka) are equally limited, though some data are available from the LGM[9]-assigned layers at Boomplaas and Nelson Bay Cave (Klein 1972, 1978). In both cases the samples are small and heavily fragmented, diminishing any potential interpretations about subsistence behaviour. Nevertheless, it can be stated that bovids are relatively well represented at both sites, with larger bovids more common than smaller bovids. Other small mammalian fauna, particularly dassie, are also prevalent in both cases. This is most notable at Nelson Bay Cave, where dassie are the most abundant mammal class overall.

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[9] LGM = Last Glacial Maximum

Environments

Antarctic ice cores indicate warming from 60-57 ka, followed by a pattern of highly variable but generally decreasing temperatures persisting until the onset of the LGM (Jouzel *et al.* 2007; Petit *et al.* 1999). By 30 ka temperatures appear to have returned to values comparable to those experienced during the peak cold of OIS 4 (Jouzel *et al.* 2007). In spite of the high degree of variability in the temperature record, conditions in many parts of southern Africa appear to have been wet for most of OIS 3. In the WRZ, marine humidity proxies suggest conditions drier than OIS 4, but wetter than present from 60-40 ka, while charcoal from Elands Bay Cave suggests relatively wet and well-wooded conditions, including afromontane forest, at some time prior to 40 000 ^{14}C yr BP (Cowling *et al.* 1999; Parkington *et al.* 2000; Stuut *et al.* 2002). The period from 60-40 ka is also notable for a dramatic increase in upwelling along the west coast, a process likely to have resulted in colder, more nutrient-rich water along the coastal margin, with possible implications for marine productivity (Stuut *et al.* 2002). In the YRZ, episodes of lunette accretion documented at ~60 ka and ~45 ka are taken to infer drier conditions (Carr *et al.* 2006a, 2006b), a contention supported by charcoal evidence from Boomplaas (Deacon and Lancaster 1988). Analysis of macro- and micromammals from Klasies River indicate increases in grassland in pre-40 ka post-Howiesons Poort layers (Avery 1987; Klein 1974, 1976).

In the SRZ, the Tswaing record indicates rainfall below present levels, excepting brief pulses around 50 ka and again ~30 ka (Partridge *et al.* 1998). The Border Cave micromammal data generally concur with the Twsaing record, suggesting rainfall at 40-55% of present levels following the onset of OIS 3 (Avery 1992). This may reflect the occurrence of generally cool SSTs in the Indian Ocean throughout OIS 3 (Be and Duplessy 1976). Despite this, precipitation appears generally to have remained above 550mm from 60-40 ka. With regard to vegetation, the initial post-Howiesons Poort (>50ka) charcoal and fauna at Sibudu reflects an increase in open habitats, though the sample size is relatively small (Allott 2004; Clark and Plug 2008). Further north, Avery's work at Border Cave suggests expansion of grasslands at the OIS 4/3 interface (Avery 1992).

The transition from Howiesons Poort to post-Howiesons Poort thus appears to have occurred in a context of minor warming and minor drying across most of the sub-continent.

Thereafter, from 40-20 ka, conditions probably became marginally colder. The terrestrial record from the Stampriet and Uitenhage aquifers suggests that temperatures at this time were some 5-6° below present (Stute and Talma 1998), while Avery (1992) suggests a drop of roughly 0.5° from early OIS 3 to later OIS 3. In the YRZ, pollen analysis indicates the presence of slightly more mesic vegetation on the southern Agulhas Plain around 38 300 ± 570 cal yr BP and 33 520 ± 690 cal yr BP (Carr *et al.* 2006a, 2006b). Marine records from the northern periphery of WRZ suggest the persistence of conditions wetter than present but drier than OIS 4, albeit with high amplitude fluctuations (Stuut *et al.* 2002). Increased upwelling appears also to have persisted through this period.

Again, there appear to be contrasts both between the SRZ and the WRZ/YRZ, and also within the SRZ from 40-20 ka. Botha and Partridge (2000) and Maud and Botha (2000) both suggest that cooler, drier conditions probably prevailed along the south east coast and hinterland 45–25 ka (also Temme *et al.* 2008), while in the interior, wet and relatively warm conditions are suggested by analysis of pollens in the Wonderkrater archive, dating 40-30 ka (Scott 1999). At Sunnyside 1, also in the SRZ interior, cool, possibly moist conditions are associated with an OSL age of 30.5 ± 14 ka. Further north, data from the Kalahari suggest episodes of increased moisture ~38 ka and ~32 ka (Burrough and Thomas 2008; Thomas and Shaw 2002). In post-50 ka units at Sibudu, species from open habitats are dominant (Clark and Plug 2008). Likewise, Wonderkrater suggests grassy conditions from 40-30 ka (Scott 1999). In layers dated ~40 ka at Border Cave, however, an increase in bushy vegetation is implied by faunal change (Klein 1977), though the sample is small.

While the SRZ record seems to provide the ideal context for the occupational pulsing model favoured by Jacobs *et al.* (2008a,b)– generally dry with wetter episodes – the WRZ and YRZ records provide no obvious explanation for the local absence of an archaeological signal. Though cold, conditions were generally warmer than those during OIS 4, and there is also no evidence for pronounced aridification. Indeed, if anything this period seems to have been markedly wet (Chase and Meadows 2007; Mitchell 2008).

By the onset of OIS 2, temperatures across southern Africa were probably 5-7° cooler than present (Temme *et al.* 2008; Thackeray 1987). In the interior SRZ this period was associated with cold and dry conditions with sparse grass coverage (Holmgren *et al.* 2003).

At Border Cave, a reduction in precipitation of some 25-55% coincided with the transitional MSA/LSA units 40-30 ka, followed by abandonment of the site around 24 ka (Avery 1992). At nearby Equus Cave, Johnson *et al.* (1997) report rainfall of around 190 ± 50 mm per year at 17 ka, which represents around 30% of present rainfall levels (~600 mm/a).

Again, there appear to be contrasts between the SRZ and WRZ, the latter of which appears to have been relatively wet and wooded during the LGM. Parkington *et al.* (2000), for example, have established the presence of afromontane forest in the area around Elands Bay Cave at this time. The YRZ pattern seems to indicate a mix of elements pertaining in the WRZ and SRZ. Deacon (1979) suggests that dominant vegetation during the LGM was probably open woodland with a grassy understorey. Xeric elements are taken to dominate the wood taxa, indicating less rainfall than present. Parkington *et al.* (2000: 546) conclude that the WRZ and YRZ were "out of phase in the colder parts of Pleistocene climatic cycles", largely due to differences in rainfall controls.

2.3 DISCUSSION OF ARCHAEOLOGICAL AND ENVIRONMENTAL PATTERNS 220 – 20ka

The pre-120 ka archaeology of southern Africa remains poorly documented. The work of Curtis Marean and colleagues at Pinnacle Point is an initial step towards remedying this issue, yet it remains that the excavation of a single site or site complex will be insufficient to characterize the great swathe of time and space involved. Fuller publications of results from sites such as Wonderwerk would be beneficial. These limitations aside, the available data, including that from transitional industries such as the Fauresmith, Sangoan and, further north, the Lupemban, are sufficient to suggest considerable archaeological variability prior to OIS 5, including early evidence for the manufacture of small blades or bladelets, bifacial points, scrapers and backed artefacts. The data from early OIS 5 sites add to this list unifacial points and even rare tanged pieces (cf., Volman 1981: 228; Singer and Wymer 1982: 70). From 120 ka though to 80 ka, these features seem to be a recurrent, low frequency component of many archaeological assemblages. In terms of subsistence, terrestrial faunal assemblages from these early sites appear usually to be dominated by medium to large bovids, though with clear evidence of predation on a diversity of smaller mammals and reptiles. Coastally-situated sites are indicative of significant flexibility in early subsistence behaviours, with both shellfish middens and small numbers of fish observed at Pinnacle Point and Blombos.

After 80 ka, and broadly coeval with the onset of the last glacial, the frequency of many technological features which were sporadically distributed in earlier sequences appears to increase. The pre-Still Bay layers at Blombos Cave and Hollow Rock Shelter suggest that minor initial increases in bifacial point prevalence preceded more dramatic frequency changes. The addition of soft hammer reduction may be the only genuinely innovative feature of the stone artefact technologies of post-80 ka assemblages, however, the remarkable blades with ground butts in the MSA 2a at Klasies River are suggestive of a deeper antiquity for detachment strategies other than direct hard-hammer (Deacon 2001: 8; Volman 1981: 259-260; Wurz pers comm. 2007; pers. obs.).

In generally terms, it seems reasonable to suggest that post-80 ka stone artefact assemblages in southern Africa are more easily characterized with respect to their retouched component than are assemblages from pre-80 ka contexts. This greater prevalence of distinctive retouched forms coincides with increased selection of finer grained rocks in many contexts, and hints at deeper changes in technological organisation. In some senses, and with exceptions such as Die Kelders, many sequences from the period 80-20 ka seem to express an alternation of point-dominant and backed artefact-dominant strategies. Thus, the point-rich Still Bay gives way to the backed artefact-rich Howiesons Poort, which in turn yields to the point-dominated early post-Howiesons Poort etc. This tendency is marked in all rainfall zones, but is most clear in SRZ sites such as Sibudu, Umhlatuzana and Rose Cottage Cave which are occupied through the later post-Howiesons Poort.

It is possible that the perception of point / backed artefact alternation is exaggerated by the reduction of sequences to a series of units, which are defined in terms of their differences from one another. For example, if both units ‘a’ and ‘b’ are dominated by scrapers, but one contains some points and the other some backed artefacts, then it is likely that the prevalence of the non-scraper implements will be used as the defining features of the respective units. More completely published assemblages such as Malan's sequence from Rose Cottage Cave (Wadley and Harper 1997), and Kaplan's (1990) sequence from Umhlatuzana help to demonstrate that, in fact, this cursory observation may be relatively robust. Figure 2.11 presents data on the frequencies of points and backed artefacts through these two sequences. In each figure, the width of the solid black shapes expresses points and backed artefacts as a percentage of the total retouched assemblage. The percentage of other retouched artefact types can be discerned from the width of the white zone which lies between the two black shapes. The figure supports the suggestion that, at Rose Cottage Cave and Umhlatuzana at least, changes in retouch can indeed be described in terms of the alternation of point-dominant and backed artefact-dominant strategies.

It is worth noting that this pattern appears to cease with the onset of the LGM, and is thus roughly coincident with OIS 4 and OIS 3. The preponderance of dates support the persistence of radial core and other aspects of MSA technologies through to the interface of OIS 3 and OIS 2, rather than the more conventionally assigned cessation point at ~40 ka[10]. Only the interior parts of the SRZ potentially have LSA assemblages antedating 30 ka. Otherwise, dates for transitional assemblages tend to be centred on or around 24 ka, with fully LSA assemblages (that is, assemblages entirely without MSA markers) only becoming prevalent around 20 ka. There is, overall, far stronger evidence for the persistence of prepared core technologies after 30 ka than there is for their abandonment before 30 ka.

A pattern of alternation may also be visible in faunal data, though relevant assemblages are rare and not always substantial. Nevertheless, the available data imply a pattern of larger terrestrial game procurement (early MSA and Still Bay) followed by a move to more small package items in the Howiesons Poort. At Sibudu, this is followed by a return to medium and larger bovids in the post-Howiesons Poort. Assemblages dating to the LGM are small and highly fragmentary, though a large percentage of dassie is observed in the sample from Nelson Bay Cave.

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[10] The cessation of MSA technologies appears to date to > 40 ka at some sites in eastern Africa (cf., Ambrose 1998), though in many cases the relevant assemblages are poorly described and it is difficult to assess whether prepared cores disappeared or simply reduced in frequency. In any case, the interest here is with patterns in southern African; the relevance of data from eastern Africa to tehse patterns is difficult to assess.

Fine scale patterning in stone artefact assemblage size and/or density are also worth noting. Specifically, Howiesons Poort assemblages often seem disproportionately large, given the apparently brief duration of the industry (probably in the order of 5-10 kyr). While the preceding Still Bay may well have been an even briefer occurrence, it remains that the multiple succeeding units identified across southern Africa are generally represented by small assemblages which belie the extensive stretch of time covered (~40 kyr). The apparently large size of Howiesons Poort assemblages needs also to be considered in relation to their surprisingly wide distribution. Unlike Still Bay assemblages, which are generally (though not exclusively) constrained to the present-day YRZ and WRZ, or 40-20 ka assemblages which occur almost entirely in the present SRZ, Howiesons Poort and early post-Howiesons Poort assemblages are known from an enormous number of sites in a range of environmental contexts. While the distinctive large backed artefacts, blades and high frequencies of fine-grained rocks with which the Howiesons Poort is associated may well render it more archaeologically visible than other late Pleistocene industries, it remains disproportionately common in multi-component stratified sites (BMP, KFR, KRM, NBC, PC, SC etc) and not only in single component sites such as Howiesons Poort Shelter. In concert with faunal patterns which seem heavily focused on small mammals, the Howiesons Poort implies re-organisation of settlement and subsistence systems.

The general correlation in age between Howiesons Poort dates and the cold conditions of later OIS 4 suggests some environmental causation, though this correlation is contested by some (e.g., Jacobs *et al.* 2008a). Complicating any such correlation is the paucity of long duration terrestrial palaeoecological records, which effectively precludes contextualization of Howiesons Poort environments in terms of preceding and subsequent conditions. That aside, there also appears to be a general correlation between the post-Howiesons Poort and the variable conditions associated with OIS 3. Environmental change, however, provides no obvious explanation for the absence of an archaeological signature in the WRZ from 40-20 ka. The limited available data suggest that conditions during this period were no drier and no colder than those pertaining during OIS 4. While it is possible that many sites occupied during this time have been drowned by subsequent sea level rise, this is equally or even more true of sites occupied during the Howiesons Poort and during the LGM, both of which are well-attested archaeologically. It thus needs to be asked whether the pattern is simply an artefact of small sample size, or whether causal mechanisms are being obscured by the poverty of palaeoecological data.

This point leads to a final observation – that the WRZ is generally poorly represented in the literature despite its long research history. Though multiple Still Bay, Howiesons Poort and post-Howiesons Poort assemblages have been excavated, only the Still Bay assemblage from Hollow Rock Shelter has been published in a widely accessible format (cf., Evans 1994). Given the apparent spatial complexity of occupation and technology across southern Africa suggested by this review, this gap in the archaeological record requires attention.

3

APPROACHES TO THE LATE PLEISTOCENE ARCHAEOLOGY OF SOUTHERN AFRICA

3.1 INTRODUCTION

The previous chapter presented information on our current knowledge of the late Pleistocene archaeology of southern Africa. This chapter considers how this information has, in the past, been approached, ordered and presented. It is argued that, due to prejudices established in formative works, late Pleistocene archaeology in southern Africa has remained largely untouched by many of the theoretical developments of the late 20th century. Archaeological studies of this period continue to reflect the influence of culture evolutionary and culture historic thought, with little attention given either to explicit theory building or to the interpretation of patterns. Existing approaches hamper the identification of processes underlying and structuring change in archaeologically-visible materials. In obscuring these processes, patterns of similarity and difference have been exaggerated, and potentially significant lines of inquiry prematurely foreclosed.

This chapter begins with a brief history of southern African archaeology. The objective is to document the existence of recurrent themes which have affected approaches taken to different parts of the archaeological record. The subsequent sections critically assess these approaches, and consider how they have influenced depictions and understandings of cultural change.

3.2 A BRIEF HISTORY OF SOUTHERN AFRICAN ARCHAEOLOGY

Southern African archaeology began with the collection of stone artefacts by antiquarians in the mid 19th century (J. Deacon 1990). The publications which soon followed were primarily concerned with demonstrating to both a European and local audience the existence of a stone age in southern Africa (e.g., Dale 1872; Griesbach 1972; Lubbock 1869, 1872; Layard 1872). Tentative, and largely premature, synthetic works began to appear not long afterwards (e.g., Feilden 1884; Gooch 1882; Rickard 1881a,b). These works attempted to organise items of material culture into units, or cultural groupings, which were then arranged into a rough temporal order. In the general absence of data concerning the order of cultural superposition, temporal sequences were developed on the general premise that "the less adapted a class of stone to the use required of it, the greater may the age of deposit in which it is found, be expected to prove itself" (Sanderson 1879: 20 – citing Gooch's unpublished notes). Without a local lexicon from which to work, finds were described using terms such as "Palaeolithic" and "Neolithic", imported from the nascent European field.

The work of Johnson (1907, 1912) and Peringuey (1911) at the beginning of the 20th century introduced a degree of rigour to the study of archaeological finds in southern Africa. Both scholars appear to have been convinced of the deep antiquity of southern Africa's archaeology, a belief which, at the time, was contentious (e.g., Balfour 1906; Codrington 1909; Feilden 1905; Jones 1899; Lamplugh 1906; Penning 1887). Indeed, Peringuey may have been among the first to contemplate an African origin for humankind (1911: 2). Like their late 19th century forbears, Johnson and Peringuey attempted to develop frameworks for the organisation of southern Africa artefacts. However, they relied much more heavily and much more directly on comparisons between African and European finds. Thus, this period saw the introduction of European constructs such as the 'Acheulean', 'Chellean', 'Mousterian', 'Aurignacian', and 'Solutrean' into the southern African literature, not only as concepts, but as cultural groupings. There were considerable differences, however, in what each scholar implied by their use of such terms.

Johnson adhered to the concept of unidirectional, progressive, cultural evolution, with the additional presumption that evolution had occurred in a series of discrete, universal stages. Thus, to Johnson, the Solutrean was a stage in human development, and expressions of the Solutrean in two different locations carried no implication of cultural linkage. Moreover, they did not carry any implication of contemporaneity. Though African prehistory was perceived to have considerable antiquity, Johnson (1907: 52) felt that developments there "lagged behind somewhat" in relation to those observed in Europe.

In contrast, Peringuey (1911: 3) rejected the idea of progressive evolution. Rather than as universal stages, Peringuey saw in the cultural groupings of southern Africa evidence of contact with the cultures of Egypt, Europe and even Mongolia. To Peringuey, the presence of units such as the Solutrean in both Europe and southern Africa reflected some degree of cultural connection between the two.

One side effect of these comparisons was the introduction into Africa of concepts associated with Europe culture-groupings, and for which, locally, there was little or no evidence. The most important example concerns the presumption that art and other cultural advances appeared in southern Africa alongside Solutrean-like implements (Johnson 1912; Peringuey 1911: 3). To Johnson, this was an indigenous development, while to Peringuey, the artists and bone tool makers of southern Africa were "the linear descendant or living representative of the man of Solutre or Aurignac" (Peringuey 1911: 215).

The 1923 arrival in South Africa of A.J.H. Goodwin was a pivotal point in the development of the archaeology of the region (J. Deacon 1990; Shepherd 2003). A South African-born, Cambridge-trained student of Miles Burkitt, Goodwin soon set about the considerable task of organising the stone artefact collections housed in the South African Museum at Cape Town. The result of this labour was the foundational work *The Stone Age Cultures of South Africa*, completed with the assistance of C. Van Riet Lowe and published in 1929.

In this work Goodwin established a new organisational framework for southern African studies. Eschewing the direct European homologies favoured by Johnson and Peringuey, Goodwin developed a new three age system of Earlier, Middle and Later Stone Ages. These ages he sub-divided into industries and variants[11]; the ESA being comprised of the Stellenbosch, Victoria West and Fauresmith; the MSA of the Glen Grey Falls, Still Bay, Howiesons Poort, Mossel Bay, Alexandersfontein and Hagenstad; and the LSA of the Smithfield and Wilton.

Goodwin was far better placed to create such a framework than previous scholars, not only because of the formidable collections at his disposal, but because of a number of important excavations which had taken place in the previous decade (cf., Arnold and Jones 1919; Goodwin 1929; Hewitt 1921; Peers 1927, 1929 Stapleton and Hewitt 1927, 1928). These new excavations, as much as any parochialism, allowed the development of an indigenous southern African terminology, and thus the abandonment of the explicitly European terms which had earlier been favoured (e.g., Collins 1915; Lewis Abbott 1913; Johnson 1907, 1912; Jones 1924; Peringuey 1911; Smith 1919; Wayland 1915).

However, while Goodwin's new scheme represented a nominal break from European tradition (cf., Goodwin 1958), it was clearly modeled on the European Palaeolithic system. The Earlier, Middle and Later Stone Ages, Goodwin (1931: 25) stated: "agree with the pre-Mousterian, Mousterian, and post-Mousterian of Europe". The appearance of Goodwin's MSA reflected an influx of "Mousterian elements", and thus a species-level population replacement, while the LSA marked the replacement of these elements by "Neo-anthropic" peoples – "an offshoot of a late Mesolithic or early Neolithic stock" (Goodwin and van Riet Lowe 1929: 7). Like several of his predecessors, Goodwin saw the post-Mousterian, or LSA, as the age of artistic endeavour (Goodwin and Van Riet Lowe 1929: 7; Goodwin 1931: 25).

More important than the European–African comparisons in Goodwin's work were the key tenets and basic structure of his industrial scheme. Like his mentor Burkitt, Goodwin was primarily interested in the identification of industries, which he saw to be the material expressions of various ethnic or cultural groups. Cultural change was viewed as a process of replacement, with migration and diffusion the mechanisms by which new cultural groups and techniques appeared. Goodwin saw each new industry as representing the arrival of a

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[11] The term "variant" was employed to describe industries identified on the basis of numerically limited or compromised samples.

wave of more advanced immigrants into southern Africa from the north. To the extent that each new group was perceived to bring advancement, Goodwin retained the idea of directionality in archaeological (and particularly technological) change articulated in the 1880's by Gooch. The intermediacy of the MSA refers to its placement between the lower and higher groupings (respectively) of the ESA and LSA. Likewise, industries within the MSA and LSA formed a rough "evolutionary series", with the Howiesons Poort seen as a hybrid of MSA and LSA techniques, or, to use Goodwin's more floral phrasing, as "throwing the road open for the Later Stone Age" (Goodwin and van Riet Lowe 1929: 101).

Goodwin and Van Riet Lowe's work has been the cornerstone of much, if not most subsequent archaeological work in southern Africa. The period following its publication was one of considerable activity. Under the patronage of General Smuts, archaeology came to be viewed as scientific discipline important to South Africa's international standing (Shepherd 2003), and though the number of professional archaeologists remained small (J. Deacon 1990), with the creation of the Archaeological Survey (in 1935) and the South African Archaeological Bulletin (in 1945), academic output increased considerably.

In 1929 Goodwin had defined seven industrial classifications with five variants. In the period between the publication of *The Stone Age Cultures of South Africa* and the closure of the Archaeological Survey in 1962, names had been coined for at least 70 groupings, many of which were reconfigurations of original classifications (e.g., Smithfield N, Late Wilton, Proto-Stillbay – Table 3.1). Moreover, the majority of these appear to have been variants rather than higher order classifications. While increases in the number of industry terms were almost certainly related to increases in the number of participating individuals, this is probably only a partial explanation of their proliferation. Most correspondence was funneled through the Archaeological Survey and the Archaeological Bulletin, and thus the coining of new terms did not occur without professional oversight. It is at least equally likely that expanding knowledge of the region's archaeology fostered an increased appreciation of its diversity. Several of Goodwin's units had been defined with reference to only a single implement type, and thus there was considerable scope for finer-scale differentiation through time and space. Mason (1957) presented one new approach, using multiple artefact attributes to explore sequential variation within, rather than between industries.

However, while local approaches and terminologies were fissioning, the influence of the first Africa-wide syntheses (e.g., Alimen 1957; Clark 1959; Leakey 1936) and the inauguration of the Pan-African Congress (in 1947), saw the initiation of classification schemes at the pan-continental level. The introduction of this new scale necessitated the use of far more generalised industrial units. Rather than create new names, however, names initially derived from single type sites were co-opted. Thus, the term 'Magosian', taken from the type site of Magosi in Uganda, came to replace indigenous southern African industrial terms such as the Howiesons Poort (e.g., Malan 1949b), while the Still Bay was called into service from the Cape to the Horn (Kleindienst 1968: 824).

The appearance of units describing patterns at vastly differing spatial scales exposed ambiguities in the meaning of terms such as "industry". The attempts of the 1965 Burg-Wartenstein conference to create more rigidly defined concepts like "archaeological aggregation" and "industrial complex" (cf., Bishop and Clark 1967) was a largely mechanical exercise – questions concerning the objectives of such classificatory systems, and the causes of similarity and difference in stone artefact assemblages at local and continental scales were left unaddressed. On the one hand, the idea of an industry as reflecting the artefact-making traditions of a group of people retained considerable currency. Sustaining such a conception at the continental level, however, would have required the kind of hyper-diffusionist thinking that had long been out of fashion (cf., Trigger 1989: 153). Instead, J.D. Clark, who devised the most pervasive early pan-continental scheme was to remark in his description of the Magosian that:

Although in what follows we shall talk of a Magosian Culture or cultures or the Magosian peoples, it is not intended to imply that the various regional forms were necessarily the product of the same race of people or that their makers had more in common than the broadly similar pattern of their stone industries. (Clark 1959:167)

To Clark, the Magosian was not a culture in the sense of a tradition, but rather a universal intermediate between two universal stages in a single evolutionary sequence, albeit one occurring in concert with broad climate changes (cf., Hole 1959). To an extent, these contrasting depictions of industries – as universal stages or as culture-groups – reflect different understandings of the causes of material culture patterning which had lain unresolved since Johnson and Peringuey.

Clark's approach to the local-fission / continental-fusion problem was to suggest that small-scale variation was the product of responses to the opportunities and constraints of local environments (Clark 1970: 117). In this, Clark was not alone, Goodwin (1958, 1946; Goodwin and Van Riet Lowe 1929) and others (e.g., Alimen 1959: 281; Innskeep 1967: 558; Mason 1957) had acknowledged the influence of environmental factors on artefact-making tendencies. Unclear, however, was how these influences played out – how, that is, environments shaped behaviours in general, and artefacts in particular.

Nevertheless, the environmental adaptationalist tone of Clark's approach was to provide a precursor to the influence of the Cambridge economic school of Grahame Clarke and Eric Higgs, and to a lesser extent, the new archaeology of Binford *et al.* (cf., J. Deacon 1990). These schools of thought emphasized material culture change as an adaptive process, influenced by existing traditions, but shaped by environmental variation. The arrival in Cape Town in 1966 of John Parkington, like Goodwin a Cambridge graduate, brought the ideas of the economic school directly to bear on southern African material. Parkington's seminal 1977 PhD thesis *Follow the San* significantly rephrased the kinds of questions being posed. Rather than attempting to identify and order archaeological units as Goodwin had done 40 earlier, Parkington was concerned with questions of how people made a living, employing the idea of a seasonal round of mobility that tracked variance in resource availability (cf., Parkington 2001).

Where Parkington's study was largely synchronic, Hilary Deacon's (1976) pene-contemporaneous study of palaeoecological and archaeological remains from two shelter sites in the Eastern Cape allowed both synchronic and diachronic assessment of adaptation to environmental variation. Like Parkington, Deacon suggested that Holocene populations had employed a strategy of seasonal transhumance, where reliance on small game hunting and plant collection was supplemented by seasonal exploitation of marine resources.

Deacon contrasted this Holocene pattern with one emphasizing game procurement, which pertained during the Late Pleistocene.

In the context of such vitalizing studies, the major synthetic work of the 1970's, Sampson's (1974) comprehensive *The Stone Age Archaeology of Southern Africa*, informed as it was by the concerns of the Burg Wartenstein conference, seemed in many ways a piece out of time. Sampson's primary interest was in the identification and description of hierarchically-ordered groups, and their distributions in time and space. Patterns of similarity and difference in assemblages were ascribed almost entirely to cultural predilections at varying degrees of abstraction – "stylistic preferences" at the finest scale and "technical traditions" at the broadest (Sampson 1974: 7-8). Comparatively little interest was shown in the effects of ecology and economics on technological expression.

Archaeological developments in southern Africa in the 1980's were dominated by the results of ethnographic studies carried out in the Kalahari (cf., Lee and Devore 1976 and papers therein; Wiessner 1977, 1982, 1983). These studies provided new levels of insight into the lifeways of mobile hunter gatherers. And while their validities as direct analogues of the past may have been questionable (Humphreys 2004; Wilmsen 1989), their influence on emerging archaeological work was clear. From the early 1980's, southern African archaeologists became heavily engaged with issues such as seasonal mobility and population dynamics (Manhire 1987; Wadley 1987), spirituality (Lewis-Williams 1981, 1982, 1983), gender (Mazel 1989a, 1989b; Wadley 1987, 1989), and territoriality (Hall 1985; Leslie Brooker 1989).

Yet what is notable about the ecological-economic archaeologies of the 1970's and the ethnoarchaeologies of the 1980's is how little impact they had on the study of materials classified as belonging to Goodwin's MSA unit. As Volman (1984: 169-170) lamented, in the flurry of late 20th century methodological and theoretical developments, the MSA had largely been left behind. The limited influence of the ecological-economic school is at least partly explained by a combination of poor preservation and a lack of effective chronometry. The inter-site comparisons of Parkington and H.J. Deacon were largely predicated on good preservation of floral and faunal material – something which was uncommon in MSA sites. Similarly, these comparisons were contingent on chronometric control to establish that assemblages in two locations were indeed like-aged despite differences in their composition. By 1972, however, Beaumont and Vogel had demonstrated that most of the MSA lay beyond the reach of available chronometric methods. The use of ethnographic analogy in the interpretation of MSA material, meanwhile, was embargoed on the basis of perceived cultural and occupational discontinuities between present and past (e.g., J. Deacon 1984a: 222).

Denied these vitalizing concepts, and in view of the absence of any effective chronometry, approaches to MSA material remained focused on the definition and seriation of archaeological units. Thus Volman's 1981 PhD thesis, discussed in Chapter 2, made little attempt to interpret the significance of changes between units, which were ascribed largely to changes in "fashion". Singer and Wymer's (1982) analysis of the Klasies River main site sequence yielded a similar result. To date, and despite the chronometric advances of the late 1980's and 1990's (cf., Aitken *et al.* 1993 and papers therein), this approach persists. Though the work of scholars such as Wurz (1997, 1999, 2000, 2002; also Wurz *et al.* 2005; Lombard 2006) has done much to improve the detail with which some industries are described, the characterization of industries and their spatial/temporal distributions remains the focus of MSA research (see also Kaplan 1990; Minichillo 2005; Soriano *et al.* 2005; Thackeray 2000; Villa *et al.* 2005; Wadley 2006). Attempts to interpret patterns remain uncommon (cf., Ambrose 2002; Ambrose and Lorenz 1990; Deacon and Wurz 1996; McCall 2007). The replacement in many of studies of traditional terms like 'culture' and 'industry' with a diverse array of alternative epithets (including "period", "phase", "stage", "sub-stage", "techno-complex" and "variant") has only served to obscure the meaning associated with these units. The foregrounding of 'style' or 'fashion' in many studies implies a cultural underpinning (e.g., Lombard 2006; Minichillo 2005; Volman 1981; Wurz 1999), while at the same time, terms such as "phase" and "stage" are more strongly reminiscent of the kinds of universalist systems favoured by Johnson and later Clark. Ultimately, however, the near-complete absence of definitions for such terms renders any interpretation of their meaning conjectural.

3.3 CULTURE EVOLUTIONISM, CULTURE HISTORY AND THEIR EFFECTS ON THE LATE PLEISTOCENE ARCHAEOLOGY IN SOUTHERN AFRICA

The theoretical roots of southern African archaeology can be described in terms of two schools of thought: culture evolutionism and culture history (cf., Dunnell 1980; Leonard and Jones 1987; Lyman *et al.* 1997; Trigger 1989). Each of these schools helped to shape early approaches to and understandings of the archaeological record in different ways. From the advent in the 1960's of the processual, and subsequent post-processual and selectionist schools, the prevalence of cultural evolutionist and culture historic theory generally waned (Lyman *et al.* 1997). As noted in the previous section, however, the vitalizing effects of many late 20th century theoretical developments had little tangible impact on studies of material categorized as 'MSA'. This section considers how culture evolutionary and culture historic thought in late Pleistocene studies have affected and continue to affect our approaches to and understandings of the archaeological record of southern Africa.

3.4 CULTURAL EVOLUTIONISM AND ITS EFFECTS ON SOUTHERN ARFRICAN ARCHAEOLOGY

3.4.1 What is cultural evolutionism?

The term 'cultural evolutionism' as it is used here refers to the idea that the evolution of human behaviours and technologies was progressive, proceeding through a sequence of improvements and leading eventually to the modern cultural repertoire (Dunnell 1980). In classic culture evolutionist works, human organisation is seen to have passed through a series of stages, with each stage marked by increasing behavioural and technological complexity. These stages do not reflect modes of behaviour transmitted from one group to another, but rather are universal modes at which groups arrive and through which groups pass independent of any cultural contact. Johnson's conception of the Solutrean is one example.

Numerous influential stage schemes have been proposed in the past, including the classic Stone, Bronze and Iron Ages of Thomsen, the tripartite classification of savagery, barbarism, and civilised life favoured by Tylor (1929 [1871]) and Morgan (1944 [1877]) and the four part 'band, tribe, chiefdom and state' system of Service (1962). In each system, increases in the sophistication of behavioural organisation are concomitant with improvements in technological efficiency and complexity. The two are inseparable in Thomsen's scheme, while to Morgan, technological improvements were a necessary precondition for the advance of social complexity (Carneiro 2003: 59-60). Tylor provides numerous specific examples, including the development of the gun and navigational aids, as well as "bronze celts, modeled on the heavy type of the stone hatchet, [which] are scarcely explicable except as first steps in the transition from the Stone Age to the Bronze Age" (Tylor 1929: 15).

Some of the subtler characteristics of cultural evolutionism can be drawn out by comparison with Darwinian forms of evolutionary archaeology (cf., Bettinger and Eerkens 1999; Boyd and Richerson 1985, 2005; Dunnell 1978, 1980; Jones *et al.* 1995; Leonard and Jones 1987; Lyman and O'Brien 1998; O'Brien and Holland 1990; Rindos 1985, 1986, 1996). In a Darwinian view of evolution, change occurs as the result of the differential persistence of certain characteristics in the face of varying selective environments. From this perspective, the probability that a given characteristic will persist is determined by the net benefit it conveys in relation to the context in which it is deployed. Beneficial characteristics tend to flourish; deleterious characteristics tend to fail. Characteristics which are neither markedly beneficial nor deleterious tend to exhibit stochastic distributions. When circumstances change, however, the same characteristic may or may not continue to prove selectively beneficial, deleterious or neutral. The advantages of a given characteristic are thus not absolute properties, but context-specific. Because of this, Darwinism views evolution simply as structured change without the necessity of any long-term tendency towards improvement.

In contrast to Darwinist thought, cultural evolutionism has its basis in the view of evolution taken by 19th century anthropologists and social theorists such as Herbert Spencer, Lewis Henry Morgan and Edward Burnett Tylor (cf., Carneiro 2003; Dunnell 1980). From a cultural evolutionist perspective, certain behaviours and technologies are simply inherently better, or more effective than others. The advantages of, or conveyed by, a behaviour or technology are not context-specific, but rather absolute properties. Because variance in context is not significant to whether one behaviour / technology is more effective than another, it becomes inevitable that with the passage of time 'better' behaviours and technologies will come to proliferate at the expense of inferior forms. It is this inevitability which lends the culture evolutionary account of history its directional or progressive aspect.

The critical difference between culture evolutionism and Darwinian evolution thus relates to the role played by the environment in which behaviours and technologies are deployed. In cultural evolutionism, advantages and disadvantages are inherent characteristics of behaviours and technologies, and pertain independent of the contexts of their use. In Darwinian evolution, on the other hand, advantages and disadvantages are evaluated relative to the context of deployment.

3.4.2 Examples of cultural evolutionism in southern African archaeology

The cultural evolutionist overtones of early southern African works are relatively clear. Gooch (as cited in Sanderson 1879) suggested that the degree of 'adaptedness' of an artefact was directly related to its age. Johnson (1907) and Goodwin and van Riet Lowe (1929) argued that technological sequences reflected increases in sophistication through time. While in the latter half of the 19th century avowedly culture evolutionist works have become relatively rare, its influence remains apparent in several areas. The use of general or universal stages is one such area. The Earlier, Middle and Later Stone Ages are general stages in a progressive sequence. Though Goodwin's subsequently-stated intention was that the use of the scheme be restricted to sub-Saharan Africa (Goodwin 1958), his willingness to draw direct parallels with the stages of the European Palaeolithic implies a level of generality not unlike Johnson's conception of the Chellean, Solutrean etc. When Clark later expanded the scheme across all of Africa, he was explicit that the stages being identified did not reflect shared traditions, or evidence of contact between geographically disparate groups. The inference was that groups arrived at the various stages of the progressive sequence independent of one another. Like Tylor's savagery, barbarism, and civilised life, the Earlier, Middle and Later Stone Age were simply phases of development through which groups invariably passed.

While terms such as ‘phase’, ‘stage’ and ‘sub-stage’ have persisted into present usage, it is not clear that they always carry culture evolutionary implications. In many cases, where concepts of ‘style’ and ‘fashion’ are emphasised (cf., Clark 1999; Deacon 1992; Deacon and Wurz 1996; Thackeray 1989, 1992; Volman 1981; Wurz 1997, 1999, 2002), their meaning seems more closely akin to the terms ‘culture’ or ‘industry’ as they were formerly used. The continued willingness of archaeologists to draw parallels between the Ages of Africa and the Palaeolithic units of Europe (cf., Bar-Yosef 2002; Foley and Lahr 2003; Klein 1989, 1995, 2001; Shennan 2001; Stiner and Kuhn 2006), however, necessitates some idea of broader level patterning in technological development occurring without the influence of information transmission between groups. Recently, Wurz *et al.* (2005) have suggested that the distinction between Middle Stone Age and Middle Palaeolithic is unnecessary and obfuscatory, implying significant differences where none exist. The fact that these terms were traditionally applied to the archaeological records of distinct hominids is taken to be less significant than the technological similarities that they purportedly mask. To Wurz *et al.* (2005: 21), the ‘Middle Palaeolithic’ is a “stage term” with “priority” over the term ‘Middle Stone Age”. The inference that all prepared core-technology using peoples, whether *neanderthalensis* or *sapiens*, whether in Europe or in Africa, can be referred to the same ‘stage’ of history bears clear comparison with ideas in the classic works of cultural evolutionism.

Even where the archaeological record is not described in terms of universal stages, there has been a marked tendency to depict technological change as having a directional element. Figure 13 in McBrearty and Brooks (2000: 530, reproduced here as Figure 3.1), for example, suggests that both the range and complexity of technologies underwent continual increase through time. As new technologies, once added, are taken to persist thereafter, the effect is strongly directional. Similar depictions of the directional nature of technological change can be found in Foley and Lahr (2003, 1997).

McBrearty and Brooks (2000) is one of many articles and books dealing with what has come to be known as the ‘modernity debate’, much of which has been phrased in culture evolutionist terms. The debate contrasts a modern behavioural and technological repertoire with its pre-modern equivalent, suggesting that the former eventually came to supercede the latter. Though there is disagreement over the ways in which this replacement occurred, most protagonists seem agreed on three points. First, that there is a mode of behaviour which appears late in human history and which allowed humans to survive more effectively than preceding mode(s). This more effective behavioural form is commonly associated with the use of language and other complex signaling systems such as music and art, as well as with a range of technologies such as bone tools, blades, backed artefacts and bifacial points. All of these are considered to have conferred significant adaptive advantages over their pre-modern forebears. The second point of agreement is that this modern mode, once established, proliferated in all contexts after its first appearance. The third is that the modern behavioural mode has never been replaced by 'pre-modern' behaviour. Thus, once it appears, it inevitably persists. The modern repertoire is therefore seen to mark a behavioural apogee of sorts. This combination of beliefs – that there is a mode of behaviour which is always advantageous regardless of the contexts of its deployment through time and space – is typically culture evolutionist. Works suggesting that the advantages of the modern behavioural mode were context-specific have been comparatively rare (e.g., Boyd and Richerson 1985, 2005).

Culture evolutionist thinking can also be observed at less general levels, with notable examples concerning the idea that the temporal occurrence of technologies should form a progression of sorts. It was this idea which dissuaded Goodwin from placing the Howiesons Poort within, rather than at the end of the MSA, despite stratigraphic evidence to the contrary (Wurz 1999: 38). Once the excavations of Klasies River and Border Cave had established that the Howiesons Poort was indeed an integral part of the MSA, researchers became inclined to describe it as 'innovative', 'precocious' and 'running ahead of time' (Butzer 1982; Vishnyatsky 1994). The Still Bay has been described in similar terms (cf., Henshilwood 2004; In Press African Upper Pal; Villa *et al.* 2009). The suggestion that these technologies are unusually innovative is odd, given that, as noted in the previous chapter, their distinguishing elements occur intermittently earlier in the MSA. Thus, these units do not mark the 'invention' of backed artefacts or bifacial points, but rather short-lived increases in their frequency. The use of terms like "precocious" provides a clearer indication of the underlying issue. The Howiesons Poort and Still Bay are unusual because their stratigraphic / temporal positions do not cohere with presumptions about the ‘evolutionary’ order in which such technologies *should* occur.

A similar point is evident in the MSA sequence schemes developed by Singer and Wymer (1982) and Volman (1984). Both denote their respective ‘stages’ of the MSA with sequential numbers; MSA 1, MSA 2, MSA 3 etc. The Howiesons Poort stands out in these schemes for two reasons; first, because it has a different naming convention, and second, and perhaps more importantly, because it is not accorded a place in the numerical sequence. The significance is more than nominal. If the Howiesons Poort is the third ‘stage’ of the MSA, why is the fourth stage denoted MSA 3? As with the appellation “precocious”, the impression created is that the Howiesons Poort is out of place in the broader MSA context.

3.4.3 The problems of cultural evolutionism

The cultural evolutionary view of history suffers from important empirical and conceptual limitations, a discussion of which helps to understand its effects on archaeology in southern Africa. Empirically, technologies are often distributed through time in a way which is inconsistent with predictions of a culture evolutionary model. As noted in the preceding chapter, supposedly advanced technologies such as backed artefacts and bifacial points often occur episodically, and in many (most?) contexts do not inexorably increase in frequency through time. Indeed, the replacement of these technologies by supposedly less advanced systems is not necessarily uncommon (Torrence 1989). Proponents of a culture evolutionary view may ascribe the loss of ‘advanced’ technologies to population extinctions (eg, Bar-Yosef 2002; Singer and Wymer 1982), or by making reference to the ‘broader pattern’. Without supporting evidence, the former argument amounts to little more than special pleading. The latter is far from compelling when one considers that late Holocene and historically recorded stone-using populations often made implements and employed reduction techniques that could not reasonably be described as end-points in a developmental sequence (cf., Brandt 1996; Conard 2007; Fagan 1960; Hiscock 2008; Maggs and Speed 1967; Poggenpoel and Robertshaw 1981; Shott and Sillitoe 2005; Weedman 2006; White 1967; White and Thomas 1972). This is not because such people lacked the capacity to make elaborate implements; some Australian Aborigines made pressure-flaked bifacial points on glass in the historic period (Harrison AO 2004; White and O'Connell 1982: 125). Many others, however, employed technological systems based on bipolar reduction of quartz without any emphasis on standardized implements. Indeed, in a number of instances in both Australia and southern Africa, systems characterised by expedient cobble reduction and a poverty of implements came to replace more elaborate systems. Idealised though Figure 13 in McBrearty and Brooks (2000) may be, the significance of its inaccuracy needs to be appreciated.

Some classes of technology do appear to become considerably more prevalent and more varied with the passage of time. This trend is most notable in organic assemblage components, including clothes, and instruments, ornaments and implements made of wood and bone. Separating real increases in such items from increases resulting from taphonomic factors, however, is exceptionally problematic. As the Schoningen spears make clear (cf., Thieme 1997), the general absence of evidence for organic technologies in early assemblages cannot reasonably be taken as evidence of absence. Moreover, as Surovell and Brantingham (2007) have demonstrated, preservation can create the appearance of directional change in cases where it almost certainly did not occur. Interpretations based on increases over time in the range and frequency of organic data must therefore be treated with considerable suspicion.

The theoretical limitations of culture evolutionism are perhaps more significant than its empirical limits. At its core, cultural evolutionism is a teleological model of the human past, proposing that history can be understood as a sequence of events leading inevitably to a (perceived) end-point; in this case, modern technologies and behaviours. The model presumes that 'inferior' technologies / behaviours eventually came to be superceded by 'superior' technologies / behaviours, such that the most recent past contains more examples of the latter than of the former. The basis on which the relative efficacy of any given technology / behaviour is assessed is thus its prevalence through time – we 'know' that technology *x* is better than technology *y* because *x* is common in the recent past and *y* is common in the deeper past. These are the only grounds on which we 'know' that Levallois technologies were better than Oldowan technologies, and that typically Upper Palaeolithic implements such as scrapers, backed artefacts and bifacial points were better that their Middle Palaeolithic forebears. Similarly, the regular production of symbolic or artistic items is known to be of benefit to human survival because of their great prevalence in recent history.

Aside from the empirical weaknesses noted above, the problem with this account of technological / behavioural efficacy is that there is little evidence to support it independent of the assumptions of the model. Indeed, culture evolutionism suffers from considerable logical circularity: if we start by *assuming* that more recent technologies are better than more ancient technologies, then to *conclude* that technology *x* is better than technology *y* because it occurs more often in the recent past is simply to beg the question. As Dunnell (1988: 180) puts it, "The notion of progress is used to create the sequence which is the "evidence" of progress". While archaeologists are wont to make statements to the effect that certain, Upper Palaeolithic-like technologies would have "substantially increased the efficiency and productivity of hunting activities" (Mellars 2006a: 9383), or "confer[red] a major adaptive advantage" (Foley and Lahr 2003: 117-118), studies which deal quantitatively with the issue of whether and to what extent the use of a given technology will increase resource capture are almost entirely absent from the literature.

A second, and related problem is that even where we can be reasonably confident that one technology will provide more effective resource capture than another, it does not necessarily follow that that technology is 'better' or that it will become more prevalent over time. The point can be illustrated with reference to the classic example of stone and metal axes.

Tylor (1929: 15) suggested that bronze axes came to replace stone axes because manufacturers realized that the "new material is suited to a handier and less wasteful pattern". To Morgan (1944: 42-43), the advent of metal tools, including the axe, was "the greatest event in human experience", without which 'civilisation' would not have been possible. At face value, the suggestion that a metal axe would be more effective than a stone axe seems eminently reasonable. If we developed an empirical test for the question: 'How much wood can this axe be used to process?', it seems highly likely that a single metal axe would turn out to be both more efficient (processing more wood per unit time/energy) and more effective (processing more wood overall) than a single stone axe.

Exploring efficiency / efficacy in this way, however, involves an unreasonable divorce of the benefits of using an implement from the cost of its procurement / manufacture.

Most hunter-gatherers probably made most of their own equipment most of the time, including procuring and processing the necessary materials. Consider, in this light, the costs of making a metal axe. Leaving aside the specific skill-set needed, the costs in terms of ore and fuel alone are likely to have been prohibitive for individuals and small, mobile groups. In the context of an individual seeking to process a given amount of wood, stone axes are likely to have been a far more cost-effective solution. Only when long-term occupation by larger groups in probably ore-rich areas allowed the costs of metal axe manufacture to be parsed out across time and population would their benefits have begun to outweigh the costs. Today, some groups continue to use stone implements instead of metal alternatives, either because of their efficacy in relation to specific tasks or because of the relatively low cost of their procurement (Brandt 1996; Shott and Sillitoe 2005; White and Thomas 1972; Weedman 2006). Thus, even though metal axes are almost certainly 'better' than stone axes in relation to the prosecution of relevant tasks, this provides no guarantee that they will come to be dominant in all contexts.

3.4.4 The effects of cultural evolutionism on southern African archaeology

Both universal stages and a belief in the generally progressive nature of behavioural and technological change have had significant impacts on approaches to and understandings of the late Pleistocene archaeology of southern Africa. The most notable of these is the foundational and persistent belief in the equivalence of the MSA and Middle Palaeolithic, and of the LSA and Upper Palaeolithic. The evidential warrant for this comparison is limited. In Europe, the suite of changes associated with the transition are both rapid and profound, and are underpinned by a change of hominid; this is not the case in southern Africa. Only the disappearance of prepared core technology clearly links the two.

It is in part this spurious comparison which isolated MSA studies from the theoretical developments of the late 20th century. Poor preservation certainly played a role, however, similar concerns did not inhibit ethnographic interpretation of LSA materials (cf., J. Deacon 1984a: 285). It is also notable that despite chronometric developments and the robust establishment of *Homo sapiens* as the author of the MSA (Beaumont *et al.* 1978; Rightmire 1979, 1984), neither significant inter-site subsistence comparisons nor ethnographic interpretations have been forthcoming in the last three decades. The absence of ethnographic analogy seems almost entirely to reflect the lingering spectre of the MSA as a pre-modern age. Goodwin's comparison of MSA people with the Middle Palaeolithic Mousterians of Europe was not redressed in the later syntheses of Leakey (1936), Alimen (1957) or Clark (1959), and was only to be reinforced by Klein's (1974, 1975, 1976; also Binford 1984) comparison of MSA and Neanderthal faunal procurement patterns. Similarly, the capacity to produce art – possibly the most quintessentially human of all behaviours – had been denied the people of the MSA throughout the history of southern African archaeology (cf., Peringuey 1911; Johnson 1912; Burkitt 1928; Goodwin and Van Riet Lowe 1929; Armstrong 1931; Goodwin 1931; Schofield 1949; Cooke 1955; Clark 1958d, 1959; Mason 1962; Cooke 1963; 1989, 1995). Indeed, it is remarkable that in recent studies of the role of ochre in the MSA, its use in graphic art has not been openly countenanced (cf., Knight *et al.* 1995; Lombard 2007; Marean *et al.* 2007; Wadley 2005; Watts 2002), despite clear evidence for it was in fact used in this way at this time (e.g., Wendt 1976).

The exception to the general embargo on ethnographic interpretation in the MSA seems only to reinforce the point. Deacon and Wurz (1996: also Ambrose 2002) have suggested that the backed artefacts of the Howiesons Poort may have functioned as social tokens in an inter-group exchange system analogous to the ethnographically-observed practice of hxaro (cf., Wiessner 1977). The Howiesons Poort is one of only two MSA industries to have borne regular comparison with industries of the Upper Palaeolithic. Goodwin himself characterized it as an MSA/LSA hybrid with clear 'neo-anthropic' elements. However, unless one starts from the assumption that the Howiesons Poort is in some way more modern that the rest of the MSA, it is not obvious why it should have been a better candidate for ethnographic interpretation than Singer and Wymer's (1982) MSA 3 or MSA4, which are considerably closer in time to the ethnographic present.

Ultimately, the exclusion of ethnographic analogy from studies of the MSA have served to reinforce existing prejudices about its pre-modern nature. As Hiscock and Faulkner (2006) have noted, ethnographic models are only applied in contexts where there is an existing sense of continuity between past and present. In southern Africa such models have largely been restricted to the LSA because of its historical association with the ethnographically-observed "San" or "Bushmen" (cf., J. Deacon 1984a: 221; Goodwin and Van Riet Lowe 1929: 147; Innskeep 1978: 84; Jones 1949: 63). The effect of using ethnographic analogy has been to generate levels of detail in descriptions of the past well beyond those available from strictly archaeological data. The particulars of spirituality, gender roles, aesthetics etc cannot be archaeologically observed, but they can be ethnographically inferred. The result is that depictions of already-familiar periods such as the LSA become even more detailed. More importantly, the unfamiliarity of those rafts of time and space to which the application of such models is precluded becomes exaggerated by contrast. A *belief* in categorical differences between the MSA and LSA, underpinned by comparison with the Middle and Upper Palaeolithic, has thus helped to develop and maintain the *perception* of categorical differences. Perhaps ironically, ethnographic analogues from southern Africa probably cannot reasonably be applied to either (cf., Humphreys 2004).

The same perception has also been reinforced by tendencies in research design and practice. Southern African research programs often focus on either MSA or LSA material. Even where dealing with sequences which cross the transition, different researchers tend to deal with material from the different Ages, while 'transitional' materials are assigned to a unit of their own (e.g., Clark 1999; Mitchell 1994). That different researchers tend to work on either MSA or LSA material has led to the development of different systems of artefact classification (e.g., Thackeray and Kelly 1988, Volman 1981, Wadley and Harper 1989 for the MSA; J. Deacon 1984a for the LSA; cf., Mitchell 2002), strongly inhibiting the identification of consistencies between them (Mitchell 1994: 22). This, allied to the theoretical discordance noted above, has created a situation in which 'MSA research' and 'LSA research' are considered to be different fields.

The second aspect of cultural evolutionism – the idea of directional trends in technological change – has also had significant impacts on late Pleistocene research. The most important has been to provide archaeologists with a theoretically poor and logically questionable basis for understanding the significance of certain technological systems. This is most clear in arguments relating to the so-called 'modernity' debate, where the appearances of certain technologies, invariably those common in the European Upper Palaeolithic, are used to infer significant improvements in human behavioural and/or technological capacities. Yet such assessments of the advantages of any given technology cannot be separated from our assumptions about the inviolable relationship between technological improvement and time. There is, for example, no clear reason to believe that bone points are ‘better’ technologies than handaxes, independent of the fact that the latter tend to occur earlier than the former. Importantly, assumptions about a linear relationship between technological change and time are demonstrably problematic. These assumptions have had the effect of suppressing consideration of the costs and benefits of different technologies, and of the relationship between the decision to use a technology and the context(s) in which it is deployed. Consequently, much work concerning stone artefacts in southern Africa, particularly in late Pleistocene, has been theoretically under-developed.

A second and related problem is that a culture evolutionary view has rendered certain changes inevitable, inuring researchers from consideration of their significance. For example, we know from the tenets of cultural evolution that more advanced technologies will come to supercede less advanced technologies. From the European record, which has so strongly influenced culture evolutionary understandings of archaeological records globally, we know that blade- and microlithic core reduction came to supercede prepared core reduction (though note Kuhn 2002). We thus ‘know’ that blade and microlithic core reduction systems are superior to prepared core reduction systems. Consequently, when prepared core reduction systems disappear from the southern African record some time between the middle of OIS 3 and the end of OIS 2 we do not pause to consider why this might have occurred, the costs and benefits, or historical factors at play. The disappearance of prepared core systems is viewed as an inevitable part of technological progress. This sense of inevitability is most clearly expressed in the paucity of attempts to explain the disappearance.

3.5 CULTURE HISTORY AND ITS EFFECTS ON SOUTHERN AFRICAN ARCHAELOGY

3.5.1 What is culture history?

Culture history is the second important school of thought in the archaeology of southern Africa. Though in some cases culture history has been used in a complementary role with culture evolutionism, its origins lie at least in part in the diminished popularity of cultural evolution in the late 19th and early 20th centuries. In Europe this loss of favour arose in the context of declining living standards in the early industrialised era (Trigger 1989). In America, it appears to have originated with the insufficiency of cultural evolution as an explanation of observed patterns in the archaeological record (Dunnell and Meltzer 1992). These differences in origin have had minor but noticeable effects on the practice of culture history among European and American researchers, and these are considered below.

As a school of thought, culture history emphasizes the role of population-specific habits, or traditions, in shaping human behaviours and their material correlates. Where cultural evolution is concerned with the tendency of unrelated groups to ‘evolve’ similar modes of behaviour in the long term, culture history has generally concerned itself with differences between groups. Early works in the school tended to discuss these differences in terms of ethnicity, equating them with ethnographically-observed ethnic groups. More recent discussion has tended to focus on the concept of style (O’Brien and Lyman 2007).

Central to culture historic discussions of the past is the idea of ‘cultures’ as units of analysis, identified by the presence of certain artefacts (e.g., fossiles directeur) or combinations of artefacts. While the reduction of data to units is a common practice in analytic disciplines generally, the nature of culture historic units is somewhat unusual. Where analytic units are commonly imposed on data in order to test hypotheses about the causes and consequences of variation, culture historic units are considered to be real things, reflections of patterns inherent in the data (O’Brien and Lyman 2007). The meaning of these patterns derives from presumptions about the causes of patterning – in the case of culture history, patterning is understood to be caused by variation in cultural expression.

With regard to understandings of the causes and nature of cultural change, there are discernable differences between the European and American schools of culture history. Originating in a context where nationalism was rife, early European culture historians tended to a belief that change had been an infrequent part of human history (Trigger 1989: 149-150). Cultures, both modern and ancient, were viewed as strongly conservative entities, and thus observable cultural differences were implied to have exceptionally deep roots – so deep in fact, as to have a biological basis. Consequently, early European culture historians often conflated cultural differences with 'racial' differences (Banton and Harwood 1975). The belief in cultural conservativism, however, meant that European culture historians often had to make recourse to external influences to explain the appearance of novelties and other diachronic changes. Two mechanisms were particularly favoured; diffusion, in which an innovation originating in one culture was adopted by others, and migration, in which an existing group was displaced by the arrival of a new (often technologically 'more advanced') group.

American culture historians, on the other hand, seem to have been more willing to embrace change as a regular feature of the human past (Lyman *et al.* 1997). Rather than seeing innovation as a rare occurrence, early American archaeologists and anthropologists were open to the possibility of multiple episodes of independent invention, and were aware of the difficulties of discerning the effects of 'convergence' from the effects of diffusion (e.g., Goldenweiser 1913; Hocart 1923; Mason 1895; Steward 1929). American culture historians were equally open to the possibility of within-culture variation, whereby the prevalence or 'popularity' of a purportedly minor characteristic, such as a style of pottery decoration, was seen to be variable through time within the constraints of a single culture (cf., Lyman *et al.* 1997: 51).

This relatively dynamic conception of cultural change allowed American culture history to serve a subsidiary role as a basis for seriation, and thus relative dating (O'Brien and Lyman 2000). If each culture had a limited distribution in time then its material correlates could be used as temporal markers. Moreover, coherent within-culture variation allowed the degree of temporal resolution obtainable from cultures to be refined. Once the sequence of cultural succession and within-culture 'popularity' changes was established, then the relative age of de-contextualised finds, such as those from open sites, single component sites and museum collections, could be inferred. In the absence of chronometry, such seriation was a useful archaeological tool.

From the second half of the 20th century, the prevalence of culture history began to wane (Lyman *et al.* 1997: 224). Its role as a basis for seriation had been rendered largely obsolete by the radiometric revolution of the 1950's. Furthermore, with the advent of the 'New Archaeology' culture history became the subject of sustained critique (e.g., Binford 1965, 1972; Flannery 1967). In the late Pleistocene archaeology of southern Africa, however, its effects remain tangible.

3.5.2 Culture history in southern African archaeology

As with cultural evolution, the influence of culture history is particularly clear in early southern Africa archaeology. Early researchers were interested primarily in identifying past cultural groups, often ascribing a biological basis to cultural difference (e.g., Frames 1899; Hewitt 1921; Kingston 1900; cf., Jones 2008). In one example, Lewis-Abbott (1913) associated a specific type of artefact (microliths, or backed artefacts) with a specific past 'race' ("pygmy implement makers"), and sought to use the present distribution of the former to map the past distribution of the latter. His unwillingness to countenance the possibility of independent invention led him to assume that the presence of these implements in Africa, Europe and Australia reflected a "great migration" (Lewis Abbott 1913: 147; see also Brown 1889; Mellars 2006a). Numerous other references to diffusion and migration as driving forces in cultural change can also be found (e.g., Armstrong 1931; Burkitt 1928; Penning 1887; Stapleton and Hewitt 1927), with Peringuey's (1911) consideration of the connections between African, European and Asian cultures among the best examples.

Similar themes pervade *The Stone Age Cultures of South Africa*. Goodwin, whose mentor Burkitt had been a contemporary and colleague of Childe (cf., Childe and Burkitt 1932), attributed almost all major archaeological variation to the arrival of new immigrants. And while local context was seen to shape cultural expression, the indigenous development of one industry from another was largely precluded. Thus, Goodwin (Goodwin and Van Riet

Lowe 1929: 7) describes MSA industries as "showing a common origin with the Mousterian of North Africa" but having "little in common with one another".

While replacement at the 'racial' level provided Goodwin with an explanation of industrial change, he also inferred the existence of replacement at a second scale – that occurring at the species-level. Where the various industries of the MSA were the result of independent waves of Mousterians, the advent of the LSA represented the replacement of Mousterians by "neo-anthropic" peoples. It was the use of these two scales which allowed Goodwin to blend the stochastic tendencies of culture history with the directional tendencies of cultural evolution. Equally, however, it was the later failure to recognize the distinction between these two scales which underlay the classificatory issues of the 1950s and 1960s.

The industries which multiplied following the publication of *The Stone Age Cultures* were typically culture historic, involving the identification of past groups or 'peoples' through distinctive items of material culture. In his Age-and-Intermediate scheme, however, Clark took a culture historic unit – the Magosian – and employed it at a cultural evolutionary scale. While the Burg-Wartenstein conference recognized the scalar underpinnings of the problem, it failed to consider that these were also different *kinds* of units. The Magosian as Clark used it was a cultural evolutionary unit, reflecting a stage of development at which groups arrived independently of one another. For culture historic units, however, contact between groups which shared characteristics was a foundational presumption. In the work which flowed most directly from the Burg-Wartenstein resolutions, Sampson's *The Stone Age Archaeology of Southern Africa*, the solution was to ascribe all patterning to cultural traditions at various levels of abstraction (cf., Sampson 1974: 6-8).

Sampson's work is also notable for making use of culture history as a chronological device. Mason (1957) had earlier explored the possibility of identifying comparable within-culture changes in multiple sites as a method of relative dating. Sampson employed similar techniques but expanded their spatial and temporal range across southern Africa. In the aftermath of Beaumont and Vogel's (1972) redating, such seriation became one of the most prominent uses of culture historic units, particularly those assigned to the MSA. Thus, Beaumont (1978), Singer and Wymer (1982) and Volman (1981) all sought to develop master sequences which would allow the relative dating of decontextualised MSA materials. In this they were largely successful, and much recent work has made use of, sometimes in slightly modified form, the units Volman (1981) in particular identified.

Because of its influence, it is worth exploring what Volman considered his units to represent. Volman was clear both that cultural norms influenced artefact-making habits, but also that "flaked stone artefact provide a poor medium for the expression or recognition of cultural identity" (1981: 15). Thus, Volman considered a number of other possible patterning agents, including availability of materials and material properties, technological capabilities / sophistication, artefact functions and random factors. Ultimately, however, though he was to emphasize environmental variation as a stimulus for technological change, Volman concluded that the form taken by a technology at any given point in time was largely the result of "fashion" (Volman 1981: 266). In this, Volman echoed one of the founding figures in American culture history, who ascribed the variable prevalence of artefact characteristics to "passing changes of fashion" (Kroeber 1909: 5, cited in O'Brien and Lyman 2007). Similarly, the units Volman developed were not formed to test or explore any hypotheses, but rather were seen to have been derived from patterning inherent in the archaeological record. Thus, though Volman eschewed the "recognition of cultural identity", the units he developed were typically culture historic. Many of the works that have followed Volman display the same basic characteristics (e.g., Clark 1999; Minichillo 2005; Sampson 1974; Thackeray 1989, 1992; Wurz 1997, 1999, 2002).

3.5.3 The problems of culture history

The problems of culture history spring from its initial under-theorization, from the nature and structure of the units it generates, and from the way it has been used to build sequences. The foundational premise of culture historic archaeology is that the patterns observable in the material record result primarily from the cultural proclivities of the groups responsible. This premise originally developed from analogy with material patterns among modern culturally-defined groupings. Though the premise was intuitively reasonable, its theoretical basis was limited. Among other problems, it was never clear precisely where or how culture-specific information was coded into material expression. Researchers like Childe attempted to identify certain classes of material which were more likely to contain such information, specifically eschewing the culture-interpretive value of strongly utilitarian items (Trigger 1989: 171). However, while this was broadly feasible for familiar materials from the recent past, differentiating functional from non-functional assemblage elements in the Palaeolithic with any degree of certainty has proven far more difficult. As O'Brien and Lyman (2007: 40) note, though the idea that archaeological groups imbued their material items with cultural information could be construed as a working hypothesis, it is one which is effectively untestable.

In southern Africa persistent recourse to culture as an explanation of patterns has led to several problems. The classificatory ructions of the 1950s and 1960s resulted from a combination of the primacy of 'culture' as an explanation of patterns, and the fact that patterns can be identified at a vast range of spatial and temporal scales. Consequently, as more researchers began to work at finer scales, a new diversity of cultural groupings (and sub-groupings) was identified. At the same time, another group of researchers were identifying patterns at the continental and sub-continental scales. As the limited theoretical basis of culture history provided no grounds for differentiating the nature of groupings at different scales they became conceptually indistinguishable. Ironically, 'cultures' existing at the scale that culture history originally set out to identify – national or ethnographic groupings – have been those which it has proved least adept at discovering, at least in Palaeolithic contexts (cf., MacEachern 1998; Wotzka 1997, cited in Shennan 2000).

The second problem of culture history relates to the reduction of history to a series of units. Caging history in such terms inevitably gives cultural/technological change a 'blocky' appearance, in which characteristics which are seen to persist sometimes for thousands of years are suddenly replaced by a new set of characteristics. Such an approach makes it impossible to discern change at levels finer than the smallest unit, and thus long term trends between units are necessarily obscured. Indeed, when faced with gradual change over a long period, a culture historian is forced either to portray the whole sequence as a single entity or to chose an arbitrary point either side of which differences are effectively portrayed as categorical. Such a depiction inevitably reinforces perceptions of rapid turnover, and thus explanations phrased in terms of diffusion and population replacement.

The third problem of culture history concerns its use in the development of relative chronologies; that is to say, in the use of assemblage form to measure time (cf., Lyman *et* *al.* 1997). Using culture historic units in this way requires that units have diagnostic features that can be identified in multiple assemblages, but which also allow any two units to be differentiated. While the characteristics of a unit need not be discrete, they must be distinctive. Allowing for the existence of suitable units, the working assumption of the method is that any two assemblages displaying similar characteristics will be similar in age. Conversely, any two assemblages displaying different characteristics are likely to be of different ages. There are two logical effects of this method.

First, the possibility of identifying spatial variation in assemblage composition at any given point in time is diminished. If the compositions of assemblages from nearby sites are different, it will be assumed that their ages are also different. This is particularly likely to be the case where sequences are discontinuous, allowing for the possibility that differing assemblages relate to periods which are only represented in one site each. Second, the similarity between any two assemblages identified as belonging to the same unit becomes categorical. While differences between two such assemblages might be noted, these will be of less relevance than observed and unit-defining similarities. The tendency in southern Africa has been to ascribe such variance to the influence of local factors of relatively little research interest (cf., Clark 1970: 117; Innskeep 1967: 558; Mason 1957; Volman 1981: 15)

The overall effect of culture-historic seriation is thus to exaggerate patterns of similarity and difference. Where similarities are observed, they become categorical. Where differences are observed, these will probably be taken to reflect differences in age or possibly the influence of minor site-specific factors. As Isaac (1977: 9) notes, the “culture historic approach … makes little allowance for the possibility that there could be markedly different stone tool assemblages being generated in the same region at the same time”. In southern Africa such engagement with inter-site variation at small spatial scales only occurred after chronometry allowed researchers to escape the assumptions of the method and demonstrate that different assemblages related to the same period of time (e.g., Parkington 1977; Mazel and Parkington 1981).

3.5.4 The effects of culture history on southern African archaeology

In the preceding section, three problems with culture history were identified. These can be summarised as problems relating to theory, problems relating to change, and problems relating to similarity and difference. The effects of all three are evident in the late Pleistocene archaeology of southern Africa.

As noted earlier, the theoretical basis of culture history is at best prosaic. As it provides few grounds for understanding where cultural information is encoded into artefacts, individual archaeologists have been left to determine how much influence ‘culture’ has had in material patterning. Since Burg Wartenstein, archaeologists, particularly those working with late Pleistocene material, have often elected to ascribe all significant variation to ‘cultural’ processes. This has had two effects. The first has been to reduce explanations of technological change to ‘just-so’ stories. As the mechanisms driving variation in cultural predilection or fashion are considered to be stochastic, there is little basis for explaining why technologies take the forms they do. Consequently, the causes of technological changes cannot be explained; their outcomes can only be described. As a result, southern African analyses concerned with documenting change over long periods of time invariably produce what O’Hara (1988: 44) has termed “chronicles” – “a description of a series of events, arranged in chronological order but not accompanied by any causal statements, explanations, or interpretations. A chronicle says simply that A happened, and then B happened, and then C happened”. The pessimistic nature of such an approach was criticised by Binford (1984: 245) a quarter century ago.

A related effect has been to obviate any engagement with theory about the causes and significance of variation in technological systems. As noted in the previous section, in culture history the ‘meaning’ of a unit derives directly from presumptions about the causes of patterning. As all but the most minor variations can be explained in terms of cultural choice, the need to engage with alternative explanations is minimal. Indeed, the few attempts explicitly to explain certain technological changes (e.g., Ambrose 2002; Ambrose and Lorenz 1990; Deacon and Wurz 1996; Wurz 1999) have still made recourse to cultural preference as an ultimate explanation of technological form. In consequence, the numerous and significant theoretical developments in stone artefact theory over the last ~25 years have had little tangible impact on the late Pleistocene archaeology of the region[12] (e.g., Bamforth 1986, 1991; Bamforth and Bleed 1997; Bleed 1986; Bousman 1993, 2005; Clarkson 2007; Collard *et al*. 2005; Dibble 1984, 1987, 1995; Hiscock 1994, 2006; Kelly 1988; Kelly and Todd 1988; Kuhn 1991, 1992a, 1992b, 1994, 1995; Nelson 1991; Parry and Kelly 1987; Shott 1986, 1989, 1996; Torrence 1983, 1989).

The second effect of culture history on late Pleistocene archaeology relates to depictions of change. The reduction of archaeological sequences to a series of units has been an entrenched facet of southern African archaeology since its inception, largely because of the European roots of culture history in the region. While useful as a basis for seriation, it is inconsistent with understandings of history as a fluid process, whereby change occurs regularly at a variety of scales. The effect of unit-based approaches is to make it almost impossible to discern change as an on-going process, the shape of change in the long term, and, consequently, of the forces underlying change.

The Blombos sequence provides one example (among many) of the significance of this effect. Other than in its initial publication (cf., Henshilwood and Sealy 1997), the Pleistocene component of the Blombos sequence has been discussed in terms of a series of units, labeled variously BBC1, BBC2, and BBC3 (Henshilwood *et al.* 2001a); BBC M1, BBC M2 and BBC M3 (Henshilwood *et al.* 2001b); or more simply M1, M2 and M3 (D'Errico and Henshilwood 2007; Villa *et al.* 2009). M1 is sometimes sub-divided into M1a and M1b. Each of these units is comprised of multiple layers excavated separately, but which are rarely discussed individually. Though the details of the sequence have been presented in the previous chapter, it is worth briefly re-describing them here.

The lowest unit, M3, contains no bifacial points and dates to between 99ka and 140ka (Henshilwood *et al.* 2001a; Jacobs *et al.* 2006). Wurz (2002) has assigned it to MSA 2b. M2 contains a few bifacial points, numerous bone points and dates to between 85ka and 77 ka (Henshilwood *et al.* 2001a; Jacobs *et al.* 2006; Villa *et al.* 2009). It has not clearly been assigned to any MSA unit. M1, including both M1a and M1b contains more than 300 bifacial points, few bone points, and dates to between 77ka and 73ka (Henshilwood *et al.*

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[12] Researchers working with LSA material have made some use of these theoretical developments (e.g., Bousman 1993, 2005; Mitchell 2000). Their absence from MSA research seems only to highlight the conceptual separation of the MSA and LSA.

2001a; Jacobs *et al.* 2006; Villa *et al.* 2009). It has been assigned to the Still Bay. Overlying M1a is a sterile sand dune, above which is an assemblage dated to the Holocene.

Reduction of the Blombos sequence to a series of units has proven a useful heuristic, in particular allowing authors to emphasise the Still Bay component of the site, and the bone point-rich nature of unit M2. In making recourse to temporally-coarse units, however, explorations of the nature and causes of change have been obscured. For example, the increase in bifacial points from M2 to M1 is considerable, as is the decrease in bone points. The fact that two contiguous units are markedly different necessarily creates the impression that the changes observed were relatively sudden and dramatic. While this may be the case, it is equally possible that changes were incremental or even episodic either within units or between units or both. Such differences in the nature of change would likely reflect different underlying causes. For example, a sudden and dramatic change might reflect the rapid introduction of a new technological system, a sudden change in site function or ‘group identity’, or might even imply that a brief but significant occupational discontinuity separates M2 and M1. On the other hand, gradual changes are more likely to reflect the phasing out of one technological system and the *in situ* development of another. Furthermore, such gradual changes occurring over thousands of years likely imply responses to long-term changes in environmental or population pressures. In a similar vein, does the appearance of the dune reflect the sudden abandonment of the site at a time when occupation and bifacial point production were in full flow? Or was site abandonment foretold by incremental decreases in site occupancy and gradual changes in technology? While McCall (2007) has valiantly tried to use the Blombos sequence to explore such questions, their resolution has effectively been foreclosed by the reduction of the sequence to temporally-coarse units.

The final effect of culture history relates to its role in shaping perceptions of similarity and difference. The development of culture historic units for the purposes of seriation has been particularly prevalent in late Pleistocene archaeology since Beaumont and Vogel’s (1972) redating program. Whether Beaumont, Sampson, Singer and Wymer, and Volman saw seriation as the primary aim of their units is unclear, but certainly this accounts for a considerable proportion of the recent use their works have seen. As noted in the previous section, the presumptions of the culture historic seriation method inevitably lead to an exaggeration of apparent similarities and differences between assemblages through time and space. The use of this method, particularly in Volman's work, has helped to develop the idea of synchronous and broadly similar changes occurring across the southern Cape. More recently, Minichillo (2005) and Wurz (2002) have expanded the applications of the method generally and Volman's units specifically across southern Africa.

It was also noted in the previous section that the tautological effects of the method can be avoided by use of chronometry. In the late Pleistocene, this has only become possible in the last 20 years. Though little data has thus far been forthcoming, particularly for the earlier MSA, the available results suggest a more complex pattern than that generated by the seriation method (see Chapter 2). This is particularly true of both the earlier MSA and later (post Howiesons Poort) MSA. Numerous large early MSA assemblages, including the sequences from Die Kelders and Yserfontein, and the M3 assemblage from Blombos, do not conform to the units within the ascribed time ranges of which they fall. Equally, there is as yet little evidence for synchronous and similar changes at a sub-continental scale in the post-Howiesons Poort. Even the disappearance of prepared core technology seems to initiate earlier in the interior SRZ than it does in the mountains or towards the coast.

There seem to be several reasons why the culture historic seriation method has not worked particularly well in this context. First, the units created have often lacked distinctive identifiers. In most cases, units have been defined on the basis of the relative prevalence of certain core types, flake forms and implements. In almost all cases, these artefacts are not exclusive to one unit, but simply vary in frequency between units. In the later MSA there are exceptions such as hollow-based points, but the occurrence of these may well be spatially restricted. This, however, only serves to prompt the question of whether it would be possible to identify spatially-restricted patterns using such coarsely-defined units as presently pertain in the earlier MSA. A second problem is that many units cover very large tracts of time. The probability of variation within such broad temporal constraints seems quite high, and the likelihood that a unit will be coherently expressed concomitantly low. A third problem is the discontinuous nature of the many, and indeed, probably most of the sequences examined (cf., Minichillo 2005). There is no reason to be confident, as Singer and Wymer (1982) and Volman (1981) appear once to have been, that any sequence completely represents the earlier MSA, or indeed, that all available sequences combined provide complete coverage.

The exceptions to the inferred pattern of temporal complexity are the Howiesons Poort and the Still Bay, both of which appear to have occurred broadly synchronously across southern Africa (Jacobs *et al.* 2008a). In comparison with most other late Pleistocene units, these units have relatively distinctive defining qualities and restricted temporal ranges. In that sense these units are relatively well suited to use as what Jacobs *et al.* (2008a) refer to as “horizon markers”. However, the Howiesons Poort and Still Bay can be used to highlight the impacts of categorical similarity.

The Howiesons Poort is identified by the presence of backed artefacts and blades; the Still Bay by the presence of large numbers of bifacial points, which form the dominant implement type. Assemblages exhibiting these characteristics are categorized as belonging to one or the other unit, and thus, in a sense, as being the same. While this outcome is appropriate to the aims of culture history, it necessarily obscures potentially informative complexity. Where high-resolution artefact data are available, for example at Klasies River, the Howiesons Poort displays a clearly complex internal structure. Similar variability can be noted at Nelson Bay Cave, also in the YRZ. However, because of a more general tendency to treat the Howiesons Poort as a single entity, it is impossible to difficult to explore these trends further. Thus questions about the relative similarity of Howiesons Poort expressions in different parts of southern Africa are largely foreclosed.

Similarly, Jacobs *et al.* (2008a) include the MSA 2 complex at Apollo XI as a Still Bay occurrence. However, while bifacial points are present, there are only four of them, and they are not the dominant implement type (there are 14 unifacial points and 11 "edge retouched points" in the sample). In all other Still Bay-assigned assemblages, bifacial points are the dominant implement. Perhaps more importantly, there are almost as many bifacial points in the overlying Howiesons Poort-assigned unit as there are in the Still Bay-assigned unit. Classifying the MSA 2 complex at Apollo XI as Still Bay implies categorical similarities with Still Bay occurrences elsewhere; similarities which mask clear and potentially important differences.

Categorical similarity also suppresses consideration of the nature and significance of spatial variance. For example, the Still Bay is at best poorly expressed in the SRZ and appears completely absent from the eastern mountains. Given the spatial lacuna between Sibudu and the cluster of Still Bay sites in the YRZ and WRZ, the obvious question is how similar are the characteristics of these clusters? If the assemblages are similar in composition and structure, and the bifacial points similar in morphology, what does this tell us about the mechanisms underlying the Still Bay? Would we expect the lacuna to become filled in with further work? Or are the two clusters indicative of the rapid initial spread of a technology which later persisted only in pockets? If so, might we not expect the degree of divergence to increase from early to late Still Bay? While all of these questions would seem interesting, we cannot reasonably approach any of them while we continue to pursue the description of coarse categories as the outcomes of analysis. As Parkington (2001: 1) has remarked, “if we are to write a history of Stone Age people we need to get beyond stratigraphic descriptions and cultural labels”.

4

THEORY AND MODELING: EVOLUTION, OPTIMAL FORAGING AND THE ORGANISATION OF STONE ARTEFACT TECHNOLOGIES

4.1 INTRODUCTION

Stone artefact assemblages display structure. Through time and across space, the numbers, sizes, and shapes of artefacts, and the techniques by which they were made exhibit patterned distributions. If the objective of analysis is simply to document what artefacts occur where and when – if, that is, the study of stone artefacts is to be its own objective – then the fact of this patterning is as irrelevant as it is convenient. If, however, the objective of analysis is to explain changes in terms of past human behaviours, then it is with the causes of this patterning that analysis must be concerned.

The approach taken here is twofold. First, it is suggested that the stone artefact technologies deployed by a group in any given context reflect a combination of particular historical contingencies (tradition effects) and selective feedback from the environment in which they are deployed (ecological effects). Most interpretations of stone artefacts acknowledge these two effects to differing degrees. Historic studies (including culture history) emphasise tradition but give little consideration to the selective effects of ecology; selectionist studies emphasise ecology but pay little attention to the effects of history (Bentley and Shennan 2003: 459). Ideally, an interpretation of technological change will take both into consideration (Boyd and Richerson 1985: 290).

Ecological studies take a different approach. Rather than marker distribution, such studies explore change in terms of the deployment of different behavioural/technological strategies. These strategies are often phrased as idealised binary alternatives, such as co-operative and non-co-operative, aggregation and dispersal etc. The efficacy of each strategy under different environmental conditions is modeled using techniques from game theory or economics. Because strategies are generalised, exploration of their distribution through time is often not amenable to the kind of fluid depictions favoured by historical scientists. Thus, ecological studies are usually phrased in synchronic form: given condition *x*, would strategy *a* or strategy *b* prove more beneficial? This generality, however, lends ecological studies a predictive capacity which historical studies lack. If we have grounds to believe that strategy *a* will be a better response to condition *x* than strategy *b*, we can hypothesise the strategy *a* will be the more likely to pertain. Concordance between hypotheses and observed patterns provides an explanation for those patterns, while discordance may imply either faults in the modeling, or the operation of particular historical factors. In the latter case, deviance should be amenable to historical analysis.

A second important point is that people do not live in order to make stone artefacts; they make stone artefacts in order to live. Stone artefacts are in most cases integrally bound up with subsistence behaviours, and their manufacture, maintenance and discard are likely to be organized around, rather than to dictate, social and subsistence behaviours. Consequently, understanding the organization of stone artefact technologies necessitates some understanding of the broader organization of subsistence and settlement strategies. In a sense, it is with these subsistence and settlement strategies, rather than the technologies symptomatic of them, that we are ultimately concerned.

The objective of this chapter is to provide techniques for historical analysis and for ecological modeling, with the deeper objective of providing a basis for interpreting spatial and temporal variation in stone artefact technologies. A generalised Darwinian framework is deployed in pursuit of these objectives. The case for the use of such a framework is made in the following section. This is followed by a discussion of optimal foraging theory, aimed at providing a means for predicting how human organisational, behavioural and technological systems are likely to have responded to environmental variation.

4.2 DARWINIAN EVOLUTION AS A CONCEPTUAL FRAMEWORK

The use of Darwinian systematics in archaeological studies has largely developed only over the last 30 years. The effective preconditions for such an approach were established by the argument of New Archaeologists that cultural systems were more than simply tradition, but also had an adaptive component (e.g., Binford 1965, 1972), and also by the demonstration that previous evolutionary systematics in archaeology were not Darwinian in character (e.g., Dunnell 1980). The appeal of a Darwinian approach is obvious: in biology at least, Darwinism allows for the unified explanation of historical and ecological effects (Boyd and Richerson 1985: 290). In practice, however, the application of such an approach to cultural materials has not been straightforward. Proponents of what is known as ‘evolutionary archaeology’ have done much to highlight the significance of both historical and ecological forces in shaping archaeologically-observable changes, however, their over-reliance on explanatory mechanisms drawn from biological studies has left them open to the accusation of developing a metaphor, rather than a theory of cultural evolution (Bamforth 2003; Boone and Smith 1998). Much of this criticism has come from proponents of another stream of Darwinian analysis – evolutionary ecology – which, though based on a robust theoretical platform, suffers from a lack of engagement with the kinds of contingency-bound historical processes which generate the characteristic diversity of the archaeological record (Neff 2000: 428).

These issues aside, the key question hanging over the use of Darwinian theory in archaeology is whether it is fundamentally appropriate to the study of cultural phenomena. The crux of this question relates to the biological origins of Darwinism, and its subsequent strong association with evolution at the genetic level. The important point to note in this regard is that in its initial formulation Darwinian evolution did not concern genes (Bettinger and Eerkens 1999: 238). Rather, it was a formalization of the idea that characteristics which enhanced the survivorship and reproductive success of an organism in relation to a given environment would become more prevalent through time than those which did not (Bettinger and Eerkens 1999; Boyd and Richerson 1985, 2005). The application of this idea to phenomena more broadly might be referred to as 'universal Darwinism' (cf., Clarkson 2004: 14).

In order to accept that cultural systems can be studied within a Darwinian framework, we must be prepared to accept three propositions. First, that cultural traits (including behaviours and artefacts) are variable through time. That is to say, that from generation to generation, behaviours and techniques are not always replicated with perfect fidelity. Second, that cultural traits are heritable. That is, that in spite of variance, the behaviours and techniques employed by one generation will in many ways resemble those of the previous generation. Third, that cultural traits affect the fitness of an individual and thereby influence their survivorship and, potentially, their reproductive success.

The first two propositions seem relatively uncontroversial: the fact of spatial and temporal diversity in cultural expression is the reason that cultural studies exist, while, if not for heritability there would be no cultural traditions. The third point is more contentious. Certainly, it can be argued that not every trait within a cultural system will convey fitness-enhancing benefits, and that not all traits that do enhance fitness will do so equally.

In this thesis, stone artefacts provide the bulk of the data to be considered. Given that stone artefacts form part of the interface between people and their environments, they are likely candidates for the operation of Darwinian forces. Moreover, empirical studies which have used Darwinian frameworks to examine through-time patterns in stone artefacts have tended to yield robust and novel explanations of technological change (eg., Bamforth and Bleed 1997; Clarkson 2004; Kuhn 1995; Marwick 2007; Neeley 2002).

For the purposes of this thesis, the proposition that stone artefacts can and often do convey fitness-enhancing benefits is accepted as a working premise. Accepting this and the propositions concerning variation and heritability, it becomes possible to use what Richerson and Boyd (1992: 62) refer to as the "substantive conclusions" of Darwinian theory: namely, that the passage of time is expected to result in the differential persistence of more beneficial traits at the expense of less beneficial traits through time, and with respect to a given environment.

However, while it will be assumed here that stone artefacts are affected by selective forces, it is also acknowledged that several researchers working on late Pleistocene artefacts in southern Africa have argued that this is not the case (eg., Thackeray 1989; Sampson 1974; Volman 1985; Wurz 1999, 2000). Though none of these researchers have formalized the idea in theoretical terms, by precluding the operation of selective forces on patterns in stone artefacts, they are in effect implying that non-selective, or stochastic forces, such as drift, sorting and founder effects (cf., Barton and Clark 1997; Dunnell 1978; Teltser 1995), are the primary determinants of the patterns they have observed. Though rejected as an operating premise for this thesis, the implications of this idea are considered and explored in Chapter 6.

4.3 TECHNIQUES FOR HISTORICAL ANALYSIS – DUAL INHERITANCE THEORY

4.3.1 Dual Inheritance Theory and the forces of cultural evolution

Evolutionary archaeology, noted above, represented an attempt to make archaeology an historical science using an explicitly Darwinian model (cf., Dunnell 1971; Jones *et al*. 1995; Leonard and Jones 1987; Lyman and O'Brien 1998). While significant for its critique of cultural evolutionism, the success of evolutionary archaeology has tended to founder on the unwillingness of its proponents to develop a theory of evolution which takes into account the peculiarities of culture as a system distinct from biology. In particular, the idea of directed, adaptive variation has been seen by some proponents as unfaithful to the biological roots of evolution, whereby variation must be random in order for natural selection to occur (Rindos 1996). This, however, generates the untenable position that the capacity of humans to learn from successes and failures, and to preferentially express and transmit successful behaviours, has not been important in shaping the evolution of our cultural systems (Boone and Smith 1998; Neff 2000).

To this end, Dual Inheritance Theory, championed by Boyd and Richerson (1985, 2005; also Bettinger 1991, Bettinger and Eerkens 1999), provides an alternative approach to cultural evolution which is consistent both with the tenets of universal Darwinism and with the observable nature of adaptation and transmission in cultural systems. As the name suggests, Dual Inheritance Theory posits that the behaviours of individuals are shaped by the transmission of both genetic and cultural information. Boyd and Richerson (1985: 9) identify five "forces of cultural evolution" – random variation, drift, guided variation, biased transmission and the operation of natural selection on cultural phenomena – as being primarily responsible for evolution in cultural systems.

The first two (random variation and drift) are mechanisms analogous with those operating on genetic material. Random variation in cultural phenomena results from commonplace events like errors in transmission (misinformation) and misremembering (Eerkens and Lipo 2005). Such random changes in information provide an undirected source of cultural variation on which selective forces can operate. Cultural drift is seen to occur among small, isolated populations, where "chance variations in which cultural variants are observed and remembered … cause substantial changes in frequency … Rare or rarely performed variants may be lost entirely" (Boyd and Richerson 1985: 9[13]).

Natural selection operates to favour those cultural traits which improve survivorship and reproductive success. However, the characteristics favoured by natural selection operating on culture may differ from those favoured by natural selection on genetic material. Unlike genetic selection, cultural selection can and often does occur at both individual and group levels (Richerson *et al.* 2005: 259).

Of interest to this thesis are the processes of guided variation and biased transmission, and an extended discussion is provided of each. The mathematical modeling from Boyd and Richerson's original formulation is left out, largely because most of the data available to this thesis are not amenable to analysis in this form. Instead, the effects of these different forces of cultural evolution are presented in generalised terms.

4.3.2 Guided variation

Guided variation involves the evaluation of the relative success of different traits in relation to a given environment, and the preferential replication of those deemed more successful by

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[13] Note that Boyd and Richerson use the term 'variant' as opposed to 'trait' – the two are considered synonymous in this context.

a given measure. Guided variation can be thought of both in terms of "trial-and-error learning" and "rational calculation" (Boyd and Richerson 1985: 9). The process of guided variation begins with the transmission of cultural norms from one generation to the next. These are then modified by the recipients to better accord with the environment with which they (the new generation) are confronted. Because learning is an imperfect process, and the outcomes of any action cannot always be predicted, these modifications invariably involve some errors, or unsuccessful trials. Ultimately, however, the alteration of trait norms through guided transmission is expected to result in incremental improvements of fit between trait norms and environments, following a process whereby each generation receives the norms of the previous generation, adapts them closer to those favoured by their environmental context, and then passes on the adapted norms to the next generation, who then adapt them again … etc (Boyd and Richerson 1985: 95). Changes continue to proceed towards optimal adaptedness because those deploying traits better favoured by the environment will have advantages over those that do not (Bettinger 1991: 187).

The degree to which the forces of guided variation influence cultural evolution is expected to relate to the degree of environmental variability. Environments exhibiting long-term stability are unlikely to reward significant adaptation through guided variation, as it is likely that unmodified traits received from the previous generation are already quite well adapted. At higher rates of environmental change, however, guided variation effectively lowers the response time for cultural adaptation. Because of the centrality of individual decision-making and adaptation in guided variation, within-population variance in traits is expected to be quite pronounced whenever this method of learning dominates (Bettinger and Eerkens 1999).

4.3.3 Biased transmission

Biased transmission concerns the mechanisms determining whether individuals will be receptive to the adoption of a certain trait. Bettinger (1991: 188) suggests that the concept contains two senses of 'bias' – "First, the individual receiving cultural information is biased in favour of some information (e.g., traits) and against others. Second, biased transmission results in a cultural population that, following cultural transmission, is a biased sample of the cultural population before transmission". Boyd and Richerson (1985: 135) differentiate three forms of biased transmission: direct bias, frequency dependent bias, and indirect bias. They illustrate the differences between the three with reference to ways of grasping table-tennis racquets. In the illustration, a child learns how to play table tennis by watching a group of adult models. Among the group, there are two methods of grasping racquets – the pencil grip and the racquet grip. The child may decide on a mode of grasping the racquet in one of three ways. First, by observing the available options, testing them for personal comfort, efficacy etc, and settling on one. This is an example of direct bias. In frequency dependent bias, the child observes which of the techniques is most prevalent within the group of models and adopts this one. In indirect bias, the child assesses which of the grasping techniques the most successful table tennis player uses and adopts this one.

Aspects of direct bias

Directly biased transmission is in some ways similar to guided variation in that both require an individual to possess some personal criteria for assessing the relative merits of different traits. However, where guided variation allows for the modification of transmitted traits in accordance with these criteria, direct bias allows only for selection of traits from those already available in the population of models. In a sense, direct bias might be thought of as a cheap alternative to guided variation – cheap, that is, insofar as it allows an individual to choose from pre-tested traits and does not require experimentation or invention.

Direct bias can be a means by which innovations are spread within a population (Boyd and Richerson 1985: 166-168). Where a new and beneficial trait is introduced from an external source, direct bias allows for the evaluation of the trait and its relatively rapid dissemination. Once established, the prevalence of the trait may be further increased by runaway effects associated with indirect bias (see below). It should be noted that when direct bias is the initial mechanism responsible for diffusion within a population, at least within relatively large populations, the assumption is that the trait being diffused will be adaptively beneficial. Adaptively neutral, or even maladaptive traits are unlikely to increase in frequency as a result of direct bias. The diffusion of such traits is more likely to occur as a result of indirect bias.

Aspects of frequency dependent bias

Frequency dependent bias (or 'conformist transmission'[14]) describes trait transmission whereby an individual preferentially replicates the most common trait in a population. Unlike guided variation and direct bias, frequency dependent bias does not involve assessment of the utility of a trait through testing and/or relative to some personal criteria of efficacy. Consequently, traits which increase as a result of frequency dependent bias will not necessarily be adaptively beneficial. The presumption is, however, that in order for a trait to become well established in the first place, it is more likely to have been adaptive than maladaptive.

Where environments are temporally variable, and where individuals may move between groups located in environmentally-differentiated areas, conformist transmission "can serve as a simple, generally applicable rule that increases the probability that individuals acquire traits that are favoured in the local habitat" (Boyd and Richerson 1985: 220). The premise here is that within each habitat, the most prevalent trait among the local group is also likely to be the most adaptive. Thus, an individual moving between such groups is likely to benefit from adopting this prevalent trait. We might think of this as the "When in Rome" rule.

Aspects of indirect bias

Indirect bias refers to the imitation of traits associated with certain individuals who are deemed by the imitator to be successful in some regard. In cases of indirect bias, a certain trait will be seen by an individual to be indicative of successfulness. Boyd and Richerson (1985: 243) refer to this as an "indicator trait", and give examples such as "number of cows, number of children, or number of publications". A person with the requisite number of one of these indicators will be seen to be successful and a worthy model. Though the individual cannot imitate the indicator trait directly (that is, they cannot elect to have 20 cows or 100 publications), they may chose to imitate other aspects of the behaviour of the successful model. These might include cultivation habits, clothes, speech idioms etc. These traits are thus seen to be "indirectly biased traits", because they are not selected after a

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[14] Frequency dependent bias can also involve "nonconformist transmission", whereby the most prevalent trait is actively avoided. For the sake of simplicity, only the conformist mode is considered here.

specific assessment of their adaptive benefits, but because of their association with the indicator trait. Indirect bias also presumes the existence of what Boyd and Richerson refer to as “preference traits” – traits which lead an individual to settle on an given indicator trait as a good measure of success.

Instances where indirect bias leads to increases in neutral or maladaptive traits may be associated with what Boyd and Richerson (1985: 287) refer to as runaway or “drift-away” effects (a case of “keeping up with the Joneses”). Runaway effects occur when the establishment of the preference trait leads the indicator trait to be sought as an end in itself. Boyd and Richerson (1985: 269-270) give the examples of yam growing on Ponapae, where what is presumed to have begun with an association between the ability to grow large yams and being a good farmer later led, through an emphasis on large yams as things to be desired in themselves, to festivals where those producing enormous (~3 m yams) were feted. By this stage, any relationship between yam size and quality of farming was probably moot – as Boyd and Richerson (1985: 277) point out: “It is likely that farmers could devote the time and energy necessary to grow gigantic yams to better purposes”.

Indirect bias processes, including those resulting in runaway effects, can be seen to have a relationship with symboling systems. In both indirect bias and symboling, convention results in the establishment of a relationship between two things, such that one is seen to ‘stand for’ the other. In the Ponapae example, large yams came to stand for good farming practices. The relationship may have a functional basis or it may be entirely arbitrary. Boyd and Richerson (1987; also McElreath *et al.* 2003) have used this property of indirect bias to model its possible role in the evolution of ethnic markers. The model involves two habitats which respectively favour different modes of subsistence behaviour (adaptive traits), and an adaptively neutral marker trait, such as a dialect. The model assumes that individuals initially receive their marker trait early in life, and then preferentially select their behavioural trait from among other individuals with the same marker trait. The use of the marker trait as a basis for selection of the behavioural trait creates the conditions under which covariance can evolve between the two. Subsequently, individuals use direct bias to adopt the behaviour and marker traits best suited to the habitats in which they subsist. Ultimately the combination of indirect and direct biases will lead to a situation in which one marker trait and one behaviour come to be dominant in each habitat, despite on-going population mixing (migrations) between the two. As Bettinger (1991: 199) notes, this is a case where “cultural transmission promotes adaptation even though some of the cultural behaviour involved (e.g., symbolic behaviour) is utterly without adaptive value or is even maladaptive”. Bettinger (1991: 200) further notes that symbolic differentiation between groups is most likely to arise where habitat contrasts between groups are most strongly marked, such as across ecological boundaries.

Like direct bias, indirect bias can be a means by which traits diffuse through a population. Unlike direct bias, however, there is no associated certainty that diffused traits will be adaptively beneficial. Bettinger and Eerkens (1999) have also pointed out that traits spread by indirect bias are likely to exhibit low within-population variance as they are disproportionately copied from a small number of models. Like frequency dependent bias, and again unlike direct bias, indirect bias is likely to be favoured in conditions of spatial environmental variability where, rather than attempting to evaluate all alternative traits encountered in a new context, individuals are likely to be well-served by identifying a successful individual and imitating their behaviours. Such an approach may also be favoured in large populations, due to the impracticality of personally assessing the efficacy of all possible traits.

4.3.4 Some notes on classification

One of the important outcomes of the evolutionary archaeology program pursued by Dunnell and colleagues has been the attention drawn to the effects of different approaches to classification and analysis. Of particular significance is the idea that the units deployed in any analysis need to be appropriate to the questions being posed (Dunnell 1971; O’Brien and Lyman 2007; Lyman and O’Brien 2002). This idea reveals important differences between two classificatory systems which might be described as ‘essentialist’ and ‘materialist’.

Essentialist classification refers to the idea that objects and concepts can be formed into units or classes by reference to a characteristic or set of characteristics which are shared by all objects / concepts in the class, but which differentiate them from all other objects / concepts. These characteristics form the *essence* of the class. As the essence of each class is unique, the units identified are seen to be discrete entities rather than divisions of a phenomenological continuum. As class are discrete, they cannot be explained as arbitrary constructs, but rather reflect the identification of real kinds that exist in the world independent of the classifier.

The alternative to essentialist classification is known as materialism. While materialism acknowledges that the characteristics of objects and concepts are patterned, classification is approached as the arbitrary partition of phenomenological continua. Because partitions are arbitrary, the resulting units or classes are not thought to be real things existing independent of the classifier (O'Brien and Lyman 2000), but as units generated in order to answer specific questions. Thus, where essentialist classification constitutes an attempt to apprehend reality, the objective of materialist classification is to provide useful units for analysis. It is this usefulness, rather than goodness-of-fit with reality, that is the key criteria by which the validity of a materialist class should be assessed (Lyman and O'Brien 2002: 73).

As noted in the preceding chapter, culture historic analyses of archaeological materials tend to the view that classes are things to be apprehended by classification, rather than being the products of classification. In the case of southern Africa, the causes of a unit such as the 'Howiesons Poort' might be debated (eg., Jacobs *et al*. 2008a; McCall 2007; Volman 1984; Wurz 1999), but the objective existence of the unit is not called into question.

For the purposes of this thesis, classes will be formulated within a materialist systems. As specific questions are to be posed of the data to be presented, classes will be used which are specific to those questions. The decision not to structure this thesis around the classes 'Middle Stone Age' and 'Later Stone Age' was taken in the same vein. These terms may well reflect real differences between technological systems, but they result in a division of the late Pleistocene which is not useful for a thesis looking to understand technological change from 120 ka to 20 ka. Similarly, though units such as the Howiesons Poort and Still Bay will be referred to throughout the thesis, they will not be used to arrange the data to be presented. As Leonard and Jones (1987) have pointed out, culture historic units are not a useful way of exploring cultural change, because they presume that which we might seek to test.

4.4 TECHNIQUES FOR ECOLOGICAL MODELING – EVOLUTIONARY ECOLOGY AND TECHNOLOGICAL ORGANISATION

This section is divided into two parts. The first part deals with the ways in which people organise their settlement and subsistence systems around variance in environmental parameters. The second deals with the impacts of environmental, settlement and subsistence variance on the organization of stone artefact technologies.

4.4.1 Evolutionary ecology and optimal foraging theory

General discussion

Evolutionary ecology is a branch of biology which uses Darwinian principles to explore variation in the organisation and behaviour of organisms in a finite and variable environment. Behavioural ecology is a sub-branch of evolutionary ecology that deals specifically with variation in the behaviour of organisms (Winterhalder and Smith 1992). The analytic process in behavioural ecology involves the formulation of models, from which are derived hypotheses to be tested against empirical data (Smith 1991: 34). Since the 1960's, the concept of optimality, or optimal foraging, has assumed a prominent role in many such models (Schoener 1987). Optimality models are predicated on the idea that selective pressures will have differentially favoured those behaviours which improve the survivorship and reproductive success (ultimately, the evolutionary 'fitness') of an organism (Foley 1985; Winterhalder 1983). Though fitness is the currency which selection optimises, fitness itself cannot be directly observed, and thus optimality models are usually phrased in terms of proxy currencies, such as energy, time, or reproduction (Winterhalder 1996: 48). Hypotheses are generated by exploring how the acquisition of these currencies might be optimized under varying environmental conditions.

While the use of proxy currencies lends to optimality models much of their simplicity and operational efficacy, it also generates fundamental inconsistencies between behaviour as it is modeled, and behaviour as it is observed. Living in a complex world involves balancing multiple needs simultaneously, and thus it becomes impossible in practice for any organism to attempt to optimize for all currencies at once, or for any one currency in isolation (Foley 1985: 223). One response to such criticisms is to substitute the concept of 'meliorization' for the concept of 'optimization' (cf., Mithen 1989). Thus, rather than requiring the optimization of returns for a given currency, selection is seen more simply to favour those behaviours that generate better returns. The distinction is, however, largely semantic; the 'optimization' in optimality models is relative only to available alternative behaviours, and should not be understood as having an absolute value (Broughton and O'Connell 1999).

Another, and perhaps more important response is to observe that optimality models do not involve making proscriptive statements about how an organism *should* behave under given conditions, but rather they involve hypothesizing how it would behave were it attempting to optimize (or meliorize) for the currency in question. Deviance from expectations is not only to be expected, but can form the basis of further analysis (Broughton and O'Connell 1999; Bird and O'Connell 2006; Bliege Bird *et al.* 2002; Foley 1985; Kuhn 2004: 563). As Winterhalder (1986: 369) has suggested, the "primary value of this approach is heuristic; it provides a systematic means of arguing from widely accepted premises to specific, testable predictions about foraging behavior".

In the following discussion, several facets of optimal foraging behaviour are considered. These are mobility, patch use, diet breadth, and settlement organisation. Rate of energetic return is the chosen currency for which optimal behaviour is modeled. Energetic return is a useful general currency because, as Hames and Vickers (1982: 358-9) note, those "that maximize their net rates of energetic intake have larger young, breed at an earlier age, have young that suffer lower mortality and buffer environmental perturbations more effectively". Moreover, optimisation of energy intake is expected to be marked where the availability of food resources is constrained, as it often is for human foragers (Schoener 1971). Necessarily, energetic return is a composite of two elements – energy acquired, and the time spent in acquisition. Foragers can improve returns either by increasing the energy acquired in a given period of time, or decreasing the time taken to acquire a given amount of energy. Time spent in acquisition is in turn composed of three elements – search times, pursuit times and processing time – discussed in more detail below.

For each facet of behavioural organisation to be considered, different optimal strategies are described in relation to variance in the abundance, variability and predictability of energy resources (or food). Abundance is taken here to refer to the quantity of food resources available in any given area. It might alternatively be phrased as ‘resource density’. In most cases abundance is a relative measure, though some reference is made to its variance in absolute terms. Variability is used to refer to spatial or temporal discontinuities, or ‘patchiness’, in the distribution of resources. Spatial variability might include the clumping of certain food plants (cf., Harpending and Davis 1977), while temporal variability might include seasonal changes in the availability of plants, game and/or water. Predictability refers to the degree to which the distribution of resources can be anticipated and planned for. In this sense, predictability is the inverse of risk (though only where risk is understood in terms of probability of failure, rather than its magnitude (cf., Smith 1988; Stephens and Charnov 1982); a fuller discussion of risk is provided later in this chapter). Where predictability is low, risk is high, and vice versa. Necessarily, unpredictable resources are also patchy (temporally), though the opposite does not hold; resources may be spatially or temporally patchy without being unpredictable.

Generalised mobility strategies

Mobility is a mechanism which enables foragers to overcome spatial and temporal fluctuations in the availability of subsistence and other critical resources (Binford 1972; Kelly 1983). To an extent, all humans are mobile. Even present sedentary populations make regular movements from their residential locations (e.g., homes) to various points around the landscape at which resources are concentrated (e.g., supermarkets, petrol stations, hardware stores, etc). Mobility among human groups is often approached as both a qualitative and quantitative variable. The most prominent system of qualitative distinction is Binford’s (1980) *residential* / *logistical* separation, where residential movements are those in which an entire group relocates to places at which resources are concentrated, and logistical movements are those where “tasks groups” range out from a residential camp in order to procure “specific resources in specific contexts” (Binford 1980: 10, italics removed). Quantitative assessments include tallying the number of movements per group per year and/or the distance moved (e.g., Kelly 1992, 1995; Read 2008; Shott 1986).

Quantitative assessments of mobility are useful because they allow the variable to be discussed in terms of energy, and thus to be considered in light of optimisation theories. Put simply, moving entails expending energy, and is thus, to an extent, expensive. Among certain desert lizard species for example, mobile predation strategies result in up to twice the energy expenditure of “sit-and-wait” strategies (Huey and Pianka 1981). Consequently, movement is only used by these animals when prey are sufficiently abundant that the costs of movement become less than the increase in energy capture that results from mobile predation. For humans, however, sitting and waiting is usually not a viable option. Mobility among human groups thus entails on-going evaluation of the costs of relocation against the rewards of foraging in new locations. The distribution of food resources is likely to have a strong determining effect on patterns of mobility.

For foragers living in resource-poor areas regular movement is an essential means of securing an adequate supply of food and water. For those living in more resource-abundant locations, mobility strategies are likely to vary depending on the patchiness and predictability of resources. Where resources are both abundant and evenly distributed through time and space, foragers can be expected to attain a subsistence-level harvest with minimal energetic outlay on movement (Harpending and Davis 1977: 275). Under such circumstances, the costs of frequent or substantial residential relocation may not result in significant improvements in foraging yield. Limited movement is thus likely to be an optimal response to such a resource configuration. Conversely, where resources are abundant but their distribution is more markedly discontinuous, either spatially or temporally, greater mobility is expected to be justified by the increased returns to be attained through regular relocation. Thus, in contexts of resource abundance, strategies featuring both high and low mobility are theoretically viable.

One means of reducing the outlay associated with mobility involves changing the way in which movements are undertaken. The most obvious strategy is to limit the number of participants in the move. Residential movements involve not only active foragers, but the entire corporate group, potentially including the very young and the very old. Though opportunistic harvest activities may be undertaken in the course of a residential move, this will nevertheless be a less efficient means of resource acquisition than one involving a subset of the foraging group equipped specifically to undertake that task. To this extent, we might view an emphasis on logistical rather than residential movements as a means of diminishing energetic outlay in foraging tasks. The net returns of a logistical trip are further improved by task-specificity, whereby an appropriate number of individuals transport only the tools necessary to the prosecution of an intended task. Necessarily, such an approach is predictability-dependent – as with mobility more generally, foraging in unpredictable environments invariably involves buffering outlays against uncertainty in returns.

Of course, logistical trips entail an expense that residential trips do not – namely, a return leg. Thus, a logistical trip includes double the travel time from residential base to harvest location, plus search and handling times (cf., Orians and Pearson 1977). Necessarily, then, there comes a point where logistical outlay is not justified by foraging returns, and a residential movement is likely (Kelly (1995: 113) suggests that a "20- to 30-kilometer round trip appears to be the maximum distance hunter-gatherers will walk comfortably in a variety of habitats"). Based on a review of factors conditioning the use of logistical mobility, Kelly (1983) makes two interesting suggestions. First, that logistical mobility is inversely correlated with effective temperature, taken as a coarse proxy for resource abundance. Second, that logistical mobility is inversely correlated with number of residential movements per year.

When considered together, the points made here seem sufficient to make some very general predictive statements about variance in mobility in relation to resource abundance and resource patchiness. Foremost, and as has been pointed out before, the demands of satisfying minimal subsistence requirements necessitate that foragers in resource-depauperate areas will be highly mobile. Mobility costs under these circumstances can be limited by the use of logistical trips where feasible, though where resources are particularly thinly distributed, harvestable resources within the practicable logistical range will rapidly be exhausted, and regular residential relocation will be necessary nonetheless.

Where resources are rich and evenly distributed, on the other hand, high mobility becomes an expense unlikely to be recouped by significant improvements in foraging yields, and diminished distance and frequency of trips is likely. Where resources are rich and patchy, even very large or very frequent trips featuring all members of the corporate group (e.g., residential trips) may be paid off by the rewards to be had in new and resource-dense foraging locations. In between extremes of resource richness and resource poverty, it seems logical that there would be a point where large scale relocations are not repaid by significant increases in foraging yield, but where resource scarcity is not sufficient to make high mobility necessary. In such intermediate contexts seems we might expect to find low overall mobility, and an emphasis on task-specific logistical trips.

The general validity of these suggestions is supported by data from Kelly (1995). In Figure 4.1, total distance covered during residential moves is plotted against resource abundance for 43 ethnographically documented groups. Resource abundance is approximated using primary productivity, following Kelly (1995: 69). Primary productivity is in turn derived from changes in effective temperature and water availability; hot and wet have the greatest primary productivity, while cold and dry conditions have the lowest. Distance covered during residential moves is used as a coarse proxy for energy expended on relocation events. Data on distance covered in logistical movements are not available, but their possible impacts are discussed below.

Consistent with expectations, the graph demonstrates considerable emphasis on residential mobility under conditions both of resource abundance and resource poverty. In between these extremes, in the primary productivity range from 30-50 g/m^2/yr, there is a notable decrease in distance covered during residential movements. The quadratic regression $y = -23.373x^2 + 0.328x + 510.576$ provides a best fit for the data, where r^2=0.304, and p=0.001 (df=40) (Figure 4.2). This fit can be improved by excluding groups with a documented heavy reliance on fish (> 30% of diet total) – an alteration which seems reasonable given that primary productivity as calculated by Kelly (1995) should only have predictive value for predominantly terrestrial diets. With fisher-foragers excluded the basic structure of the graph remains the same, but the fit improves to r^2=0.337; p=0.003, df=28 (Figure 4.3). Further improvements to this fit can be made by excluding the outlying Ngadadja, who cover an extraordinary 1600 km in residential moves per year (r^2=0.409; p=0.001, df=27).

The graph documents considerable variance in mobility under conditions of low abundance. This is almost certainly due to the exclusion of data pertaining to logistical movements. Several of the groups documented in the resource-poor part of the graph are Kalahari San. Reliance on logistical movement among these groups is highly variable, and appears largely to depend on the nature and spatial/temporal distribution of water sources (cf., Bleek 1928: 4, cited in Read 2008: 616). For example, the Ju/’hoansi have access to large dry season water sources which are not available to the G/wi. Rather than residential moves, Ju/’hoansi foragers remain tethered to these sources in the summer and undertake long logistical forays. The G/wi tend to relocate more often. Consequently, G/wi annual residential movement distance (275km) is around double that of the Ju/’hoansi (142km) (Kelly 1995: 127). Tanaka (1976) has observed similar differences between the Dobe !Kung and ≠Kade San. If we accept Kelly’s (1983) arguments about the inverse relationship between logistical mobility and resource abundance, and between logistical and residential mobility, then it seems likely that below 30 g/m^2/yr logistical moves were used whenever residential moves could be avoided. We would also expect that the low residential mobility documented between 30-50 g/m^2/yr was offset by regular logistical moves.

Failure to depict logistical movements is one limitation of Figure 4.1; variability in resources beyond the predictive capacity of primary productivity is another. Riparian and marine resources provide one example of this latter problem, while differences in water availability resulting from variation in the configuration of drainage systems provides another. Holding such issues constant, however – that is, operating in a context where neither drainage nor the nature (terrestrial vs. riparian/lacustrine/marine) of resources change dramatically – we appear to have reasonable grounds on which to base predictions about the relationship between mobility and resource abundance. These predictions are translated into a hypothetical model, expressed in Figures 4.4 and 4.5. In Figure 4.4, as in Figure 4.1, total outlay on mobility is plotted against primary productivity, again taken as a proxy for resource abundance. The ‘third axis’ of variance in the model is patchiness, which can be taken to be either spatial or temporal. In Figure 4.5, the proportion of movements undertaken logistically is plotted against primary productivity, though in this case availability of water provides the ‘third axis’.

In terms of the model, foragers are obligated to be highly mobile under conditions of resource depauperation. Wherever possible, such movements would be undertaken logistically in order to minimize energetic expense, however the viability of such an approach almost certainly depends on the availability of water. Even when water is available, the capacity of logistical trips to diminish costs is inhibited by upper limits on the range people are prepared to travel in a given logistical foray.

As abundance increases there comes a point where overall investment in mobility decreases, reflecting both the relatively weak incentives to move (relatively low probability of subsistence failure, or ease of satisficing (cf., Foley 1985)) and also the anticipated marginal increase in returns associated with large or frequent movements. Beyond exhibiting a primarily logistical system of mobility, groups occupying landscapes in this range may more effectively improve optimality of energetic returns by means other than increased mobility (e.g., expanding diet breadth – discussed below).

Under conditions of extreme resource richness foragers may be either highly mobile, reflecting large payoffs for frequent or large movements, or barely mobile, reflecting little incentive to move. In neither case, however, is there likely to be much motivation to decrease movement costs through logistical trips. Eder’s (1984) depiction of Batak movements, where whole families relocate even when there are only tasks available for one or two members, exemplifies this idea.

Patch choice and diet breadth models

The previous section dealt with mobility in a generalised sense, as a strategy of energetic outlay relative to expected returns within varying environmental contexts. Decisions made at a finer spatial resolution can be modeled in terms of patch choice, using Charnov’s (1976) Marginal Value Theorem. The theorem works on the premise that a subsistence environment is composed of a number of patches, and that foraging takes place only within these patches. On entering a given patch, a forager begins to deplete the resources therein, obtaining diminishing energetic return rates as time spent within the patch increases. Following the theorem, an optimal forager should abandon a patch at the point where within-patch returns fall below mean return rates for the subsistence environment as a whole. Within relatively resource-rich environments, high mean return rates encourage briefer foraging periods in any given patch. Conversely, resource depauperate contexts encourage more extended periods of occupancy (Charnov 1976).

In addition to resource abundance, duration of patch occupany is also affected by the distance between patches – what might be described as the overall ‘patchiness’ of the landscape. Any calculation of return rates needs to factor in the time expended during travel between patches (Orians and Pearson 1979). Where patches are dispersed, and thus where inter-patch travel times are high, the mean environmental return rate necessarily decreases. Conversely, where patches are distributed evenly and in close proximity to one another, return rates increase. Inter-patch distances thus also affect the relationship between magnitude and frequency of movements. In a resource-poor and spatially ‘patchy’ environment, groups may move far but infrequently. In a resource-rich but spatially homogenous environment, movements may be frequent but short.

Inter-patch distances aside, patches which offer return rates well above the environmental mean will be able to sustain longer foraging bouts; likewise patches containing resources capable of withstanding sustained predation (such as fish stocks). It is also worth noting that a patch use strategy geared to maximize rates of return is not markedly distinct from a strategy geared to minimize risk in an unpredictable environment, albeit that slightly longer periods of occupancy are expected for risk minimisers than for return rate maximisers (Caraco 1980; Winterhalder 1986).

Figure 4.6 provides a summary of patch use under different conditions following the marginal value theorem. In all cases, patches should be abandoned when the rates of return within the patch (energy return / time in patch) fall below mean returns for the environment overall (tangent line). Optimal time in patch is represented by t_x, and optimal energy harvested as e_x. Graphs ‘A’ and ‘B’ present optimal patch use times for the same rate of resource depletion (in effect, the same patch) given different mean environmental return rates. In graph ‘C’, the mean environmental return rate is the same as for ‘A’ but the patch depletes less quickly, resulting in extended occupancy (t_c).

Variation in resource richness also affects decisions about which prey types foragers will pursue. As a rule-of-thumb, larger prey species will produce better energetic returns than smaller prey, assuming comparable rates of encounter, pursuit and handling times, and are thus likely to be more highly ranked than small prey by foragers (Broughton and O’Connell 1999; though note Bliege Bird and Bird 1997, 2005). In resource-rich contexts, where encounter rates are relatively high, high-ranked prey species are expected to dominate the diet of foragers, while low-ranked prey should be taken relatively infrequently (Orians and Pearson 1979; Pyke *et al.* 1977). As encounter rates decline, diet breadth is expected to expand to include more low-ranked items (Stephens and Krebs 1986). Expanding diet breadth may also increase the number of patches perceived as viable for foraging, thus reducing travel time between patches and dampening the overall patchiness of a landscape – what MacArthur and Pianka (1966: 608) refer to as a "jack-of-all-trades" strategy. Again, the strategy of a risk minimizing forager in an unpredictable landscape is expected to broadly mirror that of an return rate maximiser, though with some minor but notable variations (Winterhalder 1986). Where resources are relatively rich, risk is minimized by a slightly more expanded diet than is optimal for return rates; where resources are poorer, and the chance of falling below minimum requirements are high, diet breadth is expected to contract, and the forager to pursue riskier, high return items (Caraco 1981; Winterhalder 1986).

Settlement organisation

Optimizing theories can also be used to make predictions about the distribution of foragers in a landscape, and for the use of systems to control access to resources. Horn's (1968) oft-cited model of variation in the nesting patterns of Brewer's Blackbirds provides a basis for inferring the optimal dispersion of foragers in a landscape under varying environmental conditions. Horn's model explores the impacts of two different nesting configurations (dispersed and aggregated) on foraging travel times in relation to two different resource configurations ("evenly distributed and stable" and "highly clumped and transient"). Analysis suggests that where food resources are evenly distributed and stable, optimal returns can be achieved by the dispersal of nests into spatially-constrained foraging patches across the landscape (Figure 4.7). In contrast, clumped and transient resources better favour aggregation of nests at a central point.

4.4.2 Costs and benefits in the organisation of stone artefact technologies

As with foraging behaviours, technological strategies involve a complex interplay of costs and benefits (Bamforth 1986, 1991; Bleed 1986; Bousman 2005; Clarkson 2007; Hiscock 2006; Kuhn 1994, 1995; Torrence 1983, 1989). Costs chiefly arise as a result of three related problems. First, that sources of stone suited to artefact manufacture are not ubiquitous in landscapes. Second, that sources of stone will not always occur where and when tasks requiring stone artefacts occur. Third, that stone artefacts are rapidly depleted during use and resharpening (Clarkson 2007). In order to maintain a supply of stone artefacts, therefore, foragers must outlay time and energy on the acquisition, manufacture and transport of stone artefacts and stone artefact-making materials (Kuhn 1995). The benefits derived from stone artefacts relate primarily to the advantages they provide in the successful prosecution of subsistence tasks.

Since the 1980’s, numerous researchers have attempted to develop optimality models for the organisation of stone artefact technologies (e.g., Bleed 1986; Clarkson 2004, 2007; Kuhn 1995; Marwick 2007; Torrence 1983, 1989 and papers therein). Various currencies have been proposed, including time, energy and risk, but no clear consensus has emerged on which of these is the most useful. Part of the problem may be a perception that different currencies are in conflict (e.g., Nelson 1991: 64), and that it is thus necessary to select and deal with one and only one. The approach taken here is slightly different, in that time, energy and risk are all incorporated. Time and energy are viewed as costs relating to the acquisition of stone making material and the manufacture of artefacts, and to the transportation of technological materials. Risk, or risk dampening, is seen as a benefit resulting from technological investment.

The following section begins by considering how time and energy costs are incurred, and how they can be diminished. Subsequently, the relationship between risk and technological investment is discussed. The section concludes with a model in which time, energy, and risk, and their anticipated relationship with environmental variation, are all incorporated.

The time costs of constructing and maintaining toolkits

Torrence (1983) introduced the concept of time-budgeting in stone artefact technologies. The concept hinges on the idea that hunter-gatherers have a limited temporal budget available to allocate to the various tasks of which life is comprised (including social, subsistence and technological tasks). While social and subsistence, and social and technological tasks may at times have been undertaken simultaneously, it seems likely that subsistence and technological tasks were often temporally exclusive. That is, time spent in the manufacture of a toolkit was probably time not spent actively engaged in subsistence. At times, this may have led to scheduling conflicts between subsistence and technological tasks. This section considers the issue of time-costs in technological systems, and possible causes of variance.

Magnitude costs of procurement

In most contexts, the greatest proportion of a time budget associated with the production of a stone toolkit will probably have been that expended on procurement of material. While material for artefact manufacture may occasionally have been abundant, it will often have been relatively scarce. Furthermore, even when sources of stone were readily available, procurement for the purposes of artefact manufacture would inevitably have involved costs additional to travel to and from sources, such as cobble testing. Necessarily, such costs would increase as the density of stone resources in the landscape decreased (Bamforth 1986). In material-poor environments, return travel costs alone might conceivably have been in excess of several hours.

The most effective means by which foragers could have minimized these procurement costs would have been to take on-encounter any materials suitable to artefact manufacture. Thus, if travel for the purposes of a subsistence task led foragers to an encounter with stone, its opportunistic collection would reduce the need for a dedicated procurement trip in the near future. Embedding such procurement episodes into subsistence tasks would effectively allow the same unit of time to be allocated to both technological and subsistence activities (cf., Binford 1979: 259; Torrence 1983: 12). Brantingham's (2003) neutral model provides a useful way of visualizing the material outcomes of such a minimal cost approach. If we assume that foraging opportunities were randomly distributed across landscapes, that artefacts were consumed at a constant rate, and that consumed artefacts were replaced at exhaustion with whatever material was available, then the material composition of assemblages acquired by minimal time outlay would, when aggregated, come broadly to resemble the frequency of materials as they occur in the landscape.

The downside of such an approach to procurement is that it would, in many cases, result in assemblages dominated by relatively poor-quality materials. While such materials may have been suitable to most tasks, they would equally have placed constraints on the longer-term utility of the toolkit, possibly increasing the frequency of reprovisioning events (discussed below). In order to increase the proportion of better-quality rock, foragers would almost certainly have had to increase their procurement time outlay by undertaking non-embedded procurement trips. The utility of the neutral model in this regard is that it provides a basis for identifying such instances of divergence from the minimal cost system.

Frequency costs of procurement

Embedding, or neutral procurement, represents a means of reducing the *magnitude* of costs associated with any given episode of material acquisition. Time may also have been saved by increasing the yield from a quantity of procured stone, and thus by reducing the *frequency* of procurement episodes (cf., Hiscock 1996a: 152; Kuhn 1991). There are a number of ways by which foragers could have increased yields from procured stone. The most obvious is to lower discard thresholds; that is, to lower the size at which an artefact is considered unusable and thus thrown away. Archaeologically, the functional ‘low-end’ artefact size threshold has not been clearly established, however it is clear from some cases that at various times and in various places people were prepared to manufacture and deploy implements that were remarkably small (Orton *et al*. 2005; Orton pers comm. 2007, pers obs., report complete 8mm backed artefacts from the Northern Cape province of South Africa).

With regard to cores, lower discard thresholds are likely to be manifest in a reduction in core size, and, potentially, an increase in bipolar reduction. Inertia is a significant constraint on the reduction of stone, resulting in a weight threshold below which freehand percussion is not viable (Hiscock 2003, 1996). Bipolar flaking removes this barrier, allowing further reduction. Some authors have suggested that increased yields in the form of high edge length to mass values might have been achieved through use of certain reduction systems, such as those associated with the production of blades (e.g., Jeske 1989). The absolute yield advantages of such systems, however, are not entirely clear (cf., Eren *et al*. 2008).

With regard to flakes, lower discard thresholds might be manifest as a willingness to use smaller blanks for tools, or in the heavy reduction of implements such as scrapers and points (cf., Bousman 2005; Clarkson 2002a, 2002b, 2004, 2005; Kuhn 1991). Hiscock (2006) refers to this as an extension strategy, whereby people elect to increase the use-life of an implement rather than make a new one. Following Shott (1989) we might think of yield improvements as an increase in the ratio of realized to potential utility in a transported item.

Another means of improving yields is through the use of relatively conservative reduction systems. Soft-hammer reduction can result in the production of thin flakes, one consequence of which is that less weight is stripped from the nucleus for any given detachment. When used in the reduction of retouched artefacts, soft-hammer techniques may increase the number of resharpening episodes an implement can withstand, and thus extend its usable life (Hayden 1989). Scars resulting from soft-hammer reduction also have the advantage of being relatively shallow. This means that abrupt terminations are likely to be both less common and less severe. Repeated abrupt terminations not only render a working edge ineffective, they also place significant constraints on further reduction. As Macgregor (2005) has demonstrated, removing large abrupt terminations from unifacial tools may require the removal of large, thick flakes. In the case of cores this may simply result in a waste of material; in the case of retouched flakes it may be catastrophic.

A final point to note in regard to yield increase is that not all materials have the same yield capacity. Fine grained rocks allow for the production of thinner flakes, again diminishing weight per blank removed. In a similar vein, materials which fracture predictably allow more blanks to be removed with less chance of catastrophic fracture (Goodyear 1989), while the blanks produced from particularly abrasion-resistant (hard) rocks may be able to do more work for a given quantity of procured material (Braun *et al.* 2009). It is also possible to improve the inherent characteristics of procured rocks by means heat treatment, which improves both predictability and ease of fracture, albeit at the cost of durability (Crabtree and Butler 1964; Domanski and Webb 1992; Domanski *et al*. 1994; Webb and Domanski 2008). Increasing ease of fracture decreases the amount of force needed to initiate a flake, lowering inertia thresholds, and consequently, discard thresholds. Notably, heat treatment is particularly effective in the manipulation of silcretes (Webb and Domanski 2008). In all these cases, preferential selection of fine grained, predictably flaking and/or harder rocks, and possibly their subsequent heat treatment, may have been a means of offsetting increased magnitude of procurement-time outlay with diminished frequency of reprovisioning events.

Finally, and as an alternative to yield increase, foragers might have diminished the frequency of provisioning events by increasing the amount of rock acquired at any given time of access and transporting it to a particular point on the landscape. Kuhn (1995) has described such a strategy as the *provisioning of places*, whereby foragers sacrifice increased outlay of initial time to, in effect, turn places of occupation into sources of material (cf., Parry and Kelly 1988). Again, this represents an offset of magnitude of outlay against frequency of outlay. Such an approach will regularly have been cruelled by transport costs, and is only likely to have been viable in cases where extended occupation of a given point on the landscape could be predicted (cf., Kuhn 1995; Mackay 2005). Thus, foragers who were either highly residentially mobile, or for whom mobility schedules were rendered unpredictable by resource variance, are unlikely to have been able to pursue such a strategy.

Manufacturing costs

The other element of time cost in stone toolkits relates to outlay on implement manufacture and repair (Torrence 1983). Though these costs are variable (cf., Hames 1992 Hill *et al*. 1985; Lee 1979; Tanaka 1980; Yellen 1977), they can be considerable. Hill *et al*. (1985), for example, report an average of two hours per day spent by Ache men on the manufacture and repair of tools, chiefly scheduled during down time between or immediately after subsistence tasks. Obviously in the past only a fraction of this cost would have been allocated to the manufacture and repair of stone implements, the remainder being allocated to behaviours such as the production of wooden and other organic items, and the hafting of stone implements, all of which can be difficult to detect archaeologically. Nevertheless, direct costs in the manufacture of stone implements might not always have been insubstantial, with the outlay involved increasing with both the complexity and the number of implements manufactured.

Beyond direct costs, there are additional associated costs in the manufacture of complex implements, including high rates of production failure associated with complex reduction strategies (cf., Villa *et al*. 2009), the manufacture of hafts and time spent hafting, as well as time allocated to learning complex crafts during childhood and adolescence. High failure rates in particular may result in greater rates of material waste, introducing positive feedback between manufacture costs and the magnitude or frequency costs of material acquisition.

Characteristics of time-cost aggregates

Time costs enter technological strategies at three points; in the magnitude of procurement episodes, in the frequency of procurement episodes, and in the production and maintenance of complex artefacts (the last is taken to include learning and failure-related time). In Table 4.1, high, moderate, and low costs for each of these parameters are characterized, and assigned the arbitrary values 3, 2, and 1 respectively. Figure 4.8 plots these values as a line histogram. Though in many ways a caricature, this approach is nevertheless a useful means of thinking about overall time investment in technology. Values of 5-7 (inclusive) account for 70.4% of the hypothetical outcomes (mean + one standard deviation). These values also seem generally to characterize most stone artefact technologies as they appear around the world, with minor variations on the themes of some targeted procurement, moderate discard thresholds and some production of complex implements. This approach is more useful, however, in characterising what we might think of as technological time-cost extremes, or ‘least cost’ and ‘highest cost’ technologies.

Least-cost toolkits (value 3) would be expected to feature materials in roughly the same proportions as they occur in the immediate landscape, reflecting minimum magnitude of outlay. Minimising frequency of procurement episodes would necessitate maximizing the yield acquired from procured material, and we would thus expect low discard thresholds. These could be expressed either in the exhaustion of implements or cores prior to discard, though the latter seems more likely, given that the former implies at least some investment in the manufacture of complex implements. In a least-cost solution we seem more likely to encounter maximally-reduced cores with no outlay on complex tool manufacture.

In highest cost technologies (value 9), all of these trends are reversed. Thus, we might expect targeted procurement of rare or infrequently encountered materials, the manufacture of elaborate implements, and relatively high discard thresholds. Consideration of the literature suggests that this combination of characteristics rarely pertained among hunter-gatherers. The few clear examples all appear to come from food-producing societies, featuring the production of prestige items by craft specialists (for example, Danish flint knives (cf. Apel 2008; Stafford 2003) or Mayan eccentrics (cf., Shafer and Hester 1991)). Examples of relatively high cost technologies (value 8 technologies), however, are more easily located. Any number of recorded technological systems feature targeted procurement of specific materials, the manufacture of complex implements, and relatively moderate discard thresholds.

Considering the causes of variance in technological time-costs

Time spent acquiring materials and producing complex implements will often have been time not spent actively engaged in subsistence tasks. Technological times costs might therefore be thought of in terms of lost subsistence opportunities, or *opportunity costs* (cf., Hames 1992). Complicating the relationship between technological time costs and subsistence opportunity costs is the observation that increased outlay on more complex and/or more predictably performing implements may result in more efficient prosecution of subsistence tasks – that is, in decreased handling times (cf., Bright *et al.* 2002; Ugan *et al.* 2003). Thus, the greater time invested in technology may be offset by increases in the efficiency of resource acquisition during within those periods allocated to subsistence tasks. Foragers who attempt to improve the efficiency of subsistence tasks can be referred to as pursuing a 'time minimisation' strategy (Bousman 2005; Hames 1992; Schoener 1971; Smith 1979). An alternative to time minimisation is to maximise the time spent on subsistence tasks, even if time is spent less efficiently. This is referred to as a resource maximisation strategy (Bousman 2005; Hames 1992).

Several studies (to be discussed in more detail below) suggest that more costly technologies will tend to be employed under conditions where resources are comparatively depauperate (eg., Bousman 1993; Collard *et al.* 2005; Read 2008; Torrence 1983). The implication is that under conditions of duress, foragers will tend to pursue time minimisation strategies, improving the efficiency and probably also the predictability with which they acquire subsistence resources. Hypothetically, however, there must come a point where resources availability is sufficiently poor that pursuing a time minimisation strategy will actively imperial the probability of acquiring a minimum caloric intake. As Hames (1992: 209) notes, for a resource maximiser, "alternative activities … are less fitness enhancing than foraging". Under conditions where a minimum intake cannot effectively be guaranteed, maximising the time spent engaged in subsistence, even if it is undertaken inefficiently, is likely to be the most fitness-enhancing of the available behaviours (Bousman 2005).

With respect to the factors conditioning technological time costs, we might therefore expect to see a general increase in time costs with decreases in resource availability. Much of this variability might be expected to occur within the identified cost range from 5-7, which probably accounts for the majority of known technological systems. Peak, or highest-cost technologies, however, seem more likely to be associated with craft specialists – that is, with people in food producing societies who maintain low subsistence time costs but acquire adequate subsistence intake by trading the products of their high technological time costs. Least costs, on the other hand, may represent those few conditions where subsistence is sufficiently difficult that resource maximisation – and hence the minimisation of non-resource acquisition time – is the most effective strategy.

The energetic costs of transporting a toolkit

As has been noted throughout this chapter, human foragers are, of necessity, mobile. Being mobile allows people to overcome spatial and temporal fluctuations in the availability of resources. However, being mobile also imposes costs on technological systems. While people may occasionally have been able to store technological items at focal points of occupation around the landscape (cf., place provisioning, as discussed above), more often than not, much of a foraging group's technological repertoire would regularly have been transported from location to location. Kuhn (1995) refers to this system of technological delivery as individual provisioning, whereby individuals or groups meet many of their technological needs with regularly transported items, comparable with what Binford (1979) terms "personal gear".

Where a group's movements were either infrequent or short, the energetic costs of transporting such gear are likely to have been relatively low (Torrence 1983; Shott 1986, 1989). However, as mobility increased so too would transport costs. An analogy can readily be made with modern camping gear, which must allow us to meet most of the tasks we will encounter while being easily transported from place to place. In contrast to the diverse array of large, task specific technological items we might find in our homes, items taken on a camping trip are usually restricted in number, lightweight, and multifunctional. This section considers theoretical arguments for similar effects on the composition of mobile toolkits.

Transport costs and toolkit diversity

Theoretically, the energetic costs of artefact transportation can be mitigated in two ways; first, by reducing the number of items transported, and, second, by improving the ratio of utility to transported weight (Kuhn 1994; Nelson 1991; Shott 1986, 1989; Torrence 1983, 1989). This section deals with archaeological expressions of the first issue; the second issue is dealt with below.

Shott (1986) explored the relationship between mobility and the number of technological items transported using data on number of residential moves and number of days in wet season or winter camp as proxies for residential and logistical mobility respectively, and data on toolkit diversity derived from Oswalt's (1976) ethnographic summary. Shott's analysis produced two important results. First, a significant inverse correlation was noted between residential mobility and the diversity of transported toolkits, confirming expectations. In relation to logistical mobility, however, Shott found that the inverse relationship held – a greater reliance on logistical forays tended to result in an increase in toolkit diversity.

More recently, Read (2008) has performed regression analysis on a similar dataset in order to explore the effects of mobility and risk on the diversity of implements, using number of residential moves (NMV) per year as a proxy for the former, and length of growing season (GS) as a proxy for the latter. Though Read's analysis does not easily allow the effects of mobility to be disentangled from those of growing season length, the results nevertheless support in general terms the suggestion of a broad negative relationship between number of residential moves per year and number of tools. Perhaps of more interest, Read noted that the effects of mobility on toolkit diversity are most pronounced in environments with long growing seasons. As growing seasons reduce, and environments become concomitantly poorer, the determining effects of mobility are comparatively muted. As with time costs, Read's results appear to imply that under conditions of increased subsistence duress, foragers are often prepared to incur greater transport costs in order to off-set risk, in this case through the transportation of a more diverse toolkit than would be expected were mobility the primary controlled factor. This interpretation is supported by Read's observation that implements within the toolkit become more complex as values of GS + NMV decrease.

A final point to make in this regard is that, while Read did not test the effects of logistical mobility directly, he did observe differences in toolkit composition that could be interpreted in terms of Binford's (1980) forager / collector distinction. The central observation was that two sub-populations could be identified in the regression of implement complexity measures against GS + NMV. When treated as a single population, regression analysis returned an r^2 of 0.79 for the line y = -0.038x + 5.23. When the two sub-populations were treated differently, r^2 values rose to 0.94 and 0.98 respectively for the lines y = -0.040x + 4.68 and y = -0.037x + 5.83. The difference between the two lines was in the intercept, rather than in slope. That is, while the rate of change in complexity relative to a GS + NMV was broadly similar change both populations, the implements in one population were always more complex than those in another. The majority of groups in the population with greater implement complexity were logistically organised, while the majority in the less complex group were residentially organised.

Transport costs and implement functionality

One logical inference regularly drawn from the effects of transport costs on toolkit diversity is that, assuming that the number of tasks undertaken by a group remains broadly constant, then decreases in the number of items to be transported would necessarily result in increases in the number of roles which the few transported items would be required to fulfil (cf., Kuhn 1994; Hiscock 2006; Nelson 1991; Shott 1986). This is especially important for the technologies of residentially organized groups, where task specific forays will have been comparatively less common; as noted above, logistically organized groups appear often to have maintained relatively diverse toolkits.

Assuming that the inference is valid, it follows that we would expect an inverse correlation between toolkit diversity and range of functionality of transported implements. Following Nelson (1986) we might suggest that multi-functionality could take one of two forms – versatility or flexibility. A versatile design is one considered to be "effective for a variety of tasks", while a flexible design is one which can be "recycled to other tasks when no longer useful for the primary purpose" (Nelson 1991: 63).

Several authors suggest that bifaces are good examples of versatile designs (e.g., Bamforth 1991; Kelly 1988; Nelson 1991). Kelly (1988), most notably, has argued that pointed bifaces can fulfil three relatively distinct roles within toolkits. The most obvious is their role as armatures on projectile or thrusting weapons. However, bifaces also have a sharp edge around their entire perimeter, making them suitable for use in cutting and butchering tasks (cf., Lombard 2006). The final role ascribed to bifaces is as sources of fresh flakes that might be used. As Bamforth (1991: 224) notes, "Whether individual bifaces were designed as cores or not … biface reduction produces both finished tools and a stock of potentially useful debitage". If, as Clarkson (2002b; also Andrefsky 2006) suggest, bifacial implements are regularly subject to ongoing reduction, then the "stock of potentially useful debitage" they produce will not be strictly limited to their point of initial manufacture, but might act as a more regular source of sharp edges. To these properties, Kuhn (1994) adds that bifacial reduction allows maximum control over the three dimensions of artefact form, facilitating improvement of the relationship between transported weight and utility.

More recently, Robertson *et al*. (In Press) have argued that backed artefacts might also reasonably be described as versatile implements. Based on use-wear and residue studies, Robertson *et al.* note the use of backed artefacts in a diverse array of tasks, including wood-working, butchering, and feather processing. To this can be added the recent evidence for use of backed artefacts as projectile armatures, presented by Lombard and Pargeter (2008; also McDonald *et al*. 2007). Thus, though perhaps less versatile than bifacial points (insofar as they are unlikely to have performed subsidiary roles as sources of fresh flakes), backed artefacts might well be considered versatile implements.

Exemplars of flexible implements are less easy to identify. The primary constraint on the idea of an artefact being 'recyclable to other tasks' when applied to stone (as opposed to metal) implements is that dramatic alterations of form are difficult to achieve without substantial loss of material. Consequently, any implement suited to recycling would almost certainly need to incorporate otherwise redundant mass as a buffer against the possibility of its being recycled at some point. To that extent, backed artefacts, though versatile, were probably not flexible. Bifacial points, on the other hand, which must have some redundant mass built in to allow the kind of use-life extensions noted by Clarkson and Andrefsky, may have had a greater capacity for flexibility than backed artefacts.

More plausible examples of flexible technological items are cores, particularly those designed so as to allow the production of multiple blanks of a variety of sizes without significant alteration of core morphology. Recurrent levallois cores (cf., Boeda 1994) might be one example of such a flexible design. While blade cores can also be used to produce very large numbers of blanks, and while there is no theoretical reason why these blanks could not be used to meet a full range of tasks, the advantage of recurrent levallois would be in the production of blanks which themselves would be suitable to considerable on-going maintenance and even to being recycled if required. Thus, while transported blade cores may also be examples of flexible items, they might be considered less adept in this regard than recurrent levallois.

Transport costs and artefact weight

An alternative, possibly complementary means of reducing transport costs is to ensure that the weight which is carried is useful weight, what Shott (1989) refers to as utility to weight ratios (see also Kuhn 1994). Improvements in utility to weight ratios could be achieved in a number of ways. One of these involves "stripping as much unusable material from the object as possible before transportation" (Hiscock 2006: 71; also Nelson 1991: 75). At a minimum, this might be expected to involve the removal of flawed or cortical exterior rock surfaces prior to transport. For more elaborately configured implements and cores, establishment of a stable morphology would seem beneficial.

Kuhn (1994) has used mathematical models as a means of identifying a theoretical 'optimum' for the design and composition of mobile toolkits, based on variance in utility to weight ratios for flakes and cores of different sizes. Kuhn's model suggests that the most effective utility to weight ratio for an assemblage overall is achieved with a moderate number of small, and possibly task-specific flake-based implements. As Kuhn (1994) himself notes, this result contrasts with ethnographic evidence of an inverse correlation between mobility and the number and diversity of implements. The explanation may be that the 'optimal' toolkit is well suited to a predictable range of tasks, but lacks the flexibility to allow foragers to deal opportunistically with a series of unpredictable subsistence events. For example, where it became necessary for whatever reason to meet one task repeatedly, the efficacy of a toolkit comprised of multiple task-specific tools may be compromised. Given this, it may be that the optimal design model is a better description of the toolkits of logistically organised groups, among whom tools are noted to be diverse, and for whom task-specific activities are expected to be more common. The toolkits described in the preceding section which have greater generic utility and/or more weight than optimal (e.g., some redundancy) might provide a better solution to residentially mobile foragers, or those dealing with an unpredictable range of subsistence tasks.

The risk-dampening benefits of technological investment

It is assumed here that the primary benefit attained from investing in and maintaining technological systems relates to improvements in the efficiency and efficacy with which subsistence tasks are undertaken. To that end, the main situation that people using stone artefacts would seek to avoid would be one in which a subsistence opportunity could not be pursued because of inadequate technological means. The significance of any given lost opportunity is seen to be related to the abundance and predictability of such opportunities in the subsistence context, something regularly referred to as ‘risk’ (cf., Bamforth 1991; Bamforth and Bleed 1997; Bousman 1993, 2005; Clarkson 2004; Collard *et al.* 2005; Fitzhugh 2001; Hiscock 1994, 2002; Marwick 2007; Read 2008; Torrence 1989). This section considers the relationship between risk and technological investment.

Factors affecting risk

Risk is composed of two elements – probability of failure, and significance of failure (Bamforth and Bleed 1997). These elements can be seen to vary in relation to the predictability and abundance of resources. In resource-rich environments, the probability of foragers failing to attain their minimum caloric intake is relatively low, and thus the costs (or significance) of missing any given opportunity to harvest resources are unlikely to be severe. In contrast, in resource-poor environments, where the total amount of harvestable energy harvest is low, these costs could be dire indeed (Read 2008). Similarly, in relatively predictable environments, foragers can anticipate the timing and nature of foraging opportunities and plan accordingly. However, where there is significant stochastic variation in the spatial and/or temporal distribution of resources, the costs of missing a given subsistence opportunity may be considerable if no comparable opportunities present themselves in the immediate future.

While both abundance and predictability can be viewed as independent causes of variance in risk, it is argued here that their effects should be viewed hierarchically, with abundance-related risk as the more significant. In a hypothetical situation where subsistence resources are abundant but their distribution in time and space is highly unpredictable, it seems reasonable to suggest that the costs of missing a given resource-harvesting opportunity will be moderated by the relatively good chance of encountering another such opportunity soon thereafter. In contrast, where subsistence resources are very sparse but highly predictable, though foragers can plan so as to reduce the probability of failure, the cost, should failure occur, could be catastrophic.

Effects of risk on technological investment

Several studies have explored the relationship between abundance-related risk and technological complexity among ethnographically-observed groups (cf., Collard *et al.* 2005; Read 2008; Torrence 1983). Though abundance-related risk itself cannot be directly measured (Bousman 1993), a number of reasonable proxies are available, including latitude (Torrence 1983), effective temperature (Collard *et al.* 2005) and length of growing season (Read 2008). In all of these studies, strong and positive correlations between risk and technological complexity were observed. Thus, we have reasonably strong grounds on which to base an assertion that those inhabiting riskier environments invest more in technological aids.

While comparable broad-based studies have not been performed on the relationship between predictability-related risk and technological complexity, this almost certainly reflects the difficulty of identifying general proxies for resource predictability. There have, however, been specific studies which argue that a similar relationship exists. Clarkson's (2004) study of technological change in North Australia provides one example, where the late Holocene florescence of bifacial point forms is shown to have been tied to fluctuations in the El Nino Southern Oscillation (ENSO) index (also Hiscock 2002, 2008).

While we have grounds to believe that investment in technology increases with risk, the specific forms taken by technological systems are likely to vary depending on whether risk is driven primarily by resource-depauperation or whether it also incorporates an element of unpredictability. To that end, Bleed (1986) has described two kinds of design systems which are suited, respectively, to dealing with significance-driven risk and with predictability-driven risk. These he describes as 'reliable' and 'maintainable' systems. The characteristics of these systems are discussed below. A minor critique of this approach follows this discussion.

Reliable vs. maintainable systems

As noted above, the key difference between abundance-driven risk and predictability-driven risk lies in the extent to which future events can be anticipated. While technological planning might always be expected to aim at improving the probability that a given resource-harvesting opportunity will be successfully undertaken, the means by which this can be achieved will differ depending on the extent to which the nature of that opportunity can be known in advance. If we take as an example a resource that becomes available as a result of a brief but predictable seasonal migration, we would expect foragers to organise labour and select effective hunting spots in advance, and to design technologies that are specifically effective in prosecution of the task at hand. Under such circumstances, Bleed (1986: 739) suggests that the ideal technology will be *reliable* – one "made in such a way that, come what may, the ability to function is assured" (Bleed 1986: 740)

As an alternative, if foragers are operating either in new landscapes, or where resources are in flux, it may, as Bamforth (1991: 229 [italics added]) notes, "be possible to anticipate that *something* will occur that requires a tool without knowing exactly what that occurrence will be or what kind of tool it will require". The ideal technology for such "unpredictable schedules" is one "made so that if it is broken or not appropriate to the task at hand, it can quickly and easily be brought to a functional state" (Bleed 1986: 739). He describes such systems as *maintainable*.

Reliable and maintainable systems have different characteristics which may be recognizable archaeologically. Reliable systems, for example, are expected to be overdesigned, understressed, include parallel subsystems and standby components, have carefully fitted parts and feature good craftsmanship. Bleed (1986: 740) also suggests that reliable systems will be maintained and used at different times. Overdesigned implies that quality of manufacture will exceed functional necessity, while understressed necessitates that the tool will be used well below its tolerance level. Parallel subsystems involve either having multiple parts doing the same task (design redundancy), or having replacements readily available. Multiple barbs on a spear exemplify the former, while a quiver containing multiple arrows exemplifies the latter. As Hiscock (2006) notes, reliable designs also benefit from standardization, such that individual components can be interchanged in case of failure. Standardisation also means that, where it is necessary to replace parts, the quality of fit will be maintained, and thus the efficacy of the implement will not be compromised.

Maintainable systems, in contrast, are expected to be “light and portable”, have “subsystems arranged in series”, be “design[ed] for partial function”, and be “user maintained”. In contrast to reliable systems, maintainable systems are expected to be rejuvenated and repaired during use. Where reliable systems have multiple components doing the same job, for maintainable systems, it is expected that “if any component fails, the whole system fails” (Bleed 1986: 740). This issue is offset by having spare parts readily available.

The emphasis on maintainability puts a number of specific constraints on maintainable systems. Primarily, if a stone artefact is to be suited to regular reworking, it must include some weight beyond that strictly necessary to the prosecution of tasks. This in turn places a further constraint, relating to material selection (Torrence 1989). Not all materials are suited to regular reworking, most notably those with poor fracture predictability, such as vein quartz. Thus, maintainable stone artefact technologies will require homogenous, if not also fine-grained materials.

A second, related constraint concerns the suitability of the implement’s morphology to sustain on-going maintenance. As Hiscock (2006: 72) notes, implements with “shapes and dimensions that either minimize the occurrence of features such as abrupt terminations, which can limit further reduction, or increase the capacity of the knapper to remove such detrimental features” are beneficial for maintainable systems (note also Macgregor 2005). Bifaces and flaked- or ground-edge axes are seen as examples.

As noted above, foraging in unpredictable contexts limits the capacity of foragers to anticipate tasks with any degree of precision. One consequence of this is that maintainable tools will be, of necessity, generalised. To that extent, maintainable tools, like those used by foragers with numerically limited toolkits, are expected to be multifunctional to enable foragers to deal adequately with a range of contingencies (Nelson 1991: 71). Perhaps unsurprisingly, therefore, bifaces have been argued to be exemplars of both versatile and maintainable technologies (cf., Bamforth 1991; Hiscock 2006; Kelly 1988; Nelson 1991).

A criticism and final note on the reliable / maintainable distinction

Bleed's (1986) reliable / maintainable distinction has seen considerable use in the ~20 years since its initial description. This usage has tended to rest as much on the fact that the distinction makes intuitive sense, as to any studies demonstrating goodness-of-fit with empirical reality. However, as must often be the case, intuitive appeal masks logical difficulties. In the case of the reliable / maintainable distinction, these derive from the fact that the distinction is phrased with reference to "systems", rather than parts thereof. As Kuhn (1995: 36) notes, however, "[a]rchaeologists do not study ""systems"". Rather, archaeologists study artefacts that were once incorporated into systems, but which do not necessarily, and indeed almost certainly do not, represent them in their entirety. The significance of this issue becomes clear when we consider some of Bleed's examples.

One of Bleed's (1986: 740) examples of a reliable system features a "bowman with a spear, in front of a net impoundment". In this case, reliability stems from having multiple elements aimed at achieving a single goal such that one might fail, but it is unlikely that all will fail simultaneously. Unfortunately, the probability that archaeologists would be able to recognize such complex technological redundancy is negligible. At the site in which the system is deployed we would be fortunate to find a single arrowhead or broken spear point. On their own, neither would be evidence of a reliable system. At an occupation site nearby we might find evidence of the manufacture of spear- and arrow-heads, but would have no evidence that the two were deployed together.

In two other of Bleed's examples he describes "a quiver full of identical arrows" as evidence of a reliable system, and "a bow and three or four arrows in various states of completeness", as a maintainable system. In referring to the reliable toolkit of a Nunamiut hunter, Bleed notes the presence of "2 to 4 rifles" as part of the systematic redundancy. A toolkit featuring a single rifle would, presumably, not be considered reliable, certainly not to the same extent as one featuring multiple rifles. Again, however, the chances of archaeologists being able to determine whether one rifle or many, or "a quiver full of identical arrows" or "three or four arrows in various states of completeness" were taken into the field is low.

These examples, however, serve to make an important point about the nature of reliable and maintainable systems. There has been a tendency to view these as design alternatives, even though Bleed (1986: 740, 2002) was explicit that they are not. As the example of the rifles shows, the reliability of any *system* can be increased by increasing redundancy in its components. Thus, an implement designed to be maintainable can be incorporated into a reliable system by increasing the number of such implements taken on subsistence trips. This in turn can be related to the earlier observation that reliability and maintainability are responses to independent but not exclusive kinds of risk – abundance-related and predictability-related. Where risk is abundance-driven we would expect reliable systems to pertain. Where risk is predictability-driven we would expect maintainable systems. Where risk is driven by both abundance and predictability, we would expect a system that is both reliable and maintainable.

Modeling technological responses to environmental change

The preceding discussions can be reduced to a number of pertinent points. Technological systems entail costs in terms of time and energy. These costs can be diminished by a number of methods, including embedded procurement of materials, maximization of yields from procured materials, limited investment in the production of complex implements, and transportation of few, small artefacts. Pursuing such low cost technologies, however, is likely to have deleterious consequences for the efficacy of the transported toolkit. Consequently, groups wishing to have more effective toolkits must be willing to bear higher technological costs. Ultimately, ethnographic data suggest that this is most beneficial where risk is high. The kinds of costs which are borne, however, will be tied to the kinds of risks with which foragers are faced.

For populations subsisting in lower risk environments there appear to be few incentives to invest in complex technologies. Easily procured, expediently manufactured and readily discarded artefacts are likely to be sufficient to undertake most tasks with a reasonable degree of success. While variance in mobility relating to resource patchiness may induce some changes in the weight and diversity of transported items, overall investment would be expected to remain low.

As risk increases, so too would we expect the degree of investment in technological aids to increase. Where risk is primarily predictability-driven, we might expect a technological response featuring an increased prevalence of homogenous fine-grained rocks and artefact forms suited to on-going maintenance. Where populations were highly residentially mobile, a decrease in toolkit diversity would be expected, with an attendant increase in the multifunctionality of implements. Good utility to weight ratios would be expected to pertain, including some preprocessing of materials at source. Under conditions of diminished residential mobility, and thus lower transport costs, implements might feature some potentially redundant mass to allow flexible responses to unforeseen exigencies. This last might be manifest in relatively moderate to high discard thresholds.

Where risk is primarily driven by a poverty of resources (abundance-driven risk), we might expect a technological response featuring the production of large numbers of standardized, complex implements. The increased prevalence of predictably-flaking rocks associated with maintainable implements would not necessarily occur as there may not be a need for implements or the cores from which they are produced, to sustain on-going reduction. At the same time, however, selection of such rocks would facilitate standardization of flaking products and increases in utility to weight ratios, as well as helping to diminish the frequency of reprovisioning events. Where mobility was primarily residentially-organised, implements would be expected to incorporate mulitfunctionality; where movements were primarily logistical, greater toolkit diversity would be expected.

Conditions where resources are both depauperate and unpredictable are likely to have required implements that were standardized, relatively numerous, and suited to on-going maintenance. This might be facilitated by an investment in the acquisition of predictably-flaking rocks. Diminishing the frequency of reprovisioning events through yield increase would have been advantageous, however, the need to maintain artefacts over unforeseeable lengths of time would almost certainly have required the inclusion of some potentially redundant mass in artefact form. Thus, lowering reduction thresholds may not have been a viable means of yield increase, and the use of other means such as artefact design and the use of soft-hammer reduction, is likely. It seems unlikely under such conditions that people could have been overly task-specific, even if logistically organised, and thus some degree of multifunctionality in artefact design seems probable.

A final point concerns the observation made in the section on time costs about conditions favouring least-cost and highest cost technologies. It has been argued here that increases in risk will stimulate increases in technological costs. Yet, for time costs at least, it seemed that highest cost technologies were actually more likely to occur under conditions of great resource security, and thus, of low risk. It was also argued that lowest-cost technologies, rather than a response to low risk, might have been a response to very high risk conditions, where people sacrificed technological cost outlay in order to maximize their resource capture. These points, and the above observations about energy costs and risk, can be used to formulate a rough heuristic model of technological costs and risk, referred to here as the 'tilda curve' of technological costs (Figures 4.9 and 4.10).

For the figure, the *y-axis* is a composite of time and energy costs, described as 'technological costs'. These are plotted against risk, factored primarily for abundance-related risk. Use of abundance as the primary factor relates to the earlier observation that abundance is more important to the overall configuration of risk than is predictability. Variance in predictability is tracked, in effect, by the width of the technological cost curve. Thus, for a given value of abundance-driven risk, technological costs will vary depending on whether resources are predictable or unpredictable. At penultimate risk values, where both abundance- and predictability-driven risk are high, technological costs are near maximum, featuring an emphasis on predictably-flaking materials, multiple, complex, maintainable implements and transportation (and occasional discard) of mass beyond that optimal for a given mobility regime as a hedge against the possible need for implement transformation. Increased risk beyond this point collapses the technological cost curve to minimum value, inferring a reorientation of the time and energy budget away from technological outlay in favour of direct subsistence outlay.

5

THE STUDY AREA

5.1 INTRODUCTION

The objective of this chapter is to provide information on the sites and sequences explored in the thesis, and on the resources surrounding them which are theoretically likely to have influenced patterns in subsistence and technological organisation. In most of the sequences to be considered, organic preservation is relatively poor. It is not possible, therefore, to make direct statements about past variance in faunal and floral resources. Instead, the chapter focuses on the nature and distribution of stone materials, and the past and present availability of water resources both around the sites themselves and in the study area more generally.

The chapter begins by introducing the study area, and then dividing it into three catchment zones. This is followed by a discussion of current evidence for local palaeoclimatic change. This discussion includes a summary of information previously presented in Chapter 2, along with new data derived from the phytolith record in one of the sites to be examined. Subsequently, the present configuration of water and geological resources in the three zones are described, and the sites and their sequences presented. The chapter concludes with a brief summary.

5.2 DEFINING THE STUDY AREA

The data to be used in this study derive from a total of five rock shelter sites located approximately 200 km north of Cape Town, in what is presently part of southern Africa's WRZ (Figure 5.1). The sites fall along a rough transect, 85 km from WSW to ENE (Figure 5.2). The site at the western-most edge of this transect, Elands Bay Cave, is located immediately adjacent to the present Atlantic coast. The eastern-most site, Klipfontenrand, is situated in the drainage of the Doring River, near the edge of the arid interior. In between these two sites lie three further sites: (from west to east) Diepkloof, Klein Kliphuis and Hollow Rock Shelter. Though data from all five sites will be used, much of this thesis will focus on the two with the best resolved and best dated sequences – Diepkloof and Klein Kliphuis.

5.3 DIVIDING THE STUDY AREA

For the purposes of this study, the area is divided into three zones, based on river catchments (Figure 5.3). Each zone presents a different set of environmental characteristics likely to have influenced land use and technological organisation. These characteristics are discussed in subsequent sections of this chapter.

At the western edge of the study area is the coastal Sandveld, a large area of quartzitic Table Mountain Sandstone (TMS) rocks overlain by a thick mantle of aeolian sand (Chase and Thomas 2006). The Sandveld features a gently undulating sand-surface, punctuated by occasional large sandstone outcrops which are often elongate and oriented east-west (Plate 5.1). This orientation relates to the drainage pattern of the area, which is dominated by the catchments of three highly ephemeral, east-west running rivers. At the western end of the southernmost river (the Verlorenvlei River) lies a large, brackish coastal lake, known as the Verlorenvlei. The Sandveld in this area currently receives around 150 mm of rainfall per year.

Inland of the Sandveld lies the Olifants River catchment (Plate 5.2). The Olifants is a large, permanent river, incised into a rocky landscape with generally thin soils. Like the Sandveld, the geology of the valley is dominated by TMS, though in the Olifants drainage these rocks are not covered by substantial volumes of sediment except in alluvial contexts. A low but prominent coastal range forms the watershed which divides the Olifants River valley from the Sandveld to the west. To the east lies the Cederberg Mountain Range, which reaches a maximum height of around 2000m above sea level (Plate 5.3), and which forms the watershed between the Olifants and Doring Rivers. The orographic effects of the Cederberg

Mountains result in higher annual rainfall in the Olifants River Valley than in the Sandveld, with a total in the order of 200-300 mm/yr.

The Doring River catchment forms the third, and easternmost zone in the study area. Like the Olifants, the Doring River Valley is large and well defined. It, too, is underlain by TMS and features thin, relatively poor soils in most areas. Unlike the Olifants River, however, the Doring presently tends to flow strongly only during the rain-bearing winter months. Due to the rainshadow effects of the Cederberg Mountains to the west, the Doring River Valley is relatively dry, receiving average annual rainfall of 100-150mm per year. Immediately east of the Doring Valley is the arid interior Karoo, which is markedly different in geology and topography from the TMS-dominated areas to the west (Plate 5.4).

5.4 PREVIOUS ARCHAEOLOGICAL RESEARCH IN THE STUDY AREA – HOLOCENE OCCUPATION PATTERNS AND THE SEASONAL TRANSHUMANCE MODEL

The study area has been subject to ongoing archaeological investigations since the 1960's, largely under the guidance of John Parkington and Cedric Poggenpoel. In the main, these studies have focused on patterns in Holocene, and particularly late Holocene occupation. Several excavation and large area survey programs have been undertaken, and associated studies have examined occupation and settlement patterns, stone artefact technology, carbon isotopes in skeletal materials, ochre, and the use of floral and terrestrial and marine faunal resources (Hahndiek 2007; Hubbard 1989; Jerardino and Yates 1996; Jerardino 1997, 1998, 2003; Manhire 1987; Mazel and Parkington 1981; Orton 2006; Parkington 1977, 1981, 1984; Parkington and Hall 1987 and papers therein; Parkington and Poggenpoel 1971; Sealy 1986; Sealy and van der Merwe 1985, 1986; Stewart 2007; Van Rijssen 1992). Though Pleistocene finds are also common in the area, these have, thus far, received less attention.

Holocene occupation of the area shows marked patterning. Despite numerous excavations, relatively few sites exhibit evidence of occupation in the early Holocene (cf., Manhire 1993; Parkington 1999; Jerardino and Swanepoel 1999). Through the middle, and particularly later Holocene, the number of occupied sites, both in the Sandveld and the interior, increases, with several being reoccupied after a hiatus, or displaying clear signs of use for the first time. On the coast, the occupational pattern is complicated by an alternation of rock shelter use before 3000 ^{14}C yr BP, the abandonment of shelters and presumably associated formation of vast 'mega'-middens from 3000-2000 ^{14}C yr BP, and a combination of both shelter occupation and midden formation after 2000 ^{14}C yr BP (Buchanan 1988; Jerardino 1996).

Several models have been proposed for variation in Holocene settlement organisation in the study area (cf., Hubbard 1989; Parkington 1977), of which Parkington's seasonal transhumance model is best known and most interesting for the purposes of this thesis. Parkington divided the study area into three zones, Sandveld, mountains and karroo, which broadly cohere with the Sandveld, Olifants and Doring groupings used here. The nature and temporal distribution of resources in these zones, he argued, were largely complementary. In particular, Parkington (1977: 38) noted the permanent water and abundance of shelter, food and plant resources in the mountain (Olifants) zone when compared with the aridity and seasonal game availability of the Karoo, and the ephemeral streams and marine resources of the Sandveld. Based on these contrasts, Parkington hypothesised that any groups pursuing a seasonal subsistence round would be most likely to have moved between coastal and interior contexts.

Archaeological support for this hypothesis was drawn from data suggesting summer-time occupation of the mountains, and winter-time occupation of the coast. The archaeological assemblage from the mountain site De Hangen, for example, demonstrated an abundance of dassie, tortoise, and remains of carbohydrate-rich rootstock (corms) of flowering iridaceae plants. Tortoise are generally far less active in the winter, and were thus most likely to have been captured in the summer months. Tooth eruptions in excavated dassie remains suggested that a high proportion of these animals had been taken within three months of birth. As the majority of dassie births occur within a narrow window in spring, this was taken to support the notion of a summer-oriented harvest regime. Finally, iridaceae corms would only have become easy to locate when in summer flower. In the period following flowering, rootstock would have been rapidly exhausted.

In contrast to the mountain pattern, faunal remains from the coastal site of Elands Bay Cave were taken to indicate at least some winter-time harvesting. Black mussel, for example, was abundant in the later Holocene layers at the site. Due to the frequency of algal blooms in the warmer months, such filter-feeders are often rendered toxic to humans in summer. Augmenting this line of evidence was the observation that many of the seal mandibles recovered from Elands Bay Cave indicated predation within 6-10 months of birth – again consistent with winter occupation. As a final line of support for the model, Parkington *et al.* (1984) noted the prevalence of the fine-grained black rock, hornfels, in both mountain and Sandveld sites. Suggesting that the rock was only available in the karroo, Parkington *et al.* argued that its presence in mountain and Sandveld contexts supported the idea of regular movement between zones.

Since its initial description, the seasonal transhumance model has been subject to significant criticism. Sealy and van der Merwe (1985, 1986, 1987; Sealy 1986) used stable carbon isotope analysis of human skeletal material to explore the dietary differences between individuals buried at the coast and in the mountains. Contrary to the expectations of the transhumance model, they found that individuals buried in the mountains and at the coast had, over the course of their lifetimes, consumed quite different diets. The diet of the latter was inferred to have been dominated by marine foods, while that of the former was dominated by terrestrial foods.

Parkington (1991, 2001) has subsequently contested Sealy and van der Merwe’s conclusions on a number of grounds. While Sealy and van der Merwe (1992) were able to deal with some of these criticisms effectively, many remain pertinent. The strongest of these is that no compelling alternative explanation has been put forward for the robust patterning in the archaeological record that Parkingon documented.

Ultimately, and regardless of whether one accepts the seasonal transhumance model as configured by Parkington, regular contacts between Sandveld and inland communities in the Holocene appear to be well established archaeologically. This is seen most clearly in the prevalence of marine shell at inland sites. Shells have been recorded in late Holocene contexts at Olifants catchment sites such as Andriesgrond (Jerardino 2008), De Hangen (Parkington 1972), Klein Kliphuis (Orton and Mackay 2008), and Renbaan (Kaplan 1987), as well as in the Doring catchment at Klipfonteinrand 2 (Jerardino 2008) and the open sites of the Putslaagte (Halkett 1987). Necessarily, then, either individuals moved from coastal to inland locations, or there were interactions between distinct groups in each location.

Given this, differences between Holocene patterns and the late Pleistocene patterns to be explored here may be informative of variation in the degree of integration between the Sandveld and interior zones.

5.5 LATE PLEISTOCENE CLIMATES IN THE STUDY AREA

This section presents information on changes in rainfall and terrestrial resources in the period from 120 ka to 10 ka (roughly, from the onset of OIS 5 through to the end of OIS 2). Data on rainfall derived from previous studies are summarised, and new data from one of the sites with which this thesis is directly concerned, Klein Kliphuis, are presented. Similarly, previous studies of faunal and floral variation are summarised before the general effects of temperature variation on primary productivity and stability are considered.

5.5.1 Past variance in rainfall

Previous studies

Some of the controlling effects on climates in the WRZ have previously been discussed in Chapter 2, as have existing terrestrial and marine records of change. Both controlling effects and available evidence are briefly recapitulated here before new evidence from the late Pleistocene phytolith sequence at Klein Kliphuis is presented.

The study area presently receives most of its rain as a result of the northward migration of the westerly winds during cold winter months. Several scholars have hypothesized that this process would have been exaggerated with the expansion of Antarctic sea ice during global cold phases (Chase and Meadows 2007; Nicholson and Flohn 1980; van Zinderen Bakker 1976). Most of the period from 120 ka to 20 ka was colder than present, and, hypothetically, would have received more rainfall. Combined with decreases in evapotranspiration associated with cooler conditions, we would thus expect the study area to have experienced both increased absolute and effective precipitation through most of the last glacial period.

Various data sources suggest both relatively wet and relatively dry conditions prior to the onset of the OIS 4. Stuut *et al*. (2002), for example, document reduced fluvial activity in the WRZ coincident with the onset of warm conditions in OIS 5. However, the faunal assemblage from Ysterfontein, which lies some 100 km south of the study area on the west coast suggests wetter-than-present conditions from 130-110 ka (Avery *et al.* 2008). Fauna from Klasies River in the adjacent YRZ similarly indicate relatively wet conditions around 100 ka (Avery 1987; Klein 1974). Whether these archives reflect generally wet conditions – in contrasts to the marine core studied by Stuut *et al*. (2002) – or rather that occupation was restricted to wet episodes within a generally dry period is hard to gauge, largely because of the different kinds of proxies used by Avery and Klein on the one hand, and Stuut et al on the other. It safest to conclude that that there is evidence for both dry and wet phases in OIS 5.

From 80 ka to ~60 ka marine cores and faunal data are less equivocal, suggesting humid and windy conditions (Avery 1987; Chase and Meadows 2007; Henshilwood *et al.* 2001a; Klein 1974, 1976; Klein and Cruz-Uribe 2000; Shi *et al.* 2001; Stuut *et al.* 2002), followed by slightly drier, though still wetter-than-present conditions into OIS 3 (Stuut *et al.* 2002). Several indicators from the YRZ suggest minor aridity in this later period, perhaps implying a contraction of the zone of westerly rainfall influence, though this is followed by intermittent wetter periods in late OIS 3 (Carr *et al.* 2006a, 2006b; Deacon and Lancaster 1988). Marine records from the northern periphery of WRZ suggest the persistence of conditions wetter than present but drier than OIS 4 after 40 ka, albeit with high amplitude fluctuations (Stuut *et al.* 2002). With the onset of OIS 2, the WRZ seems again to have been generally moist, though with possible dry conditions during the peak of the LGM (cf., Chase and Meadows 2007; Parkington *et al.* 2000; Scott and Woodborne 2007a,b; Stuut *et al.* 2002).

Results and interpretation of phytolith changes at Klein Kliphuis

Results of recent analysis of phytolith material from Klein Kliphuis by Dr D. Bowdery (ANU) provide additional insights into late Pleistocene vegetation and rainfall changes in the study area (report provided in Appendix A). Based on changes in phyolith assemblage composition, Bowdery identifies seven broad groupings within the lower part of the sequence, which OSL ages suggest to cover the period from OIS 4 to OIS 3 (the phytolith record of the upper part of the sequence is as yet unanalysed). The two oldest groups

(groups seven and six) are characterized by a mix of shrubs, trees and grasses, with hydrophilic plants particularly well-represented in the younger grouping (group six). This last point is taken to imply that water was regularly available close to the site. Cooler, drier conditions are seen to prevail in the subsequent grouping (five), with a marked decrease is observed in the prevalence of all phytolith types.

Moisture availability improves again in grouping four, with an attendant increase in the number and diversity of grass species represented. The implication appears to be an expansion of grasslands at the expense of shrubs. This gives way in grouping three to conditions which appear both drier and less grassy, and are in some ways similar to those prevailing during grouping five. Moisture levels subsequently improve through groupings two and one, though conditions remain dry overall. Shrubs and trees remain the dominant vegetation forms registered in the phytolith record.

Assigning the phytolith groupings to periods in absolute time is complicated by inversions in the available OSL dates for the lower parts of the KKH sequence, plotted in Figure 5.4[15]. Notable is the out-of-sequence date of 65 ± 3 ka at 80.5 cm below height datum (BHD). A linear age-depth curve incorporating all mean ages follows the formula *age = 0.23 x depth + 41.41*, with an r^2 value of 0.71. If the out-of-sequence date at 80.5 cm BHD is removed (Figure 5.5), the fit line changes to *age = 0.24 x depth + 39.56*, and the r^2 improves to 0.96. These curves are based only on the mean ages, and as such do not allow for the effects of dispersion. When the curve is regenerated for simulated populations of appropriate mean and 2 sigma dispersion (*n* is arbitrarily set at 40 for each age), r^2 falls to 0.86, but the shape of the curve does not change.

Viewed in light of the adjusted age depth curve the phytolith data suggests that the wettest phase in the sequence occurred between ~65 ka and ~62 ka, with slightly less wet conditions pertaining immediately prior to 65 ka. Drying out and a marked decrease in phytolith prevalence occurs from ~62 ka to ~60 ka. This decrease in moisture availability appears to have preceded the transition from OIS 4 to OIS 3, though it does correlate with the onset of warming in the Epica Dome C ice core (Figure 5.6). The beginning of OIS 3 is

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[15] The age depth curve is restricted to these two units because above them there are some indications of occupational discontinuity (discussed later in this thesis). As these hiatuses are not marked by sterile layers, it appears that there was no sediment accumulation at KKH without occupation. A single age depth curve cannot reasonably be fitted through these discontinuities.

perhaps better marked by the apparent efflorescence of grass species which began some time between ~60 ka and ~58 ka.

There is no readily-available explanation for the apparently sudden decrease in moisture availability evinced in the KKH sequence around 62 ka. Bowdery suggests that conditions at the time remained cool, effectively precluding warming-driven southerly migration of the westerly winds as the factor responsible. One possibility is that the peak wet conditions > 62 ka reflect the concerted effects of cold conditions and an obliquity minimum centred on ~68 ka. Obliquity minima decrease seasonal temperature variance, which, during globally cold phases, may have resulted in an extension of the duration of the wet season in the WRZ (cf., Chase and Meadows 2007). If correct, this would suggest that prior to ~62 ka the study area was not only wet, but less seasonally so, with the effect of evening out water availability through the year. As noted above, present water availability in the study area is strongly seasonally constrained. Increased obliquity after ~62 ka might have driven diminished rainfall without associated temperature change. Such a suggestion might also lead to consideration of the effects on seasonality of moisture availability induced by earlier and later obliquity minima, centred on ~112 ka and ~28 ka respectively, and on obliquity maxima centred on ~92 ka and ~48 ka. Whether or not obliquity was important in this respect, the phytolith data document significant environmental variation within the vicinity of KKH in OIS 4, with potentially interesting implications for technological change.

5.5.2 Past variance in the nature, abundance and predictability of resources

Of the sites to be considered in this thesis, only Diepkloof has significant organic preservation, and analysis of the floral and faunal material from this site is as yet unpublished. There are, consequently, few direct indicators of variance in floral and faunal resources from which to work. Those which are available are discussed below. Otherwise, changes in the abundance and predictability of resources are inferred from changes in temperature and moisture.

The study area is presently dominated by scrubby, xeric-adapted fynbos biome vegetation. Trees are absent from the Sandveld, and uncommon in much of the Doring, though

Widdringtonia cederbergensis, the 'cedar' tree for which the Cederberg mountains were named, was prevalent east of the Olifants in the historic period. Terrestrial archives, however, suggest that the fynbos-dominant pattern has probably only pertained since the terminal stages of OIS 2 (Sugden and Meadows 1991, 1993). Fauna from the site of Ysterfontein, which is currently also in fynbos-dominated surrounds, indicate the presence of more grasses and broad-leafed browse in the area in OIS 5, possibly suggesting a better environment for ungulates, and hence for hunting. Charcoal data from the site of Elands Bay Cave imply the establishment of cold-adapted afromontane woodland in the study area from probably around the beginning of OIS 4 and persisting through until around 20 ka (Cowling *et al.* 1999; Parkington *et al.* 2000).

Leaving aside the specific composition of vegetation in the study area, if we accept the proposition discussed in Chapter 3 that generally cooler conditions tend to reduce primary productivity, then it follows that much of the study period was probably relatively resource-depauperate when compared with present conditions. From ~120 ka through to the start of the Holocene, global temperatures were invariably cooler than present (Figure 5.6). Dramatic cooling from 120 ka to 110 ka was followed by around 25 kyr of generally cool, though slightly variable temperatures. A brief spike thereafter precipitated another period of relatively rapid cooling, culminating in the second coldest conditions of the last 120 ka (mid to late OIS 4). Warming thereafter into OIS 3 was followed by a resumption of the trend towards general cooling, with temperatures reaching their nadir in OIS 2.

Interpreting these changes directly in terms of primary productivity is complicated by a number of factors, including the relationship between vegetation and biomass, and also because of the effects of changing moisture availability and also insolation. Marked insolation peaks are observed centred on ~115 ka and ~93 ka, with slightly smaller peaks centred on ~70 ka, ~45 ka and ~20 ka. The degree to which insolation changes moderated the effects of global temperature change is not clear, though it may be of particular importance to conditions in the study area during the LGM, which includes a peak in both coldness and insolation. That aside, the ice core data suggest that the most energy-depauperate, and therefore resource-depauperate parts of the study period would probably have been the cold peaks in late OIS 4 and in OIS 2. Though still poor, the intervening OIS 3 would probably have seen an improvement in primary productivity. OIS 5, or at least those parts of it in which reasonable levels of moisture pertained, would probably have been the most productive time in the study period.

A second aspect of temperature change that might be considered is the degree of variance, or variability. In the absence of directly-relevant variability indicators, it becomes necessary to search for proxies of climatic instability. One option is to use ice core data to infer periods of short time-scale temperature variance. In Figure 5.7, data derived from the Epica Dome C core, which has so far been used to make generalized statements about southern hemisphere temperatures, are used to describe the discrepancy between the coldest and warmest recorded temperatures in each of 214 five hundred-year bins for the period from 18 ka to 125 ka. The y-axis reference line at 1.796 represents the mean variance value for the study period overall.

The data in Figure 5.7 are divisible into five rough groups, three displaying lower-than-average variance, and two displaying above-average variance. Below-average variance is notable in early OIS 5 from ~125 ka to ~99 ka (64% of bins below average); in later OIS 4 from ~68 ka to ~58 ka (61.5% below average); and from late OIS 3 through OIS 2 (< 45 ka; 67.4% below average). Above average variance occurs 61.1% of bins in the period from late OIS 5 to early OIS 4 (~99 ka to ~68 ka), and in 80% of bins in the period from early to late OIS 3 (~58 ka to ~45 ka).

Obviously these data are far from an ideal proxy for climatic variability of the kind of relevance to questions of human behavioural adaptation. Indeed, it can reasonably be asked whether variation at these coarse time scales would have affected human behaviours in ways comparable to variation at smaller time scales. Unfortunately, it is neither possible to resolve this question, nor to present finer-resolution data. Inadequate though they may be, it in order to approach the issues of interest to this thesis, it is necessary to make use of such data as are available. In this case, the data suggest late OIS 5 to early OIS 4, and early to late OIS 3, were probably the least stable periods, climatically, between 120 ka and 20 ka.

Summary

Taken in concert, the, admittedly very limited, data presented in this section suggest that the best conditions for occupation of the study area appear to have occurred in early OIS 5. Relatively warm, stable and at least occasionally wet conditions pertained, along with possible reductions in seasonality. Primary productivity was probably comparatively good in the wetter parts of this period. Later OIS 5, after around 100 ka through to the start of OIS 4, witnessed the onset of cooler, and more variable conditions. There are no clear indications of aridification at this time, though the available evidence is very limited. In the absence of alternative information it seems safest to assume that this period was also relatively moist. Nevertheless, the reductions in temperature and increases in variance probably colluded to render this period less favourable to human occupation than the one which preceded it.

Temperatures in early OIS 4 were again cooler than previously, and also highly variable. Most indicators continue to suggest good levels of moisture. The middle and later parts of OIS 4, from ~70 ka to ~60 ka was markedly cold and apparently stable. Unusually high levels of moisture are documented at KKH between ~65 ka and ~62 ka, with drying out initiating after ~62 ka. While OIS 4 from ~70 ka to ~58 ka is likely to have been a time of generally suppressed primary productivity, significant fluctuations in water availability will have acted both to moderate and amplify the effects of cold at different times.

Productivity was almost certainly improved by warming after 60 ka, with the KKH phytolith record suggesting reasonable levels of moisture and an expansion of grasslands. Persistent variability in temperature would probably have affected resource predictability in early OIS 3, if only at relatively long time-scales. This variability decreased after 45 ka, as a long-term trend towards reduced temperatures became established. This culminated in the coldest, and probably least productive period of the late Pleistocene in the area, centred on the LGM.

5.6 LATE PLEISTOCENE SITES AND RESOURCES IN THE STUDY AREA

5.6.1 Sandveld – water, stone, sites and assemblages

The Sandveld has the most weakly developed drainage systems of any of the zones considered here. The sandy soils, lack of surface rock and poorly defined drainage lines are not conducive to effective runoff and channeling of precipitation. At present, only the southernmost drainage, the Verlorenvlei River, retains water for any substantial period of the year, and in this case water is only found in a coastal lake (the Verlorenvlei), the water in which is sustained by supplementary saltwater inputs during unusually high tides. Water in the lake, particularly towards the western end, is consequently brackish. Other than the Verlorenvlei, available surface water is largely restricted to small pools which form on rocky outcrops following rains (Plate 5.5).

Changes in water availability on the Sandveld through the late Pleistocene are difficult to predict. Lower sea levels would almost certainly have turned the Verlorenvlei into a river. At the same time, apparent increases in moisture in OIS 5 through OIS 3, are likely to have stimulated regular, if seasonal flows. If the above discussion of past palaeoclimates is correct, then greatest water availability would have occurred between ~65 ka and ~62 ka, with less moisture pertaining thereafter and also possibly before. Given the generally weak nature of drainage systems in this area, it seems unlikely that water would have continued to flow throughout the year without renewing inputs. Summer water may thus have been restricted to deeper pools, of which the present Verlorenvlei and possibly Wadrifsoutpan (15km north of Verlorenvlei) are the most likely candidates in the area.

With regard to flakeable rocks, the Sandveld is considerably less well endowed than either of the other two zones. Regular ridges of TMS provide sandstone and quartzite, but high quality examples of the latter are not often encountered in readily flakeable form. Outcrops of silcrete of variable quality are known to occur (cf., Roberts 2003), though surveys by G. Porraz of CNRS (Porraz pers. comm. 2008) failed to detect any sources of high quality material within 20 km of the sites of interest here. This does not, however, preclude the possibility of such sources occurring offshore in now-drowned contexts. Further surveys conducted by the author in the western Sandveld revealed occasional nodules of quartz, and, to a lesser extent, fine grained silicate rocks ranging up to 80 mm in maximum dimension, but rarely greater than 50 mm. Such rocks were sometimes found clustered in or adjacent to eroding conglomerate blocks (Plates 5.6 and 5.7), but otherwise they were sparsely distributed as isolated occurrences.

The results of geological and material surveys are generally mirrored by patterns in material prevalence in excavated and open site LSA Sandveld contexts. Quartz accounts for

70-80% of artefacts in most cases, with quartzite/sandstone the next most common material (in most cases accounting for around 10%). Silcrete, CCS/FGS and hornfels rarely comprise more than 5% of assemblage totals (based on data from Jerardino and Yates 1996; Manhire 1987; Orton 2006).

Diepkloof Rock Shelter

Diepkloof is a large rock shelter perched high on a stone outcrop overlooking the Verlorenvlei (Plates 5.8 and 5.9). The site was first excavated in 1969, and is currently the subject of excavations by teams from the Universities of Cape Town and Bordeaux. In total, more than 30m^2 have so far been excavated. Original excavations demonstrated a sequence of late Holocene occupation directly overlying artefacts of Howiesons Poort and / or post-Howiesons Poort association (Parkington 1977; Volman 1981). More recent excavations have focused primarily on MSA materials.

The Diepkloof sequence is well stratified (Figure 5.8 and Plate 5.10), allowing excavation to proceed in stratigraphic units rather than spits. Towards the base of the excavation, stratigraphy becomes less well-resolved but is still discernable. As noted in Chapter 2, Rigaud *et al.* (2006) have previously divided the MSA sequence into post-Howiesons Poort, Howiesons Poort, Still Bay and earlier MSA components. The Howiesons Poort is subdivided into a younger grouping which includes decorated OES, and an older which does not. All but the earliest MSA component of the sequence have been dated by various means.

Parkington *et al.* (2006) report a single AMS determination of > 55 000 ^{14}C years BP on a piece of wood from a post-Howiesons Poort context. Subsequent OSL dating of the post-Howiesons Poort by Jacobs *et al.* (2008a) returned values of 47.7 ± 1.7 ka and 55.4 ± 2 ka.

Dating of the Howiesons Poort at DRS is complicated by wild variance in results from OSL on sediment and TL analysis on burnt rock. Jacobs *et al.* (2008a) return OSL values of 60.5 ± 1.9 ka and 61.8 ± 1.7 ka for the more recent Howiesons Poort component (with decorated OES), and four values between 58.1 ± 1.9 ka and 63.2 ± 2.2 ka for the older component (without decorated OES). Tribolo *et al.* (2008), meanwhile, return 10 TL determinations for the older component of between 60 ± 6 ka and 96 ± 1 ka (all ages summarised in Table

5.1). Both techniques provide an age for the layer denoted 'John'[16]. The single OSL age for the layer is 63.2 ± 2.2 ka; the three TL ages vary from 72 ± 7 ka to 96 ± 10 ka.

Similar variance is noted between ages for Still Bay contexts. Both techniques have been used to date the layer 'Kerry', with a single OSL value of 70.9 ± 2.3 ka, and TL values of 99 ± 10 ka and 118 ± 11 ka. Tribolo *et al.* (2008) present an oldest TL determination for the Still Bay component of the site of 129 ± 11 ka; Jacobs *et al.* (2008a) suggest that the Still Bay began some time around 73.6 ± 2.5 ka.

Two points seem to suggest that the OSL ages for the DRS sequence are the more accurate. First, the TL ages for different samples from a single layer vary considerably, suggesting that some facet of the samples other than their age is influencing the determination results. While Jacobs *et al.* (2008a) present only one OSL age per layer, these ages are derived from multiple measures with deviance factored into the age dispersion. Second, the OSL ages at DRS are consistent with those from other sites with similar technological features, while the TL ages are not. While we need to be wary of simply confirming our prejudice that similar technologies *should* occur at similar times, this consideration does provide a greater measure of confidence in the OSL ages. Overall, it seems most reasonable to proceed on the assumption that the OSL ages are the more accurate, without necessarily assuming that they are perfectly precise.

Elands Bay Cave

Elands Bay Cave (EBC) is the second Sandveld site analysed as part of this PhD. Situated on Baboon Point overlooking the Atlantic Coast, EBC was first excavated by Parkington in 1970. The site lies about 15 km north east of Diepkloof, and about 1.5 km from the point where the present Verlorenvlei River meets the ocean. With lower sea levels in OIS 5-2, the Verlorenvlei would, at this point, have been an active river channel.

Excavation of EBC revealed near-modern occupation underlain by a discontinuous sequence of Holocene, terminal Pleistocene and late Pleistocene deposits. More than 60 radiocarbon determinations have been made on material from EBC, on the basis of which

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[16] In recent excavations at DRS, a convention of named, rather than numbered layers has been used. Because of the fine, complex stratigraphy, some contexts occur only within small areas, while others occur across much of the site. Using successive numbers across the site is consequently impracticable.

four occupational hiatuses can be inferred. The first relates to the apparent abandonment of shelter sites between 3000 ^{14}C yr BP and 2000 ^{14}C yr BP noted earlier in this chapter. A second hiatus occurs in the mid Holocene (~5000 cal yr BP to ~8500 cal yr BP), and a third occurs from the peak of the LGM to the transition OIS 1 (~16 500 cal yr BP to ~21 000 cal yr BP). The final hiatus occurs between 24 500 cal yr BP and > 40 000 cal yr BP. Though three layers returned radiocarbon estimates pertaining to OIS 2 (ages ranging from 21 320 ± 420 cal yr BP (Pta-5308) to 24 429 ± 383 cal yr BP (Pta-5304)), all underlying ages were apparently infinite, suggesting an absence of occupation in late OIS 3. No dating techniques other than ^{14}C have as yet been employed on materials from EBC, and thus the pre-40 ka component of the site remains effectively undated. A single bifacial point from layer Gerrie indicates a possible Still Bay component, and overlying unifacial points are suggestive of a post-Howiesons Poort component, but there are no other potential time markers in the sequence. All Pleistocene ages for EBC are presented in Table 5.2.

5.6.2 Olifants River – water, stone, sites and assemblages

As noted earlier, the Olifants River has a well-defined and effective drainage system, which, coupled with the orographic effects of Cederberg Mountains to the east, results in permanent water flows in the river, and reliable water sources in some of its tributaries, including the Kliphuis River. Water in the area was probably readily available through much of the late Pleistocene, and variance in seasonality is likely to have been less significant here than on the Sandveld.

Flakeable rocks are also reasonably abundant in the Olifants catchment. During surveys around Klein Kliphuis, large, flakeable nodules of quartzite were regularly encountered (Plate 5.11), as were smaller (<8 cm) nodules of quartz, and cryptocrystalline and fine-grained silicate rocks eroding out of conglomerate beds (Plate 5.12). Outcrops of silcrete have been observed within 10 km (Plate 5.13) and 20 km (Plate 5.14) of the site, though surveys were not thorough and 10 km should be assumed to be a maximum distance. Interestingly, studies of the Olifants River gravels at points above and below the present dam did not reveal any rounded silcrete cobbles; only quartz, quartzite and sandstone of flakeably size were noted.

Excavated LSA assemblages from the area seem to bear out some of the differences between the availability of rocks in Olifants catchment and on the Sandveld. At both Renbaan (Kaplan 1987), and in the late Holocene layers at Klein Kliphuis (cf., Orton and Mackay 2008), quartz accounts for ~60-65% of artefact totals, with silcrete the next most common material (20-25%). CCS/FGS accounts for ~6% of assemblage totals at both sites, while quartzite is limited to ~2% - about the same amount as hornfels. Silcrete is thus four- to five times more common in these sites than in the Sandveld sites considered, and quartzite is four- to five times less common.

Klein Kliphuis

Klein Kliphuis (KKH) is a north east facing rock shelter site located on the Kliphuis River about 4 km from its confluence with the Olifants River (Plate 5.15). The shelter is formed in quartzitic sandstones, and is 18 m wide at its widest point, and 9 m deep from the drip line to the rear wall. The adjacent Kliphuis River is presently spring fed and contains water through much of the year, most notably in the relatively deep pond immediately below the site. The palaeoclimatic data discussed above suggest that water was available in the Kliphuis River through later OIS 4 and into early OIS 3.

KKH was first excavated in 1984 by a team from the South African Museum (now part of Iziko Museums of Cape Town). That excavation revealed a late Holocene component immediately overlying MSA-assigned materials (van Rijssen 1992). The pre-Holocene component of the site was removed in four coarse spits, varying in thickness from 105 mm to 250 mm. Subsequent analysis of this assemblages (cf., Mackay 2006) revealed a basal Howiesons Poort component, overlain by post-Howiesons Poort MSA and possibly final MSA artefacts in Wadley’s (2006) sense.

In 2006, a new 1 m x 1 m square was excavated at KKH as part of this PhD (Figure 5.9). The primary objective of the new excavation was to refine the known, but coarsely-resolved, sequence. Following van Rijssen (1992), the sequence was divided into four zones; A, B, C and D (Figure 5.10). The first three of these relate to the Holocene. The fourth, zone D, includes all of the Pleistocene material. Zone D was subdivided into seven stratigraphic units (Di – Dvii), which were in turn excavated in 25 mm spits (Di1, Di2, Di3 … etc). The sequence has been dated by both ^{14}C and OSL (see Jacobs *et al.* 2008a for discussion of methods used in the latter analysis).

Spit 5 in the uppermost unit in D, denoted Di5, returned a date of 18 663 ± 104 ^{14}C yr BP (Wk-20241), which calibrates to 22 315 ± 344 cal yr BP. Di5 was also dated by OSL, returning an age approximation of 33 ± 1 ka (KKH sample 8, or simply KKH8). However, the single grain analysis on which this age was based suggested the presence in the dated sample of two separate components – one dating to around 33 ka and the other to around 18 ka (Z. Jacobs, pers. comm. 2008; Jacobs *et al*. 2008a). It thus seems possible, if not probable, that the underlying unit, Dii, may date to around 30 ka. Unit Div, which underlies Dii by about 4 cm, returned an AMS determination of > 35 000 ^{14}C yr BP (Wk-20242).

Seven further OSL determinations were made, five in the new pit, and two in the existing section of van Rijssen's original excavation. Determinations at the interface of Dv and Dvi in the new pit, and at the interface of D1 and D2 in the old pit almost certainly date the same stratigraphic change. Both returned comparable age estimates of 56 ± 3 ka (KKH4) and 55 ± 2 ka (KKH3) respectively. Combined with the ^{14}C ages, and the OSL sample KKH8, these determinations provide age brackets of ~35 ka and ~55 ka for stratigraphic units Dii through Dv, thus relating them to OIS 3 occupation.

Three of the remaining determinations were made within Dvi, returning ages 58 ± 2 ka (KKH1, taken in Dvi3), 65 ± 3 ka (KKH5, taken in Dvi6) and 60 ± 3 ka (KKH6, taken in Dvi10). As noted previously, the last two ages are inverted. The final two determinations date the interface of Dvi and Dvii in the new square, and D2 and D3 in the old square. Again, these probably reflect the same stratigraphic change[17]. An adequate sample could not be taken from the precise point of transition in the new square due to the abundance of rock in the section, and in consequence the sample was taken slightly above the transition point. Nevertheless, the returned ages were again relatively similar; 64 ± 3 ka at Dvi13 in the new square, and 66 ± 3 ka in the old square.

These last two determinations represent the oldest dates for the sequence, but they are not basal, only near-basal. Some 100-150 mm of archaeological deposit lay between these ages and bedrock. Extrapolation from the linear age-depth curve provides estimates of between 65.6 ka and 68.1 ka for the base of the sequence. This is consistent with the absence of Still

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[17] As a sidenote, determinations for the D1 / D2 and D2 / D3 transitions provide bracketing ages of 55 ± 2 ka and 66 ± 3 ka for the engraved ochre discussed in Mackay and Welz (2008).

Bay finds in the original sequence, and it thus seems reasonable to suggest that units Dvi and Dvii represent occupation between ~65 ka and ~55 ka, and thus the latter part of OIS 4 and the transition to OIS 3. Table 5.3 provides a summary of the available Pleistocene ages at KKH.

5.6.3 Doring River – water, stone, sites and assemblages

As noted above, the Doring River catchment has well-defined and effective drainage systems, but its supply of water is adversely affected by the rainshadow effects of the Cederberg Mountains to the west. Presently, water flows seasonally in the area, with permanent sources restricted to springs and deeper ponds in the summer months. Water would have been more probably reliable in the late Pleistocene, but, unless there was a substantial westward extension of the summer rainfall zone, the area would probably always have been drier than Olifants catchment due to the Cederberg Mountains.

Stone resources are perhaps at their best and most abundant in the Doring catchment, particularly in areas containing Karooid rocks, rather than those of the TMS. Material types differ in notable ways from those in the Olifants and Sandveld zones. Most obviously, hornfels is relatively common in the area. Halkett (1987) observed hornfels, along with quartzite and shale, in the river gravels of the Putslaagte, located approximately 20 km north of Klipfonteinrand. In associated artefact scatters, hornfels was to found to be the dominant material accounting for ~60% of the cumulative total of artefacts from all sites. The next most common material was quartz (~20%), followed by quartzite and cryptocrystalline silicates (both <10%). Silcrete accounted for only 2.1%.

Further away from the Doring River, most notably in TMS-dominated areas to the west, the nature and prevalence of material sources become less clear. In Evans (1994) analysis of Hollow Rock Shelter, quartzite is dominant (~70%), followed by quartz (~10%). Silcrete (~8%) and hornfels (7%) account for comparably small fractions of the total, while the contribution of FGS/CCS is negligible.

Klipfonteinrand

Klipfonteinrand (KFR) is a rock shelter site, located in TMS immediately west of Karooid rocks. The shelter faces north, and is of moderate size, measuring ~12 m along the dripline and ~9.5 m from the dripline to the back (Volman 1981: 178). Unlike the previously mentioned sites, there is no substantial water source in the immediate vicinity of Klipfonteinrand, though water is known to pond in the adjacent ephemeral stream for several days following rain (Parkington pers comm. 2008). The largest nearby water sources are the Brandewyn, some 10 km to the west, and the Briedouw, some 10 km to the south. Both are highly seasonal. The Doring River itself lies approximately 15 km to the north east at its nearest point.

Klipfonteinrand was excavated by Parkington and Poggenpoel in 1969, and has not been subsequently re-excavated. In the 1969 excavation, archaeological materials were removed in nine 10 cm spits, oriented roughly parallel to the surface of the deposit (Figure 5.11). The upper four spits were found to contain Holocene materials, associated by Parkington with Wilton and more recent industries. Radiocarbon assays on material from Spit 1, and from a burial interred into Spits 2 and 3, returned age estimates of 6372 ± 58 cal yr BP (Pta-2475) and 3825 ± 83 cal yr BP (Pta-1642).

A hard black crust was encountered during excavation of Spit 5, although this was not used as a stratigraphic break. Below this break, artefacts of MSA affiliation were encountered. Volman (1981) ascribed the Spit 5 and 6 artefacts to the Howiesons Poort, and those from Spits 7-9 to MSA 2b. No post-Howiesons Poort MSA material is present, suggesting that the site was abandoned before the end of the Howiesons Poort. No dates are presently available from the MSA component of this site.

Hollow Rock Shelter

Hollow Rock Shelter (HRS), or Sevilla site 48, is a shelter formed under a large, free-standing block of quartzitic sandstone (Plate 5.16), located near the Brandewyn River approximately 10 km west of Kipfonteinrand. The Brandewyn is an ephemeral river which includes a number of ponds, with substantial flows largely restricted to periods following rains. The rock shelter was excavated in 1993 by Ursula Evans and a team from the University of Cape Town. Details of the finds recovered from this site have been discussed in Chapter 2, but salient information is précised here.

Hollow Rock Shelter was excavated in between four and six spits, varying with deposit depth. All spits were 50 mm thick and oriented with the slope of the deposit surface. Bifacial points were located in the upper four spits, with their numbers increasing towards the top. The upper two spits, at least, are clearly assigned to the Still Bay; both Watts (2002) and Wurz (2002) have suggested assigning the lowest spits to MSA 2b. The culture historic affiliation of the middle two spits is unclear. There is, however, no indication of a Howiesons Poort or later MSA component of the site, and it appears to have been abandoned during or immediately following the Still Bay. No dates are presently available for the sequence at HRS.

5.7 SUMMARY

Spatial and temporal variation in resources in the study area are summarised in Tables 5.4 and 5.5 and Figure 5.12. In Figure 5.12, black lines refer to occupational ranges inferred from chronometric ages. Solid grey lines refer to undated periods of sedimentation between two or more ages. Dotted grey lines and blank spaces are inferred from the presence of absence of certain industries dated elsewhere to the periods indicated.

Contrasts are relatively clear between the different zones in terms of the nature and abundance of materials for the manufacture of flaked stone artefacts. Flakeable stone is generally depauperate on the Sandveld, and dominant materials are quartzite and quartz. In the Olifants, materials are much more readily encountered, and though quartzite and quartz remain prevalent, silcrete seems to be more readily available. The Doring catchment is probably the richest area in terms of material sources, and is also the only area is which hornfels is known to be available. It should be noted, however, that the Doring and Olifants Rivers intersect 30 km north of Klein Kliphuis, and both empty into the Atlantic at Ebenezer on the Sandveld 60 km north of the Elands Bay Cave. Small cobbles of hornfels were located in the Doring / Olifants gravels at Ebenezer by the author in 2006. It is probable, therefore, that both the Sandveld and Olifants valley contain some hornfels, though only in areas to the north of the present study area. There is also an unresolved question of whether some hornfels-like black shale may occur in the Malmesbury formation to the south (Parkington, pers. comm. 2006).

All of the sites are expected to have had reasonably good access to water in OIS 4, particularly in the period from ~65 ka to ~62 ka. It seems plausible that even the small creek outside KFR held a good supply of water for at least for some of the year at this time. Any earlier or later changes in seasonality of moisture delivery is most likely to have affected occupation of the Doring and Sandveld zones – less so occupation of the Olifants.

Occupation of WRZ and YRZ sites outside the study area suggests that water was also available during OIS 5, though this may have been episodic. Water availability is also difficult to assess in OIS 3, though the KKH and other local/regional data imply conditions generally wetter than present. Good water availability also appears to have pertained through at least some parts of OIS 2, though dry conditions may have prevailed at the height of the LGM.

Assessing patterns of occupation in the study area is complicated by the lack of chronometric ages in most contexts. Only DRS and KKH have ages >40 ka, and these cover only parts of the sequences and are at times internally inconsistent. Partial age depth curves, as in the case of KKH, allow slightly better control over periods of occupation, yet even in this case, the ages of most contexts <55 ka are unclear. Nevertheless, correlations between assemblage composition in dated and undated contexts allows some very general statements to be made about occupation patterns.

Pre-OIS 4 occupation can be inferred for the Sandveld sites of DRS and EBC, and for the Doring site of KFR. All five sites, and thus all three zones, show some signs of occupation during OIS 4, though evidence is weak at EBC. Only DRS appears to have been occupied through both early and late parts of the stage, and even then, Jacobs *et al.* (2008a) have argued for an occupational hiatus. Howiesons Poort-assigned artefacts are present in three sites, one in each zone. Mid to late OIS 4 is thus the only period with evidence for broadly simultaneous occupation of the Sandveld, Olifants and Doring catchments.

From the end of OIS 4, occupation of the Doring site appears to have ceased. While DRS, KKH and possibly EBC were occupied in early OIS 3, only KKH exhibits any signs of occupation in the stable and cooling conditions which prevailed after 40 ka. Two sites, EBC and KKH, one in each of the Sandveld and Olifants zones, show clear signs of OIS 2 occupation. It should be noted, however, that at least one other Sandveld site, Faraoskop (cf., Manhire 1993), not analysed as part of this PhD, was also occupied in OIS 2.

Clearly, data at this resolution is insufficient to explore the relationship between variation in environment, settlement and technology. Improvements in sequence resolution will become possible once the results of fine-grained technological analysis, presented in Chapter 8, have been considered.

6

HYPOTHESES, NEW AND OLD

6.1 INTRODUCTION

Combined, the previous two chapters provide a basis from which to generate some predictions about how settlement, subsistence and technological systems might have changed in the study area from 120 ka to 20 ka. This chapter begins with an hypothesis based on theories of optimal foraging, technological organization and dual inheritance. Three further hypotheses are then presented, derived from previous explanations of settlement and / or technological change proposed by othe researchers working to explain changes in southern African. It should be noted at the outset that these alternative hypotheses were, in most cases, never specifically formulated as hypotheses, but were more often relatively prosaic, *post-hoc* explanations of variance in observed phenomena. Nevertheless, as they contain inferences or statements about causation, it is possible to reformulate them in a testable way. It should also be noted that though these models are discussed in relation to the generalised approaches which they most clearly represent (eg., Culture History, Cultural Evolutionism etc), the models as discussed are specific examples drawn from the southern African literature, and do not reflect an attempt to suggest what, for example, Culture History, in a generalised sense, would predict for the period under consideration. Finally, it is recognised that there is an obvious and inherent danger of presenting these alternative explanations as ‘straw men’. To that end, care has been taken not to overstate or misrepresent the expressed perspectives of other scholars.

6.2 HYPOTHESIS 1: DUAL INHERITANGE, OPTIMAL FORAGING AND TECHNOLOGICAL ORGANISATION

This hypothesis is based on the theoretical information presented in Chapter 4 and the environmental data presented in Chapter 5. The objective is to make predictive statements about how settlement and technological systems in the study area would have changed were theories about optimal foraging, technological organisation and dual inheritance correct. The hypothesis is presented in two parts. The first discusses theoretically optimum settlement, foraging and technological responses to environmental variance (summarised in Table 6.1). The second discusses the possible operation of transmission mechanisms.

6.2.1 Changes in settlement and technology

The central tenet of the theoretical discussion in Chapter 4 was that foraging behaviour and technological organisation are both strongly influenced by the configuration of resources in the subsistence environment. The primary drivers are seen to be changes in the abundance, predictability and patchiness of resources, and changes in the availability of water. Complicating the development of hypotheses in this respect is the poverty of the available palaeo-environmental data. The phytolith record from KKH is an important addition, insofar as it provides a local record of environmental change against which variance in foraging and technological organization can be explored. However, the KKH record is partial, and in some respects coarse, and thus does not fully resolve the issue of environmental data quality. Of greater concern is the reliance on proxies such as Antarctic temperature records to infer changes in southern African resource abundance and predictability. This is, at best, a long bow to draw. Furthermore, none of the available palaeo-environmental data allow the issue of inter-patch distances – and thus the sptial patchiness of resources – to be approached. That said, it remains that the issues of interest here are worth exploring, and to do so requires making use of such data as are available. The following hypotheses are generated with this in mind.

>100 ka

Of the periods considered, that occurring before 100 ka seems to offer some of the best environmental features for occupation of the study area. Temperatures at this time were relatively warm (Figure 6.1), with an associated insolation peak around 115 ka probably aiding primary productivity (Figure 5.12). Though temperatures cooled throughout the period, sub-millenial temperature variation was relatively low. Terrestrial records, such as that from Ysterfontein, suggest that water was, at least episodically, available in greater quantities than at present.

This combination of warm and occasionally moist conditions is unlikely to have encouraged much investment in mobility, or to have necessitated logistical organisation. Equally, however, the generally shallow, poor soils pertaining throughout most of the study area means it is unlikely ever to have been a Garden of Eden. Subsistence based on very low mobility thus seems unlikely. An optimal settlement system would probably have been one featuring low to moderate amounts of primarily residential mobility (Figure 6.2).

Generally warm, moist conditions and perhaps some diminished seasonal variance (based on the ~ 115 ka obliquity minimum) are also likely to have resulted in some ‘evening out’ of resources, particularly water, through the year. Consequently, the patch value of sites like Diepkloof, which at present is unusual in the Sandveld for having reliable water are likely to have been lessened. Low diet breadth would also be expected, while following Horn’s model, we might expect the relatively even spatial and temporal spread of resources through early OIS 5 to have favoured a greater dispersal of populations across the landscape.

The combination of low abundance-related risk and low predictability- or variance-related risk are also unlikely to have encouraged much investment in complex or high-cost technologies (Figure 6.3). Comparatively simple, low cost solutions would probably have been sufficient to ensure subsistence requirements were met in most cases.

100 ka – 80 ka

The period from around 100 ka through to 80 ka was considerably colder and more variable than that which had preceded it (Figures 6.1 and 5.6). Though water may have remained reasonably prevalent in the landscape, it is also possible that its availability was more seasonal, given increases in obliquity. Even allowing for the possibility that the insolation peak around 93 ka acted somewhat to offset declining productivity, subsistence in the study area was almost certainly less easy after 100 ka than it had been previously.

Increases in mobility are one probable outcome of these changes, though given that temperatures were as yet above glacial cold, neither very high mobility nor a significant component of logistical organisation were probably warranted (Figure 6.4). If there were increases in the patchiness of resources, either on a seasonal or longer time-scale, then the relative value of more reliable locations, such as DRS, would have increased, with extended occupation a possibility. Similar changes may have occurred in the Olifants, though no data area available to explore this possibility. A second effect of increasing climatic variability may have been to motivate a shift from more-dispersed to more-clustered population organisation.

Technologically, with higher risk we would expect greater investment in more complex systems. Accepting that variability was the key risk driver leads to the inference that maintainable technologies would have been a more effective solution than reliable technologies. Preferential selection of predictably-flaking materials seems likely, as does the production of more complex implements than those observed in earlier OIS 5 (Figure 6.5).

80 ka – 70 ka

The persistence of unstable conditions, coupled with further temperature decreases and an insolation low after 80 ka would have further increased the marginality of the landscape (Figures 2.4, 5.6 and 6.1). Whether groups responded by becoming more residentially mobile or moving to a system of logistical organisation is not easy to predict. Water appears to have been available at the start of the period, though availability may have been seasonal prior to the obliquity minimum centred on 70 ka. Given these points, it may be that initial changes featured greater residential mobility, with a move to logistical systems following improvements in water reliability (Figure 6.6). Equally, however, it should be remembered that the climate appears to have been at its most variable in the period immediately preceding 70 ka, with a sequence of five successive above-average 500-year temperature variance bins.

Diet breadth would be expected to increase with diminishing primary productivity, as would the duration of occupancy in preferred patches, though both may have decreased again with the coalescence of an obliquity minimum and an insolation peak centred on 70 ka. Similarly, clumping of populations at around 80 ka is likely to have given way to more dispersal towards 70 ka.

Technological systems in this period would probably have been required to cope both with abundance- and predictability-driven risk. As such, considerable investment would have been needed in the acquisition and transportation of large amounts of predictably-flaking material, and the manufacture of complex implements (Figure 6.7). Both reliability and maintainability would necessarily be elements of implement design.

70 ka – 65 ka

The key features of conditions in this grouping are the apparently rapid onset of glacially-cold conditions after 70 ka, and an associated improvement in sub-millenial temperature stability (Figures 5.6 and 6.1). The insolation maximum and obliquity minimum centred on 70 ka may have moderated the effects of temperature loss to some degree, though in absolute terms, temperatures appear to have been colder in this grouping than in any other part of OIS 4. Whether the onset of peak cold conditions led immediately to increases in moisture availability, or whether there was some degree of lagging is difficult to say. The both the northern WRZ marine core and the KKH phytolith records suggest generally wet conditions, though not as wet as those which followed.

The combination of low primary productivity and perhaps more reliable water seem well suited to logistical movement regimes (Figure 6.8). Evening out of water resources may have encouraged greater population dispersal and probably greater diet breadth. The significance of patches with usually reliable water (DRS and KKH) would have declined, with resulting decreases in occupancy.

If we accept that resource abundance was the primary risk driver in this period, then it follows that reliable systems would have been favoured over maintainable systems. Even allowing that the insolation peak centred on 70 ka may have partially offset the peak cold conditions reflected in the Epica Dome C core, with moisture levels probably below those in the subsequent grouping, it seems likely that the period was one of very high abundance related risk

Two technological responses to this seem plausible. The first involves very heavy investment in the procurement of predictably-flaking rocks, perhaps slightly offset by conservative reduction, and the manufacture of complex implements. As noted earlier, the design of technological systems is likely to have emphasised reliability over maintainability. The second possible response would be to move to a minimum-cost technology, effectively collapsing the 'tilda' curve. This would have resulted in an increase in the time available for subsistence tasks, albeit that those tasks may have been undertaken less efficiently. These two alternatives are both represented in Figure 6.9.

65 ka – 62 ka

Conditions after 65 ka are inferred to have remained very cold, albeit slightly warmer than in the preceding grouping, and generally stable (Figures 5.6 and 6.1). Water also appears to have been more readily available in this than in any other grouping examined. Relatively low obliquity coupled with low evapotranspiration may also have encouraged diminished seasonality of moisture availability. With this combination of low primary productivity and good moisture, this period seems to be as well if not better suited to logistical movement regimes (Figure 6.10) than that which preceded it. Population dispersal would have been at a hypothetical maximum, while, at the same time, with more water, reliance on patches like DRS and KKH would have further diminished. Diet breadth almost certainly remained high.

Technologically, abundance would have remained the primary risk-driver, and thus reliable systems would have continued to be favoured. Overall risk, though high, would have dropped from previously levels, assuming slightly warmer temperatures and greater availability of water (Figure 6.11).

62 ka – 60 ka

The period following 62 ka presents a different set of conditions to those which preceded it. Though continuing to be cold, 62 ka marks the initiation of the warming trend that led eventually to the end of OIS 4 (Figure 6.1). Moisture levels, however, apparently dropped off markedly some time around this point. Though the area continued to be wet, the capacity of moisture to offset temperature-driven losses in primary productivity would have been diminished. Thus, immediately post-62 ka occupation would probably have been considerably more difficult than pre-62 ka occupation, though with the subsequent amelioration of temperatures, conditions would no doubt have improved.

The magnitude of mobility seems almost certain to have increased at the beginning of this period, with the viability of logistical strategies coming into question given falls in moisture (Figure 6.12). While population dispersal may have continued, the duration of patch occupancy may have become more variable, with extended occupation of more reliable sources of water, and more diminished occupation of less reliable locations. Increases in diet breadth are also likely to have occurred.

As with the period from 70-65 ka, elevated levels of risk may have encouraged either greater investment in technological systems or minimal investment. With abundance-related risk remaining the primary driver, reliable systems are expected to have continued to dominate (Figure 6.13).

60 ka – 55 ka

The end of OIS 4 saw the onset of witnessed increasingly warm, and apparently moist conditions, with an expansion of grasslands indicated in the KKH record (Figure 6.1; Appendix A). Initially temperatures appear to have been relatively stable, with a shift to less stable temperatures through the period (Figure 5.7). This combination of features is likely to have encouraged a shift back towards more residential organization (Figure 6.14), with comparatively brief periods of patch occupancy, and a decrease in population clustering. Diet breadth would probably have contracted, with a renewed emphasis on larger fauna. The significance of patches such as DRS and KKH is likely to have declined.

Overall risk at this time would certainly have been lower than in the immediately preceding period. At the same time, temperatures were not warm in an absolute sense, only warm relative to preceding and subsequent conditions. Thus, subsistence risk levels would still have remained moderate at least. The important shift is likely to have been one from primarily-abundance to primarily-predictability driven risk – a shift that is likely to have become more pronounced through the period. The result is expected to have been moderate to high investment in technological systems, with an increasing emphasis on maintainability over reliability (Figure 6.15).

55 ka – 45 ka

Temperatures began to fall again after 55 ka, with high amplitude oscillations in both the medium and long-term (Figure 5.7 and 6.1). These are perhaps reflected in the vegetation component shifts noted at KKH for this period. Moisture levels, though, appear to have been generally good to moderate. This period also witnessed peaks in both insolation and obliquity.

The cool conditions probably encouraged high overall investment in mobility. Though logistical systems may have been favoured, their viability would have been responsive to moisture fluctuations (Figure 6.16). It is possible that the high amplitude of climatic shifts in this period resulted in the alternating use of different mobility systems through time. There may have been similar consequences for population clustering / dispersal. This aside, we would expect a general expansion of diet breadth when compared to the preceding period. Patch use is difficult to assess without a fuller understanding of moisture variance.

Both abundance and predictability-driven risk would have pertained from 55 ka – 45 ka. The effects may have been similar to those suggested for the period 80 ka – 70 ka, though the degree of abundance-driven risk was almost certainly more severe in the more recent period. Given this, we might expect either very heavy investment in systems that were at once reliable and maintainable, or a reversion to least-cost systems (Figure 6.17). A third possibility is that technologies alternated between these two solutions through the period.

45 ka – 30 ka

This period witnessed increasingly cold conditions, mid- to long term climatic stability, and decreases in both insolation and obliquity. Initially, temperatures were not much lower than in the preceding grouping, however, closer to 30 ka, temperatures began to approach glacial cold. If we accept previous suggestions that cold conditions and low obliquity are conducive to high levels of moisture in this part of the WRZ, then it follows that the study area would have become more moist towards 30 ka. Unfortunately no data are available to support this inference.

The changes witnessed in this period are likely to have encouraged increasing levels of mobility through the period, with a probable emphasis on logistical organization, assuming reasonable levels of moisture (Figure 6.18). Dispersal of populations may have occurred, along with further increases in diet breadth.

With regard to technology, abundance-risk appears to have been the primary driver, with relatively low variance and seasonality probably diminishing the importance of predictability-related risk. Given the similarities in temperature between this period and those between 70 and 60 ka, comparable levels of technological investment – either very high or least-cost – might reasonably be expected. The emphasis of systems is likely to have been on reliability, reflecting general temperature stability (Figure 6.19).

30 ka – 20 ka

Temperatures in this period were the coldest of any period considered (Figure 6.1). Some amelioration may have resulted from high levels of moisture, relatively stable temperatures, and an insolation peak towards the end of the period, but overall conditions were probably very difficult for subsistence. Populations would almost certainly have to have been highly mobile to ensure adequate dietary intake, and to have employed logistical systems where possible (Figure 6.20). Relative evening out of resources through low variance and low obliquity (similar conditions to mid OIS 4) may have resulted in population dispersal, while the very low temperatures almost certainly necessitated great breadth of diet, unless populations adopted a risk-prone strategy and focused primarily on high-return items.

As the coldest part of the last 120 ka, abundance-related risk was almost certainly at its greatest in this period, though there are no obvious indications of predictability problems. As such, either high cost systems or least-cost systems, are likely to have been employed (Figure 6.21). In the former case, the primary emphasis is likely to have been on reliability.

6.2.2 Processes of variation and transmission

For simplicity of modeling, this section makes the unreasonable assumptions that: (1) the study area was, behaviourally, a single, closed system from 120 ka to 20 ka, and, (2) all technological changes in this period arose as a result of direct bias acting on random and guided variation[18]. These assumptions provide a number of advantages. First, assuming that all changes were internally generated obviates the need to factor in the probably somewhat stochastic nature and timing of external influences on behaviours in the study area. It also provides a useful counterpoint to the culture historic hypothesis to be discussed subsequently, which assumes that new ideas invariably began 'somewhere else'. Additionally, assuming the operation only of direct bias improves the probability that change was adaptively beneficial, something which is consistent with the presumption of optimality which underpinned the above predictions.

Variation, random and guided

In Chapter 4 it was suggested that variation in human behavioural systems arises as a result of two processes. The first is random variation, in which actions such as mistakes in observation, misremembering, or providing misinformation result in largely uncontrolled alterations of the ways in which things are done. A second process, guided variation, is far more targeted, and is generally equated with "trial-and-error learning" or "rational calculation" (Boyd and Richerson 1985: 9). In guided variation, individuals intentionally alter existing ways of doing things with the objective of improving their degree of success. As the process involves alterations of existing systems rather than the invention of new systems altogether, changes are expected to be incremental and thus relatively slow.

While both random and guided variation are likely to operate continuously, it seems reasonable to assume that the frequency with which people deliberately trial new and potentially unsuccessful behaviours will be inversely proportional to the efficacy of current behaviours. When faced with new conditions, the probability that inherited solutions will be effective almost certainly decreases. Thus, as noted in Chapter 4, the importance of guided variation is expected to increase during periods of environmental change.

With regard to technological change in the study area, these points lead to two observations. First, we would not expect technologies in the study area ever to have been

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[18] Geneitc evidence makes it clear that thus assumption is not reasonable, particularly for the period around 40 ka, in which significant interaction between central and southern African populations appears to have occurred (cf., Behar et al 2009). However, modelling for the effects of such interactions on technological systems would be so complex as to be impracticable. The objective here is to provide a model the limitations of which can be assessed against the available data, and not to provide a depiction of the past that is necessarily accurate.

fundamentally stable. Variation, triggered either randomly or by a desire to find better ways of doing things, will have been ever-present. Second, technologies will have become more variable during environmental transitions. If guided variation was a primary factor driving technological change in the study area, then it is at such transitional points that we would expect to find evidence of its operation.

In the context of the environmental discussion in Chapter 5, and the divisions of the study period used earlier in this hypothesis, the following can be identified as points of interest for the operation of guided variation:

1. ~110 ka – 100 ka, following the end of the insolation maximum and obliquity minimum, and the establishment of cold and highly variable temperatures. It was suggested in the preceding section that prior to 100 ka, groups in the study area would have had little motivation to invest significantly in complex technological systems. Subsequent environmental contexts would have favoured more complex, maintainable technologies.
2. ~80 ka, after which temperatures begin to drop again, and insolation moves to a relative low. Subsistence in the area probably became even more difficult. This period would see the origins of technologies at once maintainable and reliable.
3. ~70 ka, after which temperatures dropped to glacial lows, but conditions became more stable and probably less seasonal. A reorientation towards predominantly reliable technological forms would have been favoured. It is alternatively possible that this period saw the abandonment of complex technologies in favour of more expedient, lower-cost solutions.
4. ~65 ka, with the potential onset of wetter conditions and minor amelioration of temperature. This period may either have encouraged either a decrease in technological investment (if the preceding systems were high-cost), or an increase (if preceding systems were least-cost). In the former case, systems will continue to favour reliability.
5. ~62 ka, at which time moisture levels dropped markedly and temperatures increased. Though a focus on reliability would have remained, technological systems must have changed, though overall investment may either have increased or decreased.

6. ~60 ka, around which time climates were warmer and wetter, but ultimately less stable. A move from reliable back to maintainable systems is predicted.
7. ~55 ka, with conditions remaining unstable but becoming cooler, technological systems would have required both reliable and maintainable design elements, perhaps not unlike those pertaining prior to 70 ka.
8. ~45 ka, stabilisation of climate in the mid- to long term and increasingly cold temperatures would have favoured a return to reliable technologies.
9. ~24 ka, peak cold conditions, which may have encouraged the abandonment of complex technologies.

Direct bias

Variation provides the grist without which evolution by selection cannot occur. Equally, however, for evolution to work effectively, some systems must be in place to ensure that adaptively beneficial traits are transmitted. For the purposes of this section, it is assumed that this process is direct bias.

Direct bias involves individuals testing a variety of available alternatives and preferentially replicating those which they find most beneficial. Because it involves testing of multiple options, the spread of traits as a result of direct bias is relatively slow, at least when compared to frequency dependent and indirect bias. At the same time, direct bias is likely to result in adaptively beneficial outcomes over the longer term.

The key aspect of direct bias is that it is not expected to result in sudden changes in the frequency of technologies. Human populations often display a marked reticence in taking up even advantageous technological systems if they are new (Hagerstrand 1967). We might thus expect direct bias to be expressed by incremental increases in the frequency of newly developed, successful technological systems. Equally, we would expect incremental decreases in the frequency of a technology when the contexts in which it is advantageous cease to hold. Because external sources of variation and other forms of transmission have been precluded in this hypothesis, the same factors which lead to frequency decreases in the dominant available system are likely also to lead to increases in the production of variation, as new solutions are sought. Combined, we might expect the process to look something like that depicted in Figure 6.22, where guided variation produces a successful new technology which increases in frequency, and then, as circumstances change, decreases to be replaced by increases in variability etc.

Complications

The obvious complication for identifying the operation of direct bias on random and guided variation involves the question of whether technological transitions will ever be archaeologically visible. People invariably discarded a fraction of what they made in contexts where they can be recovered in a temporally-controlled way, and there is no reason to believe that technologies developed during times of flux will leave a robust signature. This problem is only likely to be exaggerated in Pleistocene contexts where minimum effective time units are usually large, and short-duration processes difficult to observe. An associated issue is whether we would know how to identify transitional systems in relatively small archaeological assemblages, even were we to see them.

These are certainly important points to consider, but they should not detract from what we believe, on theoretical grounds, is likely to have happened. We have some basis for understanding how processes of change will operate, and also some basis for inferring when they are most likely to occur. While we have no reason to assume that periods of flux and technological adaptation must be archaeological invisible, we can ensure they will not be if we do not look for them.

6.3 HYPOTHESIS 2: PREDICTIONS FROM SOUTHERN AFRICAN CULTURE HISTORIC MODELS

A large number of past works concerned with stone artefact technologies in southern African have depicted assemblage change as largely the result of undirected processes, sometimes ambiguously referred to as ‘fashions’ (e.g., Clark 1999; Sampson 1974; Thackeray 1989, 1992**;** Volman 1981, 1984; Wurz 2002). The works in this oeuvre are typically culture historic, emphasizing unit formation as the objective of analysis, and presenting sequences as a succession of units, with little or no discussion of the processes by which one unit transforms into, or is replaced by, another.

Some culture historic works are site-specific, suggesting that sequences can reasonably be divided into units, and that those units are meaningful representations of changes in stylistic predilections (e.g., Kaplan 1990; Thackeray 1989). Other works are more generalized, concerning themselves with the identification of the same units in multiple sequences over a wide geographic area (e.g., Minichillo 2005; Sampson 1974; Volman 1981, 1984; Wurz 2002). Generalised models, in particular, are laden with a complex suite of assumptions which allow operational mechanisms to be inferred and hypotheses derived.

The most notable of the generalised works relevant to this study are Volman's (1981) PhD thesis and Sampson's (1974) synthetic volume. Despite considerable variance in approach and in the way in which units are organised, both Volman's and Sampson's schemes share a number of critical presumptions. Foremost, they share the belief that the same broadly defined units can be identified in multiple sites in a range of contexts across southern Africa. That this is considered to be possible necessarily implies that inter-site or inter-regional variation have relatively small determining effects on the form of artefact assemblages. Another common aspect of these works is that the appearance of new units is believed to occur broadly synchronously across the area under consideration. Consequently, a unit carries significance not only about technological form, but also about time.

In both Volman's and Sampson's models, style is seen to be a key determinant of the forms taken by technologies at any given time (cf., Volman 1981: 15; Sampson 1974: 7; note also Thackeray 1989: 53). The timing of stylistic change, is, to Volman at least, environmental mediated. Thus, he suggests that "in the southern Cape MSA … we are observing widespread changes in fashion in response to widespread environmental changes" Volman (1981: 266). In this conception, environmental change is a stimulant for technological change, while "fashion" is the determinant of assemblage form.

Given this formulation – where environment stimulates change and style determines the form change takes – there appear to be two possible explanations for why all assemblages in a given area should come to express the same general form at the same general time. The first of these is that similar assemblages occurred simultaneously across large areas as the result of multiple instances of independent invention which converged on the same outcome. Importantly, these bursts of invention cannot represent solutions to similar problems. If they do, then environmental change is almost certainly the determinant factor, rather than merely a stimulant for change. If environmental change is not the determinant factor, then this convergence is effectively stylistic coincidence on a massive scale. It seems unlikely that such an explanation would garner much support.

The alternative is that key changes initiated only in one, or perhaps simultaneously in a very few areas, and spread rapidly. If so, the mechanism generating change and shaping widespread assemblage similarity is diffusion. Given the frequent association between culture history and diffusion this seems to be the option that most proponents of culture historic models would favour. An associated point is that, in order to maintain similarity of technological expression over extended periods, groups spread across the breadth of southern Africa must have maintained regular contact. In the absence of a force operating to maintain similarity in such a way, it is almost certain that cultural drift would have resulted in spatial patterns of technological differentiation – something which southern African culture historic models do not appear to allow for (though note Mason 1957).

If new technologies are being introduced to the present study area through diffusion it follows that they will, necessarily, not appear as *in situ* developments. The primary consequence of this for the present study is that we would not expect sequences to exhibit significant technological variation prior to the appearance of a newly dominant technological form, nor trial-and-error testing of new forms at times of environmental flux. That is, the hypothesis based of direct bias acting on guided and random variation will be wrong.

Moreover, because technological systems are not seen to effloresce as a result of the benefits they convey in relation to a given environmental context, they must be at best adaptively neutral. Consequently, they may vary with or without attendant environmental change.

A final implication of the reliance on diffusion as a mechanism, though one which is not testable with data from the present study, and which may not be discernable with current techniques in any case, is that the appearance of a new technological system across southern Africa could not, in fact, be perfectly synchronous. The diffusion of innovations entails first appearance at a point (less likely, points) of origin, followed by progressive radial distribution (Hagerstrand 1967**;** Morrill 1970). The further from point-of-origin, the more delayed the appearance of the new trait should be. Moreover, there is no reason to presume that all areas will be equally receptive to new traits, and thus, considerable lags, or complete failures to take up the new system, may occur (Hagerstrand 1967). The take-up of an innovation is thus likely to be complex in time and space. Ironically, then, the appearance of similar and genuinely simultaneous changes occurring across southern Africa would, in fact, be inconsistent with necessary aspects of the culture historic hypothesis.

6.4 HYPOTHESIS 3: PREDICTIONS FROM SOUTHERN AFRICAN CULTURAL EVOLUTIONIST MODELS

Numerous works have suggested and continue to suggest that certain technological systems are inherently better than others, conveying benefits in terms of efficiency and efficacy regardless of the contexts of their deployment, and for no obvious increase in cost (e.g., Foley and Lahr 2003; Jacobs *et al.* 2008a; Klein 1995, 1999; Mellars 2006b). These works can broadly be described as 'culture evolutionary', though many are also strongly linked with the concept of behavioural 'modernity'. Many proponents of this approach are inclined to the idea that Upper Palaeolithic-like technologies were better than Middle Palaeolithic-like technologies, and helped to under-write the late Pleistocene expansion of *Homo sapiens* into the Levant, Europe and elsewhere.

To a great extent, this view is based on changes in the archaeological records of the Levant and Europe. As proponents of this view note, during earlier range expansions, *H. sapiens* groups armed with Middle Palaeolithic-like or Mode 3[19] technologies appear to have had no significant competitive advantages over Levantine and European Neanderthal populations (Foley and Lahr 2003). The apparent alternation of *H. sapiens* and *H. neanderthalensis* occupancy in the Levant under interglacial and glacial conditions prior to 50 ka implies that the relative advantages of either species were, up to this point,

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[19] Foley and Lahr (2003) phrase their argument in terms of the Clark's (1968) mode system, according to which the typical levallois-oriented technologies which define the MSA are classified as Mode 3; the blade oriented technologies of the early Upper Palaeolithic as Mode 4; and the microlithic technologies of the Mesolithic as Mode 5. According to Foley and Lahr (2003: 115), the technologies of the Howiesons Poort are classified as Mode 5, despite the presence in the Howiesons Poort of typical Mode 3 (levallois) elements. It is also worth noting that Foley and Lahr (2003: 121) themselves suggest that the transition from Mode 3 to Mode 4/5 technologies represents a "change through time, although not in any unidirectional way, toward greater technical competence or refinement". Though *unidirectionality* is precluded, directionality is not.

environmentally controlled (cf., Tchernov 1994). Some time after 50 ka, *H. sapiens* populations armed with Upper Palaeolithic-like, or Mode 4/5 technologies were able to expand across the world, becoming in the process at least complicit in the extirpation of *H. neanderthalensis*. That there was no attendant expansion of other African fauna only serves to suggest that something fundamental had changed. Proponents of directional models suggest that Mode 4/5 technologies provided a critical edge.

In southern Africa, proponents of a culture evolutionist understanding of technological change have pointed to the appearance of bifacial points and backed artefacts in the late Pleistocene as portents of the impending developments of the Upper Palaeolithic. Jacobs *et al.* (2008a), for example, have suggested that the appearance of these technologies was critical to allowing human populations to increase and expand in Africa prior to global colonization. Others, notably Mellars (2006a,b), have directly implicated these technologies in human global expansion, an argument based on apparent similarities between technological systems in southern Africa, the Levant and sub-continental Asia.

One problem for proponents of the culture evolutionist approach, as noted earlier, is to explain instances where these advantageous technologies disappear. In southern Africa, this is most notable when backed artefacts largely disappear at the end of the Howiesons Poort to be replaced by technologies apparently little different from those of the Middle Palaeolithic (Villa and Lenoir 2006; Villa *et al.* 2005). While some researchers have largely ignored such problems (e.g., Foley and Lahr 1997; Mellars 2006a), others have attempted to explain the disappearance of these technologies with reference to catastrophic population loss (Bar-Yosef 2002; Singer and Wymer 1982).

The implications of the culture evolutionary hypothesis for the present study are relatively clear. If technological systems featuring large numbers of backed artefacts and/or bifacial points are fundamentally advantageous, then we would only expect them only to be replaced by comparably ‘advanced’ systems – that is, by systems featuring different configurations of the same kinds of components. If these systems are at any point replaced by purportedly less ‘advanced’ systems – notably systems which resemble those of the Middle Palaeolithic – then we would expect this replacement to occur after an occupational hiatus. Over time, we would expect a trajectory towards increasing frequencies of Upper

Palaeolithic-like technologies to be characteristic of the technological change through the study period.

6.5 HYPOTHESIS 4: PREDICTIONS FROM THE SOUTHERN AFRICAN OCCUPATIONAL PULSE HYPOTHESIS

Several recent works have included the proposition that archaeological sequences in late Pleistocene southern Africa are the result of a series of discontinuous occupational pulses (cf., Jacobs *et al.* 2008a,b; Minichillo 2005). This idea is not strictly new (cf., Mitchell *et al.* 1998), but its application to the period under consideration has only been promoted in the last few years. Though not always directly concerned with technology, the occupational pulse hypothesis nevertheless has clear implications for the way(s) in which technological change should be expressed.

The tendency in the preponderance of studies in southern Africa has been to assume that archaeological sequences accumulated gradually and, to an extent, consistently over prolonged periods, with occasional interruptions resulting from episodes of abandonment. These has been particularly true of perceptions of deep sequence sites such as Klasies River, Nelson Bay Cave, and Border Cave. The implication is that such sites represent the full range of technological changes expressed over very long periods of time.

Recently, a number of researchers have suggested an alternative conception of sequence and assemblage formation, whereby late Pleistocene occupation across southern Africa is seen to occur as a series of ‘pulses’, with each pulse separated by a period of limited or no occupation (eg., Jacobs *et al.* 2008a,b; Minichillo 2005). Based on OSL dates from nine sites in a broad range of environmental contexts, Jacobs *et al.* (2008a) suggest that these pulses are broadly coincident across southern Africa, possibly cohering with temperature changes observed in Antarctic ice cores. With respect to the implication of synchronicity, the Jacobs *et al.* model differs from similar pulsing models proposed for terminal Pleistocene occupation of southern Africa (eg., Mitchell *et al.* 1998). Mitchell *et al.*’s (1998) suite of ^{14}C dates from three sites situated respectively in the Lesotho, the Caledon Valley and the Western Cape found complementarity of pulsing in the WRZ and SRZ sites.

The important aspect of pulsing models is in their implications for technological change. Jacobs *et al.* (2008a,b) identify each pulse with a different technological signature. Consequently, the periods between industries are inferred to cohere with periods of non-occupation. This approach is advanced as a partial solution to the issue, noted in chapter 2, of the relationship between the Still Bay and the Howiesons Poort. Jacobs *et al.* (2008a) suggest that both industries had relatively short durations (~2 kyr and ~5 kyr respectively) and that they were separated by up to 8 kyr. Relating industries to pulses in such a way overcomes the issue of how to deal with non-conforming units. If, as both Jacobs *et al.* (2008a,b) and Minichillo (2005) suggest, the temporal duration of units can be relatively short, and occupation of deep sequence sites is episodic, then it becomes possible to incorporate any number of non-conforming units (e.g., Minichillo's Die Kelders substage) without implying that technological expression may have been variable through space at any given point in time. As such, the Jacobs *et al.* / Minichillo models provide a powerful reconceptualisation of the occupational process in the late Pleistocene.

The important aspect of the pulsing model with respect to its test conditions concerns the inference that the appearance of any two technological systems will be separated by periods of non-occupation. While not specifying what happens to populations in between bursts, it is reasonable to assume either that they migrated to favourable locations (refugia, either inland or more likely along the coast), or that they simply died out locally. While Jacobs *et al.* (2008b) appear to favour the coastal refugia explanation, it is perhaps worth noting that, in the Holocene, abandonment of the interior does not seem to have resulted in population increase on the coast (Sealy 2006). This aside, if the intervals between pulses represent non-occupation, then each new pulse necessarily expresses repopulation, and thus an influx of either new groups, or the return of previous populations after several thousands of years living in other locations. To that extent, the pulsing model relies on migration (as opposed to diffusion). Moreover, as Jacobs *et al.* tie each pulse to a different technological signature, it is necessarily the case that each pulse is the archaeological expression of the arrival of immigrants with a new technological systems.

In this important regard, the pulsing hypothesis differs from the culture historic hypothesis. Specifically, the latter implies the diffusion of new technologies/techniques largely through populations already in place. As such, and as noted above, culture history logically requires a period in which the new technologies are adopted. In contrast, the pulsing model implies the movement of new population elements with new technologies into otherwise unoccupied or poorly occupied areas. Thus, technological change in the present study area would be expected to be expressed by the relatively sudden arrival of new technologies. Times between pulses should also be characterized by little or no discard of archaeological material.

Beyond these details, the pulsing model stimulates some other considerations. For example, if, as the model appears to imply, populations are restricted either to inland refugia or coastal margins (or both) during non-pulse periods, it would seem reasonable to suggest that these periods involved a degree of population fragmentation. Even if all populations were constrained to coastal margins at such times, it seems unlikely that non-pulse periods would be conducive to the maintenance of cultural norms across southern Africa. As such, we might expect these (non-pulse) periods to be an ideal context for the development of regional or local traditions, and for pulse periods to reflect the dispersal of such traditions. In contrast, however, Jacobs *et al.* (2008a) suggest that pulse periods such as the Still Bay, the Howiesons Poort and the early post-Howiesons Poort are marked by technological *similarities* across the region. Given this, the systems of variation and transmission involved are unclear.

7

APPROACHES TO HYPOTHESIS TESTING

7.1 INTRODUCTION

The objective of the chapter is to discuss methods that will allow the hypotheses presented above to be tested. The chapter is organized into four sections. The first introduces the data sets available for analysis. The second section, **Methods for sequence analysis**, considers the various indicators that have been ascribed roles in culture historic, culture evolutionary, and occupational pulsing schemes, and the ways in which these indicators are expected to vary according to each hypothesis. The third section, **Methods for technological analysis**, is concerned mainly with indicators of changes in technological organization. The final section of the chapter, **Methods for land use analysis**, considers the relationship between settlement and mobility patterns, and the composition of archaeological assemblages.

7.2 AVAILABLE DATA SETS

KKH and DRS provide the bulk of the data for this thesis, as these are the two best-dated and best-resolved of the sequences available. The DRS sample derives from a single 1 m x 1 m column, designated square ‘L6’, access to which was very generously granted by the sites’ present South African and French excavators. The data from this square are supplemented by the addition of a sample of retouched flakes, most specifically backed artefacts, from adjacent squares. Two 1 m x 1 m samples were analysed from KKH, though only one of these comes from the well-resolved 2006 excavation. Like the additional retouched flakes from DRS, the assemblage from the earlier, relatively coarse 1984 excavation, plays a largely supplementary role. The upper parts of the 2006 assemblage are partially compromised by a late Holocene pit, which affected the upper five stratigraphic units in half of the pit. Consequently, data from 1 m^2 are available for the lower two units, while data from only 0.5 m^2 are available for the upper five units.

At both KKH and DRS, all artefacts, including flakes (complete and broken, retouched and unretouched) and all cores were analysed. Unretouched flakes >15 mm were recorded in detail, while flakes <15 mm were, following inspection, simply classified by material, counted, and weighed in bulk. Given that only eight of the 481 complete retouched flakes at these sites were <15 mm, this seems a reasonable parameter for dividing flakes that may have been manufactured in order to be transformed into implements from those which were probably by-products of the flaking process. In total, ~68 500 artefacts were analysed from KKH, of which ~39 500 came from the well-resolved 2006 excavation. Approximately 10 000 of these artefacts were analysed in detail. At DRS, ~17 000 artefacts were analysed, with ~6500 analysed in detail.

The EBC sequence, though well-resolved, has only been dated by ^{14}C. Thus, the only temporally controlled contexts at the site which are of interest to this thesis are those dating between 25 000 and 16 000 cal yr BP. All retouched flakes and cores from these and the >40 ka contexts were recorded in detail. EBC thus provides a comparative sample to the OIS 2 assemblage from KKH.

The sequences from KFR and HRS are not particularly well-resolved, and are, in addition, undated. At KFR, all cores, retouched flakes and complete flakes were analysed from spits 6-9 inclusive, while only cores and retouched flakes were analysed from spit 5. The omission of flakes from spit 5 is due to some mixing of pre-Holocene and Holocene sediments during excavation of this layer. Analysis of cores and retouched flakes was undertaken with this potential mixing in mind. Due to time constraints, analysis of the HRS assemblage was limited to the bifacial and unifacial points, though additional data on material frequencies, taken from Evans (1994) sequence description, will also be used. In total, ~4500 artefacts were analysed from EBC, KFR and HRS

7.3 METHODS FOR SEQUENCE ANALYSIS

Assessing sequences of technological change is a basic exercise in stone artefact analysis. The variables considered in this section are those most directly relevant to the culture historic, culture evolutionary, and occupational pulsing hypotheses. They also have some relevance to arguments based on the transmission component of Dual Inheritance Theory. Changes in these variables will also be important to attempts to correlate the sequences in different sites (Chapter 8).

7.3.1 Implement types

Patterns in the spatial and temporal distribution of certain implement classes have long been the focus of attention in studies of southern African flaked stone artefact assemblages. Almost all early schemes for organizing southern African assemblages focused on specific implement types as the *fossiles directeur* of various industries. Some later schemes (eg., Volman 1981; Wurz 2002), and some of the more inventive early ones (eg., Mason 1957), have made use of other assemblage elements, but it remains that most of the industries in the period under consideration can be identified with respect to one or other form of implement. Thus, for example, the Still Bay is associated with bifacial points, the Howiesons Poort with backed artefacts, and the early post-Howiesons Poort with unifacial points and scrapers. Various other implements, such as notched flakes and denticulates (cf., Avery *et al*. 2008; Thackeray 1989; Volman 1981), have also been suggested to have meaningfully-patterned temporal distributions.

The sequential distribution of these different implement types has implications for the various hypotheses under consideration here. Following southern African applications of the culture history, as described in the previous chapter, each different implement type is expected to be most common at a different point in the sequence, such that their distributions through time will display little overlap. In terms of the culture evolutionary hypothesis, implements such as backed artefacts and bifacial points are expected to flourish following their initial introduction, and only to be abandoned as a result of occupational discontinuities. The occupational pulse hypothesis has similar correlates, though it anticipates that discontinuities will occur with every technological transition, resulting in a sequence of discrete technological phases. Finally, the hypothesis from technological organisation and Dual Inheritance Theory suggests that certain implements will flourish under the specific conditions which favour them, and decrease in frequency thereafter. The characteristics of implements likely to be under such selective pressure are discussed in the subsequent section. It is also implied, based on the principle of guided variation, that periods of transition may be marked by unusual technological items. To this end, it will be necessary to pay some attention to implements beyond those forms which are commonly recognised.

7.3.2 Materials

Like implements, changes in the prevalence of certain material types have been associated with certain industries. The most notable example is the increase in fine-grained rocks, most notably silcrete in the southern and western Cape regions, in association with the Howiesons Poort. As noted in Chapter 2, material changes are not always concomitant with the Howiesons Poort, and minor increases in silcrete are also associated with the Still Bay and parts of the Die Kelders sequence.

In the present study area, silcrete is common in the vicinity of one site (KKH), rare in the vicinity of two (DRS and EBC), and its distribution unknown in relation to the final two (KFR and HRS). These patterns of material distribution provide an interesting basis from which to explore the relationship between material change and other aspects of technological variability. Of most interest will be the relationship between the prevalence of silcrete and backed artefacts – both markers of the Howiesons Poort. Is it the case, for example, that both increase and decrease together, or is the relationship more complex? Some proponents of culture historic approaches (eg., Singer and Wymer 1982; Wurz 2000, 2002), suggest that the two are strongly linked, implying that they increase together as part of a technological package. Similar correlations are implied in the pulsing hypothesis.

Another idea which can also be addressed given patterns of resource distribution in the present study area is that of Ambrose (2002; Ambrose and Lorenz 1990), who suggests that the value, and consequently the prevalence of silcrete is inversely related to its local availability. That is, the value of the material increases as the distance at which it is available increases. Based on this suggestion, we would expect silcrete to be more prevalent during the Howiesons Poort at DRS, and possibly KFR, than it is at KKH. Patterns in material prevalence are also relevant to the hypothesis from technological organisation, as is discussed further below.

7.3.3 Blades

Blades have a long history of use in sequence analysis in southern Africa. Mason (1957) provides the most notable early example, using changes in the prevalence of long rectangular flakes to help relate different sequences in the Transvaal. More recently, blades have been used a markers of the Howiesons Poort. Both Wurz (1998) and Soriano *et al*. (2007) argue that blades were manufactured in order to provide blanks for backed artefacts during the Howiesons Poort. As such, their appearance and disappearance is strongly tied to the changes in the prevalence of this implement form. While alternative arguments have been posited for changes in blade frequency (eg., Mackay 2008a), this remains an avenue of inquiry important to the culture historic model. It also bears on the culture evolutionary model, insofar as the production of blades is often considered to mark an improvement in artefact manufacturing techniques (cf., Bar-Yosef and Kuhn 1999; Klein 1999; McBrearty and Brooks 2000).

Complicating the use of blades in this way are problems of interobserver variability. Experiments undertaken during an early part of this PhD (cf., Mackay 2006) suggest that the number of blades that will be identified within a given population of flakes can vary enormously between analysts. For this reason, the term ‘elongate flake’, which refers to any flake more than twice as long as it is wide, will be used in preference to the term blade during analysis.

7.3.3 Core types and flake platform types

One of the peripheral issues with which this thesis has been concerned involves the timing of the disappearance of prepared core technologies from southern Africa. In Chapter 2 it was argued that, in many cases, prepared cores appear to have persisted in the area until as late as 25 ka. In the winter rainfall zone, however, there are presently no good data relating this issue, primarily because of the noted paucity of OIS 3 occupancy. The dates for KKH, discussed in Chapter 5, however, suggest that there was some OIS 3 occupation of the site. EBC also has a period of occupancy dating to ~25 ka, and as such may also provide data relevant to this issue.

One of the limitations of relying on cores to approach the disappearance of prepared core systems is that they often comprise only a small fraction of assemblage totals. Furthermore, prepared cores themselves may comprise only a fraction of this fraction. Consequently, particularly where assemblages are small, identifying the ‘disappearance’ of a technique can become a fraught exercise. To that end, the through-time presence / absence of prepared platform types, which are strongly associated with prepared cores, may provide a supplementary line of evidence.

7.4 METHODS FOR TECHNOLOGICAL ANALYSIS

The variables considered here are primarily those relevant to the technological organisation hypothesis. As such, the section deals with the issues of time costs, transport costs, and the advantages of different technological systems.

7.4.1 Assessing time costs

Magnitude costs

It was argued in Chapter 4 that time costs are composed of multiple elements. The first of these involves the magnitude costs of acquiring material. Magnitude costs can be seen to vary depending on the general frequency of material in a landscape. In material-poor contexts, materials will be more costly to acquire than in a material-rich contexts. Costs can also vary within an environment, depending on the material that is being acquired. Thus, widely distributed materials can be acquired at lower costs than rare, or more sparsely distributed materials. All of these different combinations occur in the present study area.

In the Sandveld, for example, material is generally difficult to acquire, with quartz, quartzite and perhaps CCS/FGS being the most broadly distributed material types. In the Olifants catchment, most material types are likely to be regularly encountered, though quartz, quartzite and CCS/FGS remain more common than, for example, silcrete. At the same time, silcrete is more common in the Olifants zone than in the Sandveld, and might thus be acquired at lower costs. In the Doring catchment, materials again appear to be quite readily available, though the range of types is probably greater, and includes some otherwise rare types such as hornfels. At the same time, given that quartzitic sandstones are the parent rock for both shelter sites in this zone, it seems likely that quartzite and quartz would remain the most easily acquired material forms.

Based on these patterns, it can be suggested that minimum magnitude cost technologies in all zones would be most likely to result in assemblages dominated by quartz and quartzite. In the Sandveld and Olifants zones, higher cost technologies may feature materials such as silcrete, and even hornfels, with the relative costs of these two materials probably reversed in the Doring zone.

Frequency costs

The frequency with which material needs to be acquired can be altered by varying the kinds of materials selected, the systems by which they area reduced, and the point at which pieces are discarded. Fine-grained, homogeneous rocks such as silcrete, hornfels and fine-grained / crypto-crystalline silicates (FGS/CCS) often fracture predictably, and may be amenable to the production of relative thin flakes, allowing increased yield per unit material transported. In the Sandveld and Olifants zones, silcretes are rarely encountered, yet the cost of their procurement may be partially offset by the advantages they convey in terms of reduction. A similar point may be true of hornfels in the Doring zone. In all zones, however, FGS/CCS may regularly be encountered in weathering conglomerate rocks, and though these nodules appear often to be flawed, their preferential selection may indicate attempts to decrease procurement frequency without attendant increases in magnitude costs.

Frequency costs may also be reduced by more conservative reduction of acquired materials. Assessing the efficiency or conservativism of reduction is clearly a fraught issue. Several authors have suggested that elongate flakes may provide better reduction potential than non-elongate flakes (e.g., Mackay 2008a), a suggestion that others have contested (e.g., Eren *et al*. 2008). One measure recently suggested for assessing reduction conservativism involves examining the length of edge provided for a given amount of procured material (cf., Braun 2005; Mackay 2008b). Mackay (2008b) provides a means by which edge length can be estimated based on basic flake dimensions. These calculations were made for all complete flakes in the present study, allowing variance in the conversion of mass to edge length to be assessed. Beyond its relative use in the assessment of the conservativism of reduction, edge length to mass values may also help to clarify whether certain materials facilitate better yields per unit transported weight than others.

Heat treatment is another means by which it may be possible to diminish procurement frequency costs. Identifying heat treatment, however, is difficult, particularly when analysis is limited to macroscopic techniques. As Bowdery's (Appendix A) observation of crystobalites throughout the KKH attests, hot fires regularly occur in rock shelters, and any silicious rock exposed to sufficient heat will be physically altered whether that is the intention of the fire-maker or not. For the purposes of this analysis, the presence of heat-indicators such as luster, colour change, pot-lidding, crazing and crenation were recorded. During analysis of the KKH assemblage, two additional variables were also recorded. One of these concerned the presence of taphonomic heat indicators – those likely to have resulted from uncontrolled or post-discard heating of the artefact. The most common taphonomic indicator involved the presence of pot-lids on the ventral surface of flakes, though crazing and crenation were also assumed to be taphonomic.

The second additional variable recorded concerned evidence that the artefact had been heated then flaked. In most cases, an artefact was recorded as being 'heated then flaked' when heat was only present on more recent detachment surfaces. For example, some cores exhibited a dull exterior surface over most of their area, but one or more lustrous surfaces where flakes had most recently been detached. Similarly, some flakes exhibited dull or unheated dorsal and platform surfaces, and relatively lustruous ventral surfaces. These variables may allow assessment of whether and when heat treatment was used in the study area.

The final means by which frequency costs of procurement can be reduced – by lowering discard thresholds – has relatively clear implications for archaeological assemblages. One of these, an increased prevalence of bipolar reduction, was discussed in Chapter 4. Even within bipolar cores, and indeed, all core forms, there is scope for variance in the point at which a core is considered no longer worth reducing further. To that end, variance in core size at discard needs also to be considered. Several measures are also available to explore whether implements underwent more or less extensive reduction prior to discard (e.g., Clarkson 2002b; Eren *et al*. 2005: Kuhn 1990), however in most cases there were insufficient numbers of retouched artefacts in the available samples to assess such changes.

Manufacturing costs

Assessments of technological complexity are difficult to make without an understanding of all of the component parts of an implement in the form in which it was deployed. The ethnographic analysis undertaken by Oswalt (1976), on which subsequent works by Torrence (1983), Bousman (1993), Collard *et al*. (2005) and Read (2008) are based, included a level of detail in the description and assessment of implements not readily attainable in archaeological assemblages. With this in mind and given that only macroscopic analysis was undertaken, comparisons of manufacturing costs are kept relatively prosaic. The most useful question that can be asked is whether the tendency for people to make morphologically regular implements was variable through time. The regular production of implements almost certainly required greater manufacturing costs than reliance on unretouched flakes, or retouched but irregular flakes as tools.

Assessing transport costs

Varying transport costs can be reflected in three ways: in the weight of transported items, in the number and diversity of transported items, and in the ratio of utility to weight among transported items. Transported item weight can be reduced either by carrying a small number of larger items or a larger number of smaller items. It is necessary therefore to consider both the weight of transported items and the number of those items likely to have been in transport.

Where relatively few items are transported, those that are benefit from being either versatile or flexible. Evidence of the transformation of an implement from one form into another – recycling – may help explore this issue (cf., Hiscock 1996b). Versatility involves use of an implement in multiple tasks. As no usewear or residue analysis was undertaken for this thesis, that aspect of versatility will not be explored. One question that can be addressed is whether the bifaces manufactured during the study period may have been capable of producing flakes for use. This question seems particularly relevant to the observations of Henshilwood *et al.* (2001a) and Wadley (2007) that bifacial point-rich sites tend to be poor in cores.

A different aspect of transport costs concerns preprocessing. A pertinent concern is whether tool-making potential, specifically cores, was shaped prior to transport. The presence of absence of cortical flakes may provide one insight into this issue. If nodules were being transported to sites in an unprepared state and then subsequently reduced, which we might expect or occur during place provisioning (cf., Chapter 4), early signs of decortication may be present in flake assemblages away from material sources. Alternatively, if cores were being prepared prior to transport in order to maximize their utility to weight values we would not expect evidence of decortication.

It is important to note with respect to decortications of cores, however, that nodule size will affect the viability of removal of material and shaping of the core prior to transportation. Specifically, if nodules are very small to begin with, removing material may simply render the core useless (Dibble et al 2005). The vaiability of preprocessing thus needs to be understood in relation to other aspects of nodule selection

7.4.2 Assessing reliability and maintainability

Reliability

The reliability of any artefact system can be enhanced by increasing the number of replacement components available, and by ensuring that components are relatively standardized and thus interchangeable. As noted in Chapter 4, it is difficult if not impossible to know how many implements were deployed in the field at any given time. Thus, redundancy in this sense is not directly observable. What can be assessed is how many examples of a morphologically similar implement were manufactured at any given time. While identifying manufacturing frequency is complicated by variation in the rate at which implements are discarded, it seems reasonable nonetheless to suggest that when large numbers of implements are manufactured to serve as potential replacements, the rate at which they will be discarded will be higher than when only a small number of (presumably maintainable) implements are manufactured. Thus, increases in the redundancy of components are likely to result in increased rates of implement discard. This mirrors what Hiscock (2006) refers to as a strategy of *extension* over *abundance*. Assessments of variation in the discard rates of specific implement classes would seem to be the best way of identifying such strategic shifts archaeologically.

The second component of reliability – standardisation – also has relative clear archaeological implications. Standardisation may become particularly important when implements are used as interchangeable or replaceable haft components (cf., Weedman 2006). Standardisation can be achieved either be making regular blanks for implements, or by using retouch to standardise the size and morphology implements from irregular blanks. Assessing patterning in the shapes and sizes of blanks and implements is thus of interestto this aspect of reliability.

Maintainability

Numerous flaked stone implement types, including bifacial points, unifacial points, scrapers, denticulates and notches have been argued to be amenable to on-going maintenance (Bousman 2005; Andrefsky 2006; Clarkson 2002a,b; Dibble 1984, 1987, 1995; Hiscock and Clarkson 2007; Holdaway *et al*. 1996). Backed artefacts are, perhaps, an exception. A number of ways of improving maintainability, phrased with respect to improvements in reduction, were discussed in Chapter 4. These included the selection of material that fractures predictably, and the bifacial working of artefacts to allow abrupt terminations to be more easily overcome. A related issue involves maintenance of low edge angles. In general, flakes are more easily detached from lower edge angles than higher edge angles, with less chance of abrupt terminations (Cotterell and Kamminga 1987; Dibble and Whittaker 1981; Macgregor 2005), a problem that becomes particularly pronounced as angles approach 90°. Variance in implement edge angle, particularly when allied to predictably-flaking materials and reduction systems that allow the removal of abrupt terminations, might thus provide an insight into past emphasis on implement maintainability.

7.5 METHODS FOR LAND USE ANALYSIS

Land use patterns as discussed in Chapter 4 and 6 are composed of a number of inter-related factors, including frequency and distance of moves, form of movement organization (logistical vs. residential), time spent in patches, and the degree of clumping of populations within the landscape. Teasing the archaeological effects of these different factors apart will clearly be difficult. Several variables, however, seem likely to be of interest.

Rates of artefact discard may provide insights into intensity of patch use with implications for the frequency and/or duration of periods of occupancy. Under conditions of sustained or very regular use of a patch we would expect more artefacts to be discarded than when use is more ephemeral or less regular. Moderating the utility of discard rates is the potentially confounding effect of different systems of technological organisation. When, for example, artefact systems are strongly oriented around the maintenance of small numbers of transported items, even regular or sustained occupancy might be represented by a relatively small amount of flaking debris. Conversely, comparatively brief occupation, when it features considerable on site artefact manufacture, might result in large assemblages. Consequently, variability in discard rates needs to be assessed with systems of technological organization in mind.

Small flaking debris may help identify variance in on site artefact manufacture. The regular production of new artefacts at a site, and the attendant reduction of provisioned material that this requires, might be expected to result in greater production of small flaking debris than periods where relatively little manufacture occurred. For the purposes of this analysis, flakes <15 mm are cast in the role of small flaking debris. Variance in this measure seems particularly pertinent to the identification of logistically organized populations, who we might expect regularly to undertake gearing-up activities on site.

A final measure of interest is the presence of non-local materials in assemblages. Prevalence of non-local material can be seen to have implications both for range of habitual movements, and also for population dispersal. A number of archaeologists have, in the past, argued that as the range of habitual movements increases, so too will the prevalence of materials sourced from locations distant to the site (eg., Ambrose and Lorenz 1990). In the present study, the most pertinent material to this line of enquiry is hornfels, which is visually distinctive, has good knapping qualities, and has a highly constrained distribution. The material is known to be available in the Doring catchment, and, though it may be present in the gravels of the Olifants after the two rivers join, it is unlikely to be founds within 30 km of either KKH or DRS. Of interest, hornfels makes a regular if small contribution to Holocene stone artefact assemblages in both the Olifants and Sandveld zones, at a time when regular movements across the landscape have been argued for by some. In most cases, hornfels accounts for 2-5% of assemblage totals in these sites, providing something of a baseline for comparative assessment. Thus, where earlier movements were habitually wide-ranging, we might expect to see equal or greater prevalence of hornfels. Where movements were more constrained, we might expect to see less. Under conditions of maximum population dispersal, whereby all zones were occupied by discrete groups, we might expect to find little or no hornfels in the Olifants and Sandveld, with the possible expection of some material that may have arrived through exchange – in this case we might expect to see hornfels artefacts primarily in the form of implements, if observations made by Weissner (1977, 1983) for historic-period exchange systems hold for deeper time. It is perhaps worth noting that the implied territorial range for each group under this maximum dispersal scenario, ~700 km^2, is consistent with that maintained by a number of ethnographically observed groups, including Kalahari groups like the G/wi (cf., Kelly 1995).

8

VARIATION IN STONE ARTEFACT ASSEMBLAGES

8.1 INTRODUCTION

This chapter presents the results of stone artefact analysis in terms of the methods discussed in the preceding chapter. Definitions of the classes used and descriptions of the measures taken are presented in Appendix B. The chapter is divided into three sections, each of which deals with a different aspect of data analysis. The first section considers data relevant to questions of sequence analysis, while the second focuses on aspects of technological organization. The final section presents data relevant to variation in patterns of land use.

The presentation of sequences is not initially structured with reference to the time periods discussed in the hypotheses. This is because the necessary temporal resolution is not immediately available for sequences other than KKH, and, to an extent, DRS. Following the section on sequence analysis, however, sufficient data are available to allow an approximate synchronisation of sequences. Synchronisation is based on dates where available, but otherwise follows the premise that like technological changes probably occurred at similar times. Reference is made in this respect to changes not only within the five sequences analysed, but also by comparison with other known and dated sequences.

8.2 TECHNOLOGICAL SEQUENCE DATA

This section considers changes in a number of indicators, including implement types, the prevalence of different materials, elongate flakes, and the presence of prepared cores and faceted platform flakes. Data from the two best-resolved sequences (DRS and KKH) are discussed first, followed by those from KFR, EBC and HRS.

8.2.1 Diepkloof Rock Shelter (DRS)

DRS was excavated in a series of named layers which have been changed to sequential numbers here to facilitate data presentation. The relationship between names and numbers is provided in Table 8.1.

Changes in implement types

In the preceding chapter, patterns in the distribution of six implements types were identified as being of interest to the competing hypotheses: backed artefacts, bifacial points, unifacial points, scrapers, notched pieces and denticulates. Figure 8.1 presents histograms of the numbers of each implement type through the sequence at DRS.

Clear sequential patterns can be discerned in the distribution of some implement types. In the lowest layers, no type obviously dominates. From layer 37 through 30 a bifacial point-dominant succession of eight layers occurs, followed by a sequence of backed artefact-dominant layers (26–6), with a short sequence of unifacial point-dominant layers at the top. The backed artefacts in this succession of layers become notably more common above layer 19. Notched pieces are strongly clustered between layers 27 and 14. Scrapers and denticulates are distributed through the sequence without obvious pattern.

The data broadly conform to the divisions of the sequence as presented in Rigaud *et al.* (2006 – see discussion in Chapter 2), with unassigned MSA giving way to Still Bay (bifacial point-dominant), which is succeeded in turn by Howiesons Poort (backed artefact-dominant), and then post-Howiesons Poort (unifacial point-dominant) assemblages. Greater consideration of these data, however, reveals some more interesting patterns. The first concerns the appearance of a backed artefact in the lower parts of the sequence, replicating a pattern seen in other MSA sequences such as Klasies River (cf., Singer and Wymer 1982: 80). Of more perhaps more interest is the observation that the Still Bay component of the site is immediately preceded by the appearance of two unificial points. One of these is broken, the other complete. The complete specimen displays possible impact spalling and a line of discoloration and apparent ochre staining suggestive of hafting – Plates 8.1 and 8.2. Above layer 38, bifacial points incrementally increase in number to a peak of four in layer 34, before tailing off again.

Also worth noting in respect to this part of the sequence is the fact that backed artefacts are present in each of the three layers of the upper 'tail' of bifacial point distribution (layers 32, 31 and 30). Photos of all of the backed artefacts and bifacial points from these overlap layers for which images are available are presented in Plate 8.3. Tentatively included in the group of backed artefacts is one very unusual piece, with high angle retouch down both lateral margins, converging to a point (Plate 8.4). The point shows macroscopic signs of blunting and abrasion, possibly from use. The artefact is only a fragment, with the proximal end having broken off. Two small burin spalls appear to initiate from this break and extend down the lateral margins. The piece itself is small (31.4 mm maximum dimension), and though it had been longer, was almost certainly never very thick or wide. Most of the other backed artefacts in the overlap sequence are in truncated, or perhaps incomplete form. One is a classic 'segment' or 'crescent'.

Above layer 30, bifacial points disappear and the distribution of backed artefacts becomes somewhat episodic, until a marked cluster from layers 18 through 11. Only one of the overlying layers also contains backed artefacts, with unifacial points reappearing in layer 5.

Changes in material prevalence

The stacked bar graph, Figure 8.2, displays changes in the relative prevalence of the three dominant materials in the assemblage – quartz, quartzite and silcrete. Between them these materials account for >80% of the assemblage total. The sequence appears to be roughly divisible into six rough groups. The oldest group, from the basal layer up to layer 39, is dominated by quartzite, with quartz accounting for around one in five pieces. The contribution of silcrete in these layers is negligible. From layer 38, co-incident with the appearance of unifacial points, through to layer 30, at which point bifacial points disappear, the prevalence of silcrete increases. In the uppermost three of these layers, those which contain both bifacial points and backed artefacts, silcrete is the dominant material.

From layer 29 through 23, which contain small numbers of backed artefacts, the prevalence of silcrete drops away. With little or no change in quartzite, the shortfall is made up by increases in proportions of quartz[20]. From layer 22, silcrete again becomes dominant, and continues to be so through to layer 12. It is notable that these layers are also those richest in backed artefacts. A brief surge in quartz coincides with the fall-off in backed artefacts (layers 11 through 8), and is in turn followed by a renewed increase in silcrete immediately prior to the appearance of unifacial points. It might also be noted that though quartzite is dominant in all layers from the basal layer to layer 31, it is not dominant in any higher layer, except the very small sample (n=22) derived from the uppermost layer.

Changes in elongate flake prevalence

Figure 8.3 presents stacked bars for three elongation groups – group one includes flakes with length to maximum width values of less than 1 (e.g., flakes wider than they are long), group two includes flakes with values between 1 and 2, and group three includes flakes with values exceeding 2. Group 3 flakes are those considered elongate or blade-like. Figure 8.3 suggests that relatively wide flakes (those from group 1) were prevalent in the earliest part of the DRS sequence. Prior to layer 30, elongate (group 3) flakes never account for more than 10% of the total, while group 1 flakes regularly account for between 40% and 50% of the total. From layer 30 upwards, however, the percentage of elongate flakes more than doubles, being generally between 10% and 20%. Only in the last five layers do elongate flakes decrease in frequency again, though notably there is no return to the high proportions of group 1 flakes observed in earlier layers. The shortfall is made up by increases in group 2 flakes.

Changes in prepared core prevalence

Patterns in the occurrence of prepared cores are of interest in relation to the timing of the MSA / LSA transition. Figure 8.4 presents data on the relative prevalence of prepared cores through the DRS sequence. Because only a small number of cores occur in most layers, five groupings are used, based on patterns in the data presented above. Group five includes the layers 50-39, where implement forms are uncommon; group four includes the unifacial and bifacial point bearing layers from 38-30; group three includes the layers containing backed artefacts but poor in silcrete from 29-23; group two includes the more traditionally

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[20] Because stacked bar graphs are used, changes in material are proportional, and not absolute A necessary consequence of this form of graphical depiction is that a decrease in the proportion of one material will always be met by a rise in the proportions of one or both of the others.

Howiesons Poort-like layers from 22-6; and group one includes the unifacial point layers from 5-1.

As expected, given that the entire sequence is more than 50 ka, prepared cores occur throughout. There is, however, some interesting patterning. Prepared cores are at their most pronounced in groups 4 and 1 – those associated with point forms – accounting for 20-25% of all cores in these groups. In contrast, prepared cores are quite uncommon in the backed artefact-bearing layers, and particularly in the silcrete-poor backed artefact-bearing layers from 29-22, in which they account for less than 5% of the total.

8.2.2 Klein Kliphuis (KKH)

The KKH sequence consists of seven stratigraphic units, sub-divided into spits. Data are presented on a spit-by-spit basis, except where otherwise noted. To facilitate graphical depictions of the data, the roman numerals used to denoted units are displayed in as Arabic numerals in all figures, with spits denoted following the decimal place. Additionally, because the only data presented are those from Zone D, the zone denomination has been dropped. In consequence, spit five in unit six of zone D, referred to as Dvi5, is presented in the figures simply as 6.05. Spit 11 from this unit is presented as 6.11.

As discussed in Chapter 7, only a 0.5 m^2 sample is available from the upper five stratigraphic units, the other 0.5 m^2 having been compromised by a the presence of a late Holocene pit.

Changes in implement types

Figure 8.5 presents histograms of implement types through the KKH sequence. No bifacial points are present in the assemblage, and thus only five of the implement types of interest are presented. In addition, however a type referred to here as ‘shoulderless points’, to be discussed in more detail below, is also included.

Backed artefacts are the dominant form in the early layers of the sequence, though they exhibit a pronounced bimodal distribution. Notches are also most common in the earlier layers of the site, though their numbers tend to peak with the first peak in backed artefacts.

Some covariation in the distribution of notched pieces and scrapers can be inferred. More marked is the covariation of backed artefacts and unifacial points. Backed artefacts are common in layer Dvii1 through Dvi8, before tailing away in Dvi6 and Dvi7. Unifacial points first appear in Dvi7, overlapping with backed artefacts for two layers, and persist through to at least unit Dv. Denticulates are generally uncommon at KKH, though their presence is most pronounced immediately following the appearance of unifacial points. Below unit Dv, implements are generally uncommon.

The artefacts classified as ‘shoulderless points’, some examples of which are shown in Plate 8.5, all occur in Dvi7 and Dvi6. These are also the two layers in which backed artefacts and unifacial points overlap. In total, six examples of this implement type were recovered. Their defining attributes are the presence of short, high angle, backing-like retouch scars extending for 10-20 mm down both lateral margins from the ‘shoulder’ formed by the junction of the platform and the margin. The backing-like nature of this scarring can be explored using a scatterplot. In Figure 8.6 retouched edge angle is plotted against retouch scar length for backed artefacts, scrapers, unifacial points and bifacial points, using all late Pleistocene examples examined from the study area[21]. For the purposes of analysis, retouched pieces were divided into eight sectors (see definition of *Sectors* in Appendix B), with an indicative edge angle and longest scar length taken in each sector where retouch had occurred. The results provide 550 data points for backed artefacts, 81 for scrapers, 159 for unifacial points and 241 for bifacial points.

In Figure 8.7, the scatter points are reduced to crosshairs, where the extent of the long lines indicates mean + two standard deviations for edge angle and scar length. Short cross-lines are also placed at mean + one standard deviation. The 23 data points from the shoulderless points are plotted as black circles. Most of the data fall within the range of values for backed artefacts, and beyond the range of values for other types. The two exceptions derive from a single specimen on which the pointedness of the distal end has been exaggerated by retouched. These scars fall within the range of unifacial points and scrapers.

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[21] This includes artefacts from DRS, EBC, HRS, KFR and KKH.

Figure 8.8 presents boxplots[22] of weight, maximum dimensions, maximum widths and maximum thickness for the different implement types. The figure suggests that, by most measures, the shoulderless points are larger than backed artefacts, and tend to fall either within the size range of unifacial points, or between the ranges of unifacial points and backed artefacts. The data may be taken to imply that the 'shoulderless points' feature a blend of the retouch tendencies of backed artefacts and the blank size and general morphology of unifacial points.

Changes in material prevalence

In Figure 8.9, the three main material groups, silcrete, quartzite and quartz, are represented by black, dark grey and white bars respectively. The figure demonstrates strong diachronic patterning. Notable is the dominance of silcrete in the spits below Dvi4; silcrete accounts for more than 80% of the artefact total in many of these spits. There is, however, a bimodality in silcrete dominance, with modes from Dvii4 through Dvi12, and from Dvi10 through Dvi6. These are separated by a trough at Dvi11, where the prevalence of quartz increases briefly and dramatically.

Also worthy of remark is the tendency for changes in material prevalence to be gradual. This is most obvious with changes in silcrete, but can also be observed in quartzite and quartz. The changes from Dvi7 to Dvi2 exemplify this, with incremental decreases in silcrete being met by simultaneous incremental increases in quartzite and quartz. This is also the sequence of spits in which backed artefacts give way to unifacial points. From Dvi2 to Dv1, the prevalence of quartz increases. By Div3, quartz is the dominant material, and, with the exception of a couple of layers in Di, remains so throughout the sequence.

The dominance of silcrete in the lower layers at KKH can be seen to be at odds with Ambrose's (2000) suggestion of an inverse correlation between the availability of silcrete and its desirability. Silcrete is less common around DRS than it is around KKH. Thus, we might expect, in those periods where silcrete is favoured, that it would be more sought-after at DRS. This is not the case. Silcrete rarely accounts for more than 70% of assemblage totals at DRS; at KKH, silcrete only accounts for less than 70% in five of the 15 layers in which it is the most common material.

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[22] All boxplots presented in this thesis display median (black line), inter-quartile range (grey box) and minimum and maximum values (whiskers). Outlying and extreme values have been excluded in all cases.

Changes in elongate flake prevalence

Figure 8.10 presents changes in the proportions of flake elongation groups through the KKH sequence. Relatively high proportions of elongate flakes occur in the earliest layers of the sequence, with a gradual decline initiating immediately thereafter. From Dvii4 through Dvi10, elongate flakes generally account for 20% or more of the total flake population. Below Dvi10, most values are between 20% and 10%, with the lowest point reached in Dvi2 where no elongate flakes were recorded. From Dv2 through Div1 a second peak in elongate flakes is observed, with values as high or higher than those observed in the lowest layers of the sequence.

Unlike DRS, the degree of correspondence between elongate flakes and silcrete prevalence is at least as marked as that between elongate flakes and backed artefacts. Certainly, the backed artefact-bearing layers from Dvii4 through Dvi6 all have relatively high proportions of silcrete, however, elongate flake production does not cease, nor decline dramatically with the cessation of backed artefact production, or the appearance of unifacial points. The decline in elongate flakes is, as with silcrete, comparatively gradual.

Changes in prepared core and faceted platform flake prevalence

The KKH sequence covers the period from ~68 ka through to ~20 ka, at least episodically. As such, the sequence is of interest in relation to the timing of the disappearance of prepared cores. Figure 8.11 presents changes in prepared core prevalence. As with DRS, the layers at KKH are grouped to improve sample size. Each stratigraphic unit is treated as a single group, with the exception of Dvi, which is subdivided into upper (Dvi1-6) and lower (Dvi7-15) portions. The upper division includes the unifacial point-bearing layers, and the lower division includes layers with backed artefacts.

Figure 8.11 suggests that prepared cores were only recovered from the lower three units of the sequence. The lower part of unit Dvi has the highest overall prevalence of prepared cores (~30%), however, through-time patterning is generally less marked than at DRS. Unit Div is associated with an AMS date of > 35 000 ^{14}C years BP, while Dii has an OSL date of 33 ± 1 ka and AMS date of > 35 000 ^{14}C years BP. The graph thus suggests that prepared cores were abandoned before 35 ka – consistent with the dates for inland SRZ sites, but at odds with the cessation point for the MSA suggested in Figure 2.9. To explore this issue further, patterns in the prevalence of faceted platform flakes are also considered.

Figure 8.12 presents flakes with faceted platforms as a percentage of all platform types through the KKH sequence. The same groupings are used as were in Figure 8.11. Figure 8.12 documents the presence of faceted platform flakes through to layer Dii3, inferring that prepared cores probably disappeared from technological systems at KKH some time between ~22 ka and ~35 ka. This age range is consistent with that for YRZ and most SRZ sites.

8.2.3 Klipfonteinrand (KFR)

Data from KFR derive from five spits, numbered 5-9 from youngest to oldest. The overlying four spits are of Holocene age. Implement and core data are available for all five spits, however, for reasons discussed in the previous chapter, material data are only available for spits 6-9.

Changes in implement types

Like KKH, KFR lacks bifacial points, and thus data for only five implement types are presented. The implements derive from all five spits examined – spit numbers 5-9. Two implements, a backed artefact and a unifacial point, were recovered from bags provenienced as ‘spit 5/6’ and ‘spit 7/9’ respectively. They are not included in this analysis.

Figure 8.13 presents the distribution of implement types through the KFR sequence. No implements were recovered from the oldest unit, spit 9. Because the sequence is quite coarsely resolved, the kinds of fine-grained through time patterns observed at DRS and KKH are somewhat obscured. A number of interesting points can be made on the basis of the KFR sequence nonetheless.

Most notable is the presence of unifacial points underlying, and to an extent overlapping with backed artefacts. This reverses the pattern observed at DRS and KKH, whereby unifacial point-bearing layers overlie backed artefact-bearing layers. The fact that this overlap occurs through two layers is also noteworthy, implying as it does that it is not merely the result of a single coarse excavation unit. The overlap also complicates comparison with the sequence at DRS, where unifacial points underlie backed artefacts, but where the presence of the two is separated by five bifacial point bearing layers. As noted, there are no bifacial points at KFR.

Patterns in the presence of denticulate and notched pieces are also of interest. Denticulates are most common in the second lowest layer, spit 8, declining in prevalence thereafter, though remaining present in small numbers through to spit 5. Notched pieces, on the other hand, display two different peaks, one of which coincides with the peak in unifacial points, and the other coinciding with the peak in backed artefacts. At KKH, notched pieces were strongly associated with the older of two peaks in backed artefact numbers; much less so with the more recent peak.

Changes in material prevalence

Figure 8.14 presents data on changes in material prevalence through the KFR sequence. Data from the very small samples in spits 6/7 and 7/9 have been omitted, as has the sample from spit 5, from which only retouched flakes and cores were analysed. The materials presented here differ from those presented for DRS and KKH. The reasoning is that silcrete, quartz and quartzite do not account for as large a proportion of artefacts at KFR as they do at these two other sites. Quartz in particular is very uncommon, accounting for less than 2.5% of the analysed artefact total. By way of comparison, quartzite accounts for 45.5%, silcrete for 17.3%, hornfels for 11.9% and CCS/FGS for 10.7%. Only patterns in the occurrence of these last four materials are considered.

There are some through-time patterns in the data that are worthy of remark. Quartzite, for example, though accounting for more than 40% of artefacts in the three lowest spits, falls to about a quarter of the total (25.8%) in spit 6. CCS/FGS and hornfels, on the other hand, are at their most common in spit 6, accounting for 18.9% and 14.5% (respectively) of the total in this spit. Silcrete is, similarly, relatively common in spit 6 (22.6%), though its greatest percentage prevalence occurs in spit 8 (23.6%).

There is only a limited degree of correspondence between changes in implements and materials. The most notable of these is the fact that the layer with the most backed artefacts, spit 6, also has the highest proportion of fine-grained rocks. Notably, however, this layer is not silcrete-rich, as the backed artefact dominant layers at DRS and KKH are. Moreover, data from Volman's (1981: 180) previous analysis of spit 5 at KFR suggests that silcrete was even less common in that layer, accounting for less than 10% of the artefacts he examined. Overall, however, fine-grained rocks are suggested to account for ~60% of the artefact total in spit 5 – comparable to the value in spit 6. The correspondence between backed artefacts and fine-grained rocks appears considerably strongly, therefore, than the correspondence between backed artefacts and silcrete, or between backed artefacts and non-local rocks.

Changes in elongate flake prevalence

Figure 8.15 displays changes in flake elongation at KFR. Again, data from spit 5 are not presented. As at DRS, elongate flakes notably are depauperate in the earliest layer at KFR, though they increase dramatically in spit 8 and remain between 10-20% thereafter. Overall, the degree of correspondence between elongate flakes and backed artefacts is relatively weak, as it was at KKH. Peak values occur in spit 7, which contained fewer backed artefacts than unifacial points. In spit 6, where backed artefacts are the dominant form, elongate flakes are less common than in either of the two preceding layers.

Changes in prepared core prevalence

Though the sequence is undated, and almost certain to exceed 50 ka in the youngest layers, trends in prepared core prevalence at KFR are worth considering for comparison with the sequences at DRS and KKH. From Figure 8.16 it can be discerned that prepared cores are generally common at KFR – considerably more common than they are at the other two sites considered so far. More than half of all cores in spits 7-9 were either radial or levallois. Minimum values, which occur in both spits 5 and 6, remain around 50%. There is, however, some notable through-time patterning. Specifically, prepared cores incrementally decrease in prevalence from peak values in spit 9, through to minimum values in spit 6.

There are some similarities between the sequences at KFR and DRS, at least in so far as minimum prepared core prevalence occurs in the layers that contain the largest numbers of backed artefacts. It might also be noted that these layers are preceded by those in which prepared cores are at their most common. However, it is equally notable that the earliest layers at DRS contain comparatively few prepared cores, while this form dominates in the early layers at KFR.

8.2.4 Elands Bay Cave (EBC)

The only classes of artefact to be analysed in detail at EBC were retouched flakes and cores. Additionally, the dated component of the site covers only the last 40 ka. The primary interest in this sequence concerns changes in material prevalence, and the persistence of prepared cores. To that end, data are presented in age groups: ~16 ka, ~24 ka, and > 40 ka.

Changes in material prevalence

As at DRS and KKH, silcrete, quartz, and quartzite are the dominant materials in the analysed samples from EBC. Complicating the value of these data, however, is the fact that they derive from retouched flakes and cores, rather than from all assemblage elements. Given the noted tendency for certain materials to be preferentially retouched (cf., Orton 2008), this sample is likely to be biased in certain respects. The issue is returned to momentarily.

Figure 8.17 presents data on material changes in the three units at EBC. As with DRS and KKH, only the dominant materials silcrete, quartzite and quartz are represented. The most obvious change in the sequence is the strong surge in quartz in the OIS 2 units at the expense of quartzite, which is dominant in the > 40 ka unit. Silcrete varies from 2-10%, with greatest values observed in the youngest unit (~16 ka).

As noted, the material data from EBC are compromised by restriction of analysis to retouched flakes and cores. This is likely to lead to an over-estimation of the amount of fine-grained and predictably flaking materials involved. At the nearby site of DRS, for example, quartzite tends to be dramatically under-selected in the production of cores and retouched flakes relative to its overall prevalence (Table 8.2). Silcrete, on the other hand, is heavily over-selected. Quartz tends to be slightly under-selected for retouched flakes, but strongly over-selected for cores. The picture is quite different at KKH, though this almost certainly reflects differences in local material availability (Table 8.3). Given that they derive from the same environmental zone, the DRS data are probably the more pertinent to the situation at EBC.

In Table 8.4**,** the DRS data are used to provide suggested 'corrected' material percentages for EBC artefacts, given similar rates of selection. The results suggest that the dominance of quartz in the younger layers of the EBC sample is probably a reasonably accurate reflection of its overall prevalence, though quartzite is under-represented, and silcrete, based on the corrected figures, was probably almost completely absent from the assemblage at large.

Changes in prepared core prevalence

Figure 8.18 presence stacked bars for prepared and non-prepared core forms in the three age brackets. As might be expected, prepared cores are relatively common in the >40 ka grouping, accounting for 23.3% of all complete cores. Of greater interest is the persistence of prepared cores in very small frequencies as late as 16 ka. In both the ~24 ka and ~16 ka groups, prepared cores occur at around 3% of the core total. It might be noted that the identifications made during this analysis are consistent with those made by previous analysts of the assemblages, J. Parkington and R. Yates.

8.2.5 Hollow Rock Shelter (HRS)

The HRS sequence was not analysed in detail for this PhD. The data presented here derive from Evans (1994), and focus on patterns in implements, silcrete and prepared cores. Insufficient information is available to consider proportions of elongate flakes. Data from the four spits, IIB, IIA, IB and IA (from oldest to youngest) are considered.

Changes in implement types

Figure 8.19 presents changes in the six main implement categories through the HRS sequence. Bifacial points occur in all layers, though there is clear patterning in their distribution with incremental increases from one point in layer IIB to 25 in layer IA. Only in the uppermost two layers (IA and IB) are bifacial points the dominant form. This patterning contrasts with that in backed artefacts, which are represented by two specimens in the lowest layer, and then one in the two overlying layers. No backed artefacts occur in

IA. Notched artefacts display a similar trend, decreasing from four in layer IIB to one in layer IA. The distribution of scrapers and denticulates is less clearly patterned, while a single unifacial point occurs in the uppermost layer.

There are interesting contrasts between the pattern observed at HRS at that at DRS. This is most clear in the distributions of bifacial points, unifacial points and backed artefacts. At DRS, the appearance of bifacial points is immediately preceded by a layer containing unifacial points, while the last three bifacial point-bearing layers contain backed artefacts. This pattern is reversed at HRS, where backed artefacts, albeit in small numbers, precede bifacial points, and unifacial points occur only towards the end of the sequence. It should be noted, however, that the available samples for both sites are relatively small, and that these patterns remain to be substantiated by larger samples of implements and other sequence data from DRS in particular.

Changes in material prevalence

Unlike KFR, silcrete, quartz and quartzite are the dominant materials used in artefact manufacture at HRS, based on data from Evans (1994). Figure 8.20 presents changes in the prevalence of these materials. A relatively clear trend towards greater proportions of silcrete occurs through the spits, from oldest to youngest. Silcrete values are generally comparable to, if slightly less than those observed in layers where bifacial points dominate at DRS, ranging from 10-20%. Quartz is relatively stable throughout the sequence, while the proportion of quartzite tends to respond inversely to changes in silcrete.

Changes in prepared core prevalence

Changes in the relative prevalence of prepared cores are presented in Figure 8.21. As at KFR, prepared cores are found to be quite common at HRS, particularly in the earliest layer where they account for almost half the core total. In the remaining layers, prepared cores contribute around 35% - somewhat higher than the value observed in the bifacial point-bearing layers at DRS.

8.2.6 Brief summary and sequence synchronization

The objective of the preceding section was to present data relevant to claims made about sequences of technological change in southern Africa, and, by implication, in the study area. An interpretation of this information in relation to specific hypotheses will occur in the subsequent chapter (Chapter 9). The data presented thus far are sufficient, however, to allow an attempt to be made to synchronise the various sequences into coarsely-resolved temporal blocks that will, in Chapter 9, allow the hypotheses from technological organization to be assessed.

Synchronisation of blocks is done initially by matching-up of technological changes. There is a danger in this approach, as discussed previously, of generating the appearance of similarity though assumpting similarity in the first place. This problem is acknowledged, though it is noted that significant sequential variation within the relatively small spatial scale at which the evidence is being considered would be surprising. More importantly, some chronometric data are available to provide an independent check in the validity of this assumption.

DRS, KKH and KFR all have contiguous sets of layers in which backed artefacts are the dominant implement form. At DRS, backed artefacts occur in what might be thought of as four different parts of the sequence. First, a single specimen occurs in the lowest layers, preceding the appearance of bifacial points. Subsequently, backed artefacts have a concerted presence in the last three bifacial point-bearing layers. Thereafter, backed artefacts occur first in small numbers in layers where silcrete is rare but quartz is common, and then in greater numbers where silcrete is common. At KKH, backed artefacts only occur in the early, silcrete-rich layers, though a single instance was observed in association with the OIS 2 unit Di.

At both DRS and KKH there are suggestions of a bimodality to silcrete distribution among backed artefact-bearing layers. More notches were observed in the older of these two modes at both sites. At KFR, silcrete prevalence does not change with backed artefacts, but fine-grained rocks generally increase, while notches were recorded in both spit 5 and spit 6.

There appear to be three ways in which the backed artefact-bearing layers at these sites can be synchronised. The first is to ascribe all layers in which backed artefacts are the dominant implement form to a single grouping. Complicating this is the fact that backed artefacts dominate the last three bifacial point-bearing layers at DRS, while bifacial points are absent from KKH and KFR. Restricting the grouping to the layers dominated by backed artefacts but lacking bifacial points would include the layers at DRS in which quartz is the dominant material. There is no suggestion, however, of such a pattern at KKH. The best of the available resolutions thus seems to be to pair the layers at DRS and KKH in which silcrete peaks, falls and peaks again. This includes layers 22-6 at DRS and Dvii4 through Dvi7 at KKH. This pairing has a further advantage insofar as the distribution of notched artefacts between modes is relatively well matched.

At KKH, the oldest silcrete peak occurs in layers Dvii4 through Dvi12 – dating roughly from ~65 ka to ~62 ka, albeit that the basal spits may slightly exceed this age range. The spike in quartz prevalence marks the younger limit of this grouping, which is otherwise associated with the wettest conditions apparent in the phytolith record. Conceivably, the quartz spike marks the end of this wet phase. The comparable grouping at DRS includes layers 22-12.

The younger silcrete peak at KKH is associated with markedly drier conditions and an age range from ~62 ka to ~60 ka. The relevant layers at KKH are Dvi11 through Dvi7. The comparable layers at DRS are 11-6. In more general terms, the age range ~65 ka to ~60 ka, which is inferred to cover all of the silcrete-rich, backed artefact-bearing layers analysed, is consistent with Jacobs *et al*. (2008a) dates for the Howiesons Poort across southern Africa.

Reconciling KFR with these groupings is complicated by the comparatively coarse nature of the excavation from which the artefacts derive. Discerning variability in the distribution of fine-grained rocks between backed artefact-bearing layers at KFR is not possible. Notches are noted to occur in both spits 6 and 5, and, given the absence of overlying layers containing unifacial points, it may be that the site was abandoned prior to the second silcrete mode. While this is necessarily speculative, for the sake of graphical representation, KFR spits 6 and 5 will be grouped with DRS layers 22-12 and KKH layers Dvii4 through Dvi12.

The layers 29-23 at DRS, which contain a few backed artefacts and are dominated by quartz, have no obvious corollary in the sequences at KFR or HRS. It is possible that the four spits in unit Dvii at KKH, which probably date just beyond 65 ka, which lack backed artefacts and which show incremental increases in silcrete, overlap the last few layers in this grouping at DRS. The sample of artefacts in these layers at KKH is too small to warrant separating them out, however, and it seems simpler to group them with those artefacts in the younger grouping which they also resemble.

These issues aside, bracketing ages can be derived from the lower age limit of the younger, overlying grouping (~65 ka), and by the age of 70.9 ± 2.3 ka given by Jacobs *et al*. (2008a) for the layer Kerry (layer number 29). Jacobs *et al*. assign this layer to the Still Bay, however, in the column analysed, Kerry overlies the last bifacial point-bearing layer, and occurs at the start of the sequence of quartz-rich layers. It also overlies the sequence of three backed artefact-bearing layers. Approximate age brackets of ~65 ka and ~70 ka for the quartz-rich layers 29-23 at DRS thus seem reasonable. There is conceivably some correspondence between these layers and the sequence at Die Kelders, which otherwise fails to conform with most industries in southern Africa, which dates to some time between 70 ka and 60 ka (Feathers and Bush 2000; Schwartz and Rink 2000), and which Minichillo (2005) places between the Howiesons Poort at the Still Bay.

At both DRS and KKH, the backed artefact-bearing layers are overlain by layers containing unifacial points and no backed artefacts. At KKH, this transition seems to occur following the onset of wetter, grassier conditions ~60 ka. Both DRS and KKH have ages for these unifacial point-bearing layers of ~55 ka, however, this marks the upper limits of the sequence at DRS. KKH, on the other hand, appears to have had at least sporadic occupation persisting through to ~35 ka. The comparability between these two sequence components is thus limited to correspondence between layers 1-5 at DRS and Dvi1-Dvi6 at KKH, which can be assigned bracketing ages of ~55 ka and ~60 ka. Layers in units Dv-Dii at KKH are grouped separately, with age brackets of ~35 ka – ~55 ka.

Underlying the 70 ka – 65 ka grouping at DRS are eight layers containing bifacial points. These, and all layers at HRS, can be considered to be ‘Still Bay’, and thus can be assigned the relevant dates from Jacobs *et al*. (2008a). As noted earlier, a terminal age of around 70 ka, and an onset of around 74 ka, based on the age of 73.6 ± 2.5 ka for layer Logan at DRS would be consistent both with the central age of the industry as argued for by Jacobs *et al.*, and with the suggestion that the industry may have lasted some 4-5 ka. It is clearly possible that the period of bifacial point discard at DRS was either longer or briefer than the 4 kyr range assigned it here; their assigned range is the most conservative based on the available and most directly relevant data.

Consideration might be given to assigning the lower two layers at HRS to an earlier grouping (e.g., Watts 2002), however it seems no more reasonable to excise the 'tail' of the bifacial point-bearing layers at HRS than it would be to assign the early bifacial point-bearing layers at DRS to a separate grouping. The layers which precede 74 ka – 70 ka bracket at DRS, and spits 7-9 at KFR, which lack bifacial points but precede the 'Howiesons Poort', are allocated to a > 74 ka grouping.

A final grouping can be identified in the layers at KKH and EBC which are quartz-dominated and lack prepared cores. At both sites, these layers are associated with OIS 2 dates between ~25 ka to ~16 ka. There are no clear suggestions of occupation in the range from 35 ka to 25 ka.

These groupings are summarized in Table 8.5. As noted above, these groupings should be considered broadly indicative. The ages on which they are based have, in many cases, large error ranges. Thus, referring to an age of 73.6 ± 2.5 ka as '~74 ka' is necessarily fraught. Nevertheless, these groupings are important in the organization of data in the remainder of this chapter. In the chapter which follows, the general validity of these groupings will be reassessed.

8.3 DATA RELEVANT TO TECHNOLOGICAL ORGANISATION

8.3.1 Technological time costs

Aspects of material selection

Patterns in material selection can be seen to have relevance both to magnitude and frequency costs. Magnitude costs can be minimized by the procurement of materials on-encounter – the neutral model of procurement as discussed in Chapter 4. Frequency costs can be minimized by the preferential selection of materials with good flaking properties. In many cases, these two factors will be at opposed. Particularly in the Sandveld and Olifants zones, and with the exception of CCS/FGS rocks, preferential selection of good materials is likely to involve higher magnitude costs.

Stacked bar graphs for the three most common material types in this study – silcrete, quartz and quartzite – were originally presented as Figures 8.2, 8.9, 8.17, and 8.20. Figure 8.14 displayed patterns in silcrete, quartzite, hornfels and CCS/FGS. In Figure 8.22, these data are, with the exception of Figure 8.14 (KFR), displayed again, roughly aligned using the temporal blocks discussed at the end of the preceding section. The discussion of KFR will continue to make reference to Figure 8.14.

With respect to procurement patterns, Figure 8.22 can be used to make a number of points. In the >74 ka layers at DRS and KFR, material procurement is generally consistent with the expectations of a neutral model. Quartzite, which along with sandstone is the dominant geological feature of the region, is the most common material in both contexts. At DRS, quartz is the next most common material, both in the landscape and in early stone artefact assemblages. Silcrete, which has a constrained distribution in the Sandveld zone and which would thus be more rarely encountered, has a negligible presence. Silcrete is considerably more common in the comparable layers 7, 8 and 9 at KFR, though its local distribution is unknown.

The increase in silcrete coincident with the appearance of bifacial points at DRS after 74 ka suggests either an increased investment in the acquisition of this rock, or an increase in the frequency with which it was encountered. The former case would imply greater magnitude costs of procurement. At HRS, silcrete increases incrementally with increases in numbers of bifacial points; at DRS the change is more abrupt. At DRS, magnitude costs reach a relative maximum in the layers where both backed artefacts and bifacial points are present.

Above the bifacial point layers at DRS, at an inferred age of ~70 ka, silcrete prevalence drops markedly while quartz surges to become the dominant material. Insofar as regularly-encountered materials dominate at the expense of harder to acquire materials in these layers, the pattern bears comparison with that in the early layers at DRS. The difference is in the relative prevalence of quartz and quartzite. The possible significance of this switch is considered below.

Magnitude costs increase again after ~65 ka at DRS and are also considerable in this period at KKH, with silcrete the most common material in the majority of contexts. At both sites, peaks in silcrete are interrupted by a brief but pronounced surge in quartz prevalence around 62 ka, potentially indicating an unsustained reversion to low-magnitude cost procurement strategies.

Following the younger silcrete peak at KKH, the low magnitude cost materials quartzite and quartz both increase gradually. Silcrete is relegated to a relatively minor assemblage component, a position which it maintains through the remainder of the sequence. In the OIS 2 layers at both KKH and EBC, quartz is the dominant material.

One point made in the preceding chapter is that, in the context of the Sandveld and Olifants zones at least, CCS/FGS may offer a relatively ‘cheap’ alternative to silcrete, in that it is a readily available rock with good flaking properties. With this in mind, Figure 8.23 presents data on the relative percentage values of silcrete and CCS/FGS through the sequences at DRS and KKH. At DRS, perhaps surprisingly, there is no strong patterning in the relationship between these two materials. At KKH, however, the patterning is relatively clear. In the lowermost layers, where silcrete is generally dominant, CCS/FGS accounts for a relatively minor proportion of assemblages in each layer. After 55 ka, however, and following the marked decline in silcrete prevalence, proportions of CCS/FGS increase substantially. Of the 17 layers dating to >55 ka, CCS/FGS accounts for more than 10% in only one; in the 14 layers dating <55 ka, CCS/FGS accounts for less than 10% in only two. There appears to be some support, therefore, for a complementary relationship between the use of silcrete and CCS/FGS at KKH.

Edge length to mass changes

As the title suggests, edge length to mass (ELM) values document how much edge is generated for a given quantity of provisioned material. Mass is considered to be a useful measure of material quantity, at least partly because mass can be seen to have a relationship to transport cost. Variation in ELM may be a useful indicator of the degree of conservativism in material reduction. Figure 8.24 presents error bars of changing ELM values through the site sequences for which complete flake data are available – DRS, KKH, and KFR. Layers which display high variance – generally those with very small samples – are not included, though in general ELM values are stable on a layer-to-layer basis.

In the > 74 ka layers at DRS, ELM values are generally quite low, averaging around 20 mm/g. Comparable values occur in the early layers at KFR, though there is a clear pattern of incremental increase from spit 9 through to spit 7. Slightly higher, though still relatively low values persist at DRS from 74 ka to 70 ka, however, in the three layers above 33, which are also those which contain both backed artefacts and bifacial points, mean ELM values increase incrementally from 16.7 mm/g in layer 33 to 42.2 mm/g in layer 30.

In the subsequent quartz-rich, backed artefact-bearing layers at DRS, dating 70 ka – 65 ka, values restabilise in the region between 33 mm/g and 39 mm/g, before undergoing another increase above layer 21, concomitant with the increase in silcrete. From 65 ka – 60 ka, values are almost invariably above 40 mm/g (one exception), and are usually above 45 mm/g (four exceptions). At both KKH and KFR, comparably high ELM values occur in layers dominated by fine-grained rocks and backed artefacts. At KKH, only four of the backed artefact-bearing layers have mean ELM values below 40 mm/g, and three of these are the last (youngest) layers in the 62 ka – 60 ka grouping. A clear trend towards lower ELM values at KKH initiates around 62 ka and proceeds through to layer Dvi3 (~56 ka), where ELM values reach ~25 mm/g. A similar decline can be observed above layer 7 at DRS.

At KKH, the decline in ELM values mirrors the decline noted in the selection of silcrete, confirming in part the anticipated relationship between variation in magnitude costs and conservativism in material reduction. In the quartzite-rich layers of DRS and KKH (60 ka – 55 ka), ELM values are relatively low, while in the silcrete-rich layers (65 ka – 60 ka), values are relatively high. One point of interest concerns the quartz-rich, backed artefact-bearing layers dating from 70 ka – 65 ka at DRS. Material selection tendencies suggest that this was a period in which low magnitude costs pertained, yet one where reduction was also relatively conservative.

Variance in ELM values may also provide a partial explanation of changes in material selection. As noted earlier, quartz, quartzite and CCS/FGS are available near most sites in the study area, with quartzite and quartz particularly abundant. Notably, there are considerable differences in the maximum ELM yields attainable on each material. For example, of 1457 complete quartzite flakes >15 mm measured during this study, none returned an ELM value greater than 131 mm/g. Comparable values for quartz and CCS/FGS were 238 mm/g (n=733) and 256 mm/g (n=255) respectively. The maximum ELM value for a silcrete flake was 239 mm/g (n=3036); for hornfels the value was also 239 mm/g (n=187).

The validity of maximum values as a measure of the upper limits of ELM is questionable given that these values are derived, in effect, from a single flake for each material. Upper quartile values provide another approximate measure of the upper ELM limits. Values for the 75th percentile in each material grouping are as follows (in order from lowest to highest): quartzite = 24.1; quartz = 45.7; silcrete = 57.0; hornfels = 61.1; CCS/FGS = 76.3. The order of materials is effectively unchanged using this second measure, though the differences between materials increase.

A number of points can be made based on these data. First, maximum and upper quartile ELM values are relatively consistent among the fine grained materials silcrete, hornfels and CCS/FGS. These values appear to be unaffected by sample size. Second, the maximum and upper quartile ELM values reported for quartz are more comparable to those reported for silcrete and hornfels than they are to those reported for quartzite. Upper quartile CCS/FGS values are considerably higher. Third, quartzite has what appears to be a heavily restricted capacity for good ELM yields. In conditions where good ELM yields are emphasised, the preferential selection of quartz over quartzite might be expected. Quartz may thus be the only material in the study area that allows simultaneous reduction of both magnitude and frequency costs.

Core reduction and discard thresholds

Another means of reducing the frequency of procurement events is to lower the threshold at which artefacts are discarded. Two measures were suggested to be of interest in this respect: the relative prevalence of bipolar cores and the size at which cores are discarded.

Figure 8.25 presents sequential changes in the prevalence of bipolar cores at all sites. As with previous considerations of core changes, sample size necessitated the data be presented in groups, rather than being displayed on a layer-by-layer basis.

There are consistencies and inconsistencies between the site sequences displayed in Figure 8.25. Bipolar cores are comparatively common in the >74 ka layers at DRS, but become less common in the 74 ka – 70 ka layers. At the same time, however, bipolar cores are ten times more common in this grouping at DRS than they are at HRS. Bipolar cores are again very common in the 70 ka – 65 ka, the 65 ka – 62 ka and the 62 ka – 60 ka groups at DRS, with a peak prevalence of ~68% from 65 ka – 62 ka.

At KKH, on the other hand bipolar cores are comparatively infrequent in the 65 ka – 62 ka grouping, and though more common from 62 ka – 60 ka, they remain about one third as prevalent in this grouping as in they are in the corresponding period at DRS. Bipolar cores were generally uncommon in the 65 ka – 62 ka layers at KFR, though the available sample is small and potentially compromised by the inclusion of some but not all cores from spit 5. No bipolar cores were observed in the 60 ka – 55 ka grouping at DRS, while at KKH, bipolar cores accounted for ~18% of the core total at this time. Peak prevalence of bipolar cores at KKH occurs in the 55 ka – 35 ka and 25 ka – 16 ka groupings. Bipolar cores are also common in the 25 ka – 16 ka grouping at EBC.

At least part of the observed variance can be explained in terms of differences in the availability of flakeable stone at different sites. The Sandveld sites DRS and EBC have the poorest access to stone, and, concomitantly, the highest overall prevalence of bipolar reduction. The Olifants and Doring sites have better access to stone, and bipolar reduction is notably less common. Access to stone does not, however, explain through-time changes within sites. The data from DRS appear to imply that reduction of provisioned material peaked in the late OIS 4 groupings, while the KKH data suggest less bipolar reduction during OIS 4 than during OIS 2.

Greater resolution on the issue of changing reduction intensity can be attained by examining changes in core weight. Figure 8.26 presents boxplots of core weight for DRS, KKH, KFR and EBC. Sample size is too small to explore these changes with the data available from HRS. There is considerably greater consistency in through time changes at different sites in core weight than was observed for the prevalence of bipolar reduction. At DRS, core weights generally decrease through time from the >74 ka grouping through to 65 ka – 62 ka grouping, and then increase again through to the 60 ka – 55 ka grouping.

Similarly, at KFR, cores weights are generally very high in the >74 ka groupings, but comparatively very low in the 65-62 ka grouping.

At KKH, core weights are relatively low in the 65 ka – 62 ka and the 62 ka – 60 ka groupings, before increasing in the 60 ka – 55 ka grouping. In this respect there is comparability in core weight changes at both DRS and KKH across the transition from OIS 4 to early OIS 3. In the 55 ka – 35 ka grouping at KKH, core weights decrease again, before reaching minimum values in the OIS 2 grouping, 25 ka – 16 ka. Cores in this age grouping are also small at EBC. The 25 ka – 16 ka grouping is also notable for containing the smallest cores observed in the study. Six of the complete cores in this grouping at EBC weigh less than 0.3 g. Fourteen of these cores measure less than 12 mm in the longest axis. Five such cores <12 mm were recorded at KKH, two of which came from the 62 ka – 60 ka grouping, and one from the 25 ka – 16 ka grouping. The remaining two came from the disturbed pit context which affects units Di through Dv. Consequently, the cores in question probably date to between 55 ka and 16 ka. No cores this small were recovered from DRS, KFR or HRS.

As with patterns in bipolar core prevalence, inter-site differences in core weight tend to support the contention made in Chapter 4 that differences in material abundance would be likely to effect core discard thresholds. Figure 8.27 presents boxplots of weights for all complete cores from each of the five sites. For the purposes of the figure sites are arranged in order of zones, such that the Sandveld sites are positioned on the left of the figure, and Doring sites on the right. The single Olifants site, KKH, is placed in the middle. Consistent with expectations, cores from sites in the material-rich Doring zone are generally bigger than those in the Olifants zone site, where flakeable materials are probably slightly less abundant. Cores from the Olifants site are, in turn, generally larger than those from sites in the Sandveld zone, which is considered to be materially depauperate.

Necessarily, these inter-zone comparisons are affected by differences in the timing of occupation. Nearly 40% of complete cores in the Sandveld zone sample come from the OIS 2 grouping at EBC, thus increasing the proportion of small cores. The influence of time can be obviated to some extent by comparing cores from the same period at different sites. Samples of sufficient size from two sites in separate zones are only available for the late

OIS 4 component of DRS and KKH. T-tests[23] of these samples suggest that cores in both the 65 ka – 62 ka (mean_{DRS}=5.8, mean_{KKH}=11.9; d.f.=170; p<0.001) and 62 ka – 60 ka (mean_{DRS}=6.7, mean_{KKH}=13.9; d.f.=123; p=0.046) groupings are significantly larger in the Olifants zone site KKH than in the Sandveld site DRS.

Returning to the issue of through-time changes, the overall pattern in core reduction tends to mirror that observed in ELM variance. In the >74 ka grouping ELM values are at their lowest, and cores tend to be at their largest at point of discard. Cores become smaller though time, with the smallest cores occurring 70 ka – 60 ka, through which time ELM values are at their highest. After 60 ka cores become larger and ELM values lower.

Heat treatment

With respect to heat treatment, the first issue to be considered is whether there is any evidence that people flaked heated stone artefacts and, if so, when this occurred. Establishing that rocks were at times flaked after they were heated seems to be a necessary precondition for establishing the possibility that heat treatment occurred in the sequences under consideration. Unfortunately the variable ‘heated then flaked’ (described in Chapter 7) was only added after analysis of the DRS assemblage had been partially completed. KKH provides the only full sequence for which this information is available. Figure 8.28 presents data on numbers of heated-then-flaked artefacts, and heated-then-flaked artefacts as a percentage of artefact totals for all layers at KKH. The data suggest that people did reduce previously heated rocks at times through the KKH sequence. The distribution of evidence for heating-then-flaking is also strongly structured, being largely restricted to the lower part of the KKH sequence, with the largest numbers of heated-then-flaked artefacts occurring from Dvi5 through Dvi14. This broadly corresponds to the period from 65 ka to 60 ka. In effect, there is a strong degree of correspondence between layers with evidence for heating-then-flaking and layers in which silcrete is a large assemblage component.

With the possibility of heat treatment in mind, Figure 8.29 presents data on changes in the rates of heat affect among complete flakes in the main silicious rock categories – silcrete and CCS/FGS – through the sequences at DRS and KKH. DRS and KKH are the only two

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[23] T-tests are used in this thesis to examine differences in the mean values of two groups. T-tests are only used when Levene’s test for equality of variances suggests that variance does not differ significantly between the two test populations. When variance does differ significantly, non-parametric Mann-Whitney tests are used.

sites for which complete data sets are available. Data are presented in temporal blocks, rather than layer-by-layer – the layer-by-layer data are relatively ‘noisy’. Analysis is restricted to silicious rocks due to the comparative ease of identifying changes to luster and colour. Heat shattered pieces have been removed from the sample of artefacts designated as ‘heat affected’ in order to limit the potential influence of uncontrolled heating. Similarly, artefacts on which heating was probably taphonomic – those with ventral pot-lids, crazing or crenation – have been removed from the sample of heat affected pieces. Complete flakes are used to limit possible inflation of heat affects introduced by differential rates of post-depositional artefact breakage.

The data presented in Figure 8.29 suggest that peak rates of heat affect on flakes occurred between 65 ka and 55 ka at both DRS and KKH. Notably this is also the period for which evidence of heating-then-flaking of artefacts is at its greatest. Relatively high rates of heat affect also occur in the 74 ka – 70 ka, and in the 70 ka – 65 ka blocks at DRS. Before 74 ka and after 55 ka, heat affect is relatively rare at both sites. The data suggest that high rates of heat affect are broadly coincident with OIS 4.

Another notable aspect of Figure 8.29 is the variance in the overall prevalence of heat affect between the two sites. At DRS, 34.5% of silcrete and CCS/FGS flakes exhibit some evidence of heating. The value at KKH is 25.4%. Pearson’s Chi-square test suggests that the difference in heated to non-heated artefact ratios between sites is significant at $p<0.001$.

Through-time and inter-site variance in heat affect may be explained either in terms of incidental heating or heat treatment, or possibly a combination of the two. If the differences are incidental they may result from differences in the frequency, size, or duration of firing episodes. Thus, larger or more frequent fires may have been built at DRS than at KKH, resulting in a greater ‘background’ thermal effect. Through-time differences may be explained in terms of larger, more sustained and/or more frequent fires in both shelters during the cold conditions which prevailed during OIS 4.

An explanation in terms of heat treatment, however, would deal with both the inter-site and through-time patterns equally well. For example, if we accept that heat treatment was a means by which people could improve knapping yields and diminish the frequency of deleterious fractures, we would expect to see a relationship between heat treatment and other means of improving knapping yields. As noted earlier, knappers at DRS tended to reduce cores more heavily prior to discard than knappers at KKH, probably because of the greater scarcity of material. Peak ELM values at DRS also tend to be higher than those at KKH. Greater use of heat treatment at DRS to improve the flaking characteristics of acquired materials is consistent with this pattern. Equally, there is some correspondence between the prevalence of heat affect through time and changes in core reduction techniques, core weight at discard, and ELM values at both sites.

Consideration of the relationship between background heating levels and those within specific classes of artefacts may help provide additional insights into this issue. If heat affect is primarily incidental, we would expect its effects to be relatively evenly distributed through all artefact classes. Alternatively, if heat treatment is the primary cause of heat affect, we might expect to see greater prevalence of heating on classes of artefacts required to sustain on-going reduction. Cores are one such class. Figure 8.30 presents data on changes in the prevalence of heat affect on silcrete and CCS/FGS cores through the various temporal blocks. No cores on these materials were recovered from the >74 ka grouping at DRS.

Figure 8.30 can be used to make several points. First, peak prevalence of heat affect continues to occur in the layers between 65 ka and 55 ka. Second, cores tend to exhibit signs of heating more often than flakes. Of 224 complete cores in the age range from 74 ka to 55 ka, 45% appear to have been heated. Among complete flakes this value is 27.4% (645 of 2355). A Pearson's Chi-square test suggests that the difference is significant at $p<0.001$.

Five of the age groupings at DRS and three at KKH have both cores and flakes on silcrete and CCS/FGS, allowing ratios of heat affect to be compared. In three of these groups – the 74 ka – 70 ka, 70 ka – 65 ka, and 60 ka – 55 ka groupings, all at DRS – complete flakes exhibit higher rates of heat affect than cores. These are also the three groups with the smallest overall samples. Chi-square tests suggest that the differences in rates of heat affect between cores and flakes are not significant in any of these contexts, using a cut-off of $p<0.05$.

In the remaining five contexts heat affect is more common on cores than on flakes. In four of these contexts the difference is significant at $p<0.05$. The exception is the 65 ka – 62 ka grouping at DRS, which returns a significance value of $p=0.129$.

Though not conclusive, the data appear to support the suggestion than heat treatment was employed at times through the study period, most likely between 65 ka and 60 ka, though possibly continuing through to 55 ka. Through much of this time silcrete was preferentially sought, and reduction appears to have been relatively conservative. The use of heat treatment to improve the flaking characteristics of procured rocks is consistent with this pattern. It should also be noted, however, that in some contexts heat affect most likely resulted from incidental processes. Strongest support for this proposition occurs in the groupings dated from 74 ka to 65 ka, where relatively high rates of heat affect are observed, but where the affect does not appear to have discriminated between classes of artefacts. It seems likely, therefore, that a combination of incidental and intentional heating affects was at play through the sequences at DRS and KKH.

Technological complexity

The only way in which the question of changing technological complexity can be addressed directly by this study is through an assessment of changes in the production of implements. As noted earlier, implements occur throughout the sequences at all sites. In total, nine morphologically regular implement types were identified during this study, though the degree of regularity was variable within and between types. Six of these types were used to assist in the organization of sequences, based on previous assessments of their sensitivity as temporal indicators. A seventh type, shoulderless points, was introduced in an earlier part of this chapter. Burins and adzes are the eighth and ninth type considered here. Adzes are often associated with LSA assemblages, and indeed, are most common in the 25 ka – 16 ka layers at EBC. Some specimens, however, were recorded in >25 ka contexts at KKH.

Table 8.6 presents a range of data relating to the occurrence of implements through the various sequences, including number of implements per age grouping, and number of amorphous retouched artefacts per age grouping. In addition, in the sites for which relevant data are available, total numbers of artefacts are presented. These are used to calculate the number of implements per 100 artefacts, and ratio of implements to other retouched pieces for each age grouping in each site. The interest here is in identifying times at which large numbers of implements were made, and those when morphological regularity in retouched pieces was emphasized.

With respect to Table 8.6 it should be noted that some assemblages, notably those from DRS and KKH, derive from small excavations, while others derive from larger excavated areas. Consequently, numbers of implements are only comparable within rather than between sites. In a similar vein, assemblages from the youngest two units from KKH derive from 0.5 m^2, while the older assemblages derive from 1 m^2; arbitrarily doubled values are presented in brackets to facilitate comparison. Data from HRS are not presented, because consistency in classification between this analysis and that undertaken by Evans (1994) cannot be assumed.

At DRS, implement numbers peak in the 65 ka – 62 ka grouping, followed by the 74 ka – 70 ka grouping. These groupings also have the largest numbers of implements per 100 artefacts, and relatively high ratios of implements to amorphously retouched pieces. The 60 ka – 55 ka grouping also has a high ratio of implements to amorphously retouched pieces, however, the total samples of both implements and artefacts are quite small. In contrast to these groupings, layers dated >74 ka and 70 ka – 65 ka at DRS tend to have comparatively few implements overall, with low ratios of implements to amorphously retouched pieces.

As at DRS, the highest number of implements per 100 artefacts at KKH occurs in the 65 ka – 62 ka grouping. This grouping, and the one which succeeds it also have high ratios of implements to amorphously retouched pieces, and large numbers of implements overall. The smallest number of implements relative to assemblage total occurs in the 25 ka – 16 ka grouping. Retouched pieces in this grouping are also relatively heterogeneous.

KFR is the only other site with multiple age groupings, and consequently the only site for which internal comparison is possible. As at DRS and KKH, large numbers of implements occur in the 65 ka – 62 ka grouping, however, the ratio of implements to amorphously retouched flakes is highest in the >74 ka grouping. Implement to amorphously retouched flake ratios in the 25 ka – 16 ka grouping at EBC are comparable with peak rates at DRS, but may be considered moderate to high overall.

Insofar as these data can inform on changes in technological complexity, and, by inference, manufacturing costs, they appear to imply that heaviest investment in the manufacture of morphologically regular artefacts pertained across most of the study area from 65 ka – 62 ka. There is also evidence for the manufacture of large numbers of morphologically regular implements from 74 ka – 70 ka at DRS, and from 62 ka – 60 ka at KKH. Minimum investment appears to have pertained in the >74 ka and 70 ka – 65 ka groupings at DRS, though interestingly, high ratios of implements to other retouched flakes occur in the >74 ka grouping at KFR.

8.3.2 Transport costs

Weight of transported items

Changes in transport costs are likely to be reflected in changes in the weight of transported items through time. Complicating approaches to this issue is the fact that weight is likely to decrease through the use-life of an artefact. Thus weight at discard may not reflect weight at point of transport. This is likely to be particularly pertinent in the case of cores, but may also effect implement forms such as points and scrapers (cf., Clarkson 2002a, 2002b; Dibble 1984, 1987; Eren et al. 2007). To that end, proxies which may help identify the sizes of cores and implements at the commencement of reduction on site need to be considered in addition to the weight of the cores and implements themselves.

Figure 8.31 presents data on the weights of different classes of implements, using complete examples only. Due to the limitations of sample size, implements of each type are aggregated, with no divisions by site or by time period. Table 8.7 presents associated data on the number of samples, and mean and standard deviations of weights for all implement types.

Most notable from the figure and table are the very low weights of backed artefacts and notched pieces, and the comparatively high weights of denticulates and points, both unifacial and bifacial. Scrapers, denticulates and shoulderless points have moderate weights.

In a sense, the data are consistent with previous studies which suggest that points, scrapers and denticulates are likely to undergo on-going maintenance through their use-lives. The data presented appear to confirm the expectation that such implements would be manufactured with excess and potentially redundant weight to facilitate such reduction. Necessarily, then, these implements also have higher transport costs than low-weight items such as backed artefacts and notched pieces. Based on previously presented data, it seems reasonable to suggest that the larger implement forms were most strongly emphasized in the study area from 74 ka – 70 ka and from 60 ka – 55ka. Denticulates, which have moderate weight and which some researchers have suggested undergo multiple reduction events, are common in the >74 ka grouping at KFR but not at DRS. Lightweight implement types like backed artefacts and notches are most prevalent from 70 ka to 60 ka. These patterns in changing implement weight through time are similar to changes in core weight (cf., Figure 8.26).

As noted above, the data presented in Figure 8.31, and previously in Figure 8.26, represent minimum weights at point of transport for the implements and cores considered. Particularly in the case of cores, it may be that large blocks of material were introduced to site, heavily reduced there, and discarded as small blocks. In such cases the disparity between transport weight and discard weight may be significant. Unretouched flakes may provide insights into the sizes of cores and implements at the point at which they were introduced to site, rather than the point at which they were discarded. If cores were large when introduced and small when discarded we might expect to see both large and small flakes in the assemblage. Alternatively, if cores were small at both the point of introduction and the point of discard we would expect to see small flakes only.

Figures 8.32 and 8.33 present boxplots of weight and maximum dimension for complete flakes through the DRS, KKH and KFR sequences. The figures document heavily constrained ranges of flake size in the periods in which cores and dominant implement types are relatively small, most notably from 70 ka to 60 ka. There is no support for the suggestion that cores in these periods were large at the point of introduction, and subsequently heavily reduced. Instead, cores appear to have been small both when introduced to a site and when discarded there.

These changes in core and flake weight may also provide further insights into changes in material selection, most clearly in relation to the variable selection of quartz and quartzite among locally-available materials. It was noted earlier that quartz offers better upper-range ELM potential than quartzite. However, in Chapter 5 it was suggested that quartz nodules observed in the field were also quite small – 80 mm being around the upper size range of nodules observed in the Sandveld and Olifants zones. The archaeological data from DRS, EBC and KKH bear this out. The largest quartz flake recovered from any of these sites had a maximum dimension of 63.3 mm. The largest quartzite flake was 108.9 mm. The upper 10% of quartz flakes range in maximum dimension from 33.6 mm to 63.3 mm; the range for quartzite flakes is 56.4 mm to 108.9 mm. Selecting for quartz, then, necessarily constrains knappers to working within a more limited range of possible artefact sizes than when they select for quartzite. At times when large cores and implements were regularly transported, quartzite was the preferred local material. The period from 70 ka to 65 ka, when transported items were smaller and high ELM values were emphasized, coincides with the preferential selection of quartz.

One final point that can be made in this section concerns the relationship between the sizes of implements and the sizes of flakes. It is often implied that most flakes are produced to provide a pool of potential blanks for the manufacture of implements. Thus, the sizes of preferred implements should to some extent dictate the sizes of flakes that are manufactured. At DRS and KKH, implement trends shift from large (bifacial points) to small (backed artefacts) and back to large (unifacial points). Flake sizes, and indeed, the sizes of cores at discard (Figures 8.26, 8.32 and 8.33) do indeed appear to track these changes in broad terms.

The data from KKH, however, suggest that the relationship between flakes size and implement size is considerably more complex. From layer Dvii4 through to layer Dvi6, people made small implements like backed artefacts and notched pieces. From layer Dvi6 through to Dvi1, they made larger implements like unifacial points and scrapers. Yet flake sizes do not change abruptly either side of Dvi6. Rather, there is a smooth increase in sizes which initiates in layer Dvi11, halfway through the sequence of backed artefact-bearing layers, and continues through to Dvi3, well after the first unifacial point has appeared. Clearly, there is some independence between the sizes of implements and the sizes of flakes.

To put this in further perspective, Figures 8.34 and 8.35 present boxplots of weight and maximum dimension for all complete flakes in the two oldest units at KKH. Superimposed over this are lines representing median (solid line) and inter-quartile ranges (dotted lines) of weight and maximum dimension for backed artefacts (black lines) and unifacial points (grey lines). The figures suggest that the transition from backed artefacts to unifacial points occurs at around the point in the sequence where flakes of sufficient size for unifacial points begin to appear in reasonable numbers. Prior to this, in the backed artefact-bearing layers, flakes of this size simply do not occur with any frequency. It can also be noted that the first layers in the sequence where flakes become big enough to be transformed into unifacial points are also the layers where the unusual implement form ‘shoulderless points’ briefly appears. As discussed earlier, these implements appear to blend the retouch characteristics of backed artefacts with the blank forms of unifacial points. Occurring where they do in the sequence, these artefacts imply a short-lived experimental response to a newly available range of blanks.

The data from EBC are also relevant to the relationship between flake size and implement size. As noted, the cores in the OIS 2 layers at EBC tend to be very small, including a range of sizes rarely seen in earlier periods. It has also been noted that, at KKH, people very rarely retouched flakes less than 15 mm long. Based on the above discussion, we might expect that changes in the reduction of cores and in the sizes of flakes produced would affect the sizes of blanks considered usable. Because data on complete flakes are not available for EBC, comparison initially considers differences in core sizes. Figures 8.36 and 8.37 provide boxplots of weight and length for complete cores from the OIS 2 layers at EBC with those from OIS 4 at KKH. These two groups are compared because both include a number of similar implement forms, including backed artefacts and scrapers.

The data suggest that, indeed, cores at EBC tend to be smaller than the cores at KKH. Figures 8.38–8.41 provide boxplots of weight and maximum dimension for complete backed artefacts and scrapers at the two sites. As anticipated, implements at EBC are invariably smaller than implements in the same class at KKH. The data suggest that the size at which a flake is considered viable as a blank for implement manufacture is not consistent through time, and is probably responsive to factors such as core discard threshold.

Combined, the available data suggest that the relationship between blanks and implements is mediated by a complex set of interactions in which travel costs, conservativism of reduction, technological design and innovation all feature. The idea that people make bigger blanks so that they can make bigger implements does not hold.

Evidence of pre-processing

If transport costs varied through time, we might expect to see changes in utility to weight ratios among transported items. Utility to weight can be improved by preferential selection of predictably-flaking rocks, and by various forms of pre-processing, including establishing the basic morphology of the artefact prior to transportation, and removing soft, flawed or poorly-flaking areas of material within a piece to be transported. Issues of material selection have been addressed earlier in this chapter. Detailed assessment of artefact reduction / production sequences was not undertaken, and consequently the issue of whether and to what extent artefacts were pre-formed prior to arrival on site cannot be approached. The remaining aspect of technological variance which can be considered is that relating to changes in the prevalence of cortex on transported artefacts.

Figure 8.42 presents data on changes in the amount of cortex on complete flakes through the periods of interest at DRS and KKH. Data are presented as stacked bar graphs with flakes assigned to one of three groups – flakes with 0% cortex, flakes with 0-50% cortex, and flakes with >50% cortex.

Some of the results presented in Figure 8.42 may be seen to contradict earlier suggestions that transport costs were minimized between 70 ka and 60 ka. At DRS, the peak in flakes with >50% cortex occurs from 70 ka – 65 ka. This grouping also has a comparatively small proportion of flakes with 0% cortex. Flakes with >50% cortex are comparatively less frequent in the 74 ka – 70 ka and 60 ka – 55 ka groupings, as are flakes with any cortex at all. In general, however, through-time changes in cortex at DRS do not appear to be as strongly patterned as some of the other data considered.

One possible explanation for the apparent lack of coherent patterning is that changes in the relative contributions of local materials, including quartz, quartzite and CCS/FGS, and non-local materials, including silcrete and hornfels, may effectively be swamping the signal of change resulting from variance in pre-processing of materials. At DRS and KKH, silcrete and hornfels are derived from greater distances than quartz and quartzite. It seems probable, therefore, that by the time they arrived at these sites they may have been moderately to heavily reduced, regardless of whether that reduction occurred at or soon after the point of material procurement. To that end, Figure 8.43 presents the same data but excludes the 'non-local' materials. The revised figure adds relatively little to the picture already presented. The 70 ka – 65 ka grouping continues to have the greatest percentage of flakes with >50% cortex, and, though the percentage of such flakes in the >74 ka and 74 ka – 70 ka groupings now exceeds that in the 65 ka – 62 ka and 62 ka – 60 ka groupings, overall the relative proportions of flakes with no cortex are quite similar throughout.

In contrast to the DRS data, the data from KKH display a well-marked through-time pattern, particularly in the oldest four groupings. This pattern occurs regardless of whether or not non-local materials are excluded. In the case of KKH, this exclusion may be spurious in any case, with most common non-local material, silcrete, being available within 10 km of the site. What is notable from Figures 8.42 and 8.43 is that flakes with 0% cortex increase steadily as a percentage of the complete flake total from the 65 ka – 62 ka grouping through to the 60 ka – 55 ka grouping. Flakes with >50% cortex steadily decrease through this period. From 55 ka to 35 ka flakes without cortex continue to increase, though the contribution of flakes with >50% cortex also increases. Flakes with some cortex are most prevalent in the 25 ka – 16 ka grouping, though the sample at this time is small.

As with DRS, the data from KKH do not appear to be consistent with previous assertions about changes in transport costs. If people occupying these sites from 70 ka to 60 ka transported smaller cores and implements in order to reduce transport costs, we might expect to see more compelling evidence of pre-processing in this period. If anything, the data presented appear to suggest the opposite. What may be reflected in the various data sets, however, are different strategies for reducing transport costs, deployed under different conditions. From 74 ka – 70 ka, for example, people transported relatively large implements and cores, presumably to facilitate on-going reduction. If we assume that these increases in weight were strategically necessary, alternative means of reducing transport costs would have been required. On such alternative may have been increased pre-processing of transported materials to ensure that the weight that was carried was relatively useful weight. In contrast, from 70 ka to 60 ka losses arising from the transportation of items with some cortex may have been offset by the lower weight of items. In that respect, it is important to note that quartz, which was particularly common at DRS from 70 – 65 ka, tends to occur as relatively small nodules. As noted before, preprocessing may not be a useful strategy when initial nodule size is small. It can also be noted that cortex on the quartz nodules in the area is generally quite thin, meaning it would have little impact on the amount of useable material in the nodule. In this respect it can also be noted that the period from 65 ka to 62 ka at DRS, where there are signs that people transported items that were both small and heavily decorticated, saw an increase in the use of silcrete, which was almost certainly available in outcropping form.

Evidence of flexibility and versatility

Eighteen artefacts examined during this study display signs of recycling. In the majority of cases (16 of 18), recycling involved the manufacture of implements or other retouched pieces from previously broken flakes. The remaining two cases involved rejuvenation or transformation of a broken implement. The concept of flexibility as it has been discussed in this thesis, where the design of an artefact allows its transformation when required, appears to be more directly relevant to the latter two cases than to the former sixteen. Instances where broken flakes are used in the manufacture of implements logically appear more closely related to the kinds of material economizing behaviours associated with high ELM values and low core discard thresholds.

Patterns in the distribution of recycling appear to bear out these differences in types of recycling behaviours. Eleven of the examples of broken flakes being transformed into implements occurred at DRS between 65 ka and 60 ka. Three further instances were observed in the 74 ka – 70 ka grouping, and a single instance was observed in the oldest layer of the 60 ka to 55 ka grouping. The majority of the DRS cases thus coincide with periods of high ELM values and low core discard thresholds. Interestingly, however, no instances were observed in the 70 ka – 65 ka grouping, which also displays these characteristics.

Only one instance of the manufacture of an implement from a broken flake was observed in the sequence at KKH. In as much as one case can be used to reinforce a pattern, this recycling event occurred in the 62 ka – 60 ka grouping, when such behaviours were also at their most prevalent at DRS. Of as much interest, however, is the difference in the number of such instances at DRS and KKH. The effect is not sample size dependent – the total sample from the well-resolved excavation at KKH is more than double that from DRS, yet recycling is far more common at DRS. These differences in frequency are, however, consistent with previous evidence for the greater constraints imposed by the poverty of materials in the area around DRS.

The two instances where implements were recycled both involved points – one unifacial and one bifacial. Again, both occurred at DRS. The unifacial point occurred in layer 4 – the second oldest layer of the 60 ka – 55 ka grouping. The artefact exhibited a relatively clear break across the midsection which partially truncated some of the lateral scarring associated with the formation of the point. Necessarily then, the artefact was manufactured as a point, and broke sometime later, possibly during use or resharpening. Subsequent to breaking, however, the artefact had been reworked, presumably returning it to a functional state. The capacity for an implement to be returned to a serviceable state after breakage necessarily owes something to the additional mass built into the design of the object. This is not only consistent with a degree of flexibility, but also with implement maintainability, as will be discussed below.

The second instance of implement recycling derives from layer number 35 at DRS, in the 74 ka – 70 ka grouping. The artefact is a reworked bifacial point on fine brown silcrete, a relatively rare material at this site (Plate 8.6). The tip of the artefact appears to have been snapped off, while the butt was removed by a single hard hammer blow, forming a platform at the distal end. From this platform, multiple spalls have been removed down the lateral margins, a practice which appears to have ceased following a large hinge termination. In sum, the artefact appears to have been manufactured as a bifacial point, and, after having broken, to have been recycled as a core. To a greater extent than the unifacial point discussed above, this artefact seems to exemplify the idea of flexibility in that the additional mass incorporated into the design of the implement allowed it to be transformed into a new artefact type after it became incapable of fulfilling its initial purpose.

Versatility is the other aspect of implement design of interest to this section. As noted, the only facet of versatility which can readily be addressed here is that relating to the potential use of certain artefact types in secondary roles as sources of fresh flakes. The approach taken to this issue involves examining the size of retouch scars on different implement types. Size almost certainly provides some constraint on the utility of flakes. As noted in the previous chapter, people often appear to set lower limits on the sizes of flakes that they are willing to transform into implements. It does not seem unreasonable to suggest that similar constraints were imposed on the sizes of flakes deemed usable.

Figure 8.44 presents boxplots of flake scar sizes for several of the key implements types in this study. As with the earlier Figure 8.6, retouch scar length data are based on the largest scar in each sector of a retouched flake. Figure 8.44 suggests that there are marked differences in the sizes of flakes produced during the retouch of different implement types. Backed artefacts, notched pieces and denticulates all produce relatively small retouching flakes. Unifacial points and scrapers both produce moderate flakes. Bifacial points, however, regularly produce relatively large flakes – in the range from 9 mm to 13 mm.

These differences in the sizes of flakes produced during retouching are at least partially independent of implement size, at least insofar as it can be measured by implement weight. Bifacial points are not much larger than either unifacial points or scrapers (cf., Figure 8.31, Table 8.7) but the flakes they produce are (t-tests, bifacial points and unifacial points; $\text{mean}_{\text{bfpoints}}=11.9$ mm; $\text{mean}_{\text{ufpoints}}=6.3$ mm; df=320; p<0.001: t-tests, bifacial points and scrapers; $\text{mean}_{\text{bfpoints}}=11.9$ mm; $\text{mean}_{\text{scrapers}}=6.1$ mm; df=290; p<0.001).

Necessarily, demonstrating that bifacial points produce larger flakes than other implement types is not the same as demonstrating that they produce useable flakes. As discussed in the previous chapter, at DRS and KKH there is little evidence that people were prepared to retouch flakes much below 15 mm – a parameter that would preclude the majority of flakes resulting from reduction of bifacial points. Conceptions of what is a useful blank for implement manufacture are, however, changeable**,** as the data from EBC make clear. Moreover, implement manufacture and artefact use are not interchangeable concepts – many flakes are used without having been retouched and some flakes are retouched without ever subsequently being used (cf., Hiscock 2004).

Cores may provide additional insights into this issue. Unlike implements, for which the provision of fresh flakes is likely to be a sundry concern, cores are largely dedicated to flake production. Consequently, it seems improbable that people would continue to reduce cores much beyond the point at which they could yield useful debitage. Thus, the sizes of flakes produced immediately prior to discard are probably broadly indicative of the limits of the sizes of flakes deemed useable. Unfortunately, core scar data were not all collected in quite the same way as scar data from retouched flakes. The exception is the hemispherical core forms, radial and levallois, for which data comparable to those used for bifacial points are also available.

Figure 8.45 presents boxplots of flake scar sizes for the hemispherical core forms (as a single grouping) and for bifacial points. Table 8.8 presents data on number of cases, and the mean and standard deviation of scar size values. Overall, the two sets of values are markedly similar. A t-test for differences in mean values suggests that they are not statistically significant (p=0.316). If we accept the proposition that flake size is in part a determinant of the useability of a flake, then it appears reasonable to suggest that the flakes produced during retouch of bifacial points were often as useable as those resulting from the reduction of hemispherical core forms. Insofar as this reflects on implement versatility, it suggests that bifacial points were indeed capable of performing multiple roles.

8.3.3 Reliability and maintainability

Numbers of implements

Carrying multiple implements at any given time is one means by which the reliability of a system can be increased. The deployment of multiple implements might be thought of as ‘numerical redundancy’ in a similar vein to which the loading of a single tool with multiple similar parts may be thought of as functional redundancy. Clearly, it is not possible to assess directly whether people carried multiple implements during any given foraging expedition. What can be assessed is how many implements of a given class were manufactured at any time. The manufacture of large numbers of similar implements seems to be a necessary precondition for the transportation of multiple similar implements.

In order to calculate numbers of implements per unit time, it becomes necessary to treat as absolute numbers the age ranges inferred for each temporal grouping. The problems inherent in this approach are obvious. The age ranges are only approximations, while the continuity of occupation at any site may have been highly variable between groupings or between sites within groupings. Thus, actual amount of time for which one site is occupied within in 5 kyr will be variable fraction of that total. And in the case of the >74 ka grouping, no rates can be calculated at all. Nevertheless, and as with other data presented here, use of numbers of implements per unit time provides the approach that is available, even if it is not the ideal approach.

Table 8.9 presents data on changes in numbers of implements per unit time for each temporal grouping in the study period. Differences in excavation size will have affected numbers of implements recovered per unit time. For that reason, only data from the two 1 m^2 excavations – DRS and KKH – are presented. Even with this control, however, comparability needs to be restricted to within rather than between sites. DRS has a much larger floor area than KKH. Consequently, activities at KKH are likely to be more focalized. If we hypothesise that the same number of implements were discarded at both sites, the probability that any one of those implements would have been recovered within the sampled 1 m^2 area is necessarily higher at KKH than at DRS. For that reason we would expect return rates for any unit time within the sampled square to be lower at DRS.

Table 8.9 bears out these expectations and presents some interesting patterns. As anticipated, discard rates for implements are considerably higher at KKH than in comparably aged groupings at DRS. Of more interest are the through-time patterns within sites. At DRS, relatively few similar implements were discarded in the 70 ka – 65 ka and the 60 ka – 55 ka groupings, with moderate rates of discard pertaining from 62 ka – 60 ka and 74 ka – 70 ka. The highest rate of discard for any given class of implement occurs from 65 ka – 62 ka. At KKH, though numerous similar implements were again discarded from 65 ka – 62 ka, peak discard occurs in the 62 ka – 60 ka grouping. Thereafter, relatively few implements in a given class were discarded at any point in time.

Implement edge angles

Edge angles provide a control on implement maintainability. Sustained reduction of artefacts will be more difficult when edge angles are high than when they are low. Figure 8.46 presents data on edge angles for various classes of implements – again, due to sample size, implements from all sites and temporal groupings are considered together. Table 8.10 presents associated data on number of measured edges, mean angle and standard deviation. Notable from the graph are the very high retouched edge angles of backed artefacts, and the relatively low retouched edge angles of bifacial points. Indeed, while the retouched edges of backed artefacts are considerably higher than those of any other class, the retouched edges of bifacial points are significantly lower. T-tests reveal differences at $p<0.01$ between the mean edge angles of bifacial points and the implement classes with the two nearest mean values: unifacial points and scrapers (t-test, bifacial points and unifacial points; $\text{mean}_{\text{bfpoints}}=57.2°$; $\text{mean}_{\text{ufpoints}}=60.5°$; df=318; p=0.009: t-test, bifacial points and scrapers; $\text{mean}_{\text{bfpoints}}=57.2°$; $\text{mean}_{\text{scrapers}}=62.8°$; df=290; $p<0.001$).

If edge angles influence the capacity of an implement to sustain on-going reduction, then it follows that bifacial points convey benefits in terms of maintainability over the other implement forms considered. The presence of low edge angles around the perimeter of bifacial points may also have facilitated use in cutting and related tasks (cf., Lombard 2006). Unlike unifacial points and scrapers, bifacial points have an edge around their entire perimeter, including at the butt end. It is sometimes suggested that the butt-thinning of bifacial points was undertaken to primarily to facilitate hafting (eg., Clarkson 2006). While in some cases this may be true (eg., Ahler and Geib 2000), it is not necessarily so given that forms such as unifacial points and scrapers, which are also believed to have been hafted, rarely exhibit thinning of the butt.

If the butts of bifacial points were only thinned for hafting purposes, while the lateral and tip edges of a point were thinned for functional reasons, we might expect to see some differentiation of the resulting edge angles in these locations. If the objective was only to thin the butt, there would be no need for it to taper to a sharp edge. Figure 8.47 compares the angles of the retouched edges of bifacial points at the butt, sides and tip. All groups have similar distributions and similar median values, and t-tests suggest that any differences that can be observed are not statistically significant at a cut-off of $p<0.05$.

While interesting, on its own, the similarity of edge angles at various locations along the perimeter of bifacial points is not sufficient to counter the suggestion that thinning was primarily related to hafting. More problematic for this argument are differences between bifacial and unifacial points. Like bifacial points, unifacial points have been suggested to have been used in-haft (Lombard 2005b). If thinning of the kind applied to bifacial points was necessary for hafting, then we would expect to see similarities in edge angles at the butt end between these two implement types. Figure 8.48 compares the edge angles of the butt ends of unifacial points with those measured at the junction of the dorsal face and platform on unifacial points. Table 8.11 presents data on number of cases, mean angles and standard deviations. Butt ends of unifacial points considerably less acute then those of bifacial points. A t-test of differences in mean values suggests that the observed differences are statistically significant (t-test; $\text{mean}_{\text{bfpoints}}$=58.9°; $\text{mean}_{\text{ufpoints}}$=81.6°; df=142; $p<0.001$). If unifacial points were hafted then it seems relatively clear that tapering butts were not hafting requirements. Given this and the above observation of similarities in edge angles around the perimeters of bifacial points, it seems reasonable to suggest that the design of bifacial points created the potential, even if it was not often realized, to use a greater proportion of the edges of these implements than was common among other implement types.

Evidence of standardisation

The available sample of complete implements places significant restrictions on the assessment of standardisation for most classes. For example, only 16 of the bifacial points analysed during this study were complete and these were spread between two sites. Of nearly 90 notched flakes, only 28 were complete, and the largest sample of complete specimens from any given site was 13. Backed artefacts are the only implement type for which reasonably large numbers were analysed at more than one site, and even then sufficiently large numbers can only be attained by conflating samples from two age groups at the sites of DRS and KKH. At KKH, conflating the 65 ka – 62 ka and 62 ka – 60 ka groups allows the additional complete backed pieces from the 1984 excavation to be added to the 2006 sample. At DRS, additional backed artefacts were analysed from squares adjacent to the 1 m x 1 m area that provides the remainder of the flaked stone artefact data. All of these backed pieces derive from what has been identified as the 'Howiesons Poort with engraved ostrich eggshell' (cf., Parkington *et al*. 2006; Rigaud *et al*. 2006), which correlates here with the 65 ka – 62 ka and 62 ka – 60 ka groupings.

The questions of interest with respect to standardization are whether a) implements were made in a consistent range of shapes and sizes, and b) whether these shapes and sizes were determined by standardisation of the shapes and sizes of available blanks. Because a reliable index of shape was not applied to all artefacts in the DRS and KKH assemblages, analysis will largely focus on questions of size.

One important issue that needs to be addressed first involves identifying what kinds of blanks were used in the manufacture of backed artefacts. Wurz (2000; also Soriano *et al*.

2007) has argued that backed artefacts were always manufactured on blades, or elongate flakes. The problem with this idea is that, as noted in Figures 8.3, 8.10 and 8.15, the correlation between the manufacture of elongate flakes and the manufacture of backed artefacts is not particularly strong in the sequences considered. Elongate flake are common when backed artefacts are rare at DRS, and persist after backed artefacts have ceased to be made at KKH. Moreover, demonstrating the form of the original blank on which a backed artefact is made is difficult because retouching alters the morphology of the piece. Thus, we cannot say with any great confidence whether a given retouched flake was made from an elongate blank.

With these points in mind, Figure 8.49 presents data on the lengths and widths of all complete flakes and complete backed artefacts from relevant layers at DRS and KKH. Several points can be made on the basis of Figure 8.49. First, not all of the backed artefacts in the sample are elongate. Roughly equal numbers of elongate and non-elongate backed artefacts occur. This is not necessarily significant, given that retouching can alter both length and width, such that the elongation of a retouched piece may be either higher or lower than the elongation of the blank from which it was made. With respect to the DRS data, however, it can be noted that around one in five (20.3%) of the backed artefacts has a width exceeding 20 mm. Out of a population of 165 elongate flakes, only three (1.8%) were wider than 20 mm, suggesting that blades of such width were rarely made at or transported to DRS. Moreover, the backed artefact data are minimum estimates – retouching will have led to reductions in the widths of the original blanks in most cases. Pearson's Chi-square test suggests that the difference in prevalence of artefacts >20 mm wide among elongate flakes and backed artefacts is statistically significant at $p<0.001$.

It might be tempting to suggest that the poverty of elongate flakes >20 mm reflects their preferential transformation into backed artefacts. However, this temptation should be resisted, given that the single square from which the flake data were drawn yielded only seven complete backed artefacts. Even if we were to assume that all seven of these were manufactured from elongate blanks exceeding 20 mm in width, the resulting proportion of 10 elongate flakes >20 mm wide to 155 elongate flakes <20 mm wide remains significantly different from the proportions among backed artefacts (Pearson's Chi-square test; $p=0.001$). Taking into consideration these points, it appears much more likely that blanks for these wide backed artefacts were drawn from the non-elongate, rather than the elongate flake population.

The data from KKH are more equivocal on the question of original blank form. While there are no clear reasons to preclude the use of elongate flakes in backed artefact manufacture, neither is there significant support for this idea. Of 65 backed artefacts examined, only 22 were elongate. There is thus no reason to assume that all backed elongate flakes were used as blanks in all or even most cases. Given this, analysis of the relationship between the size of backed artefacts and the sizes of available blanks will begin with the assumption that any complete flake >15 mm could have been used in backed artefact manufacture.

Figures 8.50–8.52 give histograms of maximum dimension, maximum width and maximum thickness for all complete flakes in the 65 ka to 60 ka layers at DRS and KKH. In all cases, these dimensions display a single, heavily right-skewed mode. That is, flakes become more numerous as they become smaller. One-sample Kolmogorov-Smirnov tests suggests that all of these distributions depart significantly from normal (Table 8.12).

If the blanks for backed artefacts were randomly selected from the sample of available flakes, we would expect to see similar patterns of distribution in their dimensions. Even allowing that there was a lower limit imposed on the size of blanks that people were prepared to transform into backed artefacts, we would expect to see a peak in the numbers of backed artefact dimensions at or around that limit, with a long tail of larger dimensions.

Figures 8.53–8.55 displays histograms of maximum dimension, maximum width and maximum thickness for complete backed artefacts in the 65 ka to 60 ka layers at DRS and KKH. With respect to maximum dimension and maximum width, the distributions are modal and are not left-skewed. If anything, the distribution of backed artefact maximum dimensions at DRS is slightly right-skewed. Table 8.13 presents Kolmogorov-Smirnov tests for normal distribution for these data. The results suggest that the distributions of backed artefact dimensions do not vary significantly from normal. Thus, we can reasonably suggest that there are differences in the distributions of sizes among backed artefacts and complete flakes. The implication is that some factor other than the range of available blanks is influencing patterns in the distribution of backed artefact sizes. A second issue of interest is how the sizes of backed artefacts compare with the sizes of available blanks.

Table 8.14 presents the results of non-parametric Mann-Whitney tests for differences in the sizes of complete flakes and backed artefacts at DRS and KKH. At both sites, backed artefacts are found to be significantly larger and thinner than complete flakes. At KKH, backed artefacts are also significantly narrower than flakes, though this does not hold at DRS. It is worth recalling at this point that the dimensions, most specifically the maximum dimension and width of backed artefacts is a minimum estimate of the size of the original blank. Consequently, the comparative narrowness of backed artefacts at KKH may be a result of heavier reduction of the lateral margins. This does not, however, explain why backed artefacts are generally bigger in maximum dimension than complete flakes, nor why they are thinner.

Blanks for backed artefacts are not, it seems, drawn randomly from the sample of available flakes. Given this, and the arguments of other researchers, it seems worthwhile to explore the relationship between backed artefacts and elongate flakes. Figures 8.56–8.58 presents histograms of maximum dimensions, maximum width and maximum thickness for complete elongate flakes in the relevant layers at both DRS and KKH. With the exception of thickness at KKH, elongate flake dimensions are generally far less right-skewed than dimensions for complete flakes.

Table 8.15 presents on-sample Kolmogorov-Smirnov tests for normal distributions in the samples of elongate flakes. The data suggest that, with respect to maximum dimensions and maximum widths, the sample of elongate flakes at DRS does not depart significantly from a normal distribution. In no case, however, are the elongate flakes at KKH distributed normally.

In spite of previous arguments to the contrary, it might be considered theoretically possible that the backed artefacts at DRS were randomly selected from the available population of elongate flakes. Mann-Whitney tests are used to explore this possibility (Table 8.15).

The data suggests that there are significant differences in the maximum dimensions and maximum widths of backed artefacts and elongate flakes. In both dimensions, backed artefacts tend to be bigger than elongate flakes. These are the same two dimensions with respect to which both samples exhibited relatively normal distributions. Given that retouching can only have reduced maximum dimension and widths for backed artefacts, the data, if anything, are underestimates of the differences between these two groupings.

Any argument to the effect that patterning in the sizes of backed artefacts is dictated by patterns in the size of elongate flakes can be rejected, as can similar arguments for the relationship between backed artefacts and complete flakes. The more probable explanation for the observed patterns in backed artefacts sizes is that knappers at both DRS and KKH consistently used blank selection and retouch to make backed artefacts within a restricted range of sizes through time.

One point of further interest in this respect concerns the differences in backed artefact dimensions between these two sites. As could be noted from Table 8.13, backed artefacts at DRS have a mean maximum dimension of 35.7 mm (s.d.=8.0), while those at KKH have a mean of 29.9 mm (s.d.=5.2). Thus, the DRS backed artefacts tend to be slightly larger than their KKH counterparts. However, complete flakes at DRS tend to be slightly smaller (t-test; mean_{DRS}=26.3, s.d.=7.6; mean_{KKH}=28.1, s.d.=9.5) and narrower (t-test; mean_{DRS}=17.1, s.d.=6.6; mean_{KKH}=18.4, s.d.=8.7). Table 8.17 presents Mann-Whitney tests for the significant of the differences between flakes, and between backed artefacts at the two sites.

A number of points can be made from Table 8.17. First, there are significant differences in the sizes of complete flakes at DRS and KKH, at least with respect to maximum dimension and maximum width. Second, there are significant differences in maximum dimensions of backed artefacts at the two sites. Third, differences in the sizes of flakes do not predict differences in the sizes of backed artefacts. Knappers at DRS had access to significantly smaller flakes but made significantly bigger backed artefacts. Given these points and those discussed above, and assuming that the backed artefacts in the available samples were made on-site in both cases, it seems reasonable to conclude that a) knappers at DRS and KKH consistently made backed artefacts of similar dimensions between 65 ka and 60 ka, that b) these consistencies were not dictated by the dimensions of available flakes, and that, c) backed artefact making practices were different at these two sites.

8.4 DATA RELEVANT TO LANDUSE SYSTEMS

This section considers data pertinent to patterns of land-use across the study area. The data considered include changes in discard rates through time at sites at which this can be ascertained, changes in the prevalence of small flaking debris, and evidence of changes in mobility and population dispersal.

8.4.1 Numbers of discarded artefacts

Discard rates are often used as a coarse proxy of intensity of site use. Clearly, this approach is problematic (Hiscock 1981). Discard rates may be influenced by changes in provisioning systems and knapping techniques without any associated differences in the frequency or duration of site visits, or in the numbers of people using a site. The afore-noted problem of age approximations is also as relevant here as it was for rates of implement discard. The potential confounding influence of these factors will be considered in the subsequent chapter.

Figure 8.59 presents line graphs of discard rates for the various age groupings at DRS and KKH – the only sites for which appropriate data are available. Table 8.18 presents relevant data on artefact numbers and time elapsed. Only artefacts >15 mm are considered. Minor differences in sieve mesh sizes may potentially complicate comparisons between sites if small flaking debris are included. Artefact numbers from the 55 ka – 35 ka grouping at KKH are arbitrarily doubled to overcome the halving of the sampling area.

Discard rates are moderate at DRS and remain relatively stable from 74 ka through to around 65 ka. In the 65 ka – 62 ka grouping, discard rates increase by about 50%. This is followed by a slight fall in discard rates in the 62 ka – 60 ka grouping, albeit that in the overall context, discard rates from 62 ka – 60 ka might be considered relatively high. After 60 ka, discard drops away markedly to around 10% of peak values. Some time after 55 ka the site appears to have been abandoned and not reoccupied until the Holocene.

Discard rates at KKH in the 65 – 62 ka grouping are similar to those at DRS. After 62 ka, however, and following what appears to be some drying out of the study area, discard rates at DRS and KKH diverge. While rates at DRS decrease by around 25%, those at KKH increase nearly 300%. This peak is short-lived, with subsequent dramatic decreases returning discard rates to some 50% of pre-62 ka values. From 55 ka through to 35 ka very few artefacts were discarded at KKH. Indeed, from the inferred age of 55 ka through to OIS 2-occupation of the site around 25 ka only 432 artefacts were discarded. Thus, the number of artefacts discarded in the 30 kyr from 55 ka to 25 ka – effectively the duration of OIS 3 – is less than one tenth of the number discarded in the last 5 kyr of OIS 4.

Greater resolution on changes in discard rates at KKH can be achieved by examining differences in artefact density on a layer-by-layer basis. Unlike DRS, which had finely resolved stratigraphy, KKH was excavated in arbitrary 25 mm spits. One advantage of this is that it allows artefacts numbers per spit effectively to act as proxies for artefact density. Figure 8.60 presents changes in artefact numbers through the KKH sequence. Values for the layers below unit Dv are doubled. Figure 8.60 adds some potentially interesting detail to the information provided in Figure 8.59. Most notable are the two peaks in artefact numbers within the unit Dvi. These peaks provide a simple explanation for the bimodality in backed artefacts numbers noted earlier in this chapter. After the more recent peak – which ends around 60 ka – artefact densities rapidly decrease and, excepting a few brief reverses, remain at low values thereafter.

Separating the two peaks at KKH is a well-defined trough, centred on Dvi11. This is also the layer in which a brief but strongly marked peak in quartz prevalence was observed (cf., Figure 8.9). Though phytolith analysis suggests Dvi11 to be the last of the very wet layers at KKH (see Appendix A), though it may be that the analysed sediment sample was taken from the base, or near to the base of the layer. Certainly, some considerable reorganization of technology and site use appears to have occurred around this time.

If discard rates can inform us about changes in site use, they appear to suggest that peak occupation of both DRS and KKH occurred between 65 ka and 60 ka. Diminished site use appears to have pertained at both sites before and after this period. OIS 3 occupation appears to have been particularly brief and/or infrequent. There is, however, a notable divergence in site use between DRS and KKH after 62 ka. At this time, discard rates at DRS fall while those at KKH surge dramatically.

8.4.2 Small flaking debris

The prevalence of small flaking debris may be informative of changes in on site artefact manufacture. If artefacts are primarily transported as large pieces and discarded on site without significant reduction, we might expect to see relatively low ratios of small to large flaking debris. Alternatively, when materials are heavily reduced on site, we might expect this ratio to increase.

The problem with the concept of ‘small flaking debris’ is whether and where, on the basis of size, a line can reasonably be drawn between flakes produced as by-products of reduction and those which might have been considered useable. An associated problem is that the limits of what people considered useable clearly changed through time and space. Thus, an arbitrary limit, such as that used here between artefacts >15 mm and artefacts <15 mm, may be reasonable under some circumstances and unreasonable under others. The following results should be considered with these limitations in mind.

Figure 8.61 present bar graphs of ratios of artefacts <15 mm to artefacts >15 mm at DRS and KKH. Requisite data are not available from the other three sites. At DRS, small flaking debris is generally uncommon in layers from 30 to 50 – that is, before 70 ka. Above layer 30 there is a variable but persistent trend towards increased ratios of small to large flakes. Above layer 15 – some time between 65 ka and 62 ka – ratios reach peak values, and, though variable from layer to layer, generally persist at comparable rates through to layer 8 – some time between 62 ka and 60 ka. Thereafter, a rapid decrease returns ratios to values comparable to those pertaining prior to layer 15.

The pattern at KKH is not entirely dissimilar. A steep increase in ratios of small to large artefacts occurs some time between 65 ka and 62 ka, following a succession of layers with moderate to low ratios. High ratios persist through to Dvi9 – some time between 62 ka and 60 ka. Ratios reach a nadir in layer Dvi4. In layers above this, ratios are highly variable, probably reflecting small layer-by-layer samples. Some samples lacked small flaking debris entirely.

In order to overcome some of the sample-dependent variability in the data, and to facilitate comparison of the DRS and KKH data, Figure 8.62 presents ratios for both sites against temporal groupings. At both sites, the highest ratios of small to large flakes occur in the 65 ka – 62 ka and 62 ka – 60 ka groupings though peak values occur in the older grouping at KKH and in the younger grouping at DRS. Before 65 ka at DRS, and after 60 ka at both sites ratios of small to large artefact are generally quite low, though as noted previously, the trend to increased values at DRS commences during, rather than after, the 70 ka – 65 ka grouping. After 55 ka at KKH ratios increased but, in the overall context might reasonably be considered moderate.

If the data are informative about changes in on site artefact reduction / production, then they would tend to imply that such events peaked from 65 ka to 60 ka. The poverty of small flaking debris in earlier and later contexts would appear to imply that artefacts were transported to, and perhaps occasionally maintained on site before 65 ka, but that on site artefact production was comparatively infrequent. In the more recent groupings at KKH there are some suggestions of a return to on site production, and perhaps a mix of production and artefact transportation.

8.4.3 Variation in hornfels prevalence

Patterns in the prevalence of certain materials may help to explore changes in the range of habitual movements, and also in the dispersal of populations within the study area. Hornfels is of particular interest in this respect, being available in the Doring zone, and 30 km north of sites in the Olifants and Sandveld zones.

Table 8.19 presents data on the prevalence of hornfels as a percentage of assemblage totals for each age grouping and overall at the five sites. The inter-site comparability of the data is complicated by the fact that different classes of artefacts were analysed at different sites. Thus, while all artefact classes were analysed at DRS and KKH, only complete flakes and cores were recorded at KFR. EBC data derive from retouched flakes and cores, while the

HRS data are taken from Evans (1994). In order to help overcome these comparability problems, one column presents data on complete flakes only. This at least creates comparable data sets for one site in each of the three zones. Note that, in all cases, artefacts <15 mm are excluded. The reason for this is that material could not always be identified with great certainty on what were often very small artefacts and fragments.

A number of temporal and spatial patterns are evident in the data from Table 8.19. At DRS, the prevalence of hornfels increases markedly after 70 ka with peak percentages occurring in the 70 ka – 65 ka and 62 ka – 60 ka groupings. Relatively high percentages are also recorded in the 65 ka – 62 ka and 60 ka – 55 ka groupings. This pattern holds both among complete flakes and all assemblage components. In a similar vein, data from KFR suggest greater prevalence of hornfels after 65 ka than before 74 ka.

There is a relatively clear contrast between changes in hornfels prevalence at these two sites and at KKH. At KKH, percentages are uniformly low in pre-25 ka contexts, and there is no evidence of a significant peak in the 65 – 60 ka groupings. Only after 25 ka do percentages occur that are comparable to those reported in Holocene layers of the site (cf., Orton and Mackay 2008).

The temporal grouping data for KKH mask some important aspects of the sequential variability in hornfels prevalence at the site. In total, only 20 hornfels artefacts >15 mm were recovered from the ~40 kyr sequence. Of these, 50% (n=10), came from a single layer – Dvi11. A further 20% (n=4) came from the layer immediately above it – Dvi10. In total, only seven of the 32 layers into which the sequence is divided had any hornfels artefacts at all. This contrasts with the presence of hornfels in 43 of 50 layers at DRS, and in all layers at KFR and HRS.

Figure 8.63 plots numbers of hornfels artefacts on a layer by layer basis for the pre-55 ka layers at KKH that is, for units Dvi and Dvii. Also included in the figure are total artefact numbers. Three points can be made from the data presented. First, the peak in hornfels is brief and unsustained. Second, the peak is not a result of increased sample size – the layers above and below Dvi10/11 have more artefacts and little or no hornfels. Third, the peak in hornfels correlates with the sudden decrease in the number and density of artefacts which immediately precedes, or is possibly contemporaneous with, the onset of dry conditions at the site around 62 ka. Of perhaps further interest is the observation that at DRS, though hornfels is a contributor to almost all layers, the single highest percentage value in the sequence occurs in layer 10 – the second oldest layer in the 62 ka – 60 ka grouping. Indeed, of the 52 hornfels artefacts in this grouping, 28 (54%) derive from the two oldest layers – a pattern similar to, if less dramatic than that at KKH

Overall, the data suggest that hornfels was transported to KKH exceedingly rarely, despite its availability 30 km to the north and its consistent presence in contemporaneous assemblages 25 km east (KFR) and 50 km west (DRS). This lack of transportation cannot be explained in terms of the unsuitedness of the material to the manufacture of important implement types; hornfels is used in the production of both backed artefacts and unifacial points at DRS (though, perhaps importantly, not bifacial points). Nor can it easily be explained in terms of excessive transport distances; if the occupants of DRS could and indeed did habitually transport hornfels over distances of 30 km, why didn't the occupants of KKH? Similarly, in the Holocene, where a seasonal round of movements from the Sandveld to the Olifants has been proposed, hornfels accounts for 2-5% of assemblage totals in Olifants sites. Clearly then, at certain times and under certain conditions, people were willing to transport hornfels to the Olifants valley. The question that remains is why this did not happen before 25 ka.

The most likely explanation for the pattern appears to be that the occupants of KKH simply did not often travel more than 30 km to the north or east, or 50 km to the west, prior to 25 ka. Beyond the issue of habitual movements, this also has implications for the issue of population dispersal. In a hypothetical 'minimum dispersal' scenario, one group of people would make regular movements across all three zones of the study area. This almost certainly did not happen between 65 ka and 55 ka (where sample sizes are largest), and probably not between 65 ka and 35 ka. Indeed, the data from this period appear more consistent with the 'maximum dispersal' scenario, where each zone was occupied by a different group. If people were not regularly moving between the Doring zone and the Olifants, or between the Olifants and the Sandveld, it seems almost impossible that they were regularly moving between Sandveld and the Doring without at some stage occupying sites in the intervening zone.

Viewed in this light, the differences between backed artefact sizes at DRS and KKH, as discussed above, potentially take on greater significance. At both sites, but particularly at DRS, people made backed artefacts in ways not strictly dictated by the sizes of available blanks. The backed artefacts at the two sites, however, were consistently different. If there was little movement between the Sandveld and Olifants zones from 65 ka to 60 ka, then these differences may well reflect population-specific manufacturing habits.

While interesting, the KKH hornfels data are effectively mute on the issue of changes in mobility prior to 25 ka. Little can be said beyond the observation that distances greater than 30 km were probably rarely travelled at this time. Another rare material – a non-indurated brown shale – may be informative in this respect. Though the material is of unknown origin, it comprises 1.4% of the overall KKH assemblage. Through-time patterns in the prevalence of the materials are presented relative to temporal groupings in Table 8.20.

The data suggest little variance in the prevalence of brown shale prior to 55 ka. In spite of this, it was used in the manufacture of three of the backed artefacts in this part of the sequence. After 55 ka, however, the prevalence of this material increases dramatically, to around 7% of the assemblage total. In these contexts, the material was used in the manufacture of one scraper, one notched piece, one unifacial point, and, most intriguingly, in the manufacture of a ‘parti-bifacial point’ (Plate 8.*7*).

As noted, unlike hornfels, the origins of this material are unknown. Whether it can be used an indicator of mobility is thus unclear. However, non-indurated shale is recorded as a significant assemblage component at HRS. Furthermore, the material is quite fine-grained (though less so than hornfels) and very homogenous – flaking characteristics likely to be favoured in transported materials. Finally, the material was demonstrably popular in implement manufacture. If we accept that this brown shale was the kind of material that was likely to be procured if encountered, then its low frequency before 55 ka appears to support the proposition that a limited range of movements pertained at this time. The extension of this argument would therefore be that its increased prevalence in the upper layers is a reflection of an increase in the frequency with which it was encountered, and thus of some extension of the range of movements.

9

DISCUSSION

9.1 INTRODUCTION

This chapter is divided into four sections. In the first, the sequence synchronization which was used to structure results in Chapter 8 is reviewed. The initial synchronisation was developed on the basis of a small number of variables. The review reconsiders it in light of subsequently presented data. The second section discusses and interprets the results presented in Chapter 8 in terms of the hypotheses from optimal foraging and the organisation of technology, as presented in Chapter 6. The third section explores the evidence for technological variation at key environmental transition points. Also included in this section is a consideration of the causes underlying the disappearance of prepared cores from the study area. The chapter ends with an examination of the results in terms of the alternative hypotheses.

9.2 REVIEWING THE SEQUENCE SYNCHRONISATION

In the preceding chapter, two lines of evidence were used to organize the data into a series of age groupings. The most important line of evidence derived from chronometric dating of some of the sites. At least two of the sequences were completely undated, however, and the remaining three were only partially dated. In order to incorporate all components of all sites, recourse was taken to the principle that like changes probably occurred in the study area at like-times. Thus, changes in undated sequences were inferred to have occurred at around the same time as similar changes in dated sequences. By these means, all components of the assemblages under consideration were reconciled into a single temporal framework.

Both of the approaches used entail problems. The OSL ages from DRS and KKH have large error ranges, and in some cases are in conflict with other age estimates arrived at by the same or other means. Choices were therefore made about which ages were to be preferred with only a cursory assessment of their relative scientific validity. Furthermore, in relation to calculations like discard rates, ages had to be treated as absolute numbers, an application which is fraught at best. Unfortunately, if a study such as this one is to go ahead, these problems must simply be acknowledged and accepted.

The issues relating to the comparability of assemblages are somewhat more manageable. Primarily, as Jacobs et al's (2008a) dating program shows, the basic presumption that 'comparability in form = comparability in age' tends to work, even at relatively large spatial and temporal scales. The question at hand is how well it worked in the present case, particularly given problems of occupational discontinuities and the attempted comparison of some undated contexts.

Though four measures were discussed, the initial synchronization was largely developed using just two – implements types and material prevalence. A third measure which is sometimes used – blade prevalence – was found not to be particularly sensitive. Variance in implement types and material prevalence have been central to most of the industrial classifications developed in southern Africa. As such, the primary role they were afforded in the present synchronization allowed some reflection on the imputed ages of assemblages under consideration by comparison with the ages of similar assemblages at other sites across southern Africa. Though far from an independent check, the fact that, for example, backed artefacts become common at many southern African sites in the last half of the OIS 4 provides a measure of confidence in assigning an age within this range to the backed artefact-rich layers at DRS, KKH and KFR.

These same measures, however, highlight some of the problems of the method in the present context. For examples, at DRS and KKH, layers containing unifacial points overly those containing backed artefacts, mirroring a sequence seen elsewhere in southern Africa. At KFR, however, layers containing backed artefacts overly those containing unifacial points. How useful, then, are unifacial points as a temporal marker? More to the point, how useful are backed artefacts, given that they occur in all sites and in almost all periods considered? At DRS and KKH the backed artefact-rich layers are also silcrete-rich, yet this material is uncommon at KFR. Should we then infer that the backed artefact-rich layers at KFR are of a different age, potentially younger, than those at DRS and KKH, or can the variation be put down to the effects of local environmental factors? These problems cannot readily be resolved.

What can be considered is how well alternative measures, such as ELM, flake and core weight, core types, heat treatment and discard rates cohere with changes in implement types and materials. In general, the answer appears to be ‘quite well’. Sequences of changes in core weight, for example, are generally consistent between all sites, while tendencies in flake sizes and ELM values agree well at DRS and KKH. Where values vary between sites, variance is generally explicable in terms of differences in the availability of materials around the different sites. Thus, though bipolar reduction was common at DRS from 65 ka to 60 ka and uncommon in this period at KKH, it could be noted that material was more readily available around KKH, and that cores were, as a consequence, usually larger there than at DRS. Inter-site deviance in artefact discard rates, and the prevalence of small flaking debris, as discussed below, may be understood in similar terms. Perhaps as importantly, where values may vary between sites, changes, and the sequence in which they occur were usually found to be the same.

Ultimately, then, though the bases on which the synchronisation was developed are questionable in a number of respects, there do not appear to be any objections, based on the subsequently presented data, to its present configuration. Nor is there any obvious way in which the configuration can be improved or refined. Given these points, though its limitations need to be kept in mind, the following interpretation will proceed without alterations to the previous organization of temporal groupings.

9.3 DISCUSSION OF TECHNOLOGICAL CHANGES THROUGH SPACE AND TIME

Chapters 4, 5, 6 and 7 discussed the factors which might influence the structure of stone artefact assemblages, and thus provided some means for interpreting observed changes. In this section, those ideas are applied to the sequences presented in Chapter 8. The organisation of this section is chronological, proceeding from the oldest grouping to the youngest.

9.3.1 Layers > 74 ka

Hypothesis

This grouping is one of the more difficult to interpret, both because none of the layers involved has been directly dated, and because comparability between the ages of layers within sites or between sites cannot be assumed. Thus, though the relevant layers at DRS are internally consistent and may all be like-aged, several of the layers at KFR are quite different from one another, and also from those at DRS. Another problem is that the first of the two hypotheses discussed below, though it is entitled '>100 ka', effectively only concerns the period from 120 ka to 100 ka – that is, the earliest part of OIS 5. It is possible however, that either or both of the early sets of layers at DRS and KFR are older than 120 ka, and relate to a period of occupation in OIS 6. Again, though there is no way of resolving this issue, it is something which should be borne in mind.

Leaving these issues aside, two different sets of conditions for which hypotheses were generated fall within this age grouping. In the hypothesis for >100 ka occupation, it was suggested that relatively benign and occasionally moist conditions would have favoured low, primarily residential mobility, population dispersal, and little investment in complex technological aids. In the subsequent, 100-80 ka hypothesis, decreases in temperature and increases in variability were expected to have favoured greater mobility (albeit with a continued focus on residential organization), greater population clumping, and the development of more complex, maintainable systems.

Assessment

The former hypothesis appears to describe the assemblage at DRS, and the layer 9 assemblage at KFR, relatively well. In both cases, technological systems can be considered to be relatively low-cost overall. Material procurement patterns do not depart strongly from a neutral model, suggesting low magnitude costs (Figure 8.14 and 8.22). The general poverty of implements provides little or no evidence of significant investment in the manufacture of complex implements at either site (Figures 8.1 and 8.13). In the selection of implements which are present, there is no marked repetition of form such as might denote standardized patterns of manufacture. From this alone, any suggestion of an emphasis on reliability would be hard to support. In relation to the issue of maintainability, it can be noted that none of the forms present, which include two notched pieces, a backed artefact and a burin, are particularly amenable to extended episodes of retouch. Only in the comparatively high weight of cores and flakes at discard (Figures 8.26, 8.32 and 8.33), with the attendant implication of greater procurement frequency costs, is there a suggestion of departure from least-cost systems.

The transport of large cores may have also involved energetic costs, however, the degree to which this holds true depends on whether these cores were actually transported any great distance, and how great that distance was (e.g., how mobile populations were in the period). If people were simply acquiring material as needed and discarding it soon thereafter, then the abundance of large, particularly quartzite artefacts is simply explained by the prevalence of that material in the immediate surrounds of the site at which the artefacts were discarded. If artefacts were not being transported, the strategy being employed would not have required a great deal of planning depth, something for which the generally beneficent conditions inferred for early to mid-OIS 5 would probably have allowed.

The presence of hornfels at DRS at about 2.8% of the artefact total in these layers implies some acquisition of materials from >30 km (Table 8.19), though the fact that this value is well below the overall site average of 4.6% suggests that, if hornfels can be used in this way, then overall mobility magnitude was indeed, relatively low. Silcrete, probably derived from ~20 km away in the case of DRS, is also poorly represented at this time (3.2% of the artefact total). In relation to the preceding discussion, this would seem to imply that, though some artefacts were transported and maintained over relatively long distances, the majority were probably locally acquired and discarded at DRS. Unfortunately it is not possible to address this issue at KFR with the information presently available.

With regard to the way in which movements were organized, small flaking debris are generally poorly represented in the >74 ka layers at DRS (Figures 8.62 and 8.63) – again there are no comparable data from KFR. Ratios of artefacts >15 mm to those <15 mm are often less than 1 : 1 in layers in this age grouping; peaks values exceeding 5 : 1 occur between 65 ka and 60 ka. The implication is that comparatively little on site manufacture and/or maintenance of artefacts took place at DRS prior to 74ka, with most having been made prior to arrival on site. In concert with the small overall assemblage sizes at both KFR and DRS, the data, though not conclusive, seem consistent with brief episodes of occupation by possibly small, probably residentially mobile populations, than with prolonged occupation by large, or largely logistically-organised groups.

Layer 7 and 8 at KFR differ in several respects from those underlying them, and from the >74 ka layers at DRS. While quartzite continues to be the dominant material, there is a notable increase in the proportions of fine-grained rocks, particularly in layer 8. While this cannot immediately be assumed to have involved greater magnitude procurement costs, given that the distribution of materials around the site is unknown, it may have some relationship to the incremental increases in ELM values through layers 9, 8 and 7, and the decrease in core and flake weight at discard. The implication is of some ‘trading-off’ of magnitude and frequency costs.

Another interesting aspect of layers 7 and 8 at KFR is the large number of implements discarded. As noted in Table 8.6, ratios of implements to amorphously retouched flakes are higher in the >74 ka grouping at KFR than in any other grouping at any other site. And this includes layer 9, which contributed a single retouched flake and no implements.

The implements present in this grouping are also diverse, including multiple examples of backed artefacts, unifacial points, denticulates and notched flakes. The characteristics of these implements are also quite variable. Unifacial points and deticulates, for example, are among the heavier of the implement classes studied, while notched flakes and backed artefacts are relatively lightweight (see Figure 8.31). Unifacial points and, to an extent, deticulates, are also quite maintainable, while none of the backed artefacts examined showed retouched other than to the blunted ‘backing’ edge. Thus, while the presence of implements in quite large numbers appears to indicate considerably greater investment in technological complexity in these layers than in layer 9, the nature of those implements is quite heterogeneous, potentially implying their accumulation during multiple, separate episodes, or over long periods of time. Unfortunately, the available data do not allow these issues to be considered further at KFR.

Conclusion

The data from DRS, and from layer 8 at KFR, are generally consistent with expectations for > 100 ka occupation. There are no strong indications that populations ranged widely across the landscape at this time, and in spite of the fact that cores are quite large, there are no signs of significant on site artefact production that might be taken to imply use of the site as a base from which logistical forays were undertaken. The technological strategies employed were relatively low-cost without being least-cost.

Though limited, the available data from spits 8 and 9 at KFR seem a better fit with 80-100 ka hypothesis. Certainly, the fit here is considerably better than that in the lower layers at DRS. However, while there are no mismatches, the data are not internally coherent, and are entirely mute on issues relating to mobility and dispersal. The lack of dating is key weakness – multiple periods of occupation may well be represented.

9.3.2 Layers 74 ka – 70 ka

Hypothesis

Two sites – DRS and HRS – have assemblages dating between 74 ka and 70 ka. The hypothesis relevant to this age grouping is that generated for the period 80 ka – 70 ka. The expectations of this hypothesis were that further deteriorations in temperature, coupled with persistent long-term temperature instability would have encouraged high mobility, and, through the period, a switch of emphasis from primarily-residential to primarily-logistical. Populations were expected to move from more clumped to more dispersed, while the combination of abundance- and predictability-related risk was expected to have been reflected in heavy investment in complex technologies, with design systems featuring both reliability and maintainability.

Assessment

The onset of this period at DRS is marked by an increase in silcrete, though quartzite remains the dominant material (Figures 8.2 and 8.22). The presence of silcrete at between 10% and 30% of assemblage totals at DRS is not consistent with observations concerning the material’s prevalence in the surrounding landscape, and this it seems unlikely that such high values would result from neutral procurement. With respect to magnitude costs of procurement, therefore, this period does appear to witness an increase in costs over those pertaining earlier.

Magnitude costs at HRS are less easy to assess; the lack of information concerning the local distribution of rock types precludes assessment in terms of the neutral model, and a lack of information from earlier and later periods precludes assessment in relative terms. Nevertheless, it can be noted that the proportions of fine grained rocks generally increases through the HRS sequence (Figures 8.20 and 8.22). There is some comparability between this sequence at that at DRS, at least insofar as the latest layer in the grouping is also the most silcrete-rich at both sites.

With regard to the issue of frequency costs, it can be noted that cores are considerably smaller in this period than in that preceding it (Figures 8.26). ELM values are also slightly higher than in layers older then 74 ka (Figure 8.24). It is also notable that this is one of only two age groupings in the DRS sequence where broken flakes are recycled into implements with any great frequency, again, implying conservativism in discard practices.

With regard to implement reduction, of 15 bifacial points in the DRS assemblage, only four are complete. Of these, one is coarsely worked, and a further two might be classed as 'roughouts' (Plate 9.1). If these are excluded, breakage rates at DRS are comparable to those at Sibudu (cf.,. Wadley 2007). The fine, soft hammer-worked points which are used to characterize the Still Bay at sites like Blombos are represented at DRS primarily as broken tips. This, combined with the evidence for point recycling (Plate 8.6), suggests an unwillingness on the part of past knappers at DRS to discard points which retained substantial amounts of utility. Together, these data suggest conservative reduction of provisioned material, possibly as a means of off-setting procurement expense. At the same time, and with respect to subsequent developments, the degree of conservativism might be assayed to be relatively moderate – cores and flakes are much smaller in subsequent layers.

With respect to technological investment, the bifacial points which constitute the dominant implement form in this period could reasonably be described as among the most complex forms deployed in the study sequence. Bifacial points require comparatively large amounts of material to manufacture (Figure 8.31; Table 8.7), and, as Villa *et al.* (2009) note, they may have high rates of production failure, meaning that the time and material expended may often prove to have been wasted. In spite of these costs, the discard rate for bifacial points in this period at DRS is higher than the discard rate for any other implement in any other period, excepting backed artefacts in the 65 ka – 62 ka grouping (Table 8.9). Backed artefacts, of course, require considerably less material to make.

In this regard, it is worth recalling Hiscock's (2006) concepts of abundance and extension, whereby the limited material requirements of some implement types, notably including backed artefacts, make it easier to manufacture them en masse, while the heavier requirements of other types, including bifacial points, place greater constraints on the number that can be made (though this is off-set by their greater maintainability). In spite of the fact that the bifacial points in the study sample weighed on average ~5 times as much as the backed artefacts, their peak prevalence was more than half that of the peak prevalence of backed artefacts. The implication, consistent with observations at other sites, is not only that bifacial points are relatively complex and materially expensive, but that they were made in large numbers nonetheless. In terms of costs, and factoring in those arising from the magnitude and frequency of procurement, the overall investment in technological systems in this period at DRS, and probably also HRS, must be considered to be relatively high.

With regard to design systems, as discussed in Chapter 4, bifacial points are considered to be among the most maintainable and versatile of artefact forms. The data presented here tend to bear this out. The additional weight built into bifacial point design facilitates not only maintenance, but also the potential for recycling. Bifacial points also have lower edge angles than any of the other implement forms analysed (Table 8.10), and an edge around the entire perimeter that is perhaps better explained in terms of providing a larger potential working area than strictly in terms of hafting. In additional, bifacial points provided larger scars from retouch events than other implement forms (Figure 8.44), and the flakes produced from these events were, for at least part of the use lives of the points, comparable in size to those produced from radial and levallois cores in their latter stages of reduction (Figure 8.45; Table 8.8).

Unfortunately, due to the high breakage rate among bifacial points it was not possible to address the issue of standardization in morphology. What can be reiterated, however, is the previous point that these implements tended to be 'over-produced' at this time (Tables 8.6

and 8.9). Numbers of implements per 100 artefacts are at a peak in the 74 ka – 70 ka grouping, while the ratios of implements to amorphously retouched pieces is relatively high. Though it is impossible to say whether multiple bifacial points were deployed in the field at any given time, the abundance of these implements at least creates the possibility for this to have occurred.

One interesting facet of the DRS assemblage in this period is that hornfels does not increase in frequency (Table 8.19). Indeed, at around 2% of the total, hornfels is less common in these layers than in any other, including those underlying them, and is less common than in Holocene assemblages at the nearby site of EBC. However, while hornfels decreases in prevalence at this time, silcrete, available at around 20 km, increases markedly. There seem to be two possible explanations for this contrast. The first is that habitual ranges of movement contracted at this time, diminishing access to hornfels, but allowing for continued access to silcrete. Within this context, silcrete was then preferentially sought-after in order to improve the reduction efficiency and maintainability of artefacts.

The second possibility is that hornfels was simply not a preferred material in the manufacture of bifacial points, and was thus only collected occasionally. This second possibility is consistent with the observation that none of the bifacial points or fragments thereof at either DRS or HRS were made on this material. At the same time, bifacial points are only one aspect of the technology in use at this time – cores and other retouched flake forms continue to occur – and it seems odd that a predictably flaking material with good reduction potential was overlooked at a time when high quality materials were seeing greater use, and when reduction practices were becoming increasingly conservative.

With regard to evidence for on site artefact manufacture, small flaking debris is again quite rare, with less than one artefact <15 mm for every one >15 mm though most of the grouping (Figures 8.62 and 8.63). This contrasts with an overall ratio at DRS of 1.6 : 1, and peak ratios in excess of 5 : 1. Other than the three roughed out points, there is little evidence for significant on site manufacture of bifacial points implements. Most of the points in the DRS assemblage are represented by broken tips (n=8), and there are comparatively few butts (n=1). If points were being made on site, we might expect to see a more even ratio of tips to butts, unless butts were preferentially recycled, though the data for this is negligible. Alternatively, it is possible that the overabundance of the former reflects pieces that broke in haft without the butt having become detached, though this is simply speculative. No examples of manufacturing errors, such as those noted at Blombos by Villa *et al.* (2009), were observed in the available sample. This aside, the data are not strongly suggestive of the use of DRS as a logistical base between 74 ka and 70 ka, given which, it might be inferred that the main form of mobility organisation was residential.

If overall artefact discard rates can be taken as an indicator of patch use, the implication of the data presented in Table 8.18 is either that site visits were relatively infrequent, or relatively brief, or, possibly both. Though not as low as values registered for the period 55 ka – 60 ka, discard rates from 74 ka – 70 ka were the second lowest overall.

There are no clear indications that occupants of DRS in this period covered large territorial areas. Indeed, the diminished frequency of hornfels suggests that habitual ranges may have contracted. When considered in light both of the absence of evidence for much on site artefact manufacture and the high rate at which implements were discarded, these data might suggest a residentially mobile group moving comparatively rapidly within a constrained territorial range. The data from HRS are, again, too limited to be of much value in this regard, but perhaps more importantly, they are insufficient to compare and contrast the technological systems deployed at HRS and DRS. To conclude that the two technologies were similar would simply reflect the criteria used to group them.

Conclusion

The technological expectations of the hypothesis for this age grouping were generally met. Moderate quantities of high-quality material were acquired and large numbers of complex, maintainable implements were made. The extra weight of these implements would probably have resulted in greater energetic costs of transportation, however, people appear to have been prepared to bear these costs in order to improve the maintainability and flexibility. Similarly, though procured material was more heavily reduced prior to discard than it had been in the preceding grouping, reduction was considerably less intense than in the groupings that followed. Again, the implication appears to be that some redundancy was built into technological systems, potentially as a hedge against environmental uncertainty.

Aside from the persistence of residential organization in the initial part of the period, however, the expectations relating to mobility were largely unsupported. None of the available evidence unambiguously pointed to an increased range of movement at this time. Indeed, the indicator used implies a contraction of range. The associated inference of greater population clumping could not be sustained.

9.3.3 Layers 70 ka – 65 ka

Hypothesis

This age grouping witnessed the onset of glacially-cold temperatures, but also a reduction of medium to long-term temperature variability. Technologically, it was hypothesized that either very high or least-cost systems would be required to overcome subsistence risks at this time, with the availability of water an important unknown. In the case of high cost systems, the emphasis of technological design was expected to be on reliability. In either case, high magnitude of mobility, with a focus on logistical organization was anticipated, while potential decreases in seasonality of water availability may have favoured population dispersal.

Assessment

This age grouping is only represented at one site – DRS. It is possible that the very earliest layers at KKH relate to the tail-end of the period, however, the evidence is relatively thin, and the samples are too small in any case to be useful in isolation. At DRS, the period begins immediately after the succession of three layers in which backed artefacts and bifacial points overlap. In spite of this, the period 70 ka – 65 ka is generally depauperate in implements and displays little evidence of an emphasis on morphological regularity (Figure 8.1, Tables 8.6 and 8.9). The other key characteristics of the technological systems in DRS at this time are the emphasis on quartz, and the heavy reduction of procured materials (Figures 8.22, 8.24, 8.26, 8.32 and 8.33).

As noted in Chapter 8, material selection in this period only departs from neutral in the apparent over-selection of quartz at the expense of quartzite. The postulated reason for this was that quartz offers better reduction potential, which allows more edge length to be produced from a given amount of transported rock. In the 70 ka – 65 ka grouping, the available data suggest that people tended to transport small cores (Figure 8.26), which would almost certainly have lessened the energetic costs of artefact transportation. The maximal reduction of procured material would, in turn, have delayed the frequency with which new material was required. Combined, these points appear to exemplify the idea of least-cost systems, with minimized outlays of time on the procurement and transportation of materials, and the production of implements.

One of the other notable features of this grouping at DRS is the high percentage of hornfels in the assemblage (Table 8.19). At 6.6%, only the 62 ka – 60 ka grouping has a greater percentage, and the difference is negligible (0.1%). While there is less silcrete in this unit than previously, it was still encountered sufficiently frequently to account for 17.6% of the assemblage total at a time when material selection patterns appear to have been more strongly geared towards neutral procurement. The implication is that the range of habitual movements increase considerably over that pertaining in previous groupings.

With regard to the organization of mobility, there is a marked through-time increase in the ratio of artefacts <15 mm to artefacts >15 mm (Figure 8.61 and 8.62). Overall ratios generally exceed 1 : 1 for the first time in the sequence. The implication is of an increase in on site artefact manufacture, though ratios remain well below peak values. The period also saw an increase in artefact discard rates, though, again, the change was comparatively minor, and rates remained well below peak values (Figure 8.59). Combined, the suggestion of more on site artefact manufacture and slightly greater patch use may reflect relatively brief episodes of logistically-organised site use. In the absence of evidence for occupation of other sites in the study area, the issue of population dispersal is difficult to approach. As the data from the succeeding grouping suggest (discussed below), even the increase in hornfels, with its attendant implications of an increased range of movements, is not necessarily indicative of clumped populations moving across the study area as a whole.

Conclusion

Technologically, the data presented here strongly favour the second of the two proposed technological alternatives. There is little or no evidence of significant investment in high-cost technologies from 70 ka – 65 ka. The inferences of high mobility magnitude and primarily logistical organization were also substantiated, though weakly in the second case. In the absence of occupation at multiple sites, however, the issue of dispersal could not be addressed.

9.3.4 Layers 65 ka – 62 ka

Hypothesis

This period saw the continuation of cold temperatures, albeit slightly warmer than those in the preceding grouping, and the onset of medium to long-term temperature stability. To this picture, the phytolith data from KKH add very high levels of moisture availability. Again, it was predicted that either high-cost or least-cost systems may have pertained, though with the abundance of moisture probably tipping the balance in favour of high-cost solutions. An emphasis on reliability over maintainability was expected. The availability of water was seen to also favour a persistence of logistical organisation, though the magnitude of that mobility would necessarily have remained high, as would the dispersal of populations across the study area. An emphasis on heavy use of specific patches was not predicted.

Assessment

This grouping is the first to include evidence of occupation at three sites – DRS, KKH and KFR – though the inclusion of KFR is perhaps a little tenuous. This aside, the presence of comparably-aged assemblages in three sites and three different zones allows for a broader range of comparisons, particularly those pertaining to population dispersal.

The key technological characteristics of assemblages in this grouping are the presence of relatively large numbers of morphologically regular implements (Tables 8.6 and 8.9), most notably backed artefacts, the high percentage of fine-grained materials (Figures 8.14 and 8.22), the very small size at discard of flakes and cores (Figures 8.26, 8.32 and 8.33), and high edge length to mass values (Figure 8.24).

The increase in silcrete at DRS and KKH almost certainly required a significant increase in magnitude procurement costs. At DRS in particular, high quality silcrete is not known within 20 km of the site, yet this material accounted for more than 70% of all artefacts in many layers in this grouping. While it is probably more readily available at KKH, its presence at 75-90% of assemblage totals is clearly not consistent with its availability in the local area. Necessarily, then, procurement systems were far more targeted in this period, and locally-available materials must actively have been eschewed in favour of those with more favourable knapping characteristics.

Off-setting increases in magnitude costs were probable decreases in frequency costs brought about by greater reduction of procured materials. At all sites, cores and flakes in this grouping were very small at discard. In spite of this, an additional set of time-costs may have been borne in the form of heat treatment (Figures 8.29 and 8.30). The apparent heat treatment of artefacts in the 65 ka – 62 ka grouping at KKH and possibly DRS would have acted to improve the knapping characteristics of procured rocks at the expense of accumulating a reasonable fuel load with which to undertake the task. The viability of this process would almost certainly have been dependent on the available supply of wood in the area.

With respect to technological costs, knappers at DRS and KKH, and, to a lesser extent, KFR, invested heavily in the manufacture of large numbers of implements in this period. Implement discard rates peak in this period at both DRS and KKH (Table 8.9), while ratios of implements to amorphously retouched pieces are very high at all sites (Table 8.6). Combined, though offset by diminished frequency costs, the high magnitude procurement costs, considerable investment in complex implements, and use of heat treatment make it seem most reasonable to characterize this period as a time of heavy overall investment in technological systems.

Backed artefacts, the key implement type in this period at all sites, suggest that the emphasis in technology was probably on reliability, rather than maintainability. While the tools of which backed artefacts are components can be maintained through replacement of parts, this necessarily requires breaking down of the tool, and, assuming the use of mastic in hafting, some complex processing to return the tool to functionality. Other forms, such as points and scrapers, have the advantage of being maintainable while still in-haft. Backed artefacts do not.

With respect to their reliability, it is also noted that knappers went to considerable lengths to create backed artefacts of a consistent range of sizes at both DRS and KKH (Figure 8.49-57; Tables 8.12-8.17), and, given the very large numbers of these implements at all sites, there is the additional possibility that multiple implements were deployed in the field at any given time. The available data do not, however, allow the contention that backed artefacts were a relatively versatile tool to be assessed (cf., Robertson *et al*. In Press).

The other implement form common to this period – notched flakes – may have had an element of maintainability. Several authors have noted that the use-lives of notched and denticulated pieces can be extended by the addition of new notches through time (cf., Hiscock and Clarkson 2007; Holdaway *et al*. 1996). Of the 46 complete and broken notched flakes discarded in this grouping, however, 34 (74%) were single notched, and six of the remaining nine were doubled notched. If restricted to complete examples, the percentage of single-notched pieces increases to 80%, or 12 or 14. Multiple notching of pieces was, it seems, very rare in this period.

If hornfels provides a reasonable reflection of mobility changes at DRS and KKH, the implication would appear to be that the range of habitual movements contracted at this time. At DRS the percentage value of 4.7% compares favourably with the overall average (4.6%), but is lower than that in preceding and subsequent groupings (6.6% and 6.7% respectively – cf., Table 8.19). At KKH, hornfels was a negligible assemblage component (0.2%). Unlike the 74 ka – 70 ka grouping, where the material was not used in implement manufacture, 10 of the 235 complete and broken backed artefacts recorded during this study were made on hornfels. Four of these derive from the sample of 98 specimens at DRS. The associated percentage value of 4.1% is comparable to the overall prevalence of the material at the site in this period (4.6%), and suggests that people transformed hornfels flakes into backed artefacts at a similar rate to that at which it was acquired. Technological preference thus provides no clear explanation for the decrease in overall prevalence.

The implications of patterns in hornfels prevalence go beyond range contraction, however. Given that the material accounts for ~15% of artefacts at KFR and ~5% of artefacts at DRS, its near absence at KKH appears to suggest that movements between the three zones were highly infrequent. It also contrasts with the Holocene pattern at KKH and other sites in the Olifants zones, where hornfels regularly accounts for 2-5% of assemblage totals. The implication is that, at this time, populations may have been dispersed across the study area, consistent with the maximum dispersal scenario proposed in Chapter 7. The marked differences in backed artefact manufacturing habits at DRS and KKH provide some support for this suggestion[24]. If we take KKH as the rough midpoint of an elliptical territory

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[24] An alternative explanation for the differences in the sizes of backed artefacts at these two sites might be that they served different functional purposes. There are several problems with the explanation. First, it would imply that late Pleistocene backed artefacts were applied to a different set of tasks than backed artefacts in the

constrained to east and west by the Olifants watershed and to the north by the confluence of the Olifants and Doring, the resulting territorial range is in the order of 950 km^2 (Figure 9.1). This is well within the range of territories maintained by modern mid-high latitude African hunter-gatherers (cf., Kelly 1995). It seems plausible, therefore, that from 65 ka to 62 ka, the study area was occupied by three different population groups. Whether this has implications for dialect-level language differences (cf., Weissner 1983) obviously cannot be assessed, though it does raise the possibility that DRS and KKH occupied the fringes of a liminal zone between sandveld-organised and mountain- or interior-organised populations.

With regard to the organization of mobility, both DRS and KKH witness considerable increases in ratios of artefacts <15 mm to artefacts >15 mm, particularly towards the end of the grouping (Figure 8.62 and 8.63). The data thus suggest that more on site artefact manufacture took place at this time than in preceding groupings. This, in concert with peak discard rates at DRS and very high discard rates at KKH (Table 8.18), is consistent with a logistically-organised system of mobility, whereby sites were used as bases at which materials were reduced and implements produced, and from which logistical forays into the surrounding landscape could be launch. Discard rate suggest either that the duration of site visits in this period were comparatively long, or that they were more frequent than in previous periods, or possibly both.

Conclusion

Both high and least-cost technological systems were considered possible in this period. The data presented favour the former, with high cost, reliable systems strongly in evidence. Inferences about mobility form and population dispersal were supported. While high rates of discard suggest heavy patch use, the fact that this occurred at all sites makes it appear that all patches were occupied with equal intensity. This is consistent with the abundance of moisture associated with this period. There was no support for the suggestion of high mobility at KKH, however, and only weak support for it at DRS. The issue could not be approached with data from KFR.

Holocene, given that the two tend to differ considerably in size (cf., Thackeray 1992). Second, size does not appear to influence function in other implement forms. As Villa *et al.* (2009) point out, for example, the sizes of bifacial points can vary widely within and between bison kill sites, but the game remains the same.

9.3.4 Layers 62 ka – 60 ka

Hypothesis

At some point around 62 ka southern hemisphere temperatures began to increase and moisture levels in the study area appear to have decreased dramatically. Initial drying out is likely to have led to elevated levels of risk, and possibly either very high or least-cost technological systems. Subsequent amelioration would have lessened risk, though technological investment is expected to have remained high. A continued emphasis on reliability was predicted in either case. The viability of logistic mobility will have been drawn into question by reductions in moisture availability across the study area; magnitude of mobility is almost certain to have increased. With the availability of water was having decreases, the significance of reliable patches will have increased, with consequent spatial variability in the intensity of patch use and increased clumping of populations.

Assessment

The technological systems employed in this period display as much within-site variance as any of the groupings considered. At both DRS and KKH, the period begins with a surge in quartz, very low flakes sizes and peak ELM values (Figure 8.22). No implements were discarded in the first few layers of this grouping at DRS, while at KKH there are very few backed artefacts or notched pieces in comparison with immediately preceding and subsequent layers (Figures 8.1 and 8.5). In respect to these measures, the technological systems deployed do indeed appear to approximate least-cost solutions. It is notable, however, that silcrete continues to occur in reasonable proportions at both sites, accounting for 15-40% of artefacts at DRS and ~60% at KKH. In the case of DRS, this implies that around one quarter of all rocks in the assemblage were being sourced from at least 20 km away. In that respect, the early post-62 ka technologies seem most similar to those pertaining in the last few layers of the 70 ka – 65 ka. Increased mobility may provide a partial account of this pattern (discussed below), though it is also possible that this was a time of rapid, conceivably even seasonal, strategic switching in response to new or variable climatic conditions.

Soon after the quartz surge, technological systems at both sites revert to something more like those pertaining prior to 62 ka. Silcrete is comfortably the dominant material, ELM values decrease and flake sizes increase at both DRS and KKH, though in the overall context ELM values remain high and flakes small (Figures 8.22, 8.24, 8.32 and 8.33). There are also signs of heat treatment of procured materials (Figures 8.29 and 8.30. Backed artefacts reappear at DRS and occur in large numbers at KKH (Figures 8.1 and 8.5), and indeed, the discard rate for backed artefacts specifically peaks in the latter layers of this grouping at KKH (Table 8.9), though there are fewer implements per 100 artefacts and a lower ratio of implements to amorphously retouched pieces than in the grouping that preceded it (Table 8.6). Given these points, technological systems in the upper layers of the 62 ka – 60 ka seem to have been as costly as those in the 65 ka – 62 ka grouping.

With respect to the kinds of technological design systems involved, there is no evidence of implement maintainability. The implements that were discarded at this time are those argued to have been more reliable than maintainable. As noted, implements were also produced in relatively large numbers given the apparently short period of time involved. The evidence of backed artefact standardization discussed in the 65 ka – 62 ka grouping is also relevant to the present grouping, given that backed artefacts from both groupings were combined to provide sufficient sample size. The implications of this are worth considering. The quartz spike with which this period began almost certainly reflects some disruption of prevailing land use and technological systems (discussed further below). Yet, the samples of backed artefacts from DRS and KKH both display single modes, implying some consistency in manufacturing habits across this disruption. Unfortunately, the available samples are too small to explore whether this appearance of consistency is an artefact of sample conflation or is a real feature of technological systems at DRS and KKH.

With respect to the issue of mobility, hornfels is at its most pronounced in this grouping at DRS, accounting for 6.7% of the artefact total and 8.1% of complete flakes (***Table 8.19***). This represents a conspicuous rise over previous percentage. As noted in the preceding chapter, the increase is most pronounced in the early, quartz dominated layers 11 and 10, where 11.3% of all artefacts >15 mm are made from this material. In the uppermost layers, the value falls to less than 5%. A similar pattern is noted at KKH, where the increase in quartz correlates with a drop in artefact numbers and a significant but unsustained increase in hornfels. The implication appears to be that, for a relatively brief period after 62 ka, the frequency of movements >30 km increased at both sites. How this relates to population dispersal is less easy to assess, though it does appear to imply at the very least some greater frequency of interactions between the three zones.

In terms of the organization of mobility, ratios of artefacts <15 mm to those >15 mm are high in this period at both DRS and KKH, with peak rates occurring at the beginning of the period (Figures 8.61 and 8.62). The data are suggestive of a continuation of significant on site artefact manufacture. The inference is that logistical use of sites, whereby material was brought to and reduced on site, continued.

While there is considerable consistency between DRS and KKH in most of the measures considered, a marked divergence can be observed in overall artefact discard rates. While rates in this grouping at DRS are slightly lower than those from 65 ka – 62 ka, rates at DRS increase dramatically, reaching peak values of more than 1500 artefacts per thousand years. This would appear to suggest much heavier patch use in the area around KKH.

The apparent divergence in patch use rates at this time allows another interesting, if currently untestable scenario to be proposed. If we accept the propositions that a) water around KKH was more reliable than around any of the other sites considered, that b) water around the Doring zone sites was less reliable than elsewhere, and that c) KFR was abandoned some time around 62 ka, then the increase in discard rate and hornfels prevalence at KKH may be reconciled in terms of the disruption of occupancy in the interior parts of the study area, and an associated increase in movements from the Doring zone to the Olifants zone.

Conclusions

Though this period is one of the more complex and interesting considered, expectations were largely met. Certainly, the early part of the period, during which cold and dry conditions prevailed, saw evidence of significant disruptions to technological and land use systems in a number of markers. Technologies at this time appear to have reverted to near-least-cost, albeit with some continued acquisition of silcrete in reasonable quantities. Subsequent technological systems were more high-cost, though the emphasis on reliability persisted. Mobility also increased in magnitude at the start of the period, and the anticipated variance in patch use between well-watered and less well-watered sites appears to have occurred. Not obviously supported was the suggestions of a reorganization of mobility away from logistical systems. In spite of the dramatic decrease in moisture, it appears that groups continued to pursue systems involving on site artefact manufacture during relatively extended periods of occupation.

9.3.5 Layers 60 ka – 55 ka

Hypothesis

Temperatures in this grouping were increasingly warm but also increasingly unstable. A shift towards more residential organization is anticipated, along with comparatively brief periods of patch occupancy, and a decrease in population clustering. With lower overall risk, investment in technological systems is expected to have decreased, and the focus of technological systems is expected to have changed from an emphasis on reliability to an emphasis on maintainability in response to increasing temperature instability.

Assessment

Technological systems at DRS and KKH seem in several respects to diverge around or some time after 60 ka. At DRS, silcrete remains the dominant material in most layers in this grouping, suggesting a continued emphasis on the acquisition of costly materials (Figure 8.22). At KKH, on the other hand there is an incremental shift in material selection towards neutral ratios through the period. Similarly, though cores increase in size at both sites, there is a marked, and again incremental increase in flake sizes at KKH that is not mirrored in the data from DRS (Figure 8.26). In several respects, magnitude and frequency costs of procurement at KKH come, by the end of the period, to more closely resemble those in the >74 ka groupings at KFR than those in the 60 ka – 55 ka grouping at DRS. One notable exception is in the apparent persistence of evidence for heat treatment of silicious rocks at KKH (Figures 8.29 and 8.30), though whether this occurs at the begin, the end, or all through the period cannot be discerned with the available data.

In terms of the complexity of technological systems, the ratio of implements per 100 artefacts is relatively high at DRS and moderate to high at KKH, as are ratios of implements to amorphously retouched pieces (Table 8.6). The implication is of an increase in investment in morphologically regular artefacts at DRS, and a slight decrease at KKH.

However, there is also a relatively dramatic decline in rates of production for the dominant implement type – in this case, unifacial points –at both sites (Table 8.9), perhaps signaling a greater diversity of focus in implement manufacture, and a decrease in the numbers of any given implement available at any given time. Overall, levels of technological complexity are relatively high at DRS and moderate at KKH.

Notably, the most common implement types in this grouping – unifacial points and scrapers – might both be described as maintainable, based on analyses made elsewhere (eg,. Bousman 2005; Clarkson 2002a,b; Dibble 1984, 1987). If implement edge angles are a constraint on on-going reduction, however, it might be suggested that these forms are somewhat less maintainable than the bifacial points manufactured from 74 ka – 70 ka. Similarly, these implement forms appear to lack the facility to provide usable flakes from retouch events, making them less versatile. There is, however, some evidence of for recycling of unifacial points at DRS. Again, the point that might be taken from this is that the extra mass of unifacial points allows not only extended maintenance, but also, occasionally, some flexibility.

Overall, the technological systems employed in this period at DRS appear to have been more costly than those at KKH. While both sites witness the production of reasonable numbers of maintainable implements, the occupants of DRS continued to procure predictably flaking, but difficult-to-acquire-materials, while selection at KKH was much closer to neutral.

With respect to the issue of mobility, hornfels prevalence declines slightly at DRS (Table 8.19), but remains above average for the site overall. This appears to suggest a decrease in the frequency of movements >30 km. The frequency of such movements may be comparable with those pertaining during the wettest part of OIS 4. It might also be noted that the decline is relative to the 62 ka – 60 ka grouping as a whole. However, as discussed above, the overall value from 62 ka – 60 ka was inflated by peak values in the earliest layers, with hornfels contributing ~5% to assemblages in the later layers. In that sense, the frequency of moves >30 km appears to have changed little immediately either side of 60 ka.

At KKH, neither hornfels nor brown shale provide any indication of changes in the magnitude of mobility (Tables 8.19 and 8.20). Of equal note, the complete absence of hornfels from layers in this grouping at KKH suggests that whatever factors had led to the spike in hornfels in layers Dvi11 and Dvi10 had entirely ceased to operate by this time.

In spite of the absence of evidence for increased mobility at KKH, and the somewhat equivocal nature of the data at DRS, artefact discard rates decrease by 80% at KKH and almost 90% at DRS (Table 8.18). Less than 50 artefacts per thousand years represent the occupation of DRS in this period. Consequently, though long distance movements may not have become any more common at this time, the frequency and/or duration of visits to patches around DRS and KKH appear to have decreased considerably.

Similar decreases are noted in the ratios of flakes <15 mm to flakes >15 mm (Figure 8.62), apparently indicating a shift away from on site artefact production. This might be seen to be consistent with a shift in technological emphasis away from reliable, but non-maintainable implements, towards what might be thought of as regularly transported and maintained ‘personal gear’ (cf., Binford 1980; Kuhn 1995).

Conclusion

The apparent divergence of technological trajectories noted at DRS and KKH towards the end of the 62 ka – 60 ka grouping becomes increasingly marked in this period. Binding the two groupings is the presence of unifacial points, however, it seems entirely plausible that occupation of DRS in this period had become increasingly episodic. There are no such indications at KKH, where changes in most markers are incremental through the period.

With respect to the hypothesis, a decrease in technological investment almost certainly occurred at KKH, though this suggestion is not unambiguously supported for DRS. At both sites, however, the expectation of a switch from reliability to maintainability was met. Similarly, though mobility organization probably switched to residential at both sites, the magnitude of mobility does not appear to have changes in either case. The suggestion of diminished periods of patch use at both sites, was, however, consistent with the available data.

9.3.6 Layers 55 ka – 35 ka

Hypotheses

Two hypotheses are relevant to the data in this grouping. In the first hypothesis, that relating to the period 55 ka – 45 ka, it was suggested that highly variable but generally falling temperatures, allied to what were probably quite good moisture levels, would probably have encouraged high magnitude mobility within a primarily logistical system. It was also thought possible, however, that highly unstable conditions may have resulted in the alternating use of different mobility systems through the period. Similar consequences were expected for the dispersal of populations in the study area. Falling temperatures are also likely to have encouraged an extension of duration of patch occupancy through the period. With both abundance and predictability affecting risk, very heavy investment in systems that were both reliable and maintainable was expected, though the possibility of a reversion to least-cost systems was not precluded.

In the second hypothesis, that relating to the period from 45 ka – 30 ka, increasingly cold and stable conditions were expected to have encouraged greater mobility, though with the emphasis on logistical organization being retained, assuming reasonable levels of moisture availability. Duration of patch occupancy, given increasing resource poverty, is likely to have become extended across the study area. Given decreased variability, any emphasis on maintainability was expected to have given way to a fuller focus on reliability. At the same time, however, with conditions at the end of the grouping being as cold as any in earlier periods, the probability of least-cost systems was suggested to be greater than in the 55 ka – 45 ka grouping.

Assessment

Assessing the data from this period in terms of either of the hypotheses is complicated by the very small sample size at the only occupied site – KKH. The data that are available suggest that material selection practices were close to neutral, with quartz and quartzite the dominant rock types (Figure 8.22). Though silcrete continued to account for 10-15% of assemblage totals, it should be recalled that the material is thought to be more readily available in this area than around DRS. It can also be noted that the locally-available CCS/FGS appears largely to have subsumed the role of predictably-flaking material with good ELM potential (Figure 8.23). The implication is that, when predictably fracturing rocks were required, they were more likely to be sourced from local conglomerate beds rather than from more spatially discrete silcrete outcrops.

ELM values were highly variable through the period (Figure 8.24), though the general pattern was of an initial return to more conservative reduction, followed by a gradual decrease in conservativism. In spite of this, both cores and flakes in the period were generally very small – the cores notably being smaller on average than in any but the subsequent grouping (Figure 8.26). Bipolar reduction was also very common (Figure 8.25). Thus, in spite of the low magnitude costs, efforts also appear to have been made to reduce the frequency costs of reprovisioning.

The most obvious facet of technological complexity in this period is the near-absence of implements (Figure 8.5). Only three implements were recovered from layers in the ~30 kyr between the 55 ka date at the end of unit Dvi, and OIS 2 occupation of the site. Even factored against the very small sample size, discard rates for implements, whether measured relative to every 100 artefacts, or to amorphously retouched pieces, were exceedingly low (Table 8.6). The discard rate for implements in the dominant class – scrapers – was 0.3 per thousand years (Table 8.9). It is difficult to sustain a finding of other than low cost for the technological complexity of this period. This, in combination with near-neutral material selection and heavy reduction of procured pieces, argues strongly for a least-cost system overall.

If anything can be concluded from the implements that were recovered in this period, it is that they were generally suited to a degree of on-going maintenance. Two of the implements were scrapers and other one a unifacial point. Any conclusions based on such a small sample would be speculative in the extreme.

Discard rates for this period were very low (Figure 8.59; Table 8.18). The occupational episodes represented were likely infrequent and brief. In spite of this, there are minor suggestions of on site artefact manufacture in the form a slight increase in the ratio of artefacts <15 mm to those >15 mm above values in the preceding grouping (Figures 8.61 and 8.62). To interpret this as reflecting logistical mobility, however, seems unsound.

What may be noted with respect to mobility, though again tentatively, is the increase in the prevalence of hornfels in this period (Table 8.19). Though the increase is minor, a concomitant and more significant increase in brown shale appears to support the suggestion of a greater range of movements at this time (Table 8.20). It could be that this reflects periodic reoccupation of KKH by groups moving in from more distant locations.

Conclusion

It is not possible to identify with any certainty which of the two periods of time for which hypotheses were generated the present data best fit. The key characteristic of the period is perhaps the presence of least-cost technological systems. While this was predicted in both hypotheses, it seemed a more probable component of that developed for the period 45 ka – 30 ka. The suggestion of high mobility common to both hypotheses appears to have been substantiated, though the configuration of mobility, as with population dispersal, remains unknown. Patch use was clearly minimal.

9.3.7 Layers 25 ka – 16 ka

Prediction

Extremely cold temperatures, coupled with reasonable levels of moisture and long-term temperature stability were expected to have encouraged high magnitude of mobility within a logistically-oriented system. Extended use of patches was predicted to have resulted from diminished overall resource availability. With abundance-related risk at its highest levels, there were seen, again to be two potential outcomes in terms of technological investment – one featuring very high levels of investment, the other featuring least-cost systems. In the former case, reliability was expected to pertain.

Assessment

Two sites, KKH and EBC, show signs of occupation in this period.. The assemblage from KKH is only small, and the data collected from EBC are partial. Again, therefore, interpretations are largely suggestive.

With respect to technological organization, both sites witness an abundance of quartz and a poverty of more difficult-to-acquire rocks (Figure 8.22). The near-absence of silcrete at

KKH is particularly remarkable, given that the material is available reasonably close to the site. Again, however, the role played by silcrete in earlier contexts is probably being filled at this time by CCS/FGS (Figure 8.23).

Cores are very small at both sites, and bipolar reduction is relatively common, particularly at KKH (Figures 8.24 and 8.25). The flakes at KKH are small (Figures 8.31 and 8.32) and have moderate to high ELM values (Figure 8.23). As with the 70 ka – 65 ka and 55 ka – 35 ka groupings, the emphasis here appears to have been on acquiring readily-available materials and heavily reducing them.

Evidence of significant investment is equally poor with respect to complex technological systems. At KKH rates of implements per 100 artefacts are at their lowest, as are ratios of implements to amorphously retouched flakes (Table 8.6). At EBC, however, ratios of implements to amorphously retouched flake appear to be relatively high. Rates of implement discard per thousand years were not calculated for either site, due to the extensive area excavated at EBC and the absence of effective start and end dates for the period at KKH. These data aside, the available evidence seem to be heavily slanted in favour of least-cost technologies.

The small available sample at KKH, and the partial nature of the EBC sample hamper serious consideration of mobility magnitude in this grouping. Of the available indicators, at KKH it is noted that hornfels is at a relative peak, accounting for 2.4% of the assemblage total (Table 8.19). While this is higher than its value in any other grouping, it is based on a single artefact. Brown shale accounts for 2.4% of the total (***Table 8.20***), which is down on previous values, but again, there are only two specimens in the sample. Insofar as these data are meaningful with respect to mobility, they would appear to suggest that magnitude of mobility was moderate to high at this time.

At EBC, hornfels accounts for 5.1% of the assemblage total, though this may be an overestimate. Accepting it at face value, however, it would appear to imply mobility ranges comparable with those in parts of the early to mid-Holocene (cf., Orton 2006). Unfortunately, the only other data with which this value can be directly compared is the percentage of hornfels in layers >40 ka. In this, admittedly very heterogeneous grouping, hornfels accounts for 0.6% of the assemblage total. As with the KKH data, the limited information available here is more consistent with high mobility than low mobility.

The comparatively high ratios of flakes <15 mm to flakes >15 mm at KKH would appear to suggest that mobility resulted in regular on site artefact manufacture, and hence was probably logistically organized (Figures 8.61 and 8.62). Patch use, however, appears to have been very brief and/or infrequent, given the very small assemblage.

Conclusions

Many the aspects of the hypothesis pertinent to this period could not be directly addressed. Those that could however, were generally supported. This is most obviously the case in the appearance of least-cost technologies during what was the coldest part of the study period.

9.4 TRANSMISSION AT TRANSITIONS: PROCESS OF CULTURAL EVOLUTION

In the original hypothesis, eight points were identified in the sequence where variability in technological systems was expected to increase, with the possible appearance of novel or unusual items. This section considers the results in light of those expectations.

~110 ka – 100 ka

Data were insufficiently well resolved to approach the issue at this point.

~80 ka

The evidence suggests that around this time, DRS was reoccupied after an hiatus and HRS was occupied for the first time. At DRS there is some weak support for the proposition of technological variability in the form of unifacial points. These had no precedent in the sequence, though they do occur in what are expected to be older contexts at KFR. Perhaps more importantly, their appearance is very brief and immediately precedes the appearance of bifacial points. These later forms are initially small in number, but follow a classic ‘battleship’ curve thereafter. The nature of changes here is consistent with expectations, even though the evidence suggests that these changes followed immediately after reoccupation of the site.

~70 ka

This period witnesses the decline of bifacial points, again following a battleship curve-like decay signal. The decline occurs as backed artefacts become more common. The fact that backed artefact manufacture is not sustained with any intensity after 70 ka suggests this to have been a brief period of considerable technological variability. At least one unusual form was observed. The changes are consistent with expectations for technological adaptations within a resident population in the face of significant environmental change. The presence of backed artefacts and bifacial points, allied to the marked increase in silcrete in the last two layers of the 74 ka – 70 ka grouping, may conceivably imply relatively rapid strategic switching around the onset of peak glacial cold.

~65 ka

Brief, incremental but ultimately major increases in silcrete occur around this time at DRS. A similar phenomenon is witnessed in through the four payers in Dvii at KKH. This aside, there are no other indicators of technological variability. It remains conceivable that the changes witnessed were abrupt and ‘imposed’ rather than reflecting innovations within *in situ* populations.

~62 ka

Brief but significant technological reorganization occurred at this point, consistent with expectations. There were, however, no disruptions to the predominant technological form, and the systems which followed resembled those which preceded them. The only exception concerns the disappearance of notched artefacts. Again, the form of their disappearance was gradual, at least at KKH, though its implications are unclear.

~60 ka

The period from 60 ka through to 55 ka was one of contrasts in the data examined. At DRS, technological systems became highly variable on a layer-by-layer basis. At KKH, on the other hand, the period witnessed a major, but internally consistent technological transition. This transition was smooth by all measures and would be difficult to explain as other than an *in situ* response to changing circumstances. The period also featured the appearance of short lived technological novelties – ‘shoulderless points’ – which appeared to blend the characteristics of the impending and incumbent technological systems. Their appearance was coincident with the transition from backed artefacts to unifacial points, and occurred within the context of gradual increases in blank size.

~55 ka

Aside from a rapid increase in elongate flakes, there is nothing to indicate a period of transition or increased technological variation at either DRS or KKH around 55 ka. It seems more likely that occupation of the study area became increasingly discontinuous and episodic after this point in time. At DRS, occupation appears to have ceased entirely after 55 ka.

~45 ka

The data were generally too thin and too poorly resolved to identify any changes of note in this period. The sole feature of interest is the 'parti-bifacial point' (Plate 8.7), which derives from a compromised context, and may date to any time between 55 ka and 35 ka.

~24 ka

This point in time is only represented at KKH and EBC and in both cases occupation probably follows an hiatus. There is, thus no evidence of technological reorganization, or associated variation in technological forms.

Summary

The technological systems examined are never 'stable'. While the sequences at all sites may exhibit consistencies from layer to layer, variation is a persistent facet of all of the assemblages analysed. At some points, most notably around 70 ka , 62 ka and from 60 ka to 55 ka, the variability in technological systems does appear to increase. This includes the appearance of unusual implement forms (70 ka at DRS; 60 ka – 55 ka at KKH) and apparently rapid changes in material selection (60 ka – 55 ka at DRS; 62 ka at KKH). There are also some suggestions of increased variability around 74 ka at DRS in the sizes of flakes, and in the brief and unsustained presence of unifacial points. Equally, at other times technological changes appear to be more discrete, with the appearance of a block of internally consistent layers, followed by a new block of layers with a different and again internally consistent technological signature. To that extent, while there is clearly some support for the importance of direct bias operating on random and guided variation as a force in technological change, this provides only a partial explanation for the patterns observed. Necessarily, therefore, some other mechanisms of change were also at play in the study. Some possible candidates are considered below. First, however, consideration is given to the relationship between technological changes in the study period and the disappearance of prepared core systems.

9.5 A PARSIMONIOUS EXPLANATION FOR THE DISAPPEARANCE OF PREPARED CORE SYSTEMS?

In Chapter 2 of this thesis, it was suggested that prepared core systems had disappeared in southern Africa some time between late OIS 3 and the onset of OIS 2. In Chapter 3 it was noted that the reasons for this disappearance had not been directly addressed, and, indeed, were being obscured by unreasonable comparisons between the archaeologies of southern Africa and Europe. The data presented in Chapter 8, and their interpretation in this chapter, allow an explanation for this disappearance to be suggested.

It was argued in Chapter 4 that during periods of peak subsistence duress, populations might elect to abandon the significant time outlay involved in the production of complex technologies. This led to the concept of ‘least-cost technologies’, in which materials were taken on encounter and maximally reduced before discard, with little or no production of complex implements. On the basis of the evidence presented in Chapter 8, it was suggested that two, and possibly four periods of least-cost technologies could be identified within the time range of the present study. The first followed the onset of peak cold conditions associated with OIS 4. The last occurred during OIS 2. In between, least-cost-like technologies were suggested to have occurred with the onset of drier conditions in late OIS 4, and in the latter stages of OIS 3.

One of the common features of these technologies was the presence of very small, often bipolar cores. A link between least-cost systems and bipolar reduction was argued for on the basis that bipolar working of material allows the realization of provisioned technological potential beyond the range achievable by freehand reduction. As shown in Figure 9.2, where cores are arranged into 10 percentile groups based on weight and length, bipolar working does indeed increase in prevalence as cores become smaller (note also Hiscock 1996, 2003). One consequence of this relationship is that, as an emphasis on improving yields goes up, so to does the prevalence of bipolar cores. Necessarily, then, the relative prevalence of non-bipolar core types goes down.

In Figure 9.3, the relationship between southern hemisphere temperature and core size is explored. Temperatures from the Epica Dome C ice core are arranged into the same age groupings used to group stone artefacts. Figure 9.4[25] rearranges these data as scatterplots of median size values against median temperature. Both figures suggest a strong, positive correlation between temperature and core size through the study period. When temperatures are low, cores are invariably small, and vice versa. Concomitantly, the prevalence of non-bipolar cores also tends to decrease during these cold periods (Figure 9.5).

Radial and other prepared core forms appear to have provided a stable reduction strategy in Africa for most of the last 250 ka. However, there are limits to the reduction potential of prepared cores. Table 9.1 provides descriptives statistics for the weights and lengths of complete prepared cores. It is noted that it is rare for cores of this type to be less than 5.8 g and 26.1 mm at discard. These values effectively document the lower size limits of this reduction strategy

Figure 9.6 superimposes lines representing the 10th percentile, 25th percentile and median values for prepared core weights and lengths over the boxplots of the weights and lengths of all cores through the various time groupings. The figure provides an explanation for variance in the frequencies of prepared cores through time. More than this, it implies that for most of the ~40 kyr after 55 ka, cores in the study area were invariably too small to have seen much reduction by the prepared core method. The culmination of this period was the LGM, when most cores were at their smallest (Plate 9.2).

A related issue concerns the relative sizes of flakes yielded by different core reduction strategies. Beyond its low discard threshold, bipolar reduction often yields flakes nearly as long as the cores from which they derive. This capacity is likely to become important as cores become smaller; when cores are regularly very small, reduction strategies which produce large flakes relative to core size are likely to be favoured over those which produce flakes a fraction of core length.

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[25] Regression analysis was not run because of the use of median data. The figure is indicative only.

During analysis of cores in the present study, numbers of scars on cores were quantified using three different cut-offs. One was absolute, and involved counting all scars greater than 15 mm. Two others were relative. One cut-off involved counting all scars > 20% of the maximum length of the core. The other involved counting all scars > 50% of maximum core length. The ratio of these two measures – that is, the ratio of scars > 50% to scars > 20% – provides one means of assessing the sizes of flakes that a given reduction technique will yield relative to core size.

In Figure 9.7, data on ratios of scars > 50% to scars > 20% for the four main forms of core reduction recognised in this study are presented as boxplots. It can be noted that prepared cores have the lowest ratio, with fewer than one in four flakes greater than 50% of core maximum length for every flake greater than 20%. To put this in the context of the data previously presented, during OIS 2, with cores commonly less than 30 mm long at discard, prepared core reduction would likely have yielded more than four flakes between 6 mm and 15 mm for every flake greater than 15 mm. For bipolar and platform cores this ratio is less than two to one.

At this point, it is worth recalling the discussion in Chapter 4. History is a contingent process. Information, ways of doing, and the details of how to carry out all aspects of daily life are transferred from one generation to the next through word and deed. It is this contingency that creates the possibility of cultures as entities that display continuity through time. At the same time, behaviours, languages and techniques that fall into disuse run the risk of disappearing altogether.

For most of the 40 kyr preceding the end of OIS 2, prepared cores were very rare in the study area. Technological organisation at this time strongly emphasized the maximal reduction of small cores, and thus favoured bipolar over other core forms, including prepared cores. Even if some cores did see initial reduction via prepared core techniques, it seems likely that the poor yields of relatively large flakes and the limited reduction capacity associated with this technique meant that its use was limited. In consequence, the probability that prepared cores formed a regular part of information transfer between generations necessarily decreased through this period. It is suggested that this pattern provides a parsimonious explanation for the disappearance of the technique by the time climates began to ameliorate in the Holocene.

9.6 CONSIDERATION OF RESULTS IN RELATION TO ALTERNATIVE HYPOTHESES

9.6.1 The culture historic hypothesis

Hypothesis

A clear and predictable relationship between technological and environmental change is effectively precluded. Changes are expected to arise as a result of the diffusion of new technologies into the study area from without. There is thus no reason to expect significant technological variation to precede the appearance of new technological systems, nor for trial-and-error testing to concur with periods of environmental flux. Existing technologies are not expected to decrease in prevalence prior to their replacement. Because indirect bias is the most likely transmission mechanism, technological expression should be relatively homogenous across the study area.

Assessment

The chief tenet of the culture historic hypothesis – that technological systems reflect stylistic predilections, variance in which cannot readily predicted – is not strongly supported. There is a regular concordance between environmental variation and the timing and predicted form of technological changes. The idea that new systems are introduced from external sources is neither substantiated nor falsified by much of the available evidence, with two exceptions.

The short-lived ‘shoulderless points’ which seamlessly marry aspects of previous and impeding technological forms at KKH are consistent with expectations for *in situ* technological innovation. The alternative, culture historic explanation for this part of the KKH sequence would probably require that each of the sets of the layers that could be described as ‘backed artefact-dominant’, ‘backed artefacts with shoulderless points and unifacial points’, and ‘unifacial point-dominant’ be identified as separate units. The fact that the transition from backed artefact-dominant to unifacial point-dominant occurs at the mid-point of gradual changes in material prevalence, ELM, flake weight and elongation renders this reading of the sequence unnecessarily cumbersome, if not a little absurd.

The second exception concerns the overlap in bifacial points and backed artefacts at ~70 ka in the DRS sequence. This sequence of layers is exceptional in two ways. First, it demonstrates that bifacial points went into decline before their disappearance. Second, it demonstrates that this decline was matched by a rise in the prevalence of a new technological form. That this appears to have occurred at a time of environmental flux is also inconsistent with culture historic expectations, as noted above. More to the point, the appearance of a cluster of backed artefacts is not the prelude to a sustained period in which these technologies were employed, but rather stands as a brief and temporally isolated instance of frequency increase, followed by a period of some ~4kyr in which small numbers of these implements were intermittently produced (Figure 9.8).

A related observation has implications for the idea that implements such as backed artefacts and bifacial points can be used as markers of the diffusion of ideas. As the DRS sequence, and several others besides (e.g., Barham 2002; Beaumont and Vogel 2006; Evans 1994; Singer and Wymer 1982; Wadley 2005, 2007), demonstrates, backed artefacts tend to occur occasionally at low frequencies throughout time. Clearly, this was an implement form which had been invented, abandoned and rediscovered on multiple occasions in multiple locations. There is no logical basis to assume, then, that its appearance in multiple sites at the same time necessarily reflects diffusion from one or a few points of origin.

A final problem for the culture historic model is in the suggestion that technological expression should be homogenous across the study area. The differences in backed artefacts at DRS and KKH are instructive in this respect. These differences are probably the only aspect of variation in the study assemblages that can readily be ascribed to ‘style’ or culture-specific preferences. Yet, rather than expressing similarity, they express difference. This is consistent with theoretical understandings of the ways in which cultures come to have a material expression – that they are likely to arise and become stable in adjacent areas with different resource configurations (McElreath *et al*. 2003; Boyd and Richerson 1985; also Bettinger 1991: 200; though note Deacon and Deacon 1999: 132). DRS and KKH also diverge technologically after 60 ka, in ways consistent with environmental expectations but not with the premises of culture history. Perhaps ironically, these are precisely the kinds of differences that culture historic analysis of artefact assemblages regularly obscures, in spite of their potential behavioural significance.

Conclusion

There is little support in the data presented for culture historic explanations of technological change. The subsistence environment is more than a stimulant for technological change, it provides the selective context in which new technologies are shaped and old technologies are abandoned. The only parts of the study sequence to which a culture historic understanding might reasonably be applied are those occurring in the context of discontinuous occupation, or re-occupation after an hiatus (eg., >74 ka at DRS, 55-35 ka at KKH and 16-25 ka at KKH and EBC). These periods do not favour the culture historic hypothesis, however. They are simply cases in which its expectations cannot be tested. Such periods are perhaps better considered in light of pulsing theories. While culture history retains descriptive value, it appears to have little explanatory power in the present context.

9.6.2 The culture evolutionary hypothesis

Hypothesis

The culture evolutionary hypothesis allows that the appearance of ‘advanced’ technologies, such as those featuring backed artefacts and/ or bifacial points, may be either abrupt or gradual, *in situ* innovations. However, the hypothesis requires that these technologies should only reduce in prevalence, or altogether disappear, if replaced by other equally ‘advanced’ technologies, or if the study area is temporarily abandoned.

Assessment

The notion that any given technology will only be replaced in an extant population by another equally or more ‘advanced’ technology is consistent with the appearance of bifacial points around 74 ka, and with their replacement by backed artefacts some time between 74 ka and 70 ka. It is not however, consistent with the marked decrease in backed artefact and bifacial point prevalence ~70 ka, and the highly expedient nature of the associated technological systems which pertain thereafter. This point might be countered with the suggestion of an occupational hiatus between layer 30 and 29, however, implements aside, the technological changes at this point are not all synchronous and abrupt, and, perhaps more importantly, the date for layer 29, which follows the disappearance of backed artefacts and bifacial point and marked changes in material prevalence, is not distinct from the ages given for the bifacial-point bearing layers at DRS, or for the Still Bay more generally (cf., Jacobs *et al*. 2008a).

The more compelling example of replacement of ‘advanced’ by ‘inferior’ technologies comes, again, from KKH. There is nothing remotely disruptive in the transition from silcrete-rich, blade-rich, backed artefact-dominated layers, to those characterised by a preponderance of quartzite and quartz, a decrease in blade prevalence, and the appearance of unifacial points. Backed artefact-dominated technologies like those in the earlier grouping have been suggested by some researchers to have been pivotal in the expansion of modern humans out of Africa, and to their unseating of Neanderthals in Europe (Mellars 2006a,b). The subsequent unifacial point-rich technologies, meanwhile, have been described in other contexts as being similar in nature to technologies of the later Middle Palaeolithic (eg., Villa *et al*. 2005). Yet the replacement of the former by the latter was not the product of population replacement or loss. It was an *in situ* transition which tracked environmental variation. In this respect the transition was consistent with the principles of evolution in the selectionist sense, but entirely inconsistent with the principles of culture evolutionism.

Conclusion

Given the data presented here, and the critical evaluation of the culture evolutionary hypothesis provided in Chapter 3, it is suggested that there are no grounds, logical, theoretical or empirical, to support the notion that Upper Palaeolithic-like technologies are inherently better than Middle Palaeolithic-like technologies. While they appear to have been advantageous in periods of subsistence duress, they were clearly not selected for in less difficult times. The culture evolutionary model, insofar as it applies to the stone artefact technologies under consideration, is falsified.

9.6.3 *The occupational pulse hypothesis*

Hypothesis

Following the occupational pulse hypothesis, site use should occur in bursts separated by periods of non-occupation. Each burst of occupation is expected to be associated with a new form of technological expression, reflecting the arrival of immigrant populations. Technological change should thus be abrupt, with new technological items appearing without precedent.

Assessment

Complicating assessment of the occupational pulse hypothesis is the fact that non-occupation is difficult to detect at sites in the study area. None of the known or inferred hiatuses at KKH, DRS or KFR are marked by accumulation of sterile sediments. To that extent, all sites appear to follow the principle of "no sedimentation without occupation" (cf., Hughes 1977).

This aside, the concept of occupational pulsing almost certainly has considerable merit. There is a strong degree of internal consistency to several of the groupings used in this study which could be taken to imply that they formed under a specific and time-limited set of conditions. Equally, the sequences at sites like HRS, KFR and EBC demonstrate that brief, discontinuous periods of occupation are the norm at many times in many sites. On this basis alone it seems probable that the sequences at sites DRS and KKH are in fact composites of multiple and occasionally discrete periods during which occupation flourished.

The greater problem with the pulsing model as proposed by Jacobs *et al.* (2008a) is in the fact that each pulse is seen to be tethered to a different form of technological expression, and that pulsing can thus provide an explanation for technological change. It is on this basis that the logic of the hypothesis requires changes to be abrupt. Clearly, however, they are not always so. Again, this is most marked between 60 ka and 55 ka at KKH. Jacobs *et al.* (2008a) suggest that ~4 kyr elapsed between the end of the Howiesons Poort and the beginning of the post-Howiesons Poort. While this suggestion is not problematic in the case of DRS, it is irreconcilable with the archaeological evidence from KKH. It might also be noted that the age given for the mid-point of the transition at KKH is the out of sequence estimate of 65 000 ± 3000 (KKH5) for Dvi6. The nearest underlying and overlying determinations were 60 000 ± 3000 (KKH6) for layer Dvi10 and 58 000 ± 2000 (KKH1) for Dvi3 respectively. Given that the six layers over which the transition takes place – Dvi9 through Dvi4 – are effectively undated, the dates are no more suggestive of an hiatus than the artefact data.

Several other changes also pose problems for the occupational pulse hypothesis as proposed. The incremental rise of silcrete at the end of the 70 ka – 65 ka unit, for example, is not consistent with the idea that all aspects of the classic 'Howiesons Poort' appeared together abruptly, nor is the presence of elongate flakes throughout this grouping, in spite of the fact that backed artefacts are poorly represented.

Both the beginning and the end of the 74 ka – 70 ka grouping raise similar issues. Though the grouping itself may represent an occupational pulse, or at least reoccupation after an hiatus, it does not obviously reflect the migration into the region of bifacial point-bearing people. The unit begins with unifacial points, followed by two layers with only a few bifacial points. Only after the third layer of the grouping do numbers of bifacial points increase, and then they do so incrementally, before again decreasing in frequency with the appearance of backed artefacts. This appearance is also an issue. If each pulse is associated with a particular technology then why are two different forms otherwise considered iconic in late Pleistocene southern Africa both present in the same unit? The hypothesis favoured in this thesis provides a ready explanation. The occupational hypothesis with associated implications about technological change does not.

Conclusion

The occupational pulse hypothesis provides a robust explanation of patterns of occupational change in southern Africa. Its merit with respect to technological change is limited. Technologies may change from pulse to pulse, but, equally, they may change within pulses. Thus, though pulsing may correlate with technological turnover, it is not the cause of that turnover.

10

CONCLUSIONS

10.1 INTRODUCTION

This chapter considers the results and implications of the thesis. In the first section, the results presented in Chapter 8, and interpreted in Chapter 9, are summarized. In the second section, the results of the new information presented in the thesis are integrated with the results of past studies, as discussed in Chapter 2. The implications of the thesis for our understanding of and approaches to the late Pleistocene archaeology of southern Africa are then considered. The final section looks at the implications of the thesis for broader issues in prehistory.

10.2 A PREHISTORY OF THE STUDY AREA FROM 120 ka TO 20 ka

This section has three parts. The first part provides a summary of the occupational history of the study area from 120 ka to 20 ka. The second part examines the mechanisms of change which operated through this period, with particular reference to competing models of *in situ* and introduced variation. The third part considers future work that may improve the understanding arrived at in this thesis.

10.2.1 Summary of the archaeology of the study area

Homo sapiens were almost certainly present in the study area as early as OIS 6, given that the species appears to have emerged before 160 ka (Behar et al. 2008; MacDougall *et al*. 2005; White *et al*. 2003), and that its greatest genetic diversity occurs among southern

African populations (Tishtkoff *et al*. 2009). OIS 6 occupation is probably reflected in the earliest deposits at EBC, though the early layers at DRS and KFR may also be this old. The operating assumption has been that DRS and KFR were occupied after 120 ka, though as noted earlier, this is speculative. The following summary proceeds as though this assumption were valid, though future work may prove it to be otherwise.

The earliest technological systems at DRS and KFR were relatively simple and low cost, and probably reflect use of the sites by residentially-organised groups who appear to have covered reasonably large territorial areas. The cooling of temperatures and greater instability which occurred in later OIS 5 were expected to have fostered greater investment in technological systems, and well as to have encouraged some reorganization of movements, at least in terms of their magnitude. This seems at least partially borne out in the data from spits 7 and 8 at KFR. The fact that KFR appears to have been occupied in OIS 5 is interesting in itself, given that available data suggest the Doring zone to have been otherwise irregularly occupied during much of prehistory – this issue of absence of evidence is returned to below.

The onset of OIS 4, and the cold, unstable temperatures with which it was initially associated saw further increases in technological complexity. Mobility systems appear to have remained residentially-organised, at least to the extent that there was little evidence of substantial on site artefact manufacture at DRS. There was, however, no evidence of an extension in the habitual range of group movements. The limitation here may be the use of hornfels to assess mobility magnitude, though changes in hornfels in other parts of the DRS sequence in particular seem generally to conform to expectations. It might also be that the lack of hornfels is a reflection of the dominant technological provisioning system. The chief strategy in place given residential mobility is probably for people to have provisioned themselves with one or more maintainable implements (bifacial points in this case) made from predictably flaking rock, and to have made supplementary use of locally available materials as encountered, a strategy consistent with Kuhn's (1995) idea of 'individual provisioning'. As hornfels does not seem to have been used for bifacial point manufacture, its absence might simply reflect preferential selection of silcrete, and a tendency to acquire hornfels on encounter and to discard it after expedient use. Clearly, more work needs to be done on this front before any proscriptive statements are made.

Changes into and out of the bifacial point bearing layers at DRS and HRS are fascinating and instructive. As at Blombos and Hollow Rock Shelter, small numbers of bifacial points precede later increases. Soon after they peak in number, however, backed artefacts appear and bifacial points decline. Subsequently, just as it seems that backed artefacts are set to replace bifacial points as the preferred implements in the dominant technological strategy, both implement types disappear and least-costs systems emerge. The best interpretation of this part of the sequence is of a series of rapid strategic changes tracking the sharp decline in temperatures, and presumably resources, with the onset of glacially-low temperatures.

Technologies in the period from 70 ka – 65 ka exemplify expectations for least-cost systems. Temperatures were as cold as at any other time in the study period barring the peak of the LGM. As importantly, temperature-driven falls in productivity were probably not off-set by increases in moisture availability to the same extent that they were after 65 ka. The dominant technological strategy of acquiring and heavily reducing locally available rock would have altered the balance of time allocation between technology and subsistence in favour of the latter. Though the result may have been less efficient in terms of caloric yields for time outlaid, it may have diminished the probability of falling below minimum caloric intake. An associated shift at this time saw an extension of time spent in patches such as DRS, and a change towards more logistical use of sites.

After 65 ka, moisture availability in the study area seems to have increased substantially, thus off-setting to some extent the low temperatures of later OIS 4. Temperatures at this time were also slightly warmer than those prevailing previously. The concerted effect of these two changes was to encourage a return to more high-cost technological systems. Thus, in effect, an amelioration of conditions led to an increase in technological investment – something inconsistent with much theoretical work on the relationship between risk and technological investment (eg., Bousman 1993; Collard *et al*. 2005; Read 2008; Torrence 1983), but consistent with the 'tilda curve' of technological costs argued for here. Another consequence of this amelioration was an apparent decrease in the range of habitual movements, albeit that logistically-oriented systems continued to prevail.

Around 62 ka there is a short lived reversion to near least-cost systems, probably as a result of drying out of the study area. The fact that silcrete remains a reasonable contributor to assemblages at DRS and KKH may imply a series of rapid shifts between least-cost and high cost systems, conceivably even at seasonal timescales. This is also the only period in which hornfels makes a substantial contribution to any assemblage at KKH. Wiessner's (1977, 1982; also Cashdan 1985) notion of risk management through increased rates of visitation to neighbouring patches in times of environmental uncertainty is an appealing explanation for the observed changes, though it is difficult to reconcile the contrasting timescales between the anthropological and archaeological data. Sadly, no 35-45 mm backed artefacts made from hornfels appear at KKH in these assemblages.

Technologies after the quartz spike are similar in many respects to those pertaining before 62 ka, in spite of differences in temperature and water availability. This has important implications for the concept of the 'Howiesons Poort' as it is currently used, and for understandings of the relationship between technology and environmental variation. Both are discussed later in this chapter.

Perhaps the more interesting facet of the technologies associated with this second silcrete surge is that their occurrence is brief, and their peak seems to initiate a gradual transition to systems dominated by unifacial points and quartzite. This transition appears to track increases in temperature through the end of OIS 4 particularly well. By the end of this period, at around 55 ka, technological and land use systems had changed markedly, without that change at any point appearing abrupt. Though Jacobs *et al*. (2008a) suggest an hiatus between backed artefact-dominant and unifacial point-dominant systems, it is difficult to see how such an explanation could be applied in the present case.

Viewed as a whole, the period from 65-55 ka is certainly the richest, archaeologically speaking, of any in the study. Enormous numbers of artefacts were discarded at KKH, and DRS, and KFR also saw the deposition of large assemblages at this time. Indeed, more than 75% of the artefacts discarded at DRS and KKH from OIS 5-2 appear to date to later OIS 4. Added to this is the fact that all three zones show signs of occupation at this time, and that there are reasonably strong intimations that at least two if not all three zones were occupied by different groups. This is consistent with the suggestion in the KKH data that the earlier part of this period was exceptionally wet. The idea that KFR may have been abandoned following the abrupt drying inferred for ~62 ka provides an elegant resolution for the sudden and short lived appearance of hornfels in the KKH sequence, and it would also be consistent with the suggestion that the Doring catchment was difficult to occupy under dry conditions.

Whether elegance is sufficient justification for this argument however, is another matter. For example, if absence of evidence is taken to signify absence of occupation then the lack of finds from pre-65 ka contexts in the Olifants zone becomes meaningful. Yet bifacial points were identified in sites within 15 km of KKH during casual surveys, suggesting that this is not the case. At one open site in particular, located below a rock shelter at the edges of the present Clanwilliam Dam (which is the flooded valley of the Olifants River), ten bifacial points or fragments thereof were identified, along with a number of other radially-worked pieces (Plate 10.1). The absence of a bifacial point-dominant component at KKH does not mean that there is no such technology in the area more broadly. If the absence of such technology at KKH in this time does not imply absence of occupation in the area more broadly, then we cannot reasonably read anything into the cessation of occupation at KFR in late OIS 4.

The archaeological signal in the study area after 55 ka, and for OIS 3 generally, is intriguing. The period is no colder than OIS 4 and is hypothetically quite wet. Yet of five examined sites, only one has sound evidence for occupation at this time, and this is fragmentary. Why? It might be suggested that populations moved to the now-drowned OIS 3 coastline and episodically pulsed back into the study area, but this would simply be to defer, rather than to provide, an explanation. If people were predominantly on the coast in OIS 3, why were they not there in OIS 4? It may be that the combination of cold and highly variable conditions made the study area more difficult to occupy in OIS 3 than in OIS 4, and this would not be inconsistent with the suggestion of near-least-cost technologies. It might also be that the fact that west coast waters were relatively nutrient-rich in OIS 3 made the coastal plain more attractive at that time than it had been earlier (cf., Stuut *et al*. 2002). The bigger issue here is that the available archaeological sample from this period is simply too small to form any strong opinions on the nature of the changes represented.

Data from OIS 2 are only marginally better, but this is at least partially a result of the inadequacy of the analysis of the EBC assemblage undertaken for this thesis, given that this is the most sizeable OIS 2 assemblage presently known in the area. Adding Faraoskop (cf., Manhire 1993) to the analysis would also have helped. Nevertheless, OIS 2 was almost certainly the coldest of any period considered, and the available evidence suggests a return to technological systems as low cost as any deployed in the preceding 100 kyr. People again appear to have organized themselves logistically, though the range they habitually covered is beyond the capacity of the data to assess. Like OIS 3, OIS 2 occupation of the study area remains somewhat enigmatic.

10.2.2 Assessment of mechanisms of change – in situ or in vogue

The tendency in southern Africa has been to view technological change in terms of passing fashions or directional tendencies. Belief in the latter, it might be suggested, is largely an artefact of chronic under-theorization. The former, as discussed in Chapters 3 and 6, carries a large number of implications that are rarely considered. Logically, the three most problematic aspects of the argument from fashion are that a) new ideas must always begins somewhere else, that b) all people in the area under consideration are always equally receptive to the new fashion, and that c) once established fashions do not drift but are instead sustained across vast tracts of time and space by unspecified mechanisms.

At the same time, the assumption favoured here, that all changes resulted from locally-developed, adaptively-beneficial responses to environmental variation, is equally unsound. People clearly influence people, the environment is composed of more than temperature and water, and fashions demonstrably exist. However, the '*in situ*' explanation has the advantage that it does not rely on agents that must always remain archaeologically invisible. To that extent, the argument from fashion, dependent as it is on things that seem never to be directly witnessed in the archaeological record, cannot provide a parsimonious explanation for technological variation if invoked *a priori*.

In the present study, direct bias acting on random and guided variation provides an adequate explanation for most of the observed variability. Backed artefacts, for example, occur in almost all units examined – indeed, the only temporal grouping to contain no backed artefacts was that covering the period from 55 ka – 35 ka, and the sample involved was exceedingly small. Unifacial points, likewise, can be found in the >74 ka, the 74 ka – 70 ka, the 60 ka – 55ka and the 55 ka – 35 ka units. What varies through time is less the presence of these forms than their frequency, and these frequency changes are consistent with expectations for what would have been adaptively beneficial technologies under the circumstances in question. Given this, on what reasonable grounds would we seek to argue that these frequency changes were in fact reflections of imported ideas of what was, technologically, *in vogue*?

Bifacial points may provide an exception, given their largely unprecedented appearance in the DRS and HRS sequences, but leaving aside the fact that they do not emerge in sudden abundance, their disappearance is entirely consistent with a gradual frequency change rather than an abrupt replacement. Moreover, as was discussed in Chapter 2, bifacial points do occur in southern Africa prior to OIS 4, and their absence prior to 74 ka in the study area has to be considered in light of the present paucity of the local OIS 5 and OIS 6 records.

As important, if not more so than changes in implement frequency, is the independence of variation in different technological parameters. The frequency of elongate flakes, for example, does not vary with the prevalence of backed artefacts. Similarly, a taste for silcrete is not commensurate with backed artefacts or elongate flakes. There are, in short, few genuine technological *packages* in evidence in the archaeological sequences considered.

The final advantage of the *in situ* explanation of technological change is that it deals so simply with the disappearance of prepared cores. Viewed as either an expression of diffusion or migration, the disappearance of prepared cores after ~230 kyr seems to mark a seismic shift in the archaeology of southern Africa. Viewed as an expression of historical contingency, on the other hand, the disappearance reflects the loss through extended disuse of a technological system which otherwise had remarkable long-term stability. Note that this loss does not equate to final abandonment, nor is it necessarily unprecedented. The archaeological record is far too thin with respect to OIS 6 to state that the production of prepared cores had not ceased and re-emerged on previous occasions. And the 12 kyr that have elapsed since the end of OIS 2 is not sufficient to suggest that it might not have later re-emerged, as the assemblages from Bonteberg and Glentyre attest (Fagan 1960; Maggs and Speed 1967).

The only aspect of technological variation that is not obviously adaptively beneficial concerns the differences in backed artefact manufacturing practices at KKH and DRS in late OIS 4. No obvious and compelling economic or functional explanation accounts for why two groups with access to blanks of similar sizes would end up making different sized backed artefacts, nor why material selection practices should vary so strikingly between the two. Dual Inheritance Theory, however, does provide an answer, in the form of indirect bias. As McElreath *et al*. (2003; also Boyd and Richerson 1987) note, interaction (including migration) between two groups in different settings provides a context in which indirect bias can produce stable but adaptively neutral differences in behaviour. Once established, these differences can take on the role of symbolically meaningful ethnic markers. As Bettinger (1991: 200) notes, these markers are most likely to arise when the two groups in question occupy different ecological zones. This appears to have been the case in the present study area. This pattern also serves to remind that concepts of fashion are as much about differentiation as they are about widespread uniformity.

10.2.3 Suggestions for future work in the study area

Further work in the study area is required to overcome some of the limitations of this thesis, but also to test some of the predictive statements that were made but which could not be examined with the available data.

Further work related to limitations should in the first instance focus on improving the spatial and temporal coverage of the stone artefact data set. Explanations in terms of absence of evidence, particularly as it relates to occupation, were discussed but could not be pursued with any vigour. This inhibits attempts to examine patterns in the use of the study area, and thus to explore the articulation of occupation in different zones. As noted, in the absence of early OIS 4 data from the present Olifants sample is not meaningful, then what reasonably can be drawn from the apparent abandonment of the study area in OIS 3?

A related issue concerns the suggestion that multiple, different groups occupied the study area at the same time. The data from late OIS 4 are suggestive of broader possibilities, but with such small and spatially incomplete assemblages from earlier and later contexts, these cannot yet be explored to any useful degree. Bigger samples of implements from point-rich and backed artefact-rich assemblages from across the study area, as well as sourcing of materials where possible, would be an important first step. If the inference of oscillation between dispersed, logistically organised groups and clumped, residentially organised groups is correct, then we might anticipate an associated waxing and waning of differentiation in implement form across the study area.

Moving away from strictly archaeological data, the poverty of the available palaeo-ecological data should again be noted. Marine cores (eg., Stuut *et al*. 2002) provide important general information about past environments, but the benefits of local-scale records, such as the phytolith record from KKH, are clear. Arguments about differences in patch use would be far more solid if independent records were available from all of the sites under consideration. Similarly, better reference collections would allow such archives to be used for more than simple contrasts between ‘wetter’ periods and ‘drier’ periods. Understanding of shifts in vegetation and how these may have affected the composition of faunal communities would add far greater resolution to the coarse picture painted here.

On a similar, but somewhat more positive note, a number of predictive statements were made in Chapter 6 about expected shifts in diet breadth through time, even though it was never possible to address them in this thesis. The objective was to provide an independent means for the predictions of the thesis to be explored. As it is unlikely that a large-scale study such as this one will be undertaken in the study area by other researchers in the near future, the broader predictions as they relate to stone artefacts will probably remain untested for some time. The results of current work on the faunal assemblages at DRS by R.G. Klein (U Standford) and T.E. Steele (UC Davis), will, in this respect, be intriguing.

10.3 THE PRESENT STUDY IN REGIONAL CONTEXT

This section considers the implications of this thesis for the archaeology of southern Africa more broadly. The section has two parts. The first part considers the implications for the thesis for understandings of the past and the processes of change in the late Pleistocene. The second part examines the implications for the way late Pleistocene materials are analysed and presented.

10.3.1 Implications for the archaeology of southern Africa

Integrating the results of the present study into a broader regional context is hampered by a lack of comparable data. As discussed in Chapter 3, it is common practice in southern African studies to present data in units, and to focus on limited classes of data, most notably morphologically regular implements. Presentation of data on a layer-by-layer basis, or of simple attributes such as changes in the weight of flakes and cores, is rare. In spite of this it remains possible to examine a number of interesting patterns in the late Pleistocene archaeology of southern Africa and on which the results of this thesis have some bearing.

In the present study it was suggested that a cooling of climate after 100 ka may have encouraged an increase in technological complexity and reduction efficiency. At KFR, these changes are witnessed from layer 9 to layers 8 and 7. In the earlier grouping implements are absent, quartzite is the dominant material and ELM values are very low. Through the next two layers, numbers of implements, percentages of fine-grained, predictably flaking rocks, and ELM values all increase. A number of similar changes are observed at Klasies River in the transition from MSA 2a to MSA 2b. In the latter grouping artefacts generally become small and implements, along with retouch in general, become far more common (Thackeray 1989; Volman 1981; Wurz 2002). An increase in diet breadth may also be implied from the increased prevalence of smaller faunal items (Klein 1976). These changes occur in the context of cool global temperatures, and a reduction in Indian Ocean SST's, which are likely to have decreased the amount of summer rainfall delivery to the YRZ (cf., Be and Duplessy 1976; van Campo *et al*. 1990), though this may have been off-set by greater inputs from the WRZ from 100-85 ka (Avery 1987; Klein 1974; Stuut et *al*. 2002).

After 80 ka, following further cooling and increased temperature instability, bifacial points appear at a number of sites. At both DRS and HRS, increases in the numbers of bifacial points are incremental. At DRS, the appearance of bifacial points is preceded by a layer containing unifacial points. At Blombos Cave, numbers of bifacial points increase from unit M2 to the overlying M1 unit. M2 is also the richest layer, in percentage terms, in unifacial points. A question thus arises of whether there may have been some structure to the appearance and disappearance of unifacial points through the BBC sequence. Could it be, for example, that a decline in unifacial points is complementary with a rise in bifacial points, inferring a strategic shift across the OIS 5/4 boundary? Minichillo (2005) has suggested ascribing M2 to its own 'stage' of the MSA, based on the low frequency of bifacial points and the prevalence of bone points. Such an approach, however, would only continue to obscure potentially informative processes of transition and transformation[26].

Similar questions arise with respect to the bifacial point-bearing layers at Sibudu Cave. Backed artefacts are noted to occur by Wadley (2007), but how they relate to the broader sequence is unclear. At DRS, backed artefacts briefly effloresce at the termination of the 'Still Bay'. Is this symptomatic of a broader pattern? Henshilwood at al. (2001a) and Villa *et al*. (2009) note no backed artefacts in the BBC assemblage – does this imply that the site was abandoned during the period in which bifacial points were still common? Or is it simply that the DRS pattern is DRS-specific?

Both Henshilwood et al. (2001a) and Wadley (2007) have suggested that one characteristic of the assemblages at both Blombos and Sibudu is a lack of cores. At both sites, cores account for between 1 in 500 and 1 in 1000 artefacts. The study of bifacial points presented here may provide some resolution for this pattern. Following Kelly (1988) it was suggested that the bifacial points at DRS and HRS may have been capable of acting as cores in providing useable flakes from retouching events. Analysis of the points suggested that in many cases, the flakes derived from bifacial points during retouch were comparable in size to the flakes derived from hemispherical core forms. Insofar as size may inform on utility, this was taken to imply that the bifacial points examined in the present study may have functioned in this auxiliary capacity. Given the wealth of bifacial points recovered from Blombos in particular, this attribute of the implement class may help explain why dedicated cores were so uncommon.

At DRS bifacial points briefly peak in number, and then they begin to decline. This decline is incremental, coinciding with the appearance backed artefacts and immediately preceding a marked reduction in complex implement production on site. HRS, on the other hand, appears to have been abandoned when bifacial points were at their most numerous. From the point of view of understanding how the Still Bay ends, it would be interesting to known which of these patterns best describes the sequences at Blombos and Sibudu Cave. The

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[26] And this is without considering the problem of identifying a 'stage' based in part on the prevalence of organic data, in this case bone points, when late Pleistocene preservation is generally so rare.

present mode of data presentation, in which coarse units are used, means this question cannot be addressed.

The possibility that either an hiatus or an unidentified industry occurred between the bifacial point-bearing Still Bay and the backed artefact-rich Howiesons Poort was discussed in Chapter 2. In the present study, it has been suggested that a period of least-cost technologies, associated with the peak cold conditions of OIS 4, intervened between the two at DRS. In a similar vein, Minichillo (2005) has suggested that the sequence from Die Kelders may fall temporally between south coast Still Bay and Howiesons Poort groupings. Thackeray (1987), notably, has suggested that the period during which the Die Kelders assemblage was formed was considerably colder than the period during which the Howiesons Poort layers at Klasies River were deposited. Climatically, then, there may be some correspondence between the two. The Die Kelders assemblage is also noted for its poverty of implements (Thackeray 2000). In this and other respects Die Kelders bears some similarity to the assemblages at DRS from layer 23 to layer 29, though further study would be required before any firm statements were made on this issue.

If the assemblages at DRS, KKH and KFR from 65 ka to 60 ka can be classified as 'Howiesons Poort' then a number of parallels can be drawn between patterns in the study area at this time and in southern Africa more broadly. The first of these concerns the visibility of the Howiesons Poort. As noted in Chapter 2, compared with pre-65 ka assemblages, those assigned to the Howiesons Poort exhibit a remarkably wide-spread distribution. These assemblages are often also disproportionately large. In the present study, the period 65 ka – 60 ka is the only one in which all three zones show simultaneous occupation, and more than 75% of the artefacts examined date to this time.

The large assemblage sizes of the Howiesons Poort may in part be a consequence of the prevailing mode of mobility organization. If, as hypothesized, land use was primarily logistically-organised during the Howiesons Poort, it is likely that the period witnessed a greater frequency of on site artefact manufacture. Larger assemblages are thus likely to have been formed than during periods where on site artefact manufacture was rare.

The great visibility of the Howiesons Poort across southern Africa may, on the other hand, be partly explained by the distinctive set of features with which it is identified. Would a Die

Kelders-like assemblage be as easily identified as a Howiesons Poort-like assemblage? Would it be as readily assigned to an industrial grouping? A similar point can be made with respect to the Clovis industry of North America, which, though it occurred only very briefly, is disproportionately identifiable at least in part because its key features are so distinctive (cf., Waters and Stafford 2007).

Greater identifiability can only provide a partial explanation for the Howiesons Poort pattern, however. The Still Bay also has distinctive features, but is rarely recovered from controlled contexts. Indeed, it may be that this last point is the most important. The assemblages that usually form the basis of discussion of about past patterns of occupation and land use derive in the main from rock shelters. But rock shelters are relatively rare in many landscapes. Furthermore, there is no reason to assume that the degree to which people relied on rock shelters as habitation loci was continuous through time. It is possible that the Howiesons Poort was a period in which the use of rock shelters increased. At present, the factors that condition the use or otherwise of rock shelters remain largely unknown.

Another important aspect of the Howiesons Poort is its internal complexity. A bimodality in artefact numbers and patterns of material prevalence was noted at Klasies River in Chapter 2. Similar patterns were noted at both DRS and KKH. In these latter cases, two peaks in silcrete prevalence were separated by a surge in quartz, with the intervening assemblages characterized as least-cost systems. At Klasies River there is a surge in silcrete, followed by a surge in quartz, but no second silcrete peak. At KKH, the second silcrete peak is associated with considerably drier conditions,. Could it be that Klasies River was abandoned with the onset of drier conditions? Klasies River is presently situated in the YRZ, receiving both summer and winter rainfall. If the period from 62 ka – 60 ka was dry in the WRZ, but still sufficiently cold to preclude effective monsoonal storms developing in the SRZ, it seems possible that this period was one of considerable aridity and, potentially, of disruption to patterns of occupation. Certainly, assemblages at DRS become smaller and more variable in this period.

These questions have implications for the timing of the Howiesons Poort. Jacobs *et al*. (2008a) have argued that the industry occurred across southern Africa within a single, tightly constrained period of time. Jacobs *et al*. (2008a) also argue that the Howiesons Poort was separated from subsequent industries by an hiatus of some ~4 kyr. This would seem to fit well with the idea of a period of increased aridity and occupational disruption around 62-60 ka. Yet there was clearly no hiatus at KKH, a well-watered location in a relatively rich valley. And in presenting an apparently seamless transition from the Howiesons Poort to subsequent systems rich in unifacial points and lacking backed artefacts, KKH is not alone. Similar arguments have been made on different grounds for the transition at Rose Cottage Cave (cf., Soriano *et al*. 2007).

The problem here is that Jacobs *et al*. (2008a), like many others, treat the Howiesons Poort as a single internally coherent, and indivisible entity. Demonstrably, it is not. These failures are largely a consequence of the prevailing culture historic model, in which industries are treated as entities divorced from their contexts of deployment, rather than as complex and contingent technological responses to circumstances.

The cessation of the Howiesons Poort under warming conditions at the end of OIS 4 gives rise to unifacial point-dominated assemblage in the WRZ, YRZ and SRZ. Soon thereafter, however, patterns across southern Africa appear to diverge. In the SRZ, the period from ~55ka to ~ 25 ka is one in which technological systems alternate between point-dominant and backed artefact-dominant. In the WRZ and YRZ, however, sites are either abandoned in this period, or tend to have very small assemblages deposited. In either case, the occupational signal of the SRZ appears to be much stronger through OIS 3 than that of the WRZ and YRZ. The reasons for this remain unclear; far greater resolution in palaeo-environmental modelling, including some exploration of the interactions between moisture, temperature, seasonality, vegetation, and fauna is essential (Mitchell 2008[27]).

One aspect of the Howiesons Poort to post-Howiesons Poort transition noted in Chapter 2 that is worth recalling here concerns changes in diet breadth at Sibudu Cave. Clark and Plug (2008) suggest a relatively wide diet breadth pertained during the Howiesons Poort, with a large proportion of small fauna in the assemblage, and a great diversity of species overall. In the post-Howiesons Poort, however, larger animal become more prevalent. This is particularly well marked in changes in the proportions of small, medium and large

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[27] Mitchell (2008), following Chase and Meadows (2007), also suggests that depletion of atmospheric CO^2 may have significantly weakened the productivity of the C_3 pathway grasses which dominate the WRZ. Notably, however, CO^2 was not obviously poorer during OIS 3 than during OIS 4, and was probably poorer still during OIS 2 (cf., Petit *et al*. 1999), for which the archaeological signature in the WRZ is relatively strong.

bovids. In the Howiesons Poort, medium to very large bovids account for less than 40% of the bovid total. In the post-Howiesons Poort this rises to >80%. These changes conform in general terms to the expectations of the hypotheses presented in Chapter 6.

By around 25 ka temperatures reached their coldest point for over 100 kyr. In the present study this encouraged a return to least cost systems with very heavy reduction of procured material and little production of complex implements. This pattern seems to describe the Robberg industry, which occurs across southern Africa at this time, very well (cf., Mitchell 2002). It is also around this time that prepared cores disappear. An explanation in terms of historical contingency has been posited for that disappearance in the present study. It remains to be seen how well this explanation holds for southern Africa more broadly, though, again, it can be noted that a switch from prepared cores to bipolar and platform techniques – the two forms argued in Chapter 9 to provide good flake size yields for small cores – is symptomatic of many assemblages at this time. How these changes relate to the timing and contexts in which prepared core systems disappeared from Africa more broadly is a far more complex questions, and one well beyond the scope of this thesis.

10.3.2 Methodological implications

This thesis has been critical of several aspects of past approaches to, interpretations of and presentations of late Pleistocene archaeological data in southern Africa. This section focuses on three of those issues.

The first issue concerns the over-emphasis on implements in discussions of stone artefact assemblages. Morphologically regular retouched artefacts are important as indicators of technological organization, but they are not the totality of artefact systems. Often, discussions of flakes and cores are phrased entirely in terms of their role in providing blanks for the dominant implement form (eg., Soriano *et al*. 2007; Wurz 2000, 2002). Yet, as the assemblages from both DRS and KKH attest, changes in implements need not dictate changes in flaking practices, and vice versa. At DRS, for example, elongate flakes are common from 70 ka through to 60 ka. Both Wurz (2000) and Soriano et al. (2007) have argued that elongate flakes are made to serve as blanks for backed artefacts. At DRS, backed artefacts are rare from 70 ka to 65 ka, and only become common from 65 ka to 60 ka. In spite of this, there is no change in the prevalence of elongate flakes either side of 65 ka. At KKH, flakes begin to get bigger from around the middle of the backed artefact-dominated layers and continue to get bigger through to well after the transition to unifacial point assemblages. The relationship between blanks and implements, as noted in Chapter 8, is complex. To discuss one as entirely subsidiary to the other is to suppress this complexity.

A related problem is the absence of metric data in many studies. The sizes of cores in particular have been shown to be sensitive to environmental variation at large time scales. Like flakes, the sizes of cores at transport and discard are likely to have complex relationships with patterns of implement production. Core size has also been implicated in the disappearance of prepared core reduction systems. Patterns such as the relationship between flake size and implement form at KKH, and between core size and temperature in the study area more broadly, can only be drawn out using metric data. Given that theories exist for interpreting these patterns, it seems unfortunate that metric data are so rarely presented.

The second of the issues to be considered concerns data presentation. Southern Africa has the great fortune to have many late Pleistocene sites with well-preserved stratigraphy and large assemblages. Consequently, it is unnecessary to present data in coarse units, rather than on a layer-by-layer basis. Yet this remains the dominant means of data presentation, particularly with respect to stone artefacts. The most significant outcome of this approach is that the fluid processes of technological change are lost or obscured, something which becomes particularly important during periods of flux or transition. Any consideration of the processes driving or mediating change through these periods is effectively precluded.

The persistence of unit-based approaches to data presentation owes much to the continued dominance of culture history in late Pleistocene studies. The reasons for this persistence were considered in Chapter 3. Among them was the absence of effective chronometry during most of the history of late Pleistocene studies. Without chronometry, descriptive frameworks that allowed assemblages from different sites to be compared and relative chronologies to be developed were important facets of late Pleistocene archaeology. This problem is no longer as important as it once was. Given that, it remains to ask whether culture historic units such as industries, phases, stages and Ages are necessary devices in a chronometric era?

In the present study it was possible to present, interpret and discuss a broad range of data without making reference or recourse to existing culture historic units. The advantage of such an approach was that it allowed units to be formed that were pertinent to the questions at hand, rather than relying on units developed over the preceding 100 years to prove themselves useful or relevant. The lingering defence for culture historic units is often that they have heuristic value. In this thesis, these units have generally proved themselves useful in this particular capacity, allowing the results presented here to be related to those from past studies. There is a certain circularity in this line of defence, however. The heuristic value of culture historic units is not an inherent property, but a consequence of past work being presented in culture historic terms. If this is the justification for future work being so-presented then their value in this respect becomes self-fulfilling. It needs to be considered whether continuity in this respect is worth the attendant suppression of complexity in technological systems, and the loss of information about the shape of change and the mechanisms driving it. If this thesis had maintained a strict divide between the MSA and the LSA it is unlikely that the processes linking one to the other would have been identified. The final indictment of culture historic units is that they probably do not even identify ‘cultures’ in any meaningful sense.

10.4 BROADER IMPLICATIONS OF THE STUDY

This section considers the implications of the study for three broad issues in archaeology. The first two concern the concept of style in stone artefact studies, and the relationship between technology, risk and environmental variation. The final issue to be considered is how the results presented here relate to models of human evolution in the late Pleistocene.

10.4.1 Implications for the concept of style in stone artefact technologies

The identification of ‘style’ in archaeological materials is a complex and often vexing issue (eg., Sackett 1977, 1982, 1985; Wiessner 1983, 1984, 1985), and one which seems to become increasingly fraught in contexts of deep antiquity. In the present case, there seem to be relatively good reasons to believe that observed differences in backed artefact manufacturing practices had their origins in differences between the populations that made them. Assuming that the benefits of the forms of these backed artefacts were, in both cases, selectively neutral other than with respect to their social contexts of deployment, it seems reasonable to describe their variance in terms of style (cf., Hegmon 1992).

Accepting this carries a number of implications. Several recent studies, for example, have suggested that stylistic variation in stone artefact technologies emerged at large (regional) scales across Africa in the late Pleistocene, and that this emergence may in some way reflect on the capacity of early human groups to express cultural difference (Marean and Assefa 2005; McBrearty and Brooks 2000). This is the same spatial scale at which Palaeolithic cultures have been identified in Europe, and which have been noted to be difficult to reconcile with ethnographic scales of variance in cultural expression (cf., MacEachern 1998; Wotzka 1997, cited in Shennan 2000; note also Weedman 2006). While it may be that 'style', given a sufficiently generous definition, is effectively a scale-less process (cf., Parkinson 2006), the fact that these broad regional entities are identified without reference to the influence of biogeography on technological systems is problematic. Thus, whether these differences reflect active style, passive style (drift), or broadly similar technological responses to broadly similar environments – or possibly a combination of all three – remains unconsidered. As noted above, style cannot be invoked *a priori* as an explanation of difference.

The present study demonstrates that style can be a local phenomenon, particularly when the local area incorporates ecological boundaries. Presently, studies which look at inter-site assemblage variance on a local scale are, in the Pleistocene at least, very rare. Studies in southern Africa which have looked for stylistic variation have been less coarse-grained but have suffered from a lack of control over the context of the relevant evidence (cf., J. Deacon 1984b: 298-301). As Humphreys (2004: 39) has remarked with respect to southern African archaeology: "our lithic analyses seem to mask social patterns like territoriality".

If the origins of style / ethnicity / culture-specific markers are of interest, then redefining the scale of enquiry may be a beneficial step. Such an approach would be more sound both theoretically and logically than those in which broad similarities between isolated finds separated by vast tracts of time and space are inferred to have their origins in shared cultural systems (eg., Bouzouggar *et al.* 2007; Mellars 2006a; Zilhão 2006). That these differences may also carry implications for differences in language, at the dialect level at least (cf., Weissner 1983), is tantalising but remains, and is likely to remain, beyond the reach of available evidence.

10.4.2 Implications for the relationship between technology and environmental variation

Studies examining the factors shaping technological organisation emerged from the shadows of culture history in the 1960's and 1970's (eg., Binford 1973, 1977, 1979; Oswalt 1976). These and subsequent works have since done much to improve the interpretive power of stone artefact analyses, particularly when they are placed within the framework of evolutionary ecology (eg., Clarkson 2004, 2007; Hiscock 1996; Kuhn 1995; Mackay 2005; Marwick 2007; Torrence 1983, 1989). Combined, technological organization and evolutionary ecology allow us to understand not only what aspects of a given technology are beneficial, but also the circumstances in which they are likely to be favoured. The result is a theoretical body that can both predict and interpret technological change.

Among the many mechanisms that have been put forward as primary drivers of technological change, 'risk' has been one of the most useful and important. Both archaeological and ethnographic studies suggest that changes in the magnitude and configuration of subsistence risk will effect the organization of technological systems (Bousman 1996, 2005; Clarkson 2004, 2007***;*** Collard *et al*. 2005; Hiscock 1996; Marwick 2007***;*** Read 2008; Torrence 1983). Ethnographic studies, in particular, demonstrate that technologies will tend to become more complex as subsistence risk increases. More specifically, they suggest that places with colder temperatures and shorter growing seasons generally carry greater subsistence risk than places that are warmer and/or have longer growing seasons, and are thus more likely to favour complex technologies.

In the present study, the expected relationship between cooler temperatures and greater technological complexity has, to some extent, been borne out. Yet this study also serves to highlight a weakness in this rather unidirectional view of the risk / technological complexity relationship. Most notably, the coldest periods of the study were actually those in which the least complex technologies pertained.

The weakness in the existing modeling comes from an emphasis on the benefits of technological complexity, but a failure to consider their costs. Failure to consider costs is, as noted in Chapter 3, common in culture evolutionary studies of technology, but is an interesting facet of technological organization studies, given that costs were a consideration in some foundational works in the field (eg., Torrence 1983). Thinking of the unidirectional risk / technological complexity relationship in culture evolutionary terms also prompts a potentially important question: If more complex technological systems convey benefits over simple technological systems, why would people ever revert to simple systems? That is, if the costs of both complex and simple systems are equal, but the former are more beneficial than the latter, under what conditions would simple systems ever be selected for? On the grounds of sexual selection alone, we would expect the unidirectional risk / technological complexity model to have the same long-term implications as the culture evolutionary model, and that is inevitable increases in complexity through time. The fact that some ethnographic groups still employ comparatively simple systems demonstrates that this did not occur.

This issue aside, the present study does not support the idea that greater risk will always lead to greater technological complexity. The differences between 70-65 ka technological systems and those deployed 65-60 ka is a case in point. The latter period was warmer and wetter, but featured more evidence for complex technological systems than the former. This result lies in direct contrast to the expectations of the unidirectional, or ‘cost-free’ risk / technological complexity model, but is consistent with the expectations of the ‘tilda curve’ model, where time budgets are split between technological and subsistence tasks. Even if we are to reject the tilda curve of risk and technological complexity promoted here, consideration of costs needs to be factored into future thinking about technological systems.

A second issue in a similar vein concerns over-simplification in environmental modeling. In recent attempts to apply insights from technological organisation and evolutionary ecology to southern Africa it has been argued that cold conditions invariably impose greater constraints on subsistence systems than warm conditions and thus that we might expect more complex technologies to be co-terminus with cooler periods (eg., McCall 2007). An older model of a similar nature was developed by Ambrose and Lorenz (1990), who argued that the cold conditions of OIS 4 would have decreased primary productivity, forcing people to become more mobile.

In the present context, the differences between technologies from 65-62 ka and those from 62-60 ka are instructive. Conditions from 65-62 ka were colder than those that followed them, and thus we might expect this to have been a time of greater technological complexity and greater mobility. Yet technological systems differ little between the two, and mobility actually appears to increase after 62 ka. The key change is water availability, which has a determining effect on primary productivity (cf., Kelly 1995). In the WRZ, cool conditions are likely to be favourable to greater moisture, both through increased precipitation and decreased evapotransipration. Thus greater cold does not always lead to less productivity in the WRZ, though it may well do so in the SRZ. The point is that environmental generalisations that fail to take into account the nature of local climate systems may lead to erroneous characterizations of shifts in resource availability.

The kinds of problems generated by these over-simplified models are perhaps best highlighted in the recent paper by Jacobs *et al*. (2008a). In their review of the timing of the appearance and disappearance of complex technological systems in southern Africa, Jacob’s *et al*. note no clear correspondence between periods of cold and technological complexity. They thus conclude that no such relationship exists. The problem is not with the work or reasoning of Jacob’s et al, but with the over-simplified models to which they are responding. That there is a relationship between technological systems and environmental variation is clear and demonstrable. Figures 9.3 and 9.4 could not be less ambiguous in this respect. The challenge is to develop models sufficiently complex to understand this relationship.

10.4.3 Implications for models of human prehistory

Flaked stone artefacts from southern Africa have been used to inform models of the human past at a global scale for more than a century. In a notable early example, John Allen Brown (1889) identified similarities in the designs of artefacts in South Africa, Syria, India and England and posited that they were the result of the diffusion of a population group through Africa, Asia and Europe. Subsequent explanations for similar patterns likewise focused of connections between Africa, Asia and Europe, either in the form of diffusion or as universal stages in cultural evolution (eg., Johnson 1907, 1912; Peringuey 1911). Goodwin's seminal work, *The Stone Age Cultures of South Africa*, was a hybrid of both culture history and culture evolutionism (Goodwin and van Riet Lowe 1929). Among its more significant achievements was the establishment of enduring relationships between the Middle Stone Age and Middle Palaeolithic, and between the Later Stone Age and Upper Palaeolithic.

In *The Stone Age Cultures of South Africa*, people and ideas moved from north to south, filtering slowly into the cul de sac of southern Africa. In the MSA these people were Mousterians; in the LSA they showed 'Capsian affinities'. The realizations of the 1970's that the people of the MSA were modern humans and not Mousterians, and that their appearance in Africa antedated their appearance in Europe, had significant consequences for the prevailing view of human prehistory. First, it implied that *Homo sapiens* was probably an African species. Second, it implied that *Homo sapiens* had spent a considerable period in Africa before emerging to over-run Europe and colonise the world. This in turn prompted a number of questions: If the people of the MSA were modern humans, why were their material remains so similar to those of the Neanderthals? Why did they not produce complex technologies, art or symbolic items? And what caused them to emerge so suddenly from Africa after tens of thousands of years of relative cultural stasis?

These questions formed the genesis of the 'modernity' debate, which has dominated studies of the late Pleistocene archaeology of Africa for the past 20 years (Conard 2005; Deacon 2001; Klein 1989, 1995; Marean and Henshilwood 2003; McBrearty and Brooks 2000; Mellars 2006a,b; Minichillo 2005). The modernity debate concerns itself with the issues of how and when 'modern human behaviours' arose. The debate features several well-established and competing views. In one view, the various facets of modern human behaviour arose suddenly and simultaneously between 60 ka and 40 ka, at which point modern humans exited Africa and became a global species (eg., Klein 1989, 1995). In a second view, the various components of modern human behaviour coalesced through the late Pleistocene, resulting in the appearance of 'fully modern behavioural repertoire' at the end of the MSA, around 40 ka (eg., Marean and Henshilwood 2003; McBrearty and Brooks 2000). In a third view, humans may have been behaviourally modern for some time well before the end of the MSA, but it was only with the invention of new technological forms that they became capable of significantly expanding their occupational range (eg., Mellars 2006b).

An important aspect of the modernity debate is that 'fully modern behaviour' is largely identified in terms of the defining characteristics of the Upper Palaeolithic (Chase and Dibble 1987, 1990; McBrearty and Brooks 2000). Thus, art, symbolic items, flexible faunal predation patterns and the production of organic and/or morphologically regular retouched flaked stone implements, most particularly bifacial points and backed artefacts, are all held to be important in differentiating modern from non-modern behaviour. This is in spite of the fact that such items do not accurately characterize the late Pleistocene archaeological records of many modern human groups in places outside of Europe (Brumm and Moore 2005; Mackay and Welz 2008).

Perhaps as importantly, the use of the Upper Palaeolithic record as an arbiter of what is modern behavioural expression has tended to reinforce the perceived significance of the MSA / LSA transition. The equivalence of the MSA / LSA transition with the Middle to Upper Palaeolithic transition was effectively built into Goodwin's definition of the Ages. In respect to this issue, the significance of the present thesis is draw into question one more of the supporting lines of evidence for this questionable comparison. Previous evidence suggests that the Middle Stone Age did not lack art, symbolic expression, ornamentation, flexible faunal predation patterns or the production of complex, organic and morphologically regular implements (cf., Bouzouggar *et al.* 2007; Clark and Plug 2008; D'Errico *et al.* 2005; Faith 2008; Henshilwood *et al.* 2002, 2004; Mackay and Welz 2008; Parkington *et al.* 2006; Vanhaeren *et al.* 2006; Yellen *et al.* 1995; Wendt 1976). The data presented here suggest that the MSA / LSA transition was not coincident with the transition from the Middle to Upper Palaeolithic, nor did the two share a common underlying cause. The Middle to Upper Palaeolithic transition came about as a result of population replacement. The MSA / LSA transition came about as the result of the loss of a specific core reduction system under the influence of the coldest conditions of the last 120 kyr. The MSA, then, is not the Middle Palaeolithic, nor is the LSA the Upper Palaeolithic. The primary legacy of their equivalence has been the generation of false mysteries.

This thesis also has a bearing on one more issue relating to models of human prehistory, and that is the role of technology in underpinning modern human expansion out of Africa.

Mellars (2006b) has recently argued that the advent of technological systems such as those dominated by bifacial points and backed artefacts may have been pivotal to allowing humans to move and adapt rapidly to new circumstances as they emerged from Africa. The data presented here suggest that this was probably not the case. Bifacial point and backed artefact-dominated technologies are advantageous only with respect to the contexts of their deployment. In late Pleistocene southern Africa, only certain circumstances favoured their production; other circumstances favoured the production either of very simple systems or of the production of different implement types. Given this, it seems improbable that bifacial points or backed artefacts were found to be advantageous in every environmental setting from southern Africa to Europe, and throughout the period from 60 ka to 40 ka.

The data presented here suggest that if technology did play a role in human expansion, it was probably not in the forms which dominated certain systems, but rather in the ability of modern humans to switch strategies rapidly as circumstances demanded. In the period from 74 ka to 58 ka, a least six different technological strategies were deployed in the study area. This rate of turnover is comparable to anything witnessed in the Holocene in southern Africa. Given this, and other points presented in this thesis, there seem to be few reasons to treat the recent and deeper modern human pasts of southern Africa as categorically different entities.

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APPENDIX A

KLEIN KLIPHUIS ROCKSHELTER SITE

WESTERN CAPE, SOUTH AFRICA

PHYTOLITH ANALYSIS REPORT

31 March 2009

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Phytolith analysis of ten sediments from Klein Kliphuis Rockshelter site, Western Cape, South Africa

(32°07'59.99 S 18°57'00 E)

Report for	Alex Mackay, School of Archaeology and Anthropology, ANU
By	Doreen Bowdery, School of Archaeology and Anthropology, ANU

Reasons for phytolith analysis: To categorise the Klein Kliphuis sequence in terms of phytolith changes, from this to discuss the results in terms of water and vegetation at the site.

Environmental data on the area of the site and adjacent region for the time period under analysis is sparse; currently the region is classified as 'high fynbos' vegetation. It was anticipated that phytolith data would provide background environmental data as a proxy towards an explanation of the large variation in the Howiesons Poort lithic assemblage through the time period of interest. At 200 m asl and now some 57 km from the sea, the shelter is located in a narrow valley, facing ENE, about 15 m above and overlooking a presently-permanent river, the Kliphuis, (Van Rijssen 1992:34). Quartzitic sandstone blocks form the shelter; sparse vegetation now grows in between the blocks. In the winter of 2007 the river valley below the shelter had a covering of medium/small trees and shrubs dominated by the invasive black wattle (*Acacia sp.* or *rooikrans*). A phytolith reference collection was not available for this area. Identification of phytoliths recovered was made from published illustrated morphologies and my own reference collection.

Details of Klein Kliphuis (KKH) sediments selected for phytolith analysis are shown in **Table 1**. Excavation squares were within the shelter dripline. Depth between samples varied with a minimum of 3.2 cm to a maximum of 8.2 cm. Approximately 45 ka of sediments have been compressed into ~50 cm.

METHODS

Sediments were processed following an established heavy liquid flotation method using Sodium polytungstate at 2.28 sg (Bowdery 1998: Appendix 14.1). The protocol followed is shown in Table 2 (Phytolith extraction worksheet). Sediment identification shows that samples were not taken from a contiguous column. The three oldest sediments were from different squares to the main column. Material recovered from tubes was mounted on slides with Eukitt™. This material contained phytoliths and other microfossils. Analysis was a 'quick-look' to record morphology presence in the ten sediments. Slides were scanned at x425 and x625 magnification and plants and all other microfossils presence noted; a quantitative analysis was not undertaken.

RESULTS

Table 2: *Klein Kliphuis phytolith extraction worksheet*

Column 5 of Table 2 indicates the number of changes made to clear a sample of clay. After deflocculation of the clay a residual very fine, loess size dust was removed by hand before heavy liquid flotation. The sediments were similar in grain size composition throughout (col. 9). Change in sediment colour was noted. The older sediments and dust (Dvii1 H2C - Dvi8 I12D) were reddish in hue whereas the younger sediments (Dvi5 I2D - Div2 I2D) had a pink/grey hue with the exception of Dv1 I2D when the dust was grey. These changes in sediment dust colour suggests a change of source of the aeolian sediments being deposited in the shelter. The largest amount of floated material containing all microfossils with a specific gravity <2.28 was recovered from the two youngest sediments, Div2 I2D and Dv1 I2D (col. 11).

Table 3: *Klein Kliphuis presence of phytoliths and other microfossils*
Presence of phytoliths and other silica and non-silica microfossils observed for each slide is given in Table 3. Phytolith morphologies noted in the slide scans are classified under broad headings, tree/shrub/grass, elongates and grass. Morphologies vary within a classification and for this reason a presence does not represent one particular plant. Psilate sphere is a ubiquitous morphology with many variations within this class, many were noted some with a cavity, however, the orientation of these small spheres on a slide is likely to produce both morphologies. Grasses are, in general, high phytolith producers, for example, elongate, another ubiquitous morphology in many instances attributed to grasses, is represented in the table as short, medium and long, further subdivided into small, medium and wide and then type of termination. Occurrence of articulated phytoliths is shown under group 59, however, after centrifuge processing phytoliths, in general, are discrete. By combining morphologies where possible the total groups number was reduced to 57.

The final row of Table 3, total groups n=10, shows number of occurrences for each morphology group through the sediments with a total count of 364 occurrences. Group 58 shows total number of groups noted for each slide.

Other microfossils observed during scanning are noted under groups 60-68. Carbon inclusions (60) refers to cytoplasmic carbon from groundwater uptake encapsulated by silica. Few carbon particles (61) were observed, these woody and not from Poaceae. A conversion from silica to cristobalite (62) can take place at 890-900°C and stabilises above 1470°C (Cole 1934). A variety of plants produce starch grains (67) in their fruit, bulbs and roots, eg, Cyperaceae and *Phragmites*. Starch grains are non -silica microfossils and may be identified under cross polars at low magnitude by their birefringence and extinction cross. Few starch grains were observed in the samples. Border pits (68) are cellulose deposits from woody plants and were noted in four sediments; little has been published about these microfossils.

Tentative identification of morphologies to plant families is shown under groups 69-77. Much of the illustrated literature relating to phytoliths in South Africa identifies phytoliths to their morphological classification, not to plant species. Poaceae angular (groups 46-52) show many similarities to illustrations made available by Lloyd Rossouw (pers. comm. 2008) of phytoliths extracted from ten South African Danthonia/Festucoid Poaceae C_3 species, their habitat wet and cool. The few lobates illustrated are represented in KKH phytolith assemblage (groups 36-45). Given that grasses are high phytolith producers the high presence of tree/shrub morphologies throughout the column does not indicate open grassland, rather savannah with scattered trees. Grass presence increases and new morphologies are introduced in the younger levels.

Morphology UID3 (group 57) has similar attributes to a phytolith illustrated and described as a brachiform by Bamford and colleagues (2006:Figure 8f). Recovered from VEK Trench 111 (an eastern Olduvai Gorge palaeolake margin site), the trench dated to *c*.80 kyr (2008:96). This morphology was noted in the three oldest and two other sediments at KKH.

Table 4*: Klein Kliphuis presence of hydrophilic indicators*
Given the close proximity of a river to the rockshelter it was not surprising to note the presence of hydrophilic indicator plants. *Phragmites* and *Oryza* are examples of grasses that produce large-celled fans as are sedges and non-plant microfossils such as diatoms and sponge spicules. All prefer a high water regime and habitats such as river and lake margins or damp, wet sites. There was no obvious evidence for water seepage in the past or at present to account for a natural occurrence of diatoms and sponge spicules and a taphonomic process is speculated for their presence in the shelter. A correlation can be seen between total group numbers and presence of hydrophilic indicators. Least indicators and lowest total groups were recorded by sediments Dvi8 I2D and Dvi9 I2D.

The largest *Phragmites* phytoliths occurred in wet sediment Dvi13 H1C. *Phragmites* noted in the intermediate sediments, Dvi5 I2D and Dvi3 I2D, were at least 30% smaller in size giving an indication of the difference in water availability between wet and intermediate.

Table 5*: Klein Kliphuis suggested climate/vegetation components*
From Table 3 fifteen groups, representing all of the broad classification range of groups (n = 10), were noted as occurring in all sediments (150 groups). Total number of groups recorded was 364 with a median at 182. These 150 groups represent the phytolith 'noise' index for the rockshelter and surrounding area for the time period under study. A morphology can represent a phytolith from different species in the same plant family, thus morphologies represented in the site noise can represent different species through time. To resolve this ambiguity a quantitative analysis may provide some resolution on possible species present, this has not been undertaken for this quick look study. With nearly 50% of groups assigned to site noise it is to the other groups and fossils that site differences may be noted.

From Table 4 a wet/dry index (median 27) was constructed based on presence of fan morphologies, other hydrophilic indicators and dust.

The presence of many sponge spicules and renewed presence of Cyperacea and diatoms at Dvi5 I2D suggests that this sediment should be grouped with Dvi3 I2D rather than the older, drier sediments below.

Based on the various data and observations presented in the tables the ten sediments were grouped into seven climate/vegetation components as shown in Table 5.

Table 6: Klein Kliphuis summary of microfossil presence data
A short summary of each sediment giving salient differences/similarities is given in Table 6.

DISCUSSION

Klein Kliphuis shelter is protected on two sides by the valley slope that it is located in and the opposite, higher, side of the river. Through time aeolian sediments would be deposited by prevailing winds blowing from the NW or SE. A change of wind direction is suggested when changes in deposited sediment and dust colour occurred. Throughout the column the phytolith assemblage changed with time. The broad phytolith classifications of Table 3 shows that a core of phytoliths representing all the classification groups were present throughout the ten sediments analysed. Oscillations over time in climate and vegetation were noted when species within the same groups were recorded as changes of morphology. The period of interest at KKH was preceded by Toba eruption volcanic winter. This study indicates that an amelioration of climate had occurred, if indeed the extreme climate conditions had reached the shelter, before the sediments of the phytolith analysis were laid down.

Addressing the components of Table 5:
Component 7 is relatively drier than component 6 with fewer morphologies, in particular fans. However, both components are noted as the wettest of the 10 samples with largest phytoliths, particularly *Phragmites* fans, and from this species now preferred habitat, a probably (relatively) warmer temperature than the other sediments may be inferred in components 7 and 6, tree/shrub phytoliths dominated. There is some correlation to the Sunnyside 1 site at Clarens

> "Phytoliths recorded in Unit 7 (dated to 62.3 ka) indicated C3 mountain grassland with locally moist but regionally cool growing conditions. … undiagnostic bullilform [fan] morphotypes is extremely small but may also refer to relatively wet conditions" (Henderson et al. 2006:143).

A sampling hiatus exists between components 6 and 5, the two sediments of component 5 were dry with a low presence and diversity of phytoliths. *Phragmites* had dropped out of the assemblage indicating a decline in water availability and perhaps a cooler temperature. Grass presence still low.

Change is evident again by the two sediments of component 4. A change of sediment and dust colour in the older sediment suggests a change of wind direction through the valley. In spite of an increase in dust the presence of many sponge spicules and diatoms, a reappearance of *Phragmites,* though much reduced in size, indicates a wetter, warmer period at the site albeit not as high as components 7 and 6. The grass to tree/shrub ratio increases towards grasses suggesting a more open grassland presence.

Component 3 was drier than 4, tree/shrub dominated again. This sediment is similar to the oldest sediment of component 5 but with a higher number of grass morphologies and introduction of new grass morphologies. A C_4 grass makes a brief appearance.

At component 2 a second change in dust colour was noted, this time to gray, again suggesting a change of wind direction and source material. The component was wetter relative to component 3. C_3 grass morphologies increased however tree/shrubs still dominated.

Component 1 though still dry, was relatively wetter than component 2. The highest number of all phytolith group morphologies was recorded with an increase in grasses relative to component 2. A C_4 grass makes a brief appearance. Tree/shrub morphologies increased to a similar presence as the wettest sediment in component 2, a possible warm, dry period. Dust colour returns to the pink/gray of component 3.

Broadly, a tree/shrub, savannah landscape was maintained throughout the period of study with the spherical/oval, with or without a cavity, tree/shrub morphology dominant throughout. C_3 grass morphologies were low during the earlier wet period (components 7 and 6) and very low during the subsequent dry period (component 5).

Relative to each other the changes through time in phytolith morphology presence in the ten KKH sediment samples analysed indicate changes in vegetation thus reflecting oscillations in climate through wet and dry periods. Fluctuations in tree, shrub and grass availability would affect browser/grazer populations and from this a change in the hunter-gatherer toolkit, posing the query - was there any correlation between wet/dry periods and lithics?

When a phytolith reference collection becomes widely available an identification of KKH phytoliths may be rewarding. When time permits sampling and analysis of sediment gaps over 4 cm would tighten up the changes.

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KKH ID	**dbs cm**
Div 2 I2D	55.00
Dv 1 I2D	61.5
Dvi 1 I2D	64.5
Dvi 3 I2D	70.13
Dvi 5 I2D	77.00
(Dvi6)	
Dvi 8 I2D	85.13
Dvi 9 I2D	88.38
Dvi 11 H1B	94.13
Dvi 13 H1C	101.25
Dvii 1 H2C	106.83

Table 1: Klein Kliphuis sediments submitted for phytolith analysis

1	2	3	4	5	6	7	8	9	10	11
Site	Sample	dbs	Sample	Number of deflocs	HCl	H2O2	After 250µ sieve			NPTH <2.28 Recovered
							weight	seds	tube	
KKH ID	db ID	cm	g				g		ml	g
Div2 I2D	1023	55.00	5	27	no reaction	no reaction	3.26	vp sort <5.70	1.0+	0.16
Dv1 I2D	1024	61.50	5	24	no reaction	no reaction	2.61	vp sort <5.70	1.0+	0.09
Dvi1 I2D	1025	54.50	5	24	no reaction	no reaction	2.60	vp sort <5.70	1.0+	0.03
Dvi3 I2D	1026	70.13	5	29	no reaction	no reaction	2.81	vp sort <5.70	1.0+	0.03
Dvi5 I2D	1027	77.00	5	21	no reaction	no reaction	3.06	vp sort <5.70	0.5+	0.02
Dvi8 I2D	1028	85.13	5	19	no reaction	no reaction	2.88	vp sort <5.70	1.0+	0.01
Dvi9 I2d	1029	88.38	5	17	no reaction	no reaction	2.57	vp sort <5.70	1.0+	0.01
Dvi11 H1B	1030	94.13	5	24	no reaction	no reaction	2.38	vp sort <5.70	1.0+	0.01
Dvi13 H1C	1031	101.25	5	29	no reaction	no reaction	2.24	vp sort <5.70	0.75+	0.02
Dvii1 H2C	1032	106.83	5	15	no reaction	no reaction	2.50	vp sort <5.70	0.75+	0.01

Table 2: Klein Kliphuis phytolith extraction worksheet

	TREE/SHRUB/HERB																								
	Spherical/Oval/Irregular																								
	Psilate								Verrucate																
Phytolith morphology	sphere/oval	sphere with cavity	oval/irr w cavity	gray irregular	pink/brown irregular	spherical echinate	nodular concentric	nodular	Verrucate	with dark centre	amorphous	anticlinal - cuticle	arc/circle/ring/ curve	Asteraceae sp.	complex	Cyperaceae sp.	facetted	hair	hair base	ornamented rectangle	perforated	sheet	stomata	rracheid	3D block
Morphotype Group #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
Div2 I2D	x	x	x	x	x		x	x	x	x	x	x		x	x	x		x	x	x	x	x	x	x	x
Dv1 I2D	x	x	x	x			x			x	x	x	x	x			x	x	x	x	x	x		x	x
Dvi1 I2D		x	x				x	x	x	x				x		x	x			x				x	x
Dvi3 I2D	x	x	x	x		x	x		x	x				x						many				x	
Dvi5 I2D		x	x	x			x			x			x	x		x		x	x	x					
Dvi8 I2D		x		x	x		x			x				x			x			x		x		x	x
Dvi9 I2D		x			x		x		x	x				x				x		x				x	x
Dvi11 HxB	x	x	x	x	x	x	x		x	x	x		x	x		x			x	x	x			x	x
Dvi13 HxC	x	x		x	x	x	x	x		x	x		x			x				x	x	x		x	x
Dvii1 H2C	x	x		x			x		x		x								x	x				x	x
	6	10	6	8	5	3	10	3	6	9	5	2	4	8	1	5	3	4	5	10	4	4	1	9	8

x or p = presence noted; ? = possible presence noted; Figure indicates number of sub-groups observed within a major group

Table 3: Summary of microfossil presence data – tree/shrub/herb

	TREE/SHRUB/HERB/POACEAE										
	Elongate							**Points**			
Phytolith morphology	short (n,m,w)	medium (n,m,w)	long (n,m,w)	square	sinuous	tapered	trichome Tx	T2	T3	T4 (G)	short (n,m,w)
Morphotype Group #	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**26**
Div2 I2D	3	3	2		x	x	x	x	x	x	3
Dv1 I2D	3	3	2		x	x	x	x	x	x	3
Dvi1 I2D	3	1				x	x	x	x	x	3
Dvi3 I2D	3	1	1	x		x	x	x	x		3
Dvi5 I2D	3	2	2		x	x	x	x		x	3
Dvi8 I2D	2	2				x	x	x	x	x	2
Dvi9 I2D	2	3	1	x	x	x	x	x			2
Dvi11 HxB	3	3	2		x	x	x	x	x	x	3
Dvi13 HxC	2	2	2	x		x	x	x	x	x	2
Dvii1 H2C	3	3	3	x		x	x	x	x	x	3
	10	10	8	4	5	10	10	10	8	8	10

x or p = presence noted; ? = possible presence noted; Figure indicates number of sub-groups observed within a major group

Table 3 (cont): Summary of microfossil presence data - tree/shrub/herb/poaceae

	POACEAE																								
	Bilobes										Angular														
Phytolith morphology	Bx (G)	B2 (G)	B3 (G)	B4 (G)	B5 (G)	B6 (G)	B7 (G)	B8 (G)	B9 (G)	B10 (G)	Ax1 (G)	A2 (G)	A3 (G)	A4 (G)	A5 (G)	A6 (G)	A7 (G)	Fan (G)	ornamentedrectangles (G)	UID x	UID 2	UID 3			Total Groups Present
Morphotype Group #	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**			**58**
Div2 I2D	9		5	1	2	10		x	2	x	x	x	x	x	x	x		5	x	x	x				49
Dv1 I2D	4		4	3		8			2		x	x	x	x	x	x	x	4	x	x		x			43
Dvi1 I2D	1		6	2		7		x	1	x	x	x	x	x	x	x	x	3	x						35
Dvi3 I2D	1	x	1			2			1		x	x	x		x	x		6		x		x			
Dvi5 I2D	2		8			8				x	x	x	x	x	x	x		6	x						31
Dvi8 I2D	2		2			3					x	x	x	x				4	x	x		x			30
Dvi9 I2D	1		4		1	1					x	x			x	x		1	x	x	x				30
Dvi11 HxB	2	x	2			7	2				x	x				x		9	x	x	x	x			40
Dvi13 HxC	2		2			3			1		x	x	x	x	x	x		9	x	x	x	x			40
Dvii1 H2C	2	x	3			5			1		x	x	x	x	x			7	x	x	x	x			34
	10	3	10	3	2	10	1	2	6	3	10	10	8	8	8	8	2	10	10	8	5	5	364		

x or p = presence noted; ? = possible presence noted; Figure indicates number of sub-groups observed within a major group

Table 3 (cont): Summary of microfossil presence data – poaceae

	OTHER OBSERVATIONS											TENTATIVE IDENTIFICATIONS								
Phytolith morphology	Articulated	Carbon inclusions	Carbon particles	Cristobalite	conglomerates	adherents	Diatoms	Sponge spicules	Starch grains	Border pits		Acacia sp	Asteraceae sp	Cyperaceae sp	Gahnia	Palm sp ?	Danthonia	Eriachne sp C4	Phragmites C3	Themeda sp C4
Morphotype Group #	**59**	**60**	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**		**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**
Div2 I2D	p			p	p	p	p	p	p			p	p	p			p	p	p	p
Dv1 I2D	p			p	p	p	p	p					p				p			
Dvi1 I2D	p			p			p	p		p		p	p	p			p	p		
Dvi3 I2D	p						p	p								?	p		p	
Dvi5 I2D	p			p			p	m	p	p		p	p	p				p	p	
Dvi8 I2D	p	p		p				p	p			p	p					p		
Dvi9 I2D				p				p	p	p		p	p							
Dvi11 HxB	p			p				p				p	p		p	?			p	
Dvi13 HxC	p	p	p	p			p	p				p	p		p	?	p		p	?
Dvii1 H2C	p	p	p	p			p	p		p		p				?	p		p	
	9	3	2	9	2	2	7	10	4	4		8	8	3	2		6	4	6	1

x or p = presence noted; m = many; ? = possible presence noted; Figure indicates number of sub-groups observed within a major group

Table 3 (cont): Summary of microfossil presence data – other observations and tentative identifications

KKH ID (Table 3)	**Fans (col. 53)**	**Cyperaceae (col. 16)**	**Diatoms (col. 65)**	**Sponge spics (col. 66)**	**Total Groups (col. 58)**
Div2 I2D	5	p	p	p	49
Dv1 I2D	4	-	p	p	43
Dvi1 I2D	3	p	p	p	35
Dvi3 I2D	6*	-	p	p	32
Dvi5 I2D	6	p	p	many	31
Dvi8 I2D	4	-	-	p	30
Dvi9 I2D	1	-	-	p	30
Dvi11 H1B	9*	-	p	p	40
Dvi13 H1C	9*	p	p	p	40
Dvii1 H2C	7*	p	p	p	34

* indicates *Phragmites* presence

Table 4: Klein Klipuis presence of hydrophilic indicators

KKH ID	Total groups (col.58)	Relative Wet/Dry index 1 = Wet 10 = Dry		Climate/ Vegetation components
Div2 I2D	49	6	dry	1
Dv1 I2D	43	7	dry	2
Dvi1 I2D	35	9	dry	3
Dvi3 I2D	32	4	intermediate	4
Dvi5 I2D	31	4	intermediate	4
Dvi8 I2D	30	7	dry	5
Dvi9 I2D	30	10	dry	5
Dvi11 HiB	40	1	wet	6
Dvi13 HiC	40	1	wet	6
Dvii1 H2C	34	3	wet	7

Table 5: Klein Kliphuis suggested climate/vegetation components

KKH ID	**1. dbs** **2. approx.date** **3. # gps** **4. w/d index**	**General comments for all scans:** **All sediments were dusty** **Many phytoliths were pitted and degraded, edges not clear**
Div2 I2D	1. 55.00 2. ~45 ka 3. 49 4. D6	Many OR grass/shrub/articulated. Higher presence of angular grasses than bilobe grasses. Increase in microfossils recovered. Dust colour reverts to gray
Dv1 I2D	1. 61.50 2. ~ 50 ka 3. 43 4. D7	Increase in spheres, elongates, tracheids, ornamental rectangles grass and shrub type, articulated. Change of dust colour to gray
Dvi1 I2D	1. 64.50 2. ~ 55 ka 3. 35 4. D9	Few elongates, tracheids, spheres with dark centres, points. Spheres dominate
Dvi3 I2D	1. 70.13 2. ~ 56 ka 3. 32 4. Inter. 4	Spheres with dark centres dominate, many ornamented rectangles and tracheids, few bilobes, more angular grasses, very long elongates. Few new shrub-type morphologies.
Dvi5 I2D	1. 77.00 2. ~ 58 ka 3. 31 4. Inter. 4	Change of sediment colour from red (iron presence?) to pink/gray; most dust, wetter - diatoms, many sponge spicules, spheres dominate. Change of morphologies.
Dvi8 I2D	1. 85.13 2. 60 ka 3. 30 4. D7	Small particles of debris. Irregular (tree/shrub) sphere dominates. Lowest presence of all microfossils
Dvi9 I2D	1. 88.38 2. ~ 61 ka 3. 30 4. D10	Driest, less of everything, except pink/brown irregular (tree/shrub) sphere, few *Acacia*
Dvi11 H1B	1. 94.13 2. ~ 62 ka 3. 40 4. W1	Wet, large phytoliths. Irregular pink/brown sphere dominates. Many small pieces of broken phytoliths
Dvi13 H1C	1. 101.25 2. ~ 64 ka 3. 40 4. W1	Wettest sediment with largest morphologies of the assemblage. Many *Phragmites* (largest 160µ length) and sponge spicules. Fewer grass bilobes other than B6, fewer angular. Hints of vine thicket with palm. Psilate sphere dominates.
Dvii1 H2C	1. 106.83 2. ~ 65 ka 3. 34 4. W3	Morphologies large and small, perhaps indicating seasonal rainfall regimes (for grasses). Large *Phragmites*, hints of vine thicket; possibly palm present (very degraded); heavy pitting

Table 6: Klein Kliphuis summary of microfossil presence

APPENDIX B

DEFINITION AND DESCRIPTION OF CLASSES AND MEASURES

Adze

A retouched flake with unifacial retouch applied to the dorsal surface along one or both lateral margins. The lateral margins are usually straight, and the retouched edge includes many step terminations and is often slightly concave in form.

Artefact

Used in this thesis with specific reference to stone artefacts. Taken to mean any rock showing signs of modification by flaking, grinding or battering, and found in a context such that humans can reasonably be assumed to have been the agents responsible for the modification observed.

Artefact class

Synonymous with technological classes. Four artefact classes were identified during this study: flakes, retouched flakes, cores and flaked pieces. Artefacts classified as 'heat shatter' are a subset of flaked pieces. Definitions of individual classes are provided below.

Backed artefact

A retouched flake showing high angle retouch along one margin. In most cases, retouch exceeded 75°, and the retouch scars were relatively short (see Figure 8.6 in Volume 2).

Burin

A retouch flake where one or more retouch blows were oriented along the lateral or distal margins, rather than onto the ventral or dorsal faces.

Core

An artefact with one or more complete negative flake scars and no positive percussive features.

Core, levallois

A core with two distinct hemispheres of sub-equal volume separated by a single continuous perimeter. All flake scars directed on to either hemisphere derive from this edge. The defining feature of a levallois as opposed to a radial core is the presence of one or more scars extending for more than half of the length of the longest axis of the core. These scars were usually produced late in the reduction of the core.

Core, platform

A core with one or two, though more rarely three, working platforms from which the vast majority of flake scars derive. Differentiating platform from hemispheric (radial and levallois) cores is the absence of a single working perimeter which divides the core. Differentiating platform from rotated cores is the smaller number of platforms (usually) and the high ratios of scars to platforms (invariably).

Core, radial

A core with two distinct hemispheres of sub-equal volume separated by a single continuous perimeter. All flake scars directed on to either hemisphere derive from this edge.

Core, rotated

A rotated core is core form on where flakes have been removed from multiple platforms. The ratio of scars to platforms is usually much lower on rotated cores than on platform cores.

Cortex

Cortex refers to the weathered exterior surface of a rock.

Denticulate

A retouched flake with two or more simple notches along its lateral margins.

Dorsal face

The dorsal face refers to the exterior surface of a core that is removed in the formation of a flake (see Figure B.1). Each flake thus has a dorsal face, which retains the scar characteristics of the core face from which it was derived, and a ventral face (see below).

Edge angle

Edge angle was measured on all radial and levallois cores, and in each retouched Sector of a retouched flake. In all cases, edge angle was measured to the nearest degree at the junction of the dorsal and ventral faces (retouched flakes), or of the two hemispheres (cores), using a goniometer.

Edge length to mass (ELM)

A calculation in which the edge length of a flake is estimated by the following formula: length + maximum dimension + maximum width. This value is then divided by the weight of the artefact. The resulting calculation is an estimate of the ratio of flake edge length to mass, expressed as millimetres per gram (mm/g).

Elongation

The ratio between the length of a flake and its maximum width.

Flake

An artefact on which at least one set of positive percussive features can be identified (see Figure B.1).

Flake, retouched

A flake with scarring that disrupts, and was therefore formed subsequently to, the ventral face of the flake. Retouch may be directed onto either the dorsal face from the ventral, or onto the ventral face from the dorsal, or both, or along the lateral or distal margins of the flake.

Flaked piece

An artefact with one or more incomplete negative scars and no complete negative scars or positive percussive features. A flaked piece is, in effect, a percussively worked artefact that cannot be definitively identified as a flake or core.

Heat shatter

A flaked piece which has been broken by the application of excessive heat. Heat shatter often, but not always, displays other signs of heating, such as crazing, crenation, pot-lidding, colour change, and lustre.

Implement

Implement refers to a recognised class of morphologically regular retouched flakes. For the purposes of this thesis, the following implement types were recognised: adzes, backed artefacts, bifacial points, burins, denticulates, notched flakes, scrapers, shoulderless points and unifacial points.

Length, core

The longest distance from any used platform to the distal end of a core (see Figure B.2).

Length, flake

Length refers here to the distance across the ventral face of a flake from the point of initiation along the percussion axis (see Figure B.3). For this thesis, length was measured to one tenth of a millimetre using digital callipers.

Maximum dimension

Maximum dimension is the longest distance across the ventral face of a flake (see Figure B.4). For this thesis, maximum dimension was measured to one tenth of a millimetre using digital callipers.

Notches

A notch is a pronounced though often quite narrow concavity on the lateral edge of a flake, formed by one or more retouch scars. Notches may be either simple or complex. Simple notches are comprised of a single scar. Complex notches are comprised of multiple scars.

Notched flake

A retouched flake displaying one or more complex notches along its lateral margin.

Percussion features

When a core is struck, a cone of force passes through the core body, often resulting the detachment of a flake. The flake retains the positive features of this cone, including a ring crack at the point of impact and a pronounced bulb below the ring crack. Less often, the flake retains an errailure scar in the bulb, and lines of force emanating from the blub and extending across the ventral face. The core retains the negative impression of these features, most notably a negative bulb of percussion (see Figure B.5).

Platform, core

The surface of a core to which force is applied and from which flakes are struck (see Figure B.1).

Platform, flake

The surface to which force was applied in the detachment of the flake (see Figures B.1 and B.5).

Point, bifacial

A retouched flake or hemispheric core with retouch/scarring to both faces/hemispheres. The defining feature of the artefact is that retouch/scarring is such that it results in the formation of a 'point' on at least one end of the artefact. Bifacial points are also characterised by relatively low thickness to width ratios, and can also be differentiated from other hemispheric core forms by their comparative elongation.

Point, unifacial

A retouched flake exhibiting retouch to the dorsal face only. Retouch is such that it exaggerates the distal tapering of the flake, forming a point.

Recycling

Recycling is used in this thesis to refer to the reworking of an artefact after breakage, or where an implement is transformed from one identifiable form into another. In the former case the broken margin usually truncates existing flake scars, and is then itself overlain by fresh scars.

Scar length

Scar length was measured on all radial and levallois cores, and all retouched flakes. In all cases, the artefact was divided into *Sectors* (see below), with the longest scar measured for each sector. Measurement was taken from the edge of the artefact to the termination of the scar. Scar length was only measured on scars for which a termination, though no necessarily an initiation, could be identified. Initiations were often obscured by subsequent small scarring along the working or platform edge. To that extent, the measure is a minimum estimate of the length of the longest scar.

Scraper

An retouched flake displaying unifacial retouch directed onto the dorsal face only. Scrapers are a heterogeneous class, and can be defined as any unifacially retouched flake where the retouch does not result in the formation of a point, or in the formation of notches along the lateral margins.

Sectors

Following Clarkson (2002a), all retouched flakes were divided into sections, or sectors, for the purposes of analysis. Retouched scar angle and maximum retouched scar length were recorded in each sector. For complete retouched flakes, eight sectors were identified (see Figure B.6). Where broken retouched flakes were analysed, an estimate of the number of sectors represented was made, and an appropriate number of measurements taken.

Shoulderless point

A retouched flake with short, high angle retouch scarring extending from the platform along both lateral margins of the flake (see Plate 8.5). The pointedness of the flake may or may not be exaggerated by retouch to the distal end.

Thickness

Thickness refers to the distance from the ventral face of a flake to the dorsal face, measured at 90° to the ventral face. In this thesis, the thickness data used are maxima, or ‘maximum thickness’, which refers to the greatest distance from the ventral face to the dorsal face at 90° to the ventral face (see Figure B.7). For this thesis, maximum thickness was measured to one tenth of a millimetre using digital callipers.

Ventral face

A ventral face is formed in the detachment of a flake from a core. The ventral face is the flake surface that retains the positive percussive features of the detachment event (see Figure B.1 and B.5).

Weight

Weight refers to the mass of an object. Weight was measured to one tenth of a gram using digital scales.

Width

Width refers to the distance across the ventral face of a flake, measured at 90° to the axis of percussion (see *Length*). In this thesis, the width data used are maxima, or ‘maximum width’, which refers to the greatest distance across the ventral face at 90° to the axis of percussion (see Figure B.8). For this thesis, maximum width was measured to one tenth of a millimetre using digital callipers.

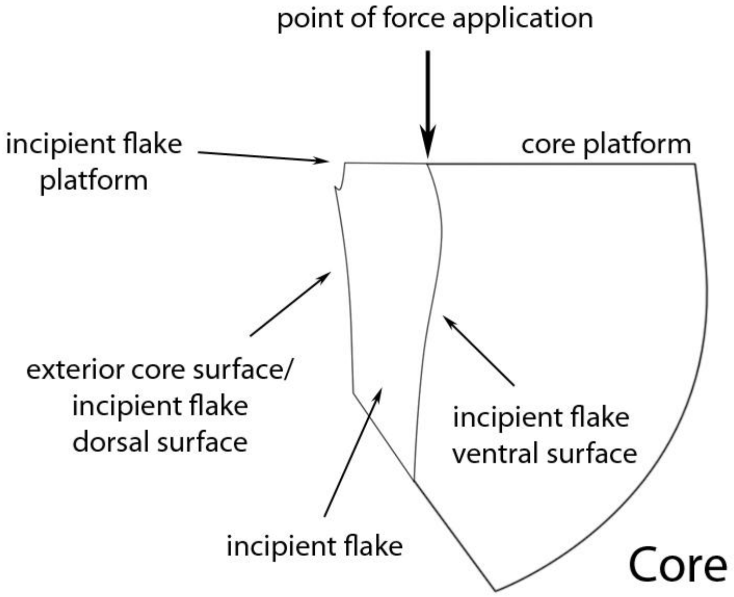

Figure B.1 Flake formation and core features

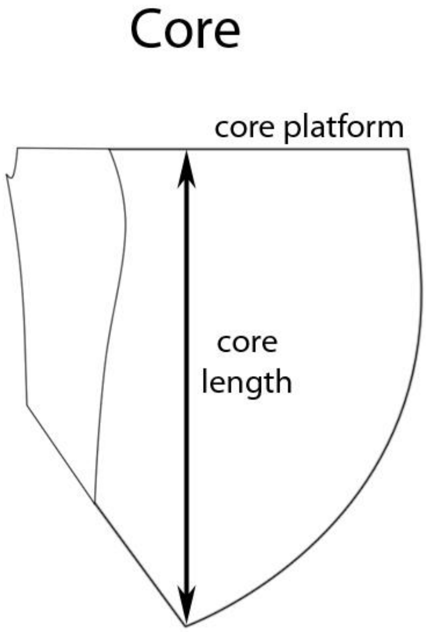

Figure B.2 Measuring core length

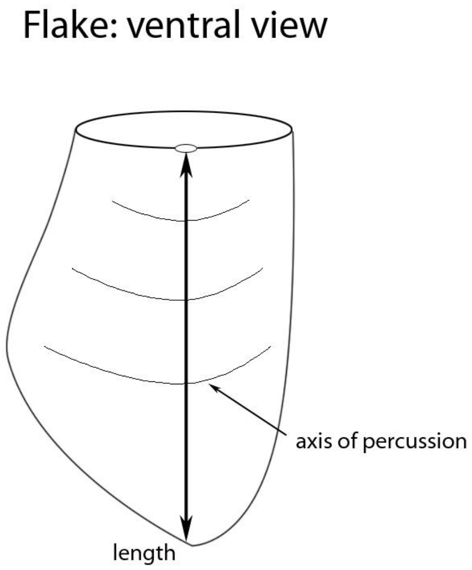

Figure B.3 Measuring flake length

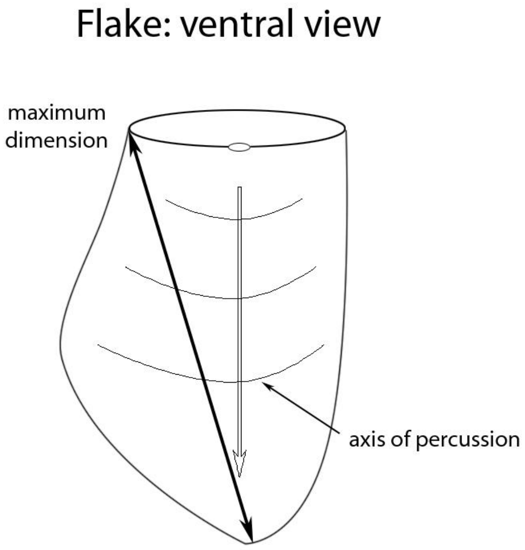

Figure B.4 Measuring flake maximum dimension

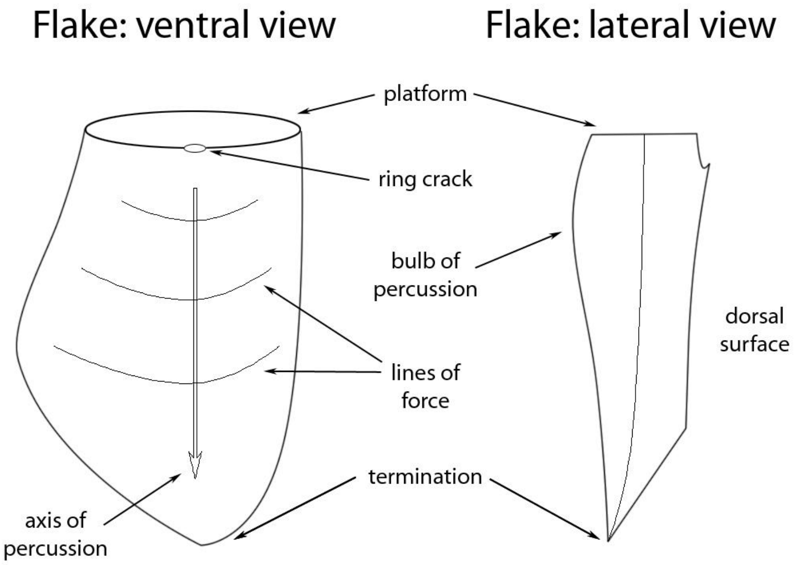

Figure B.5 Flake features

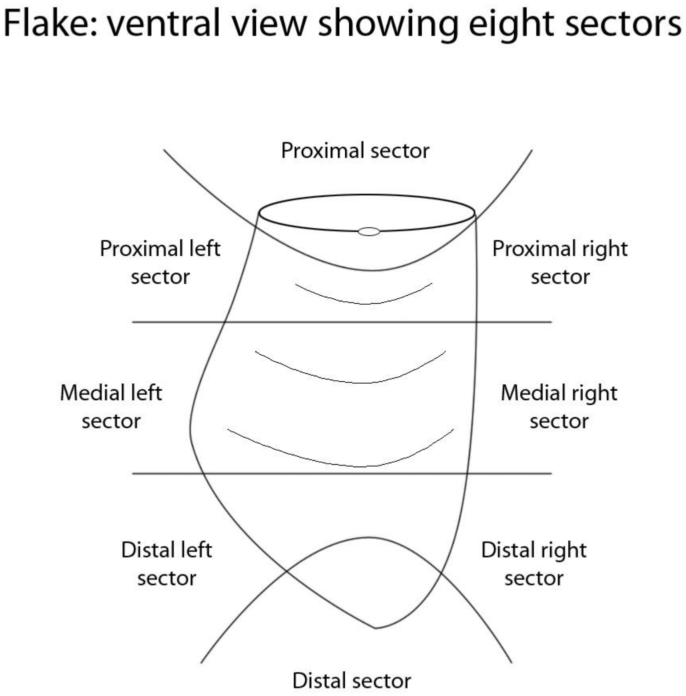

Figure B.6 Flake sectors

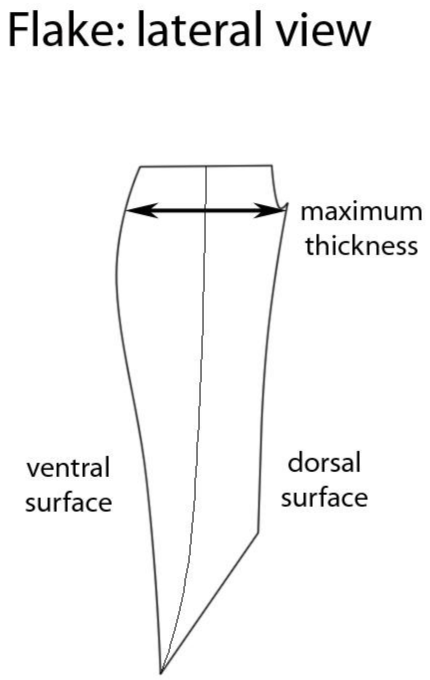

Figure B.7 Measuring flake maximum thickness

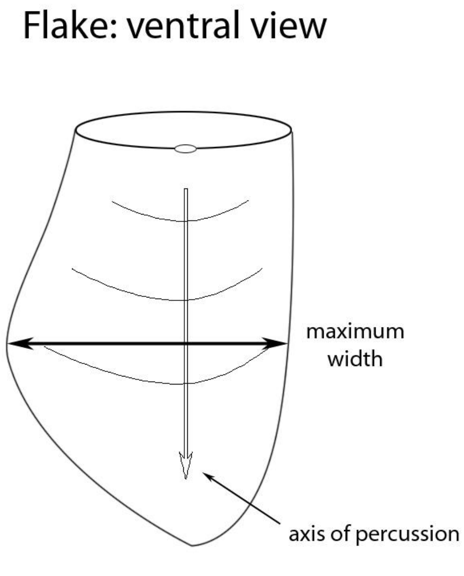

Figure B.8 Measuring flake maximum width

HISTORY AND SELECTION IN THE LATE PLEISTOCENE ARCHAEOLOGY OF THE WESTERN CAPE, SOUTH AFRICA

Volume 2

Alex Mackay

Thesis submitted for the degree of Doctor of Philosophy of The Australian National University

October 2009

I hereby declare that the work contained in this thesis is entirely my own except where the work of others has been acknowledged. This thesis has not previously been submitted in any form for any other degree at this or any other university.

Alex Mackay

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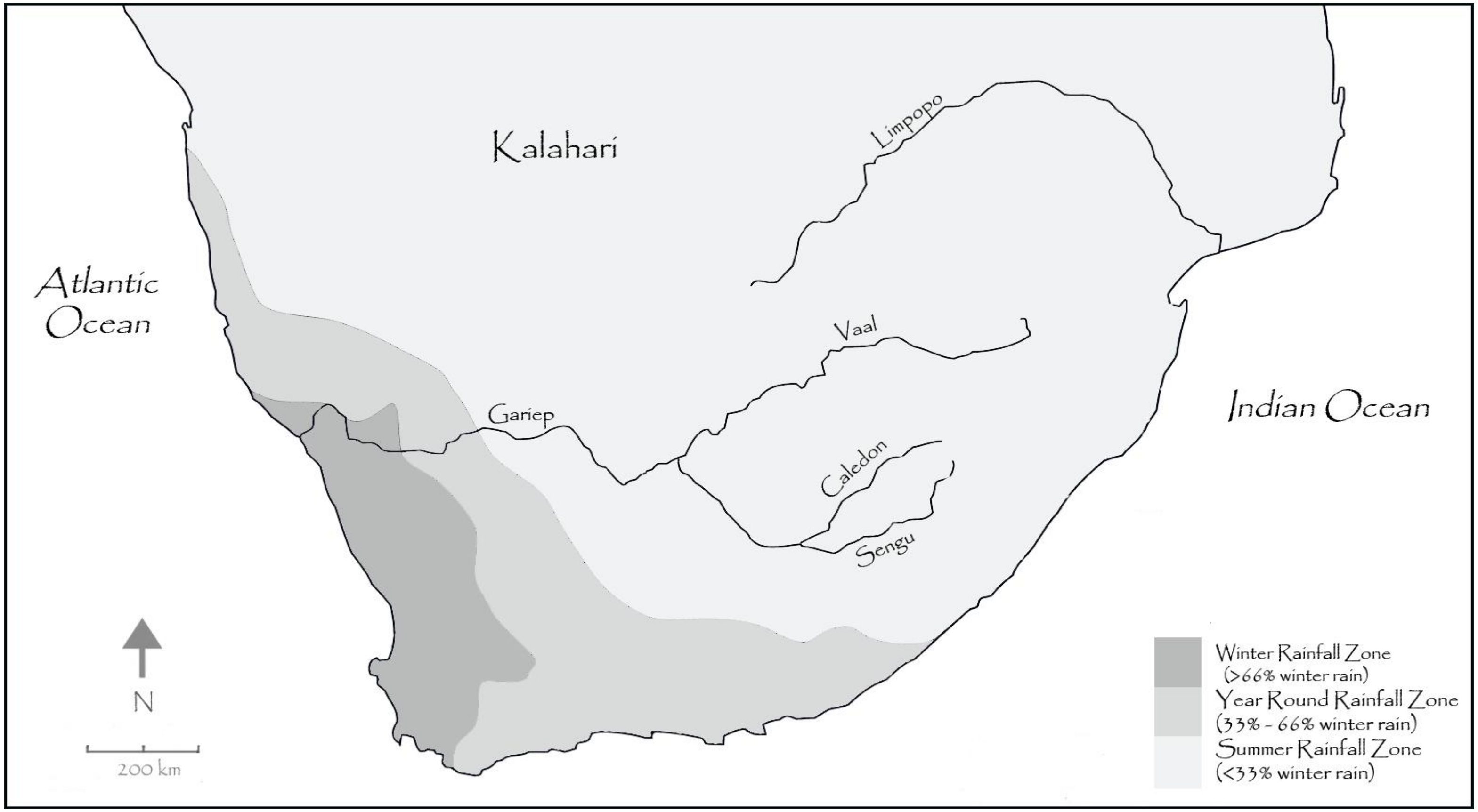


FIGURE 2.1: Current rainfall zones of southern Africa

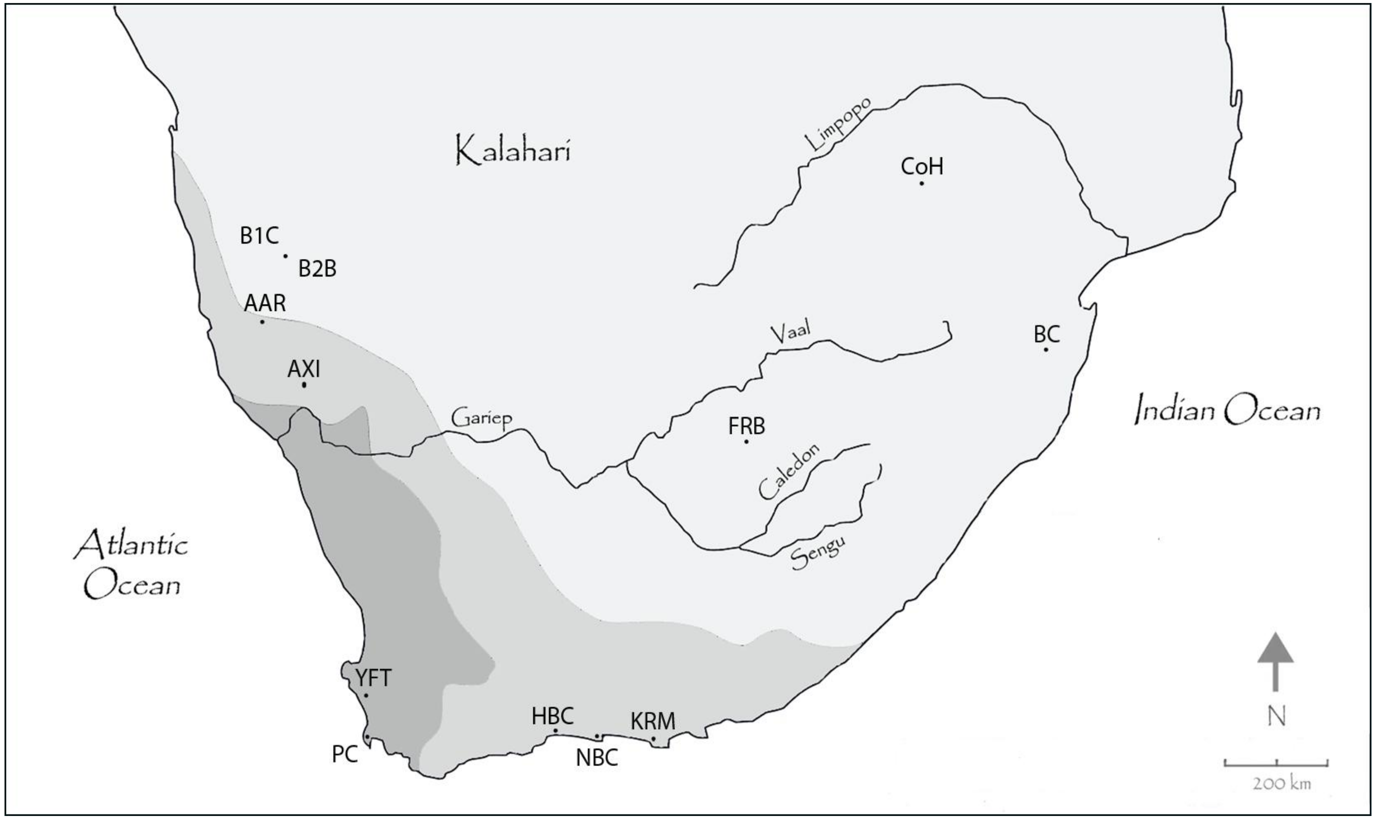


FIGURE 2.2: MSA 2a sites in relation to present rainfall zones

(AAR=Aarhuis; AXI=Apollo XI; B1C=Bremen 1C; B2C=Bremen 2C; BC=Border Cave; CoH=Cave of Hearths; FRB=Florisbad; HBC=Herolds Bay Cave; KRM=Klasies River; NBC=Nelson Bay Cave; PC=Peers Cave;YFT=Ysterfontein)

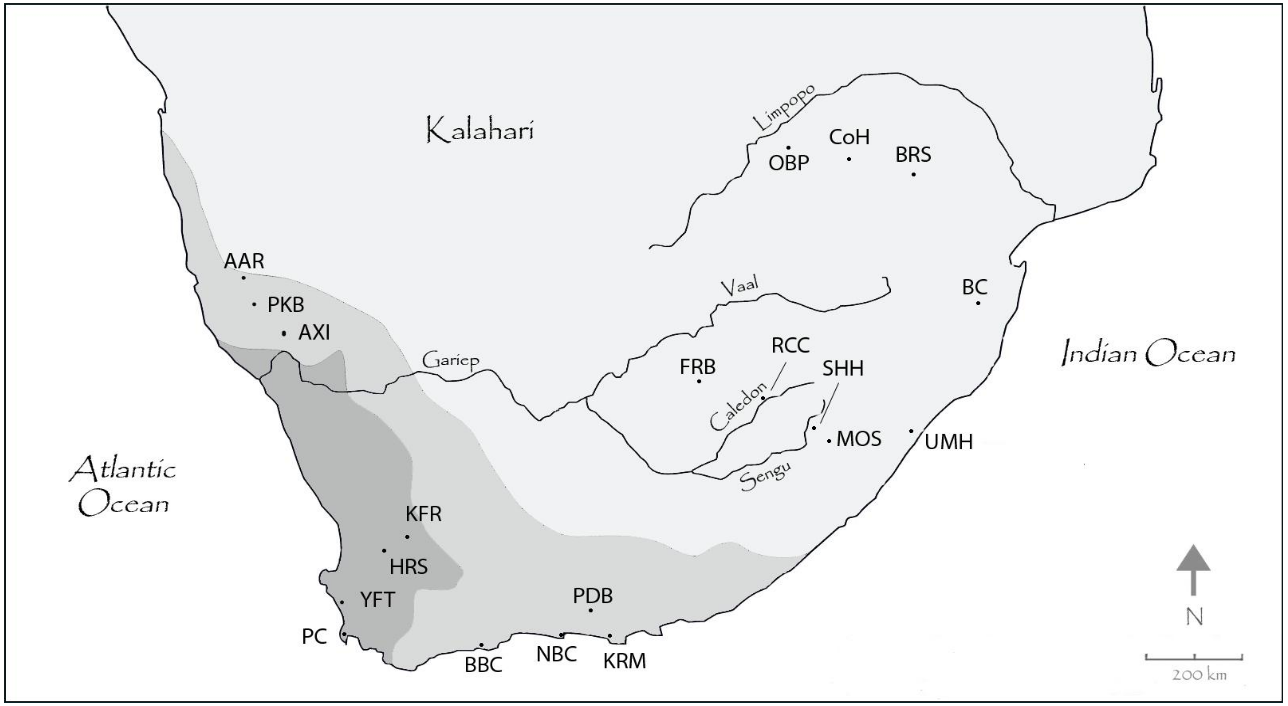


FIGURE 2.3: MSA 2b sites in relation to present rainfall zones

(AAR=Aarhuis; AXI=Apollo XI; BBC=Blombos Cave; BC=Border Cave; BRS=Bushman Rockshelter; CoH=Cave of Hearths; FRB=Florisbad; HBC=Herolds Bay Cave; HRS=Hollow Rockshelter; KFR=Klipfonteinrand; KRM=Klasies River; MOS=Moshebis; NBC=Nelson Bay Cave; OBP=Olieboomport; PC=Peers Cave; PDB=Paardeberg; PKB=Pockenbank; RCC=Rose Cottage Cave; SHH=Sehonghong; YFT=Ysterfontein; UMH=Umhlatuzana)

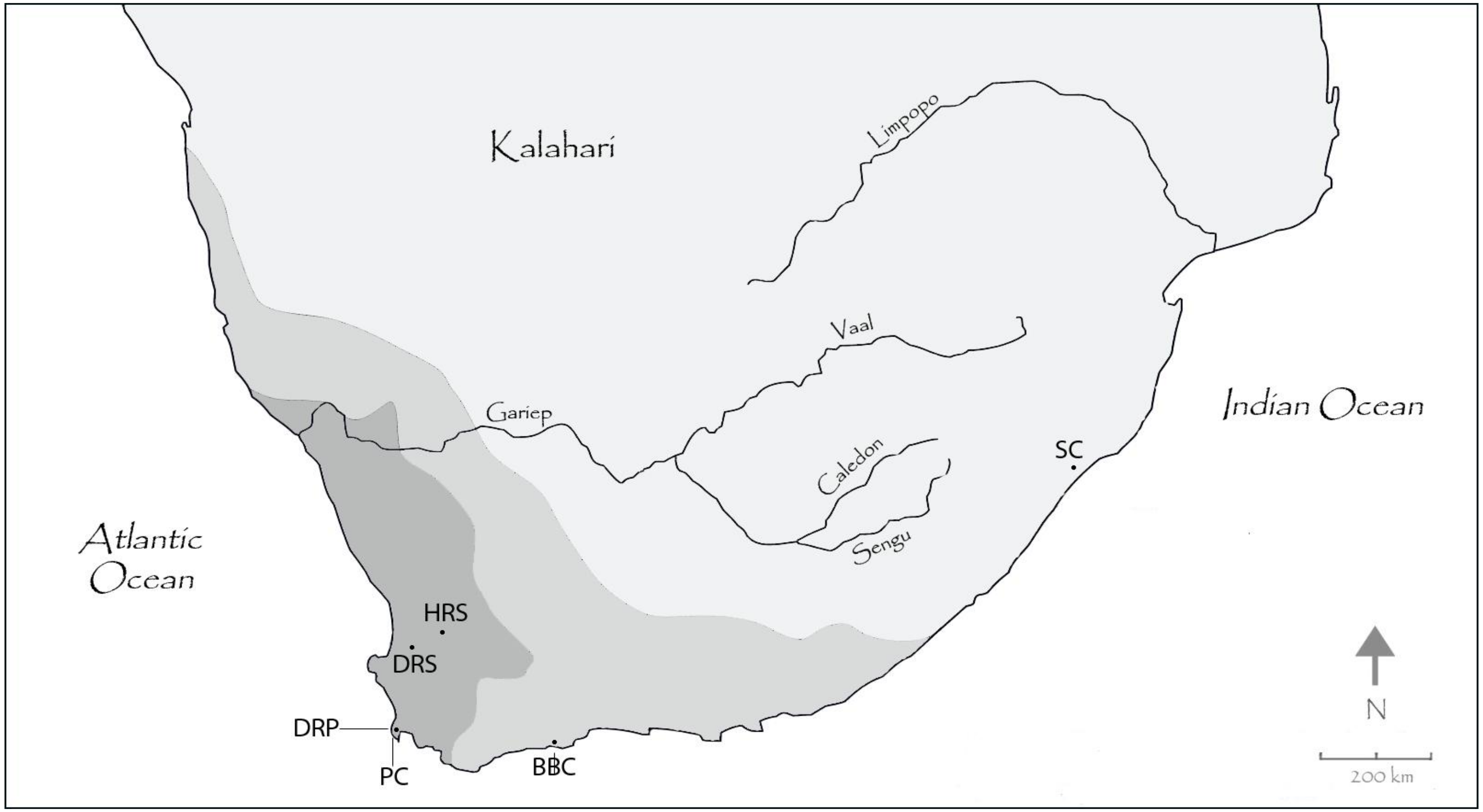


FIGURE 2.4: Still Bay sites in relation to present rainfall zones

(BBC=Blombos Cave; DRP=Dale Rose Parlour; DRS=DiepklooRockshelter; HRS=Hollow Rockshelter; PC=Peers Cave; SC=Sibudu Cave)

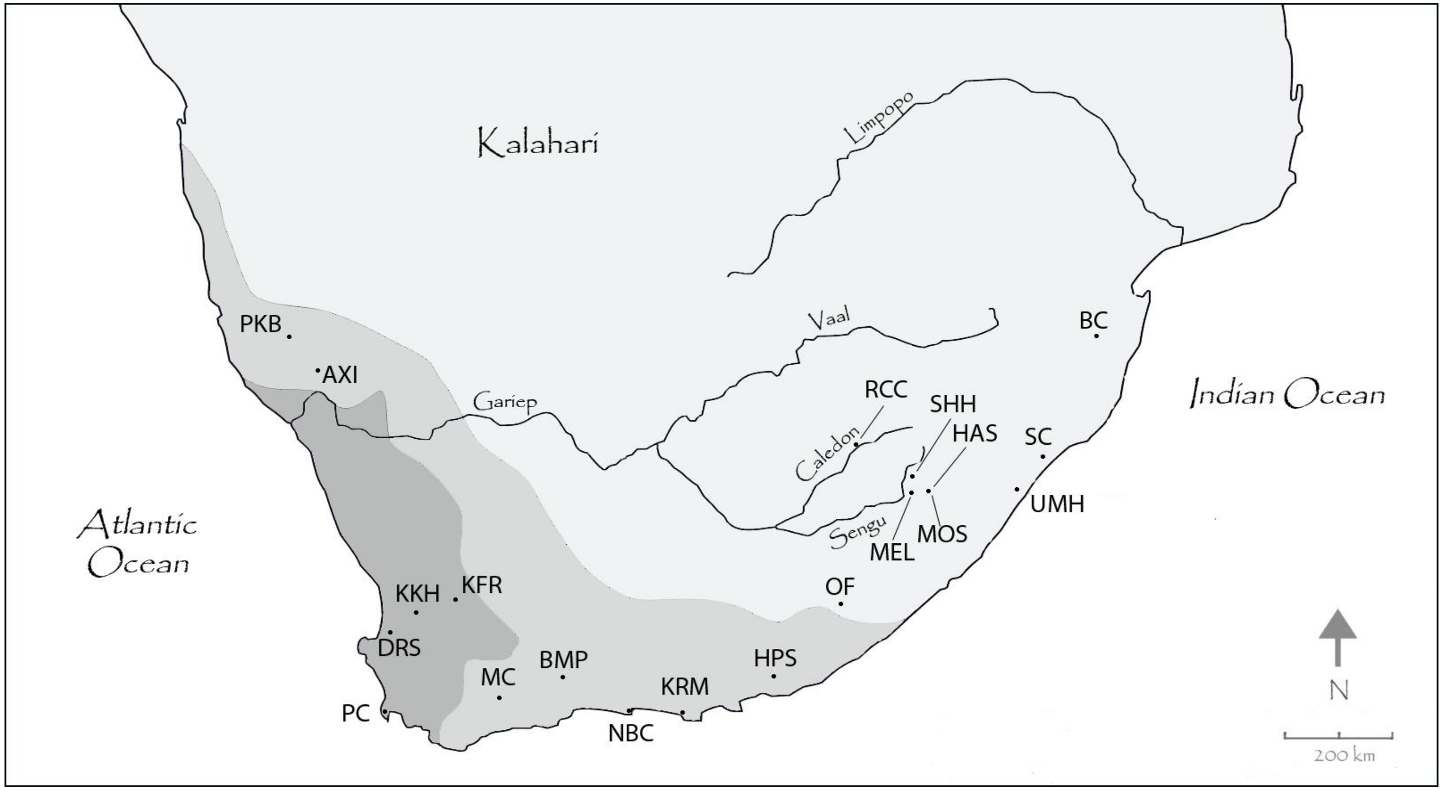


FIGURE 2.5: Howiesons Poort sites in relation to present rainfall zones

(AXI=Apollo XI; BC=Border Cave; BMP=Boomplaas; DRS=Diepkloof Rockshelter; HAS=Ha Soloja; HPS=Howiesonspoort Rockshelter; KFR=Klipfonteinrand; KKH=Klien Kliphuis; KRM=Klasies River; MC=Montagu Cave; MEL=Melikane; MOS=Moshebis; NBC=Nelson Bay Cave; OF=Orange Farm; PC=Peers Cave; PKB=Pockenbank; RCC=Rose Cottage Cave; SC=Sibudu Cave; SHH=Sehonghong; UMH=Umhlatuzana)

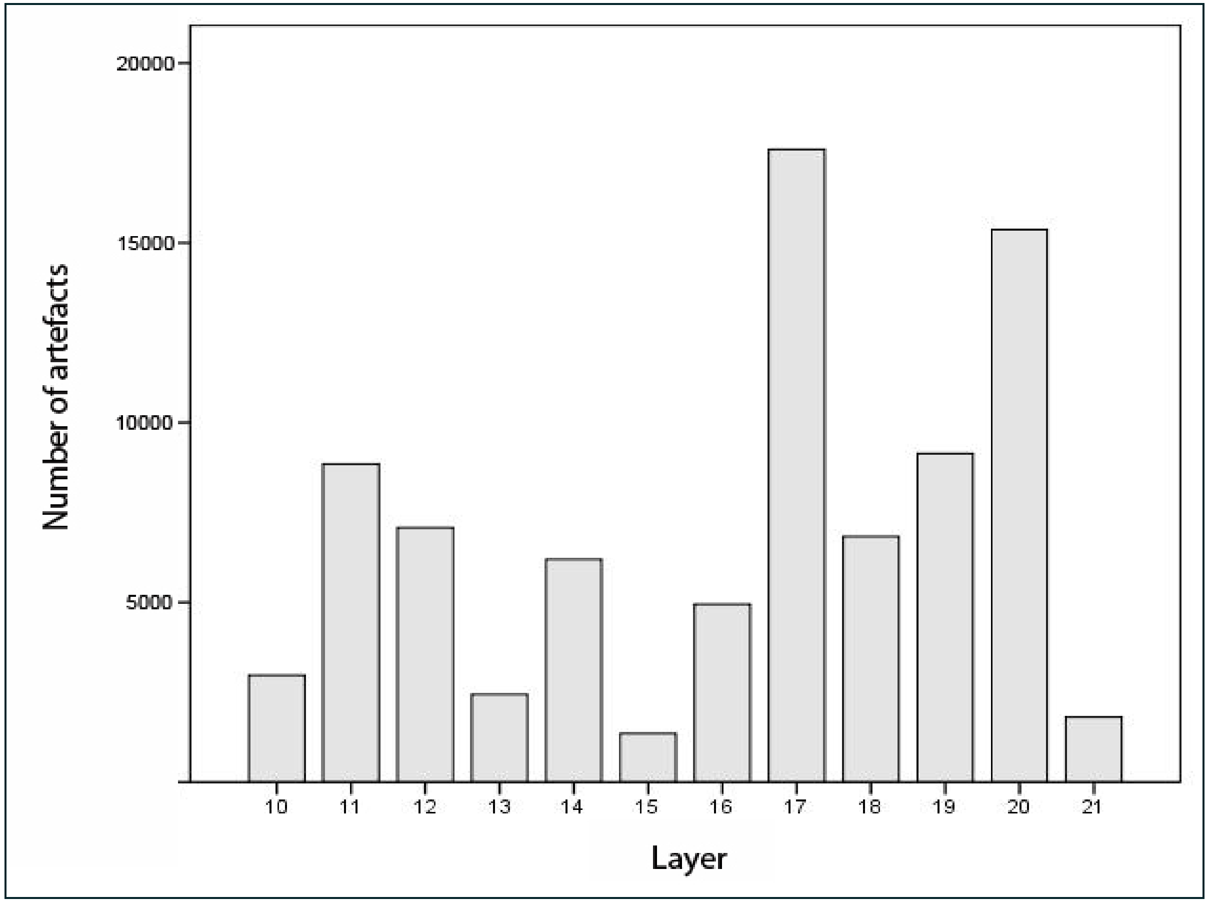


FIGURE 2.6: Numbers of flakes by layer at Klasies River main site

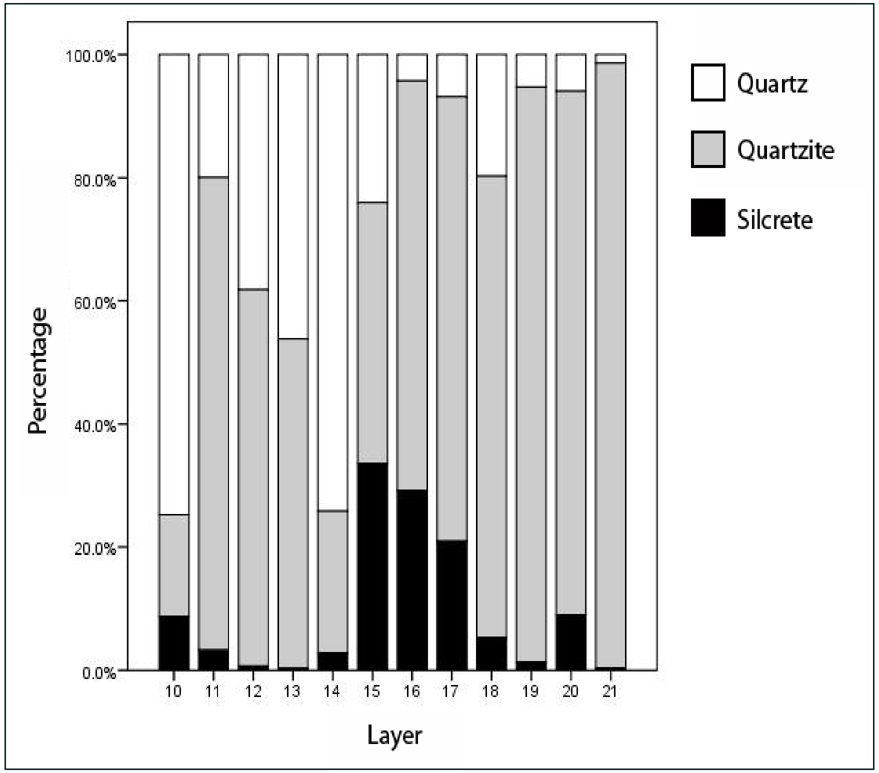


FIGURE 2.7: Material changes at Klasies River main site

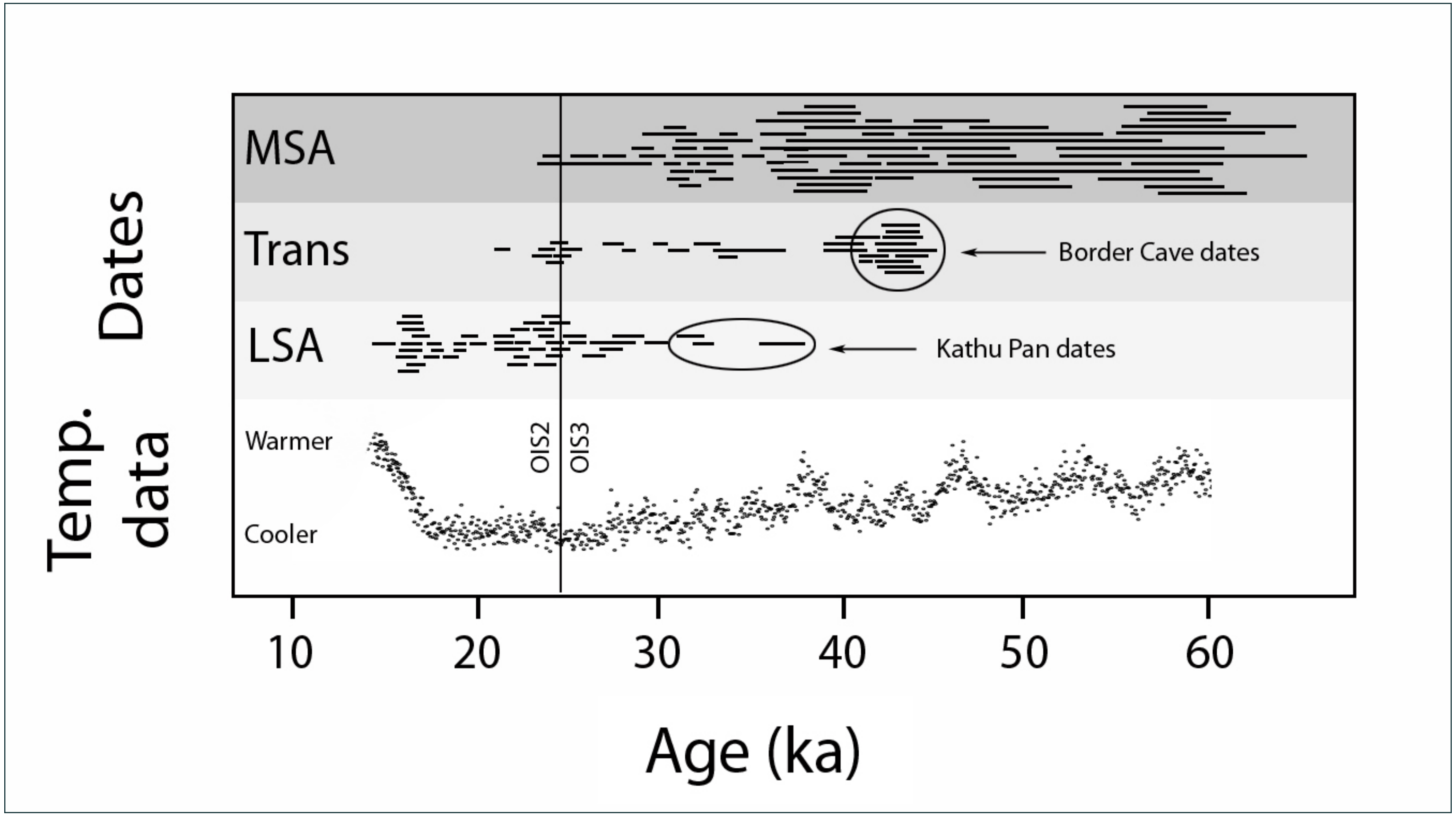


FIGURE 2.8: MSA and LSA dates against temperature change in the Epica Dome C core

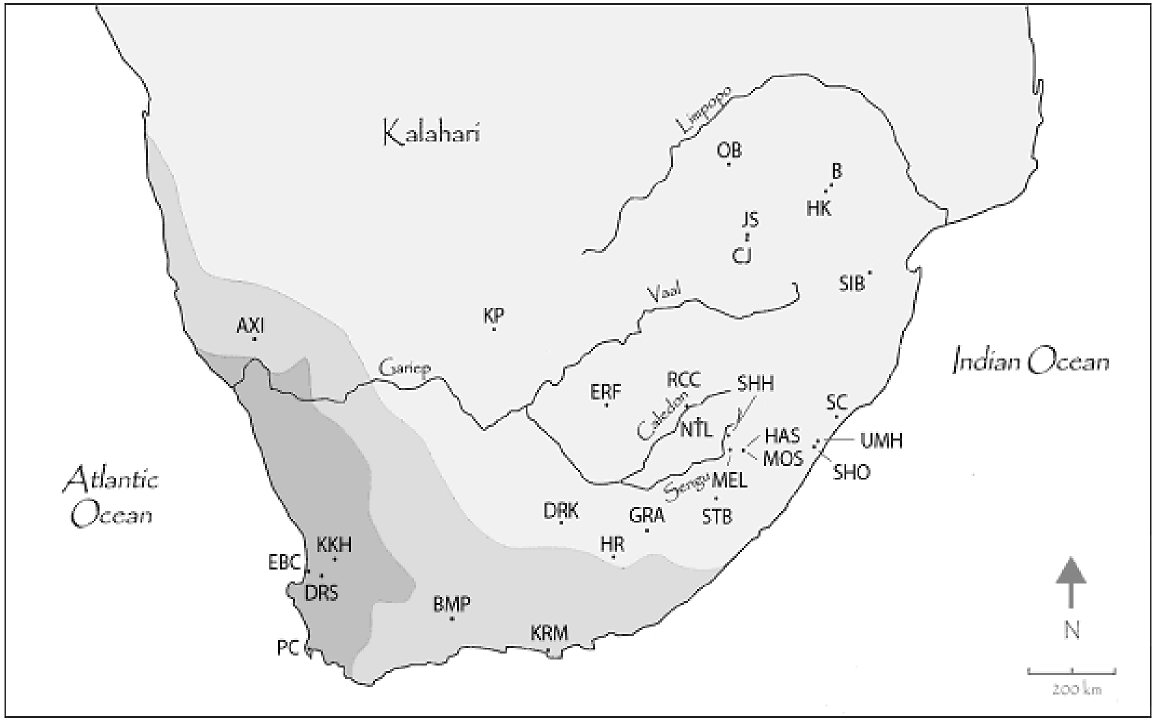


FIGURE 2.9: All sites occupied between 60 ka and 20 ka in relation to present rainfall zones

(AXI=Apollo XI; B=Bushman Rockshelter; BC=Border Cave; BMP=Boomplaas; CJ=Cave James; DRK=Driekoppen; DRS=Diepkloof Rockshelter; EBC=Elands May Cave; ERF=Erfkroon; GRA=Grassridge; HAS=Ha Soloja; HK=Heuningneskrans; JS=Jubilee Shelter; KKH=Klein Kliphuis; KP=Kathu Pan; KRM=Klasies River; MEL=Melikane; MOS=Moshebis; NTL=Ntloana Tsoana; PC=Peers Cave; RCC=Rose Cottage Cave; SHH=Sehonghong; SHO=Shongweni; SIB=Sidebe Shelter; SC=Sibudu Cave; STB=Strathalan B; UMH=Umhlatuzana)

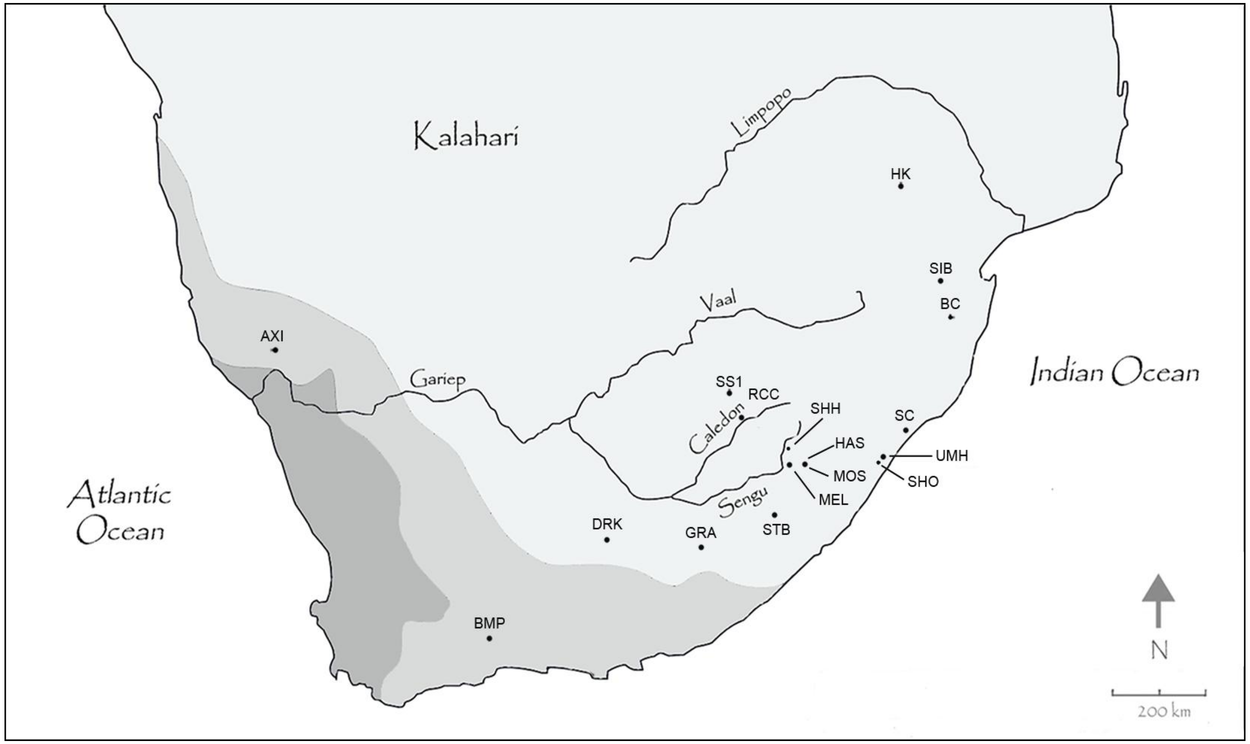


FIGURE 2.10: All sites occupied between 40 ka and 24 ka in relation to present rainfall zones
(AXI=Apollo XI; BC=Border Cave; BMP=Boomplaas; DRK=Driekoppen; GRA=Grassridge; HAS=Ha Soloja; HK=Heuningneskrans; MEL=Melikane; MOS=Moshebis; RCC=Rose Cottage Cave; SHH=Sehonghong; SHO=Shongweni; Sibudu Cave; SIB=Sidebe Shelter; SS1=Sunnyside ; STB=Strathalan B; UMH=Umhlatuzana)

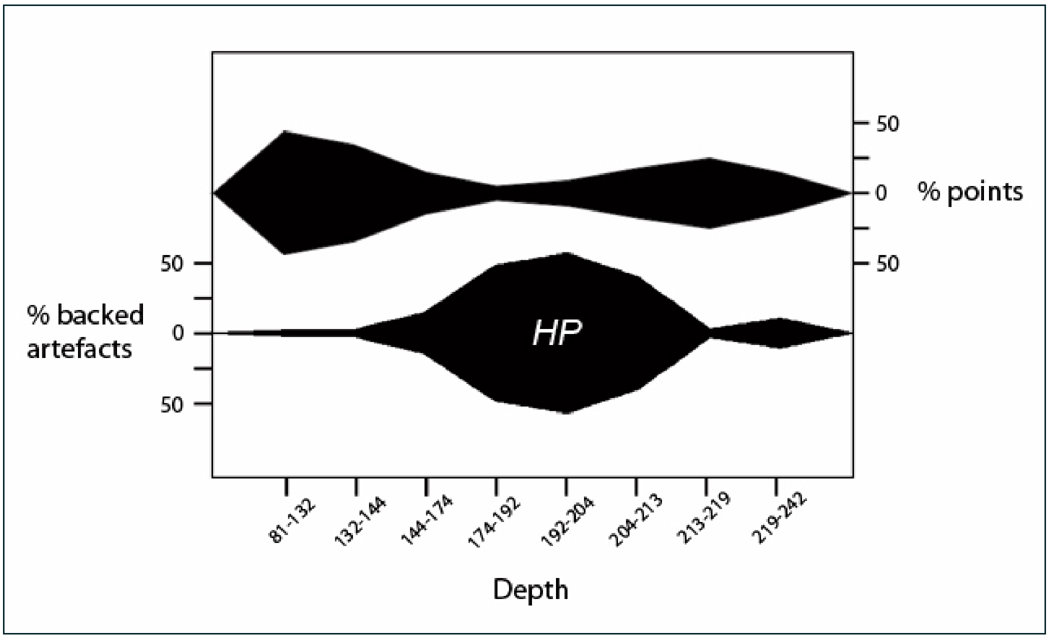


FIGURE 2.11a: Changes in percentages of backed artefacts and points at Rose Cottage Cave

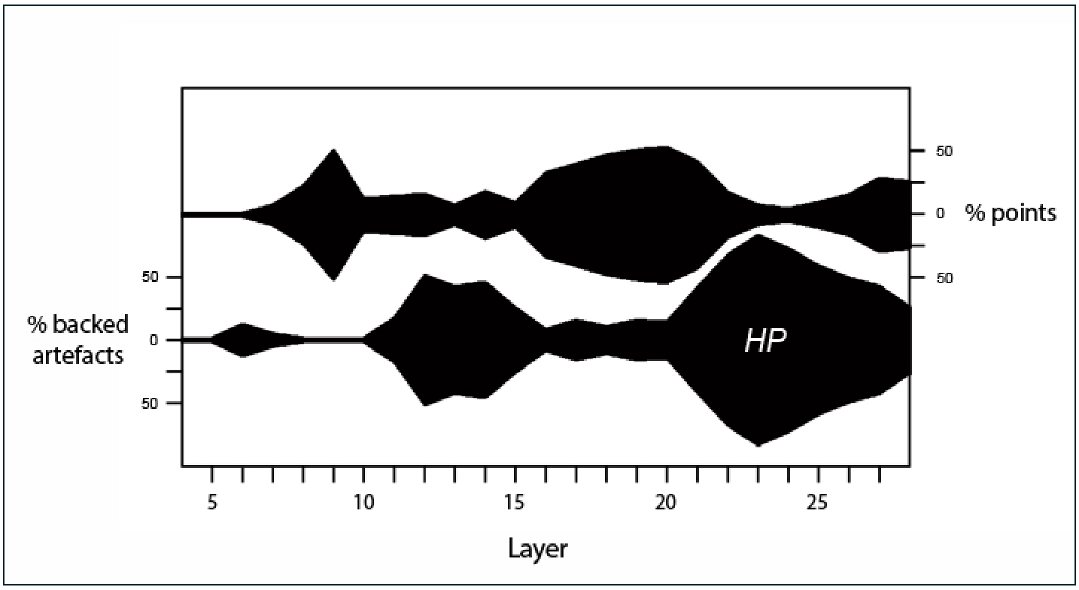


FIGURE 2.11b: Changes in percentages of backed artefacts and points at Umhlatuzana

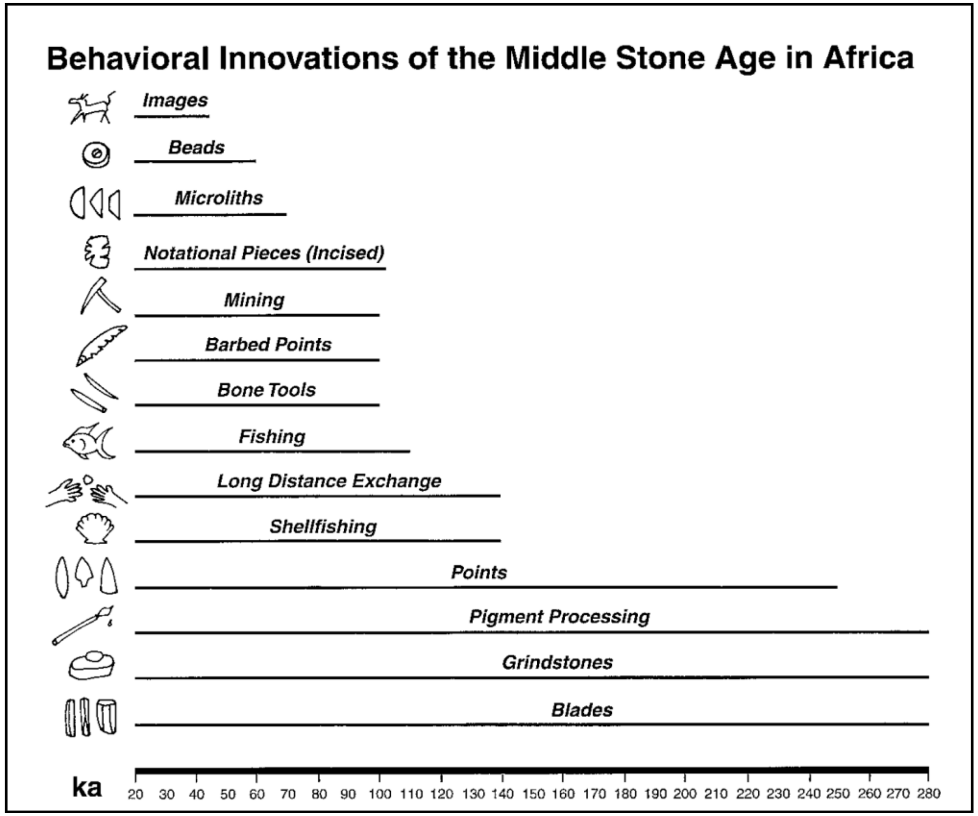


FIGURE 3.1: Sequences of technological change in Africa, from McBrearty and Brooks 2000: 530

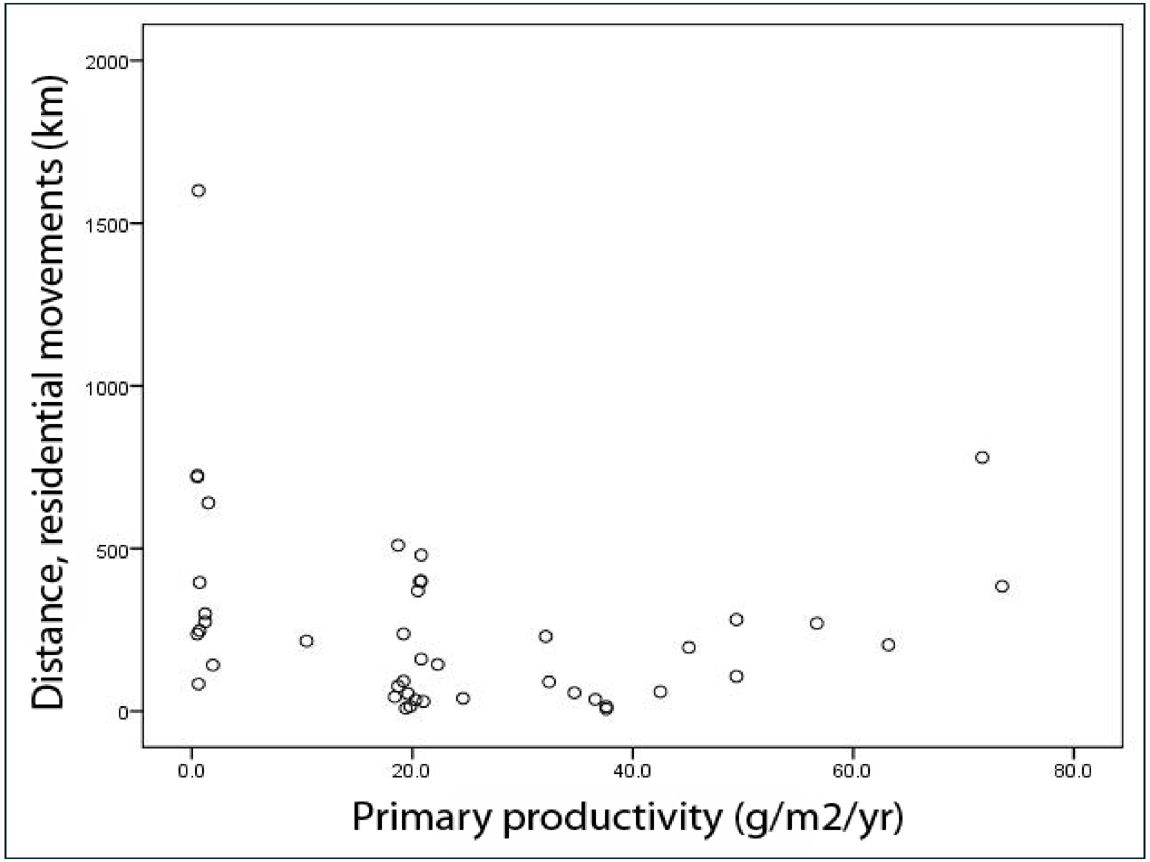


FIGURE 4.1: Ethnographic data on the relationship between distance covered in residential movements and primary productivity

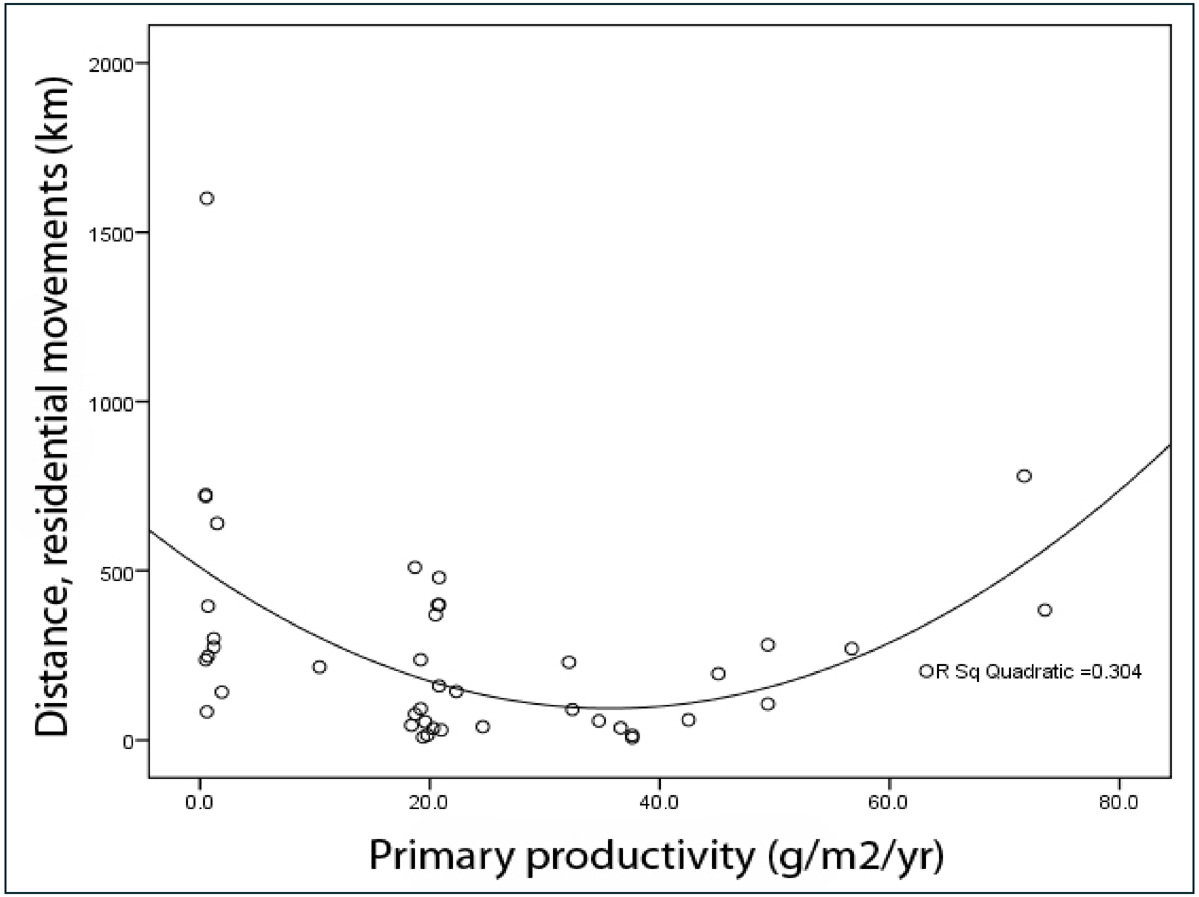


FIGURE 4.2: Relationship between distance covered in residential movements and primary productivity with fit line

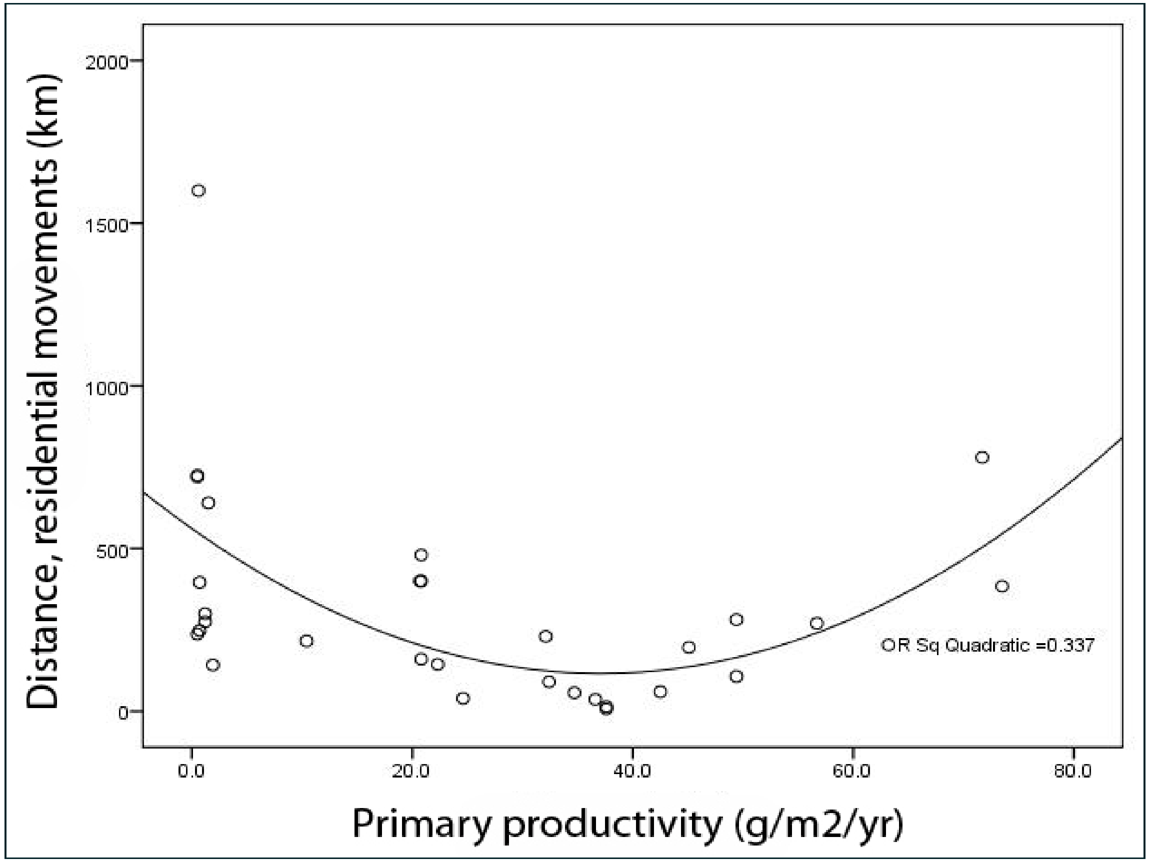


FIGURE 4.3: Relationship between distance covered in residential movements and primary productivity with fit line, hunter fishers excluded

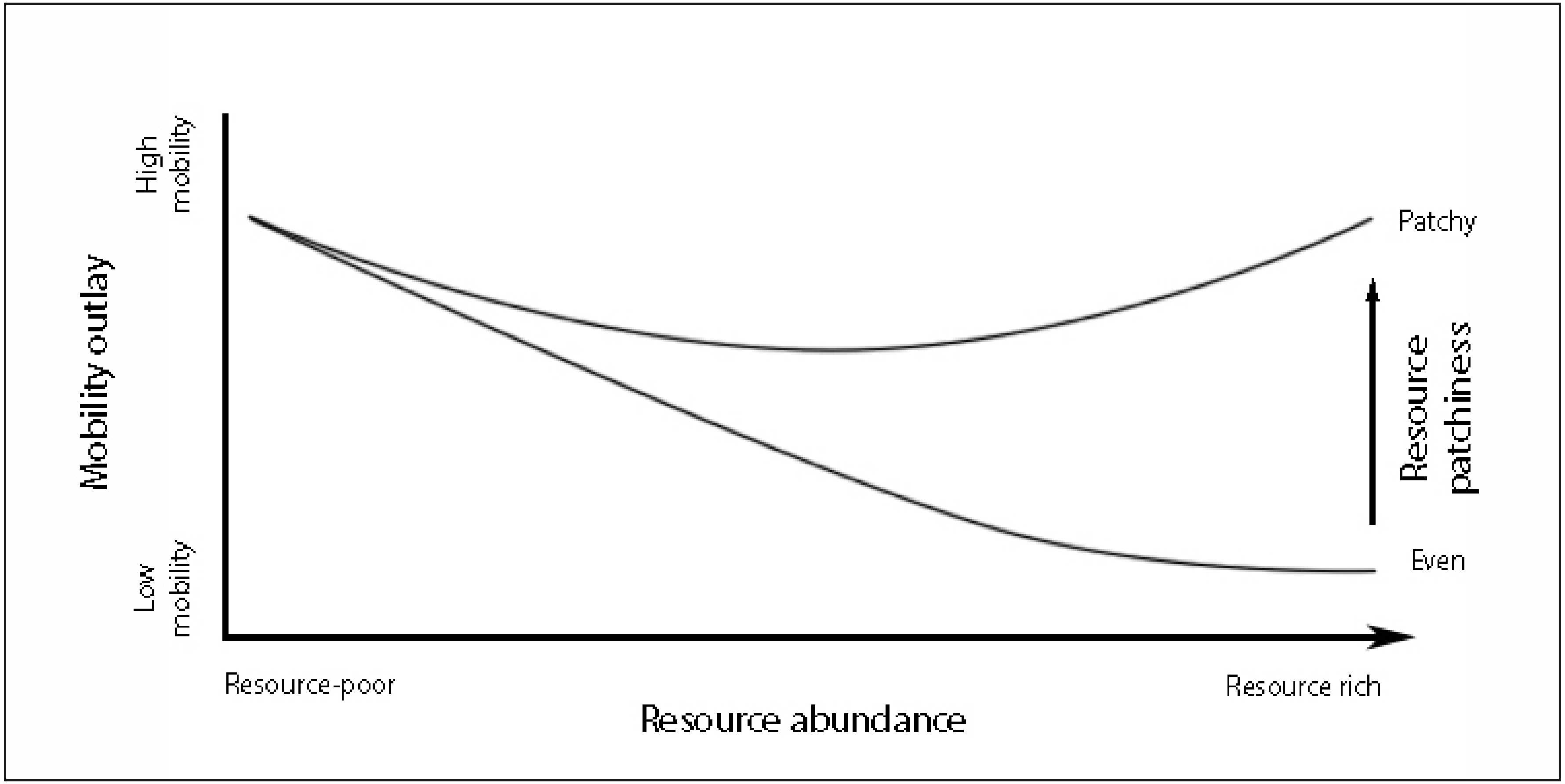


FIGURE 4.4: Hypothetical model of the relationship between magnitude of mobility, resource abundance and resource patchiness

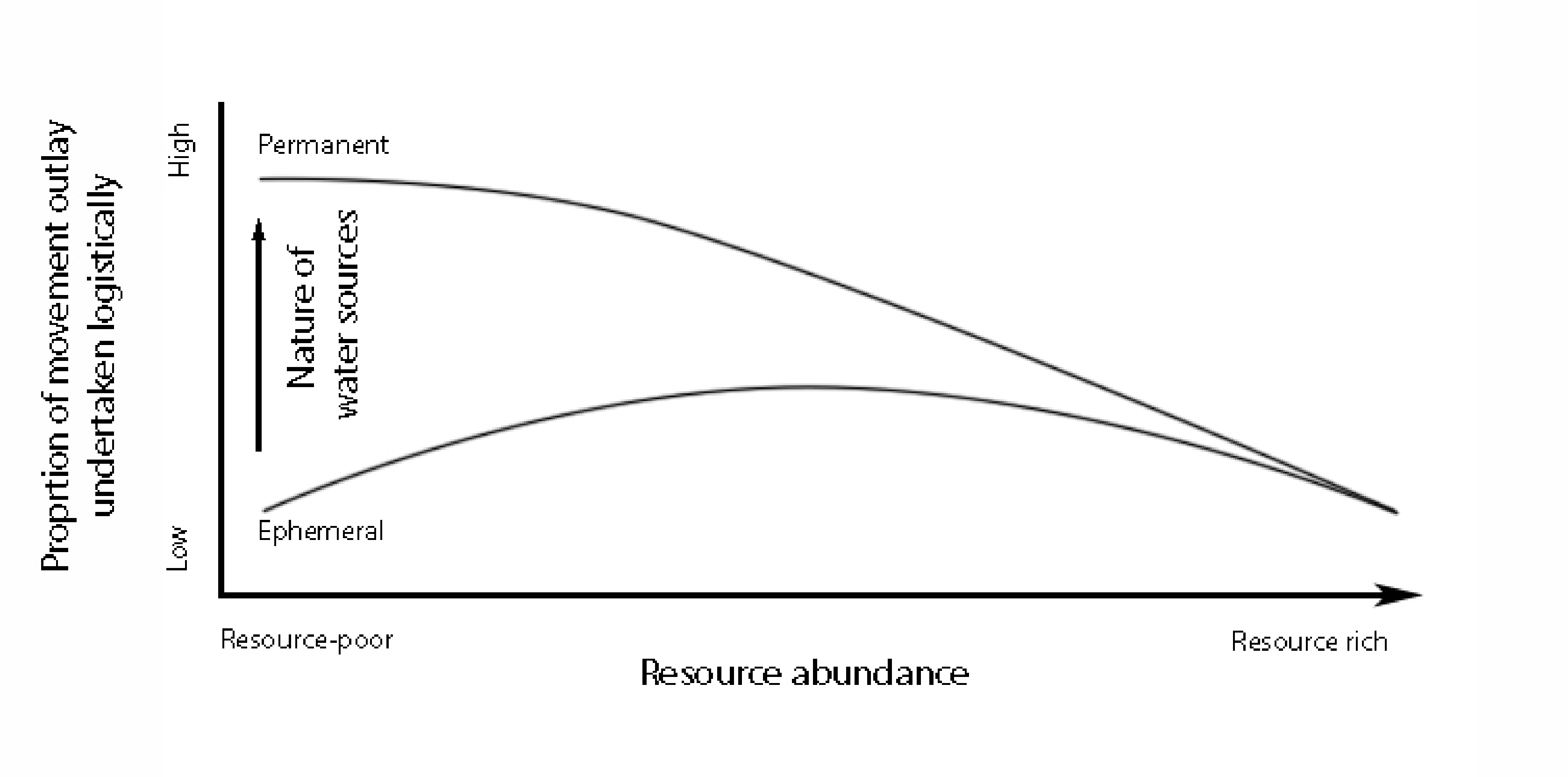


FIGURE 4.5: : Hypothetical model of the relationship between organisation of mobility, resource abundance and availability of water

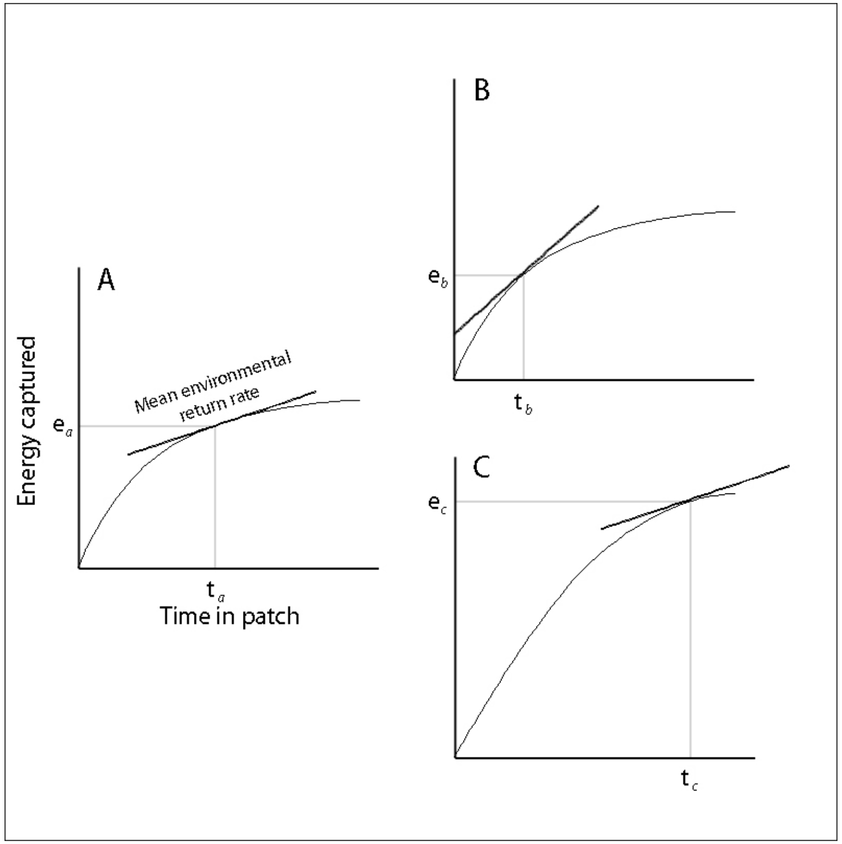


FIGURE 4.6: Marginal value theorem under three different conditions. In (a) and (b) the patch depletes at the same rate but mean environmental return rates differ. In (c) mean environmental return rate is the same as for (a), but patch depletion is slower.

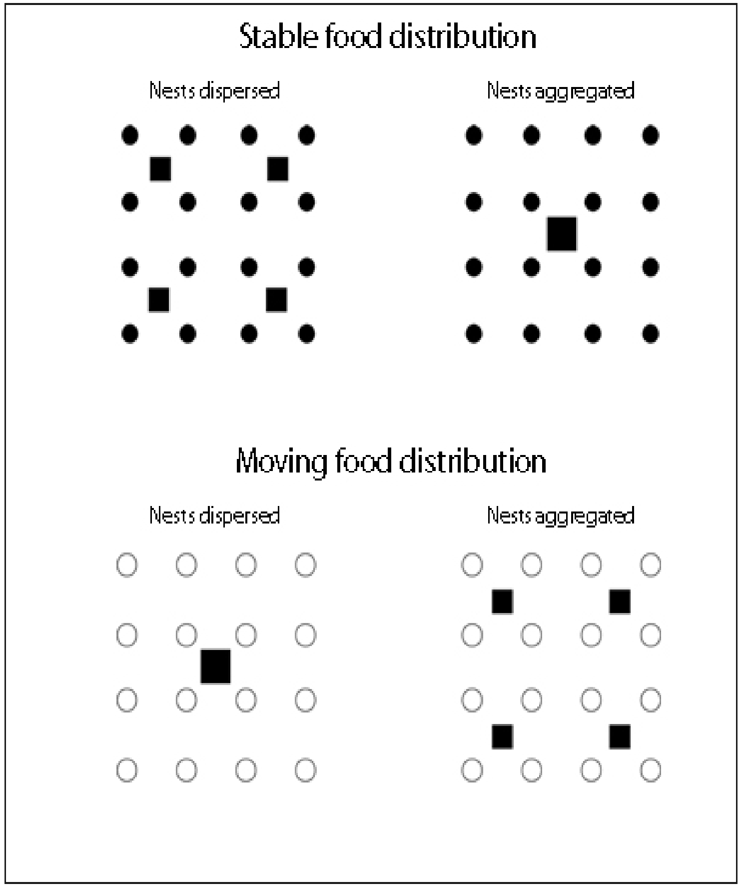


FIGURE 4.7: Population clumping and dispersal under four conditions, following Horns (1968) dispersion model

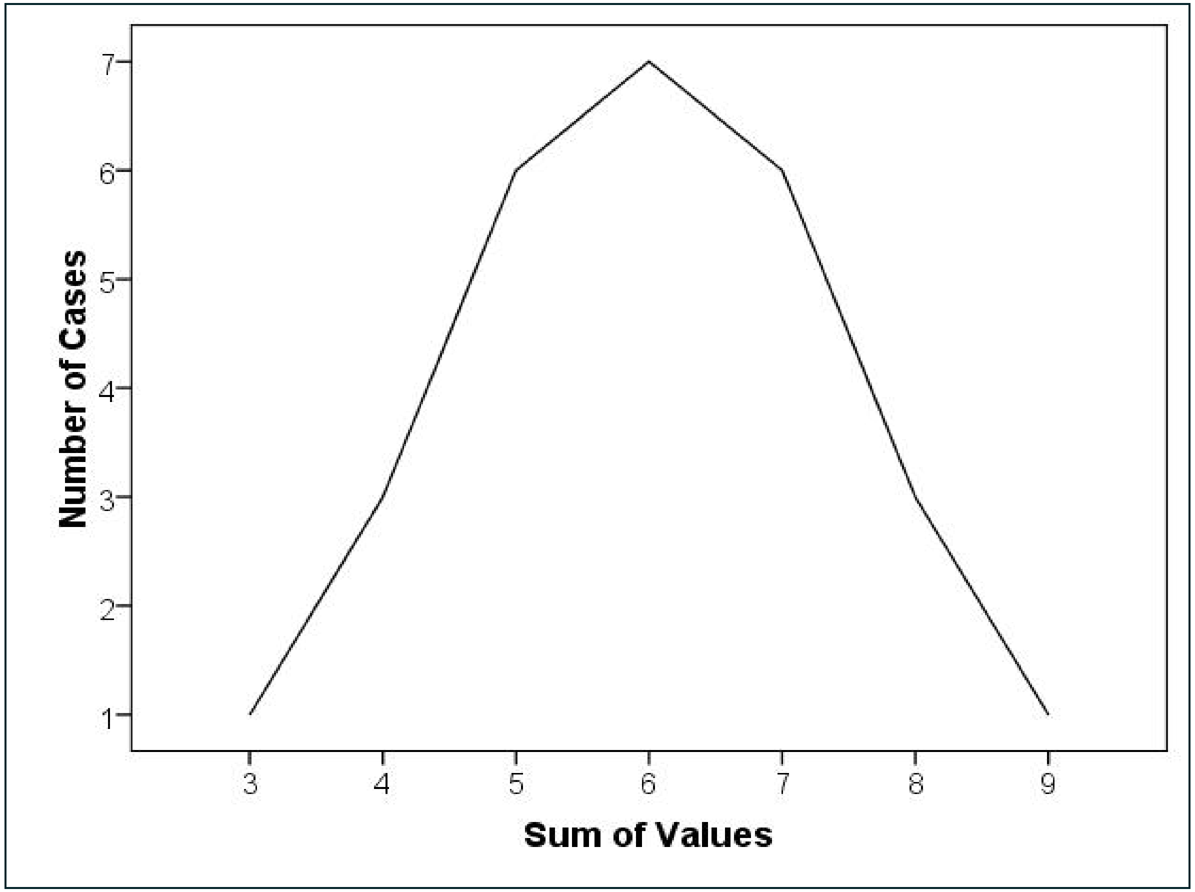


FIGURE 4.8: Line histogram of aggregated time costs

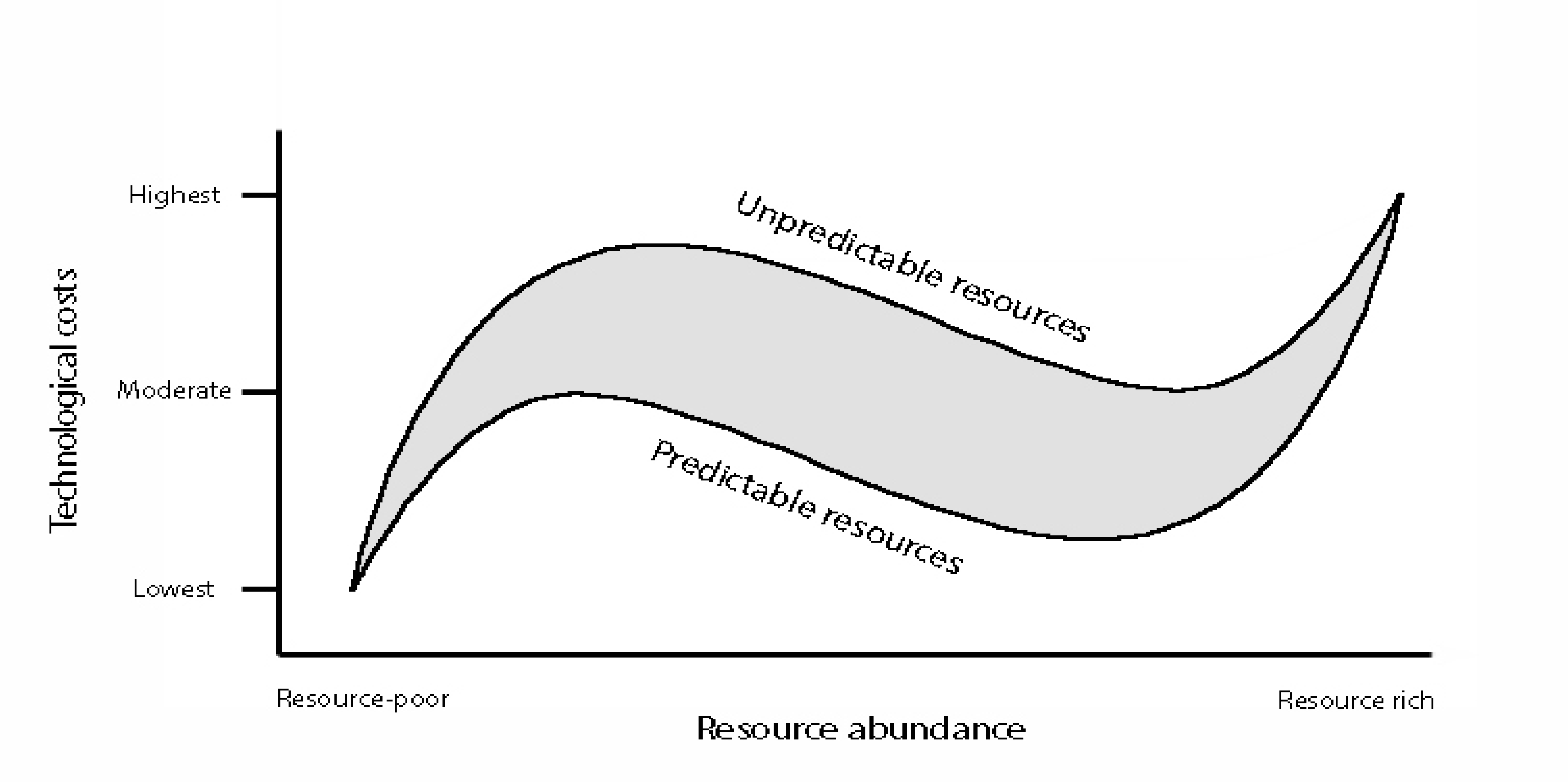


FIGURE 4.9: ‘Tilda’ curve of technological costs in relation to the abundance and predictability of resources

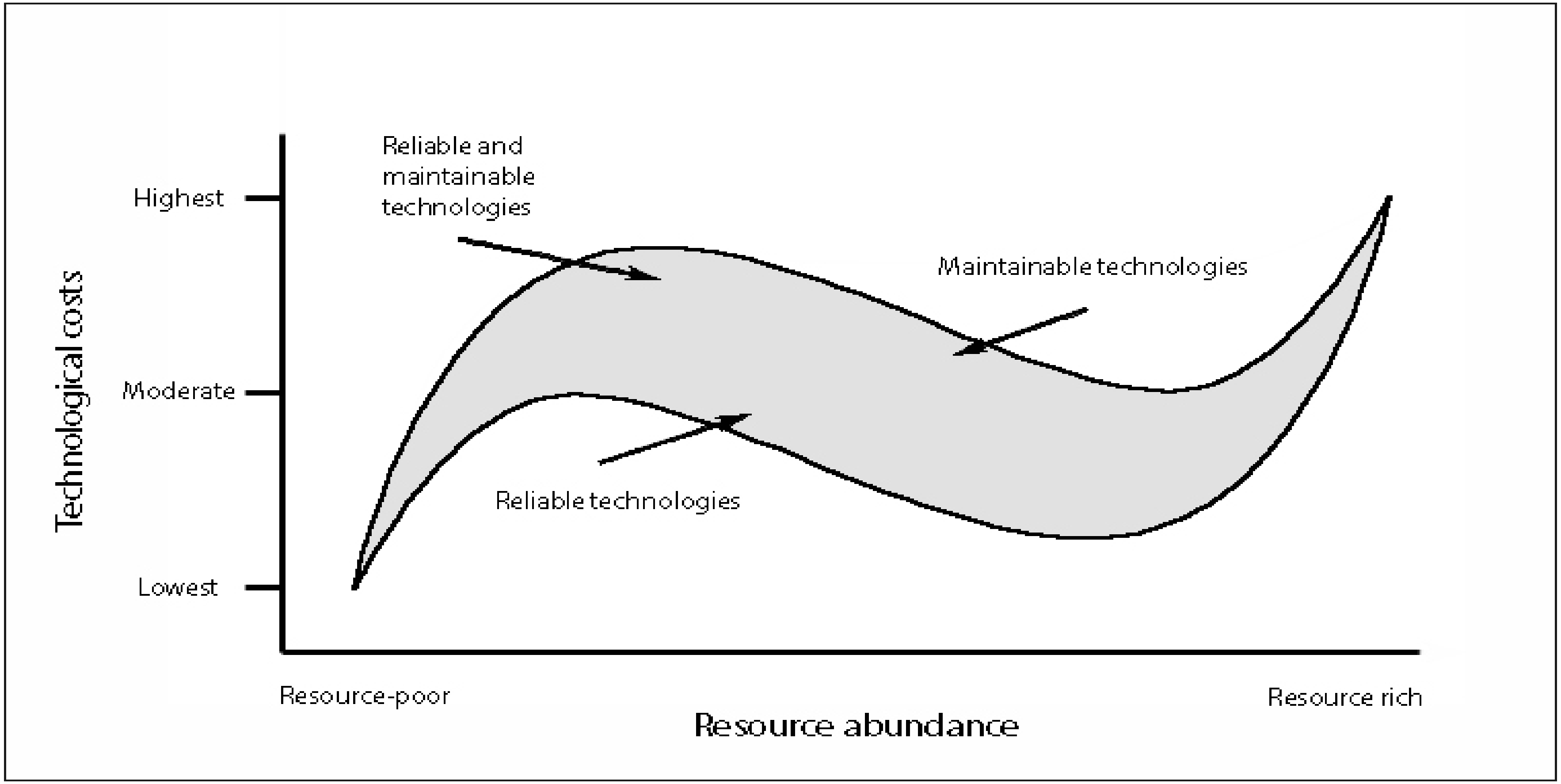


FIGURE 4.10: 'Configuration of technological strategies in relation to the abundance and predictability of resources

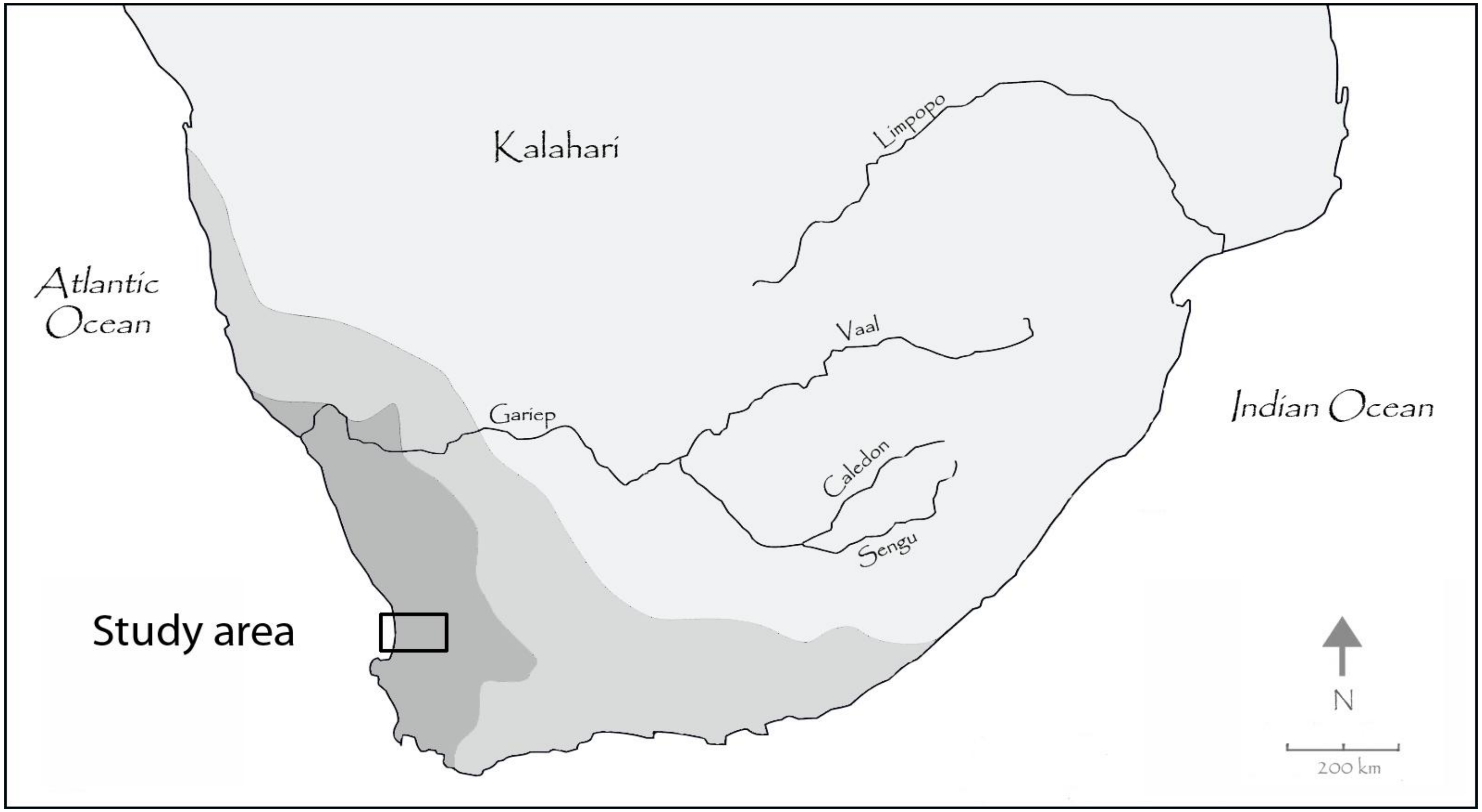


FIGURE 5.1: Location of the study area in relation to present rainfall zones

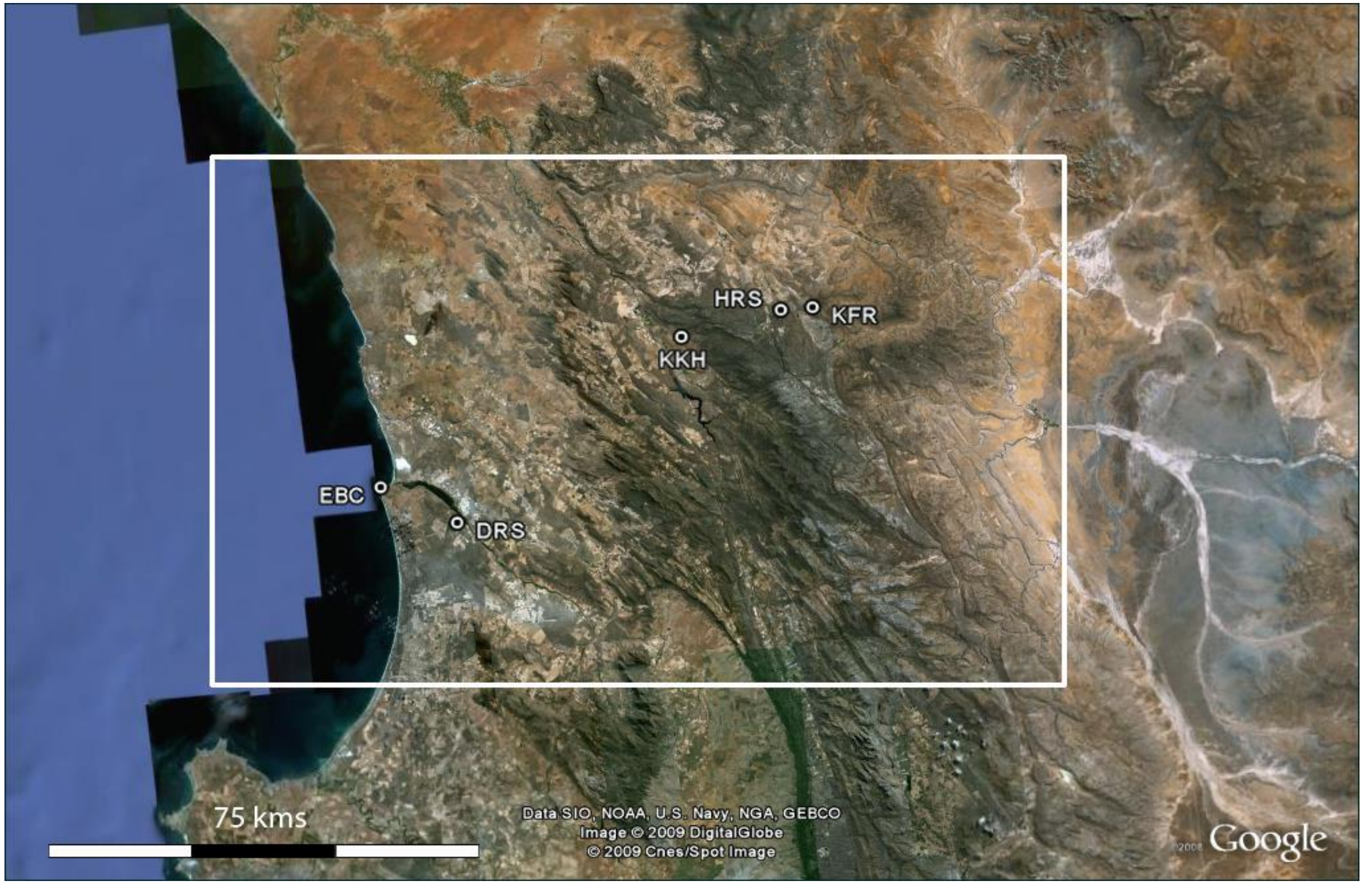


FIGURE 5.2: Satellite image of study area showing location of sites discussed in the thesis

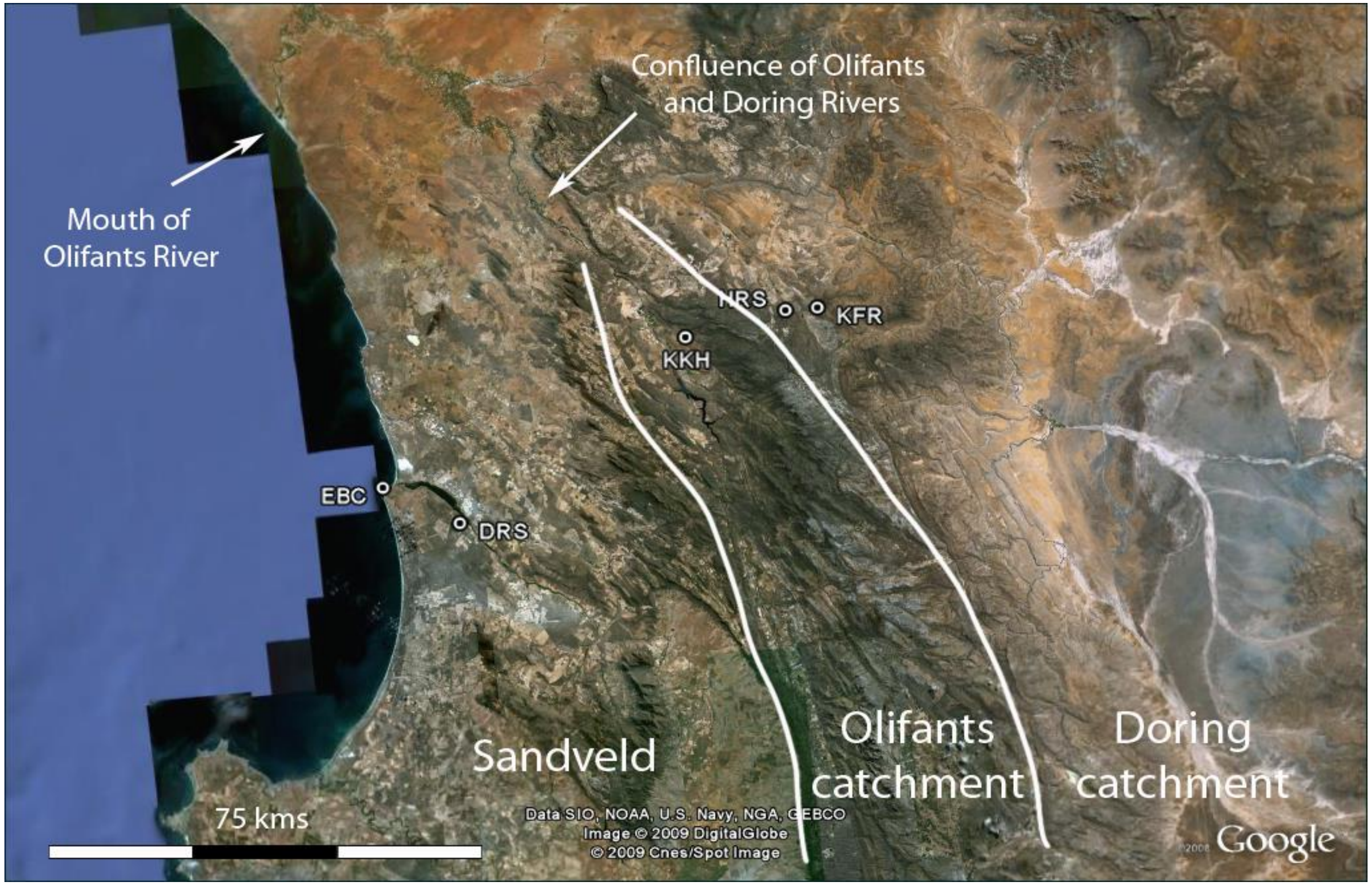


FIGURE 5.3: Satellite image showing the three catchment zones used in the study.

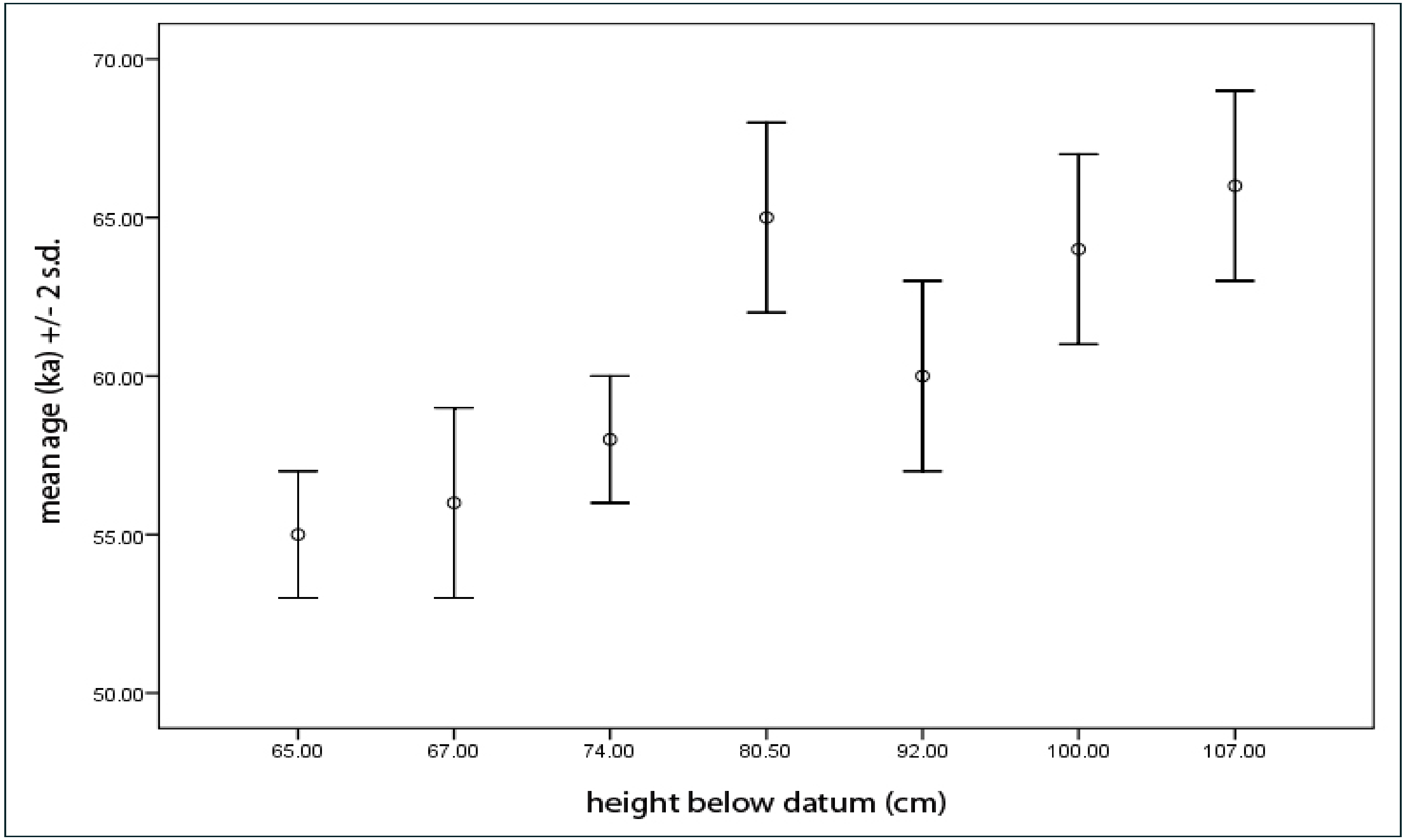


FIGURE 5.4: OSL ages for Klein Kliphuis relative to depth

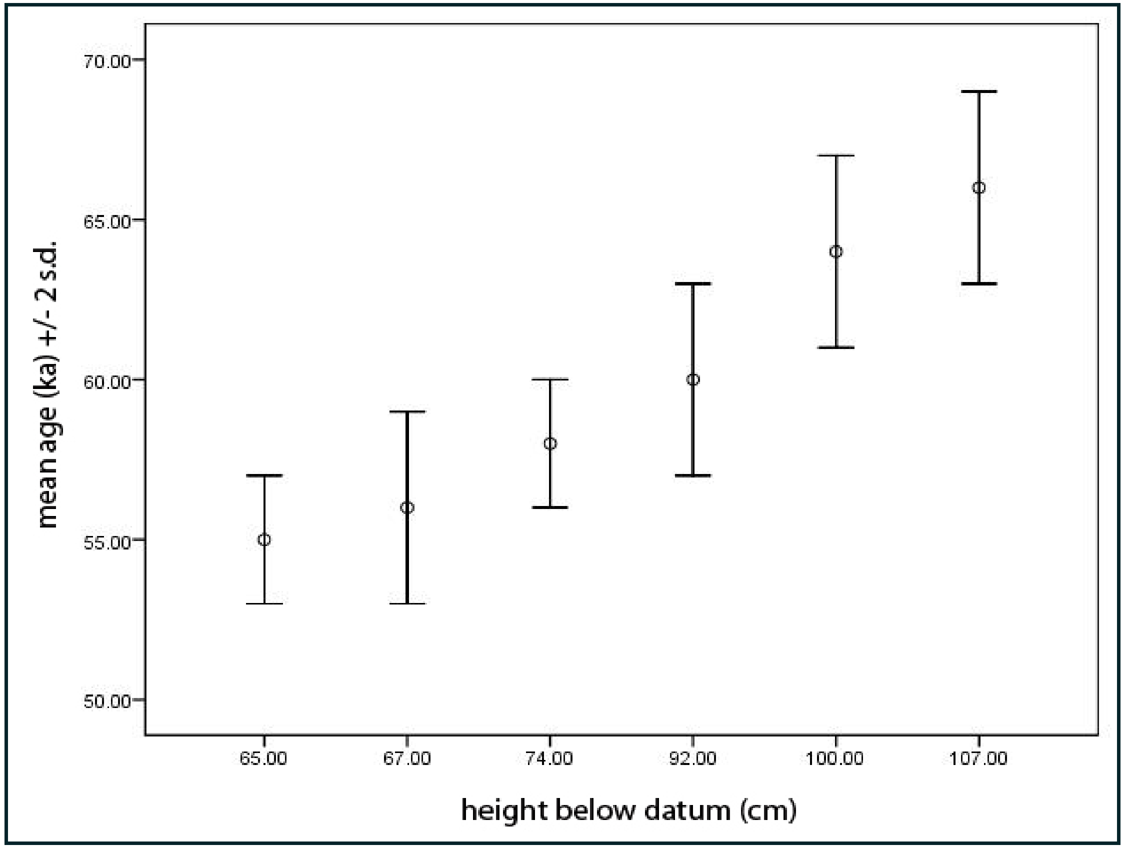


FIGURE 5.5: OSL ages for Klein Kliphuis relative to depth with outlying value removed

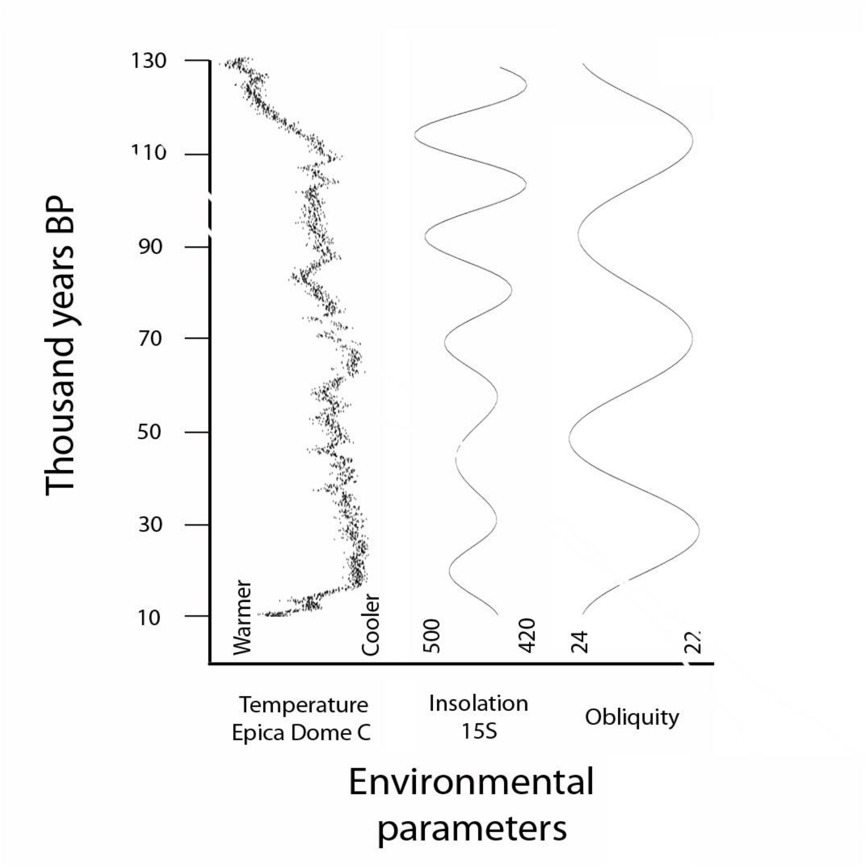


FIGURE 5.6: Environental parameters in the WRZ

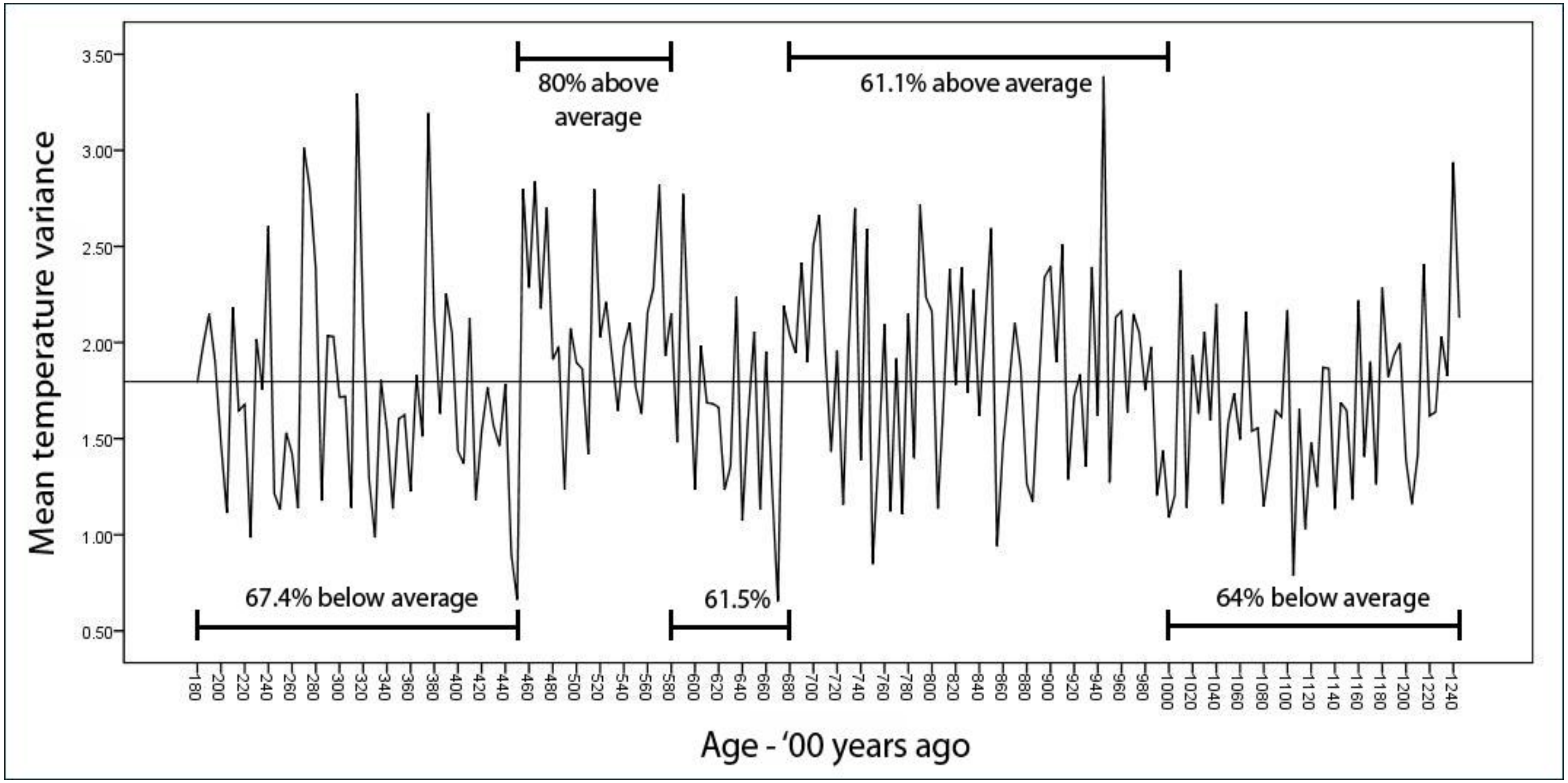
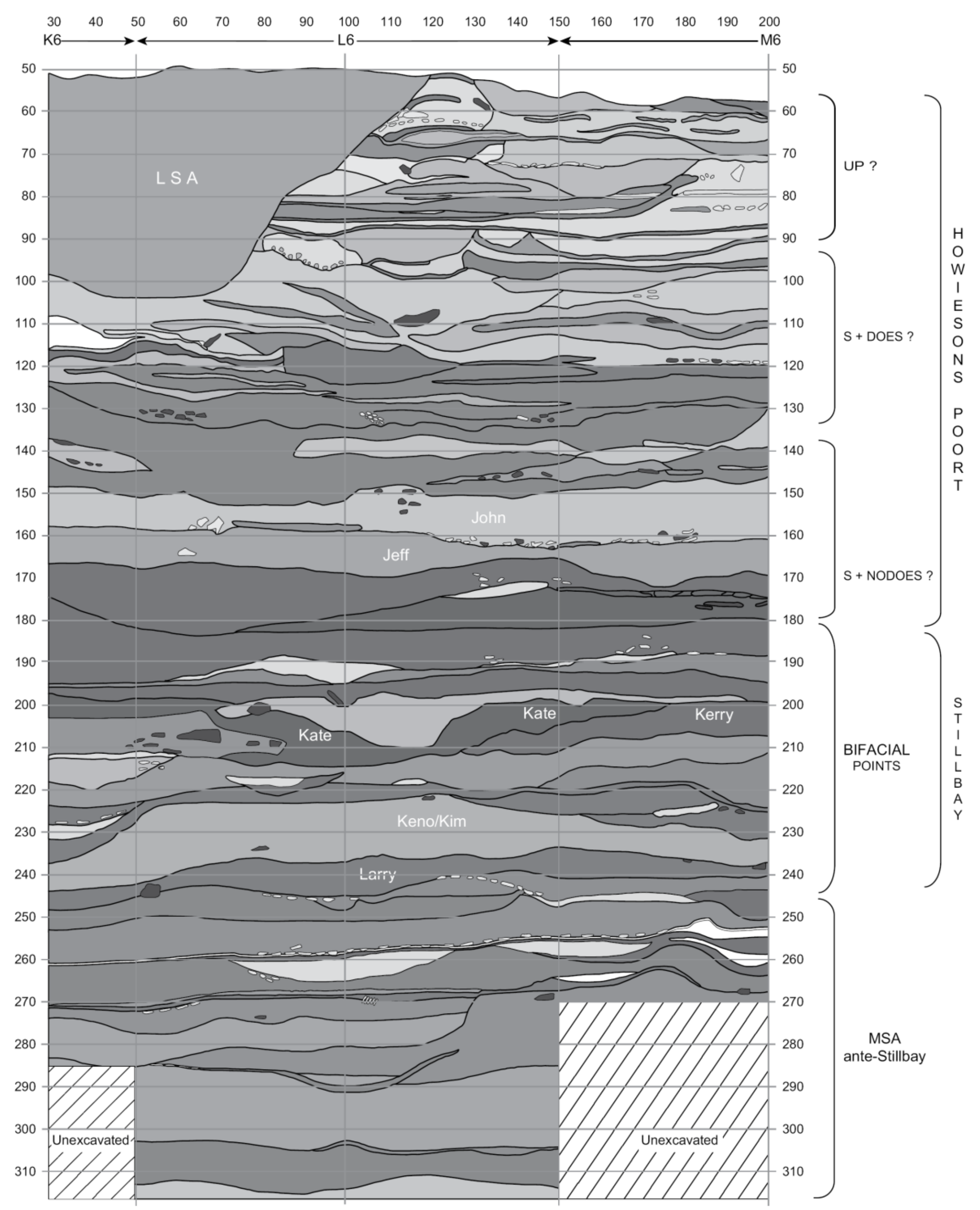


FIGURE 5.7: Temperature variance in 500 yr bins in the Epica Dome C core



Drawing : J. Buisson-Catil and M. Grenet; CAD : P.-J. Texier

FIGURE 5.8: DRS stratigraphic section for square L6 (from Tribolo *et al*. 2009: 734)

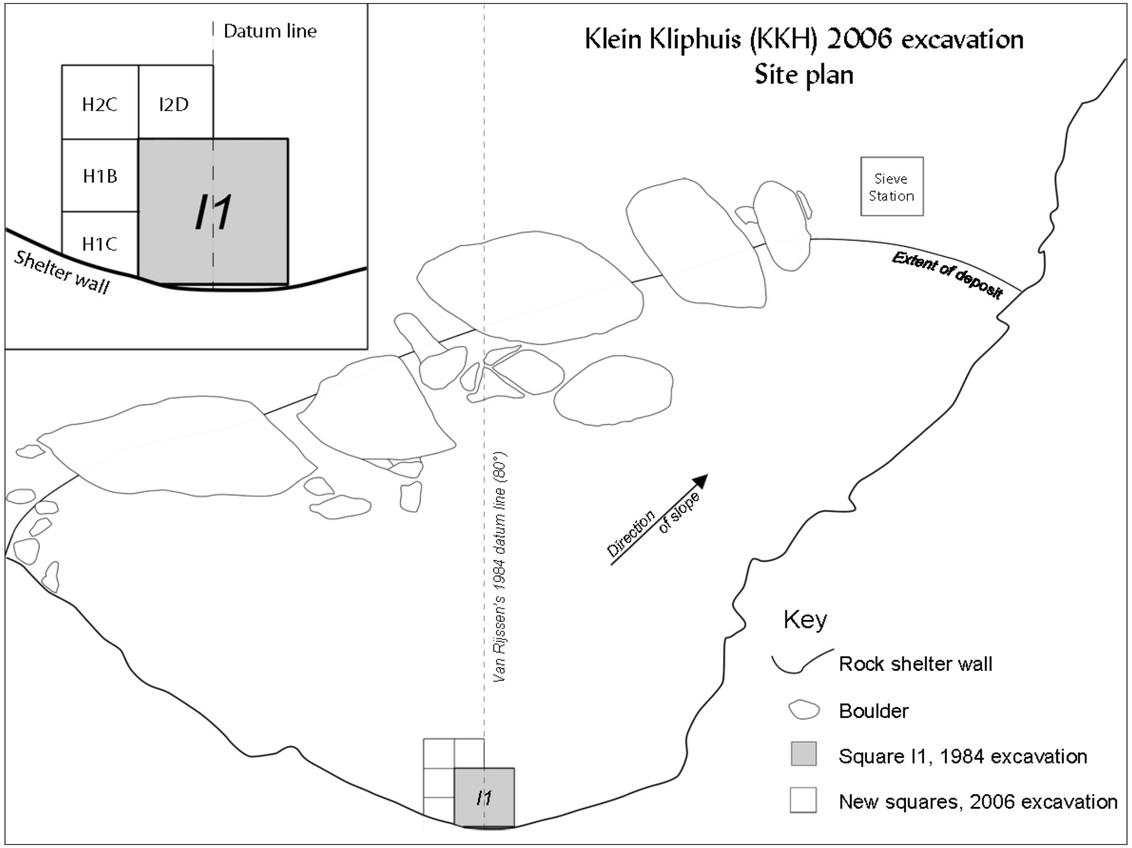


FIGURE: 5.9: KKH site plan showing layout of excavated squares

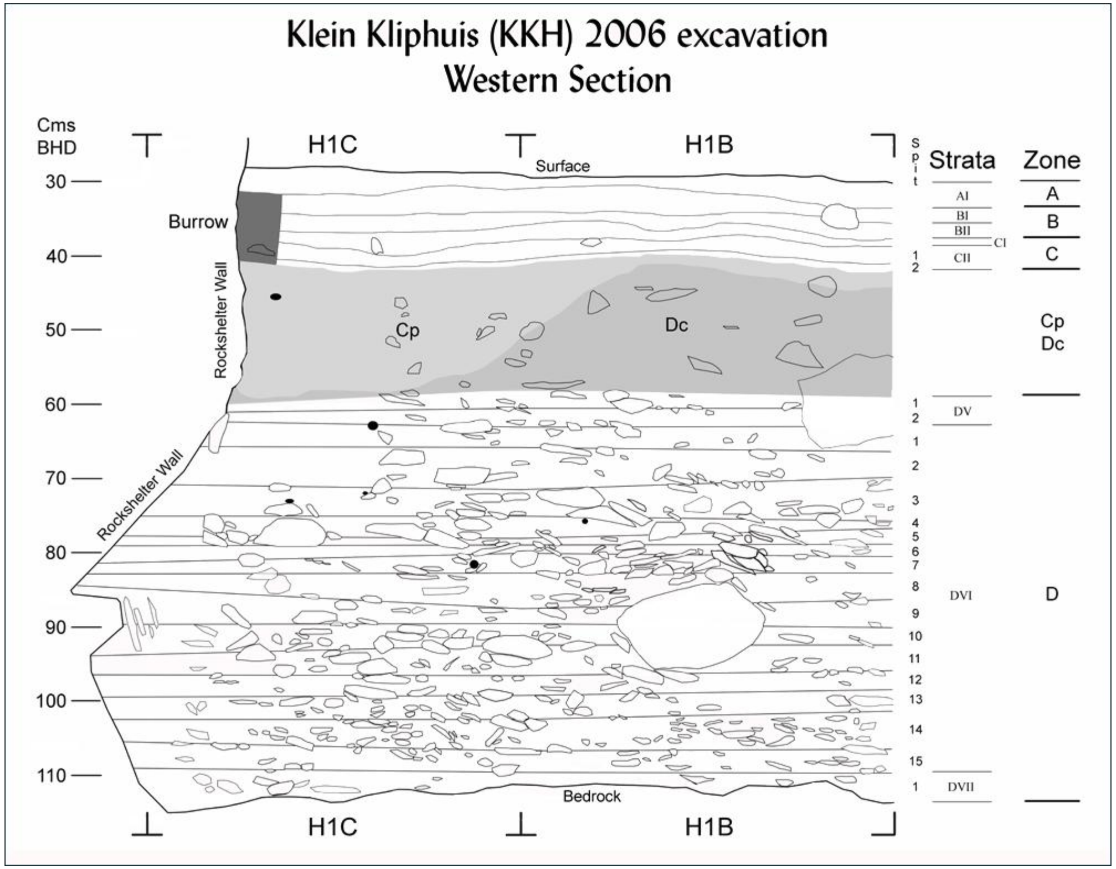


FIGURE 5.10 (a): KKH west section – spits shown in grey are those compromised by an intrusive Holocene pit

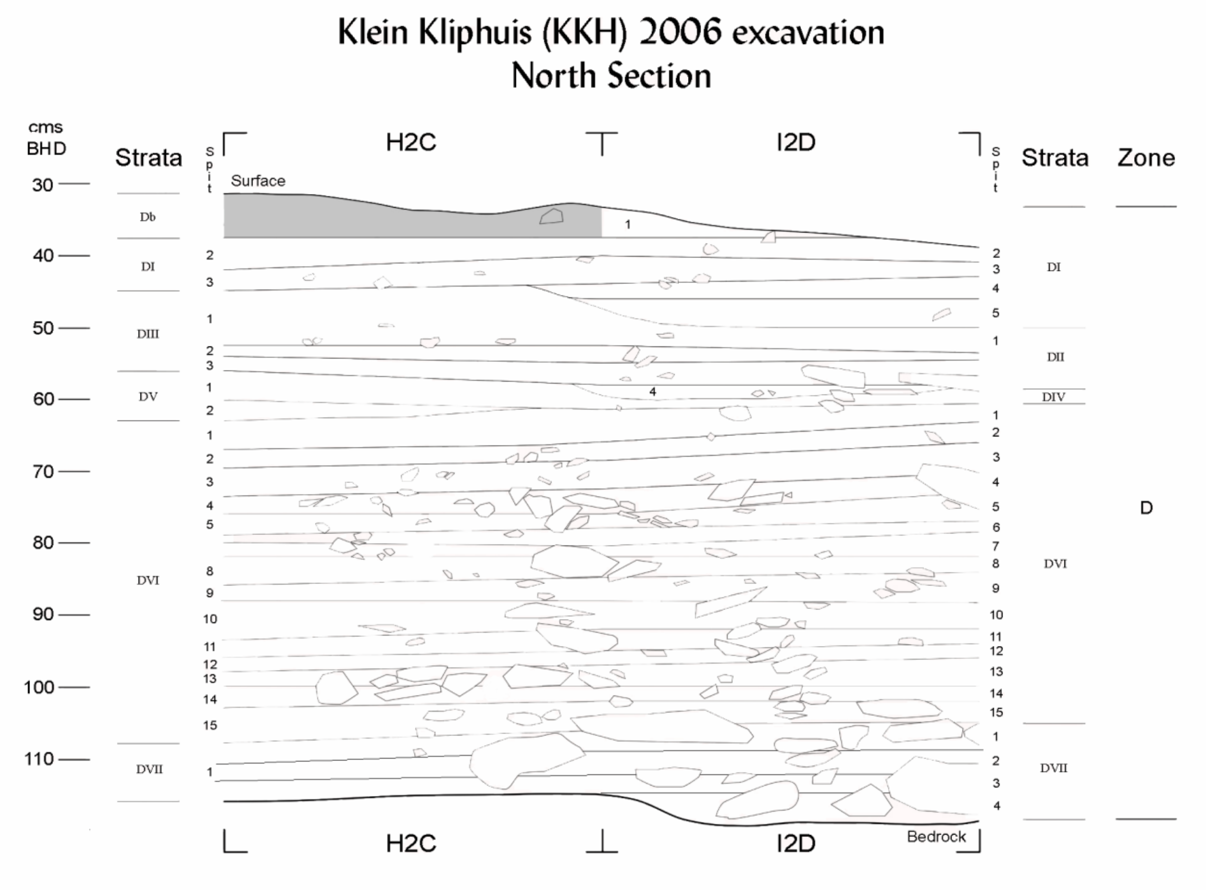


FIGURE 5.10 (b): KKH north section – spit shown in grey is that compromised by backfill from the 1984 excavation

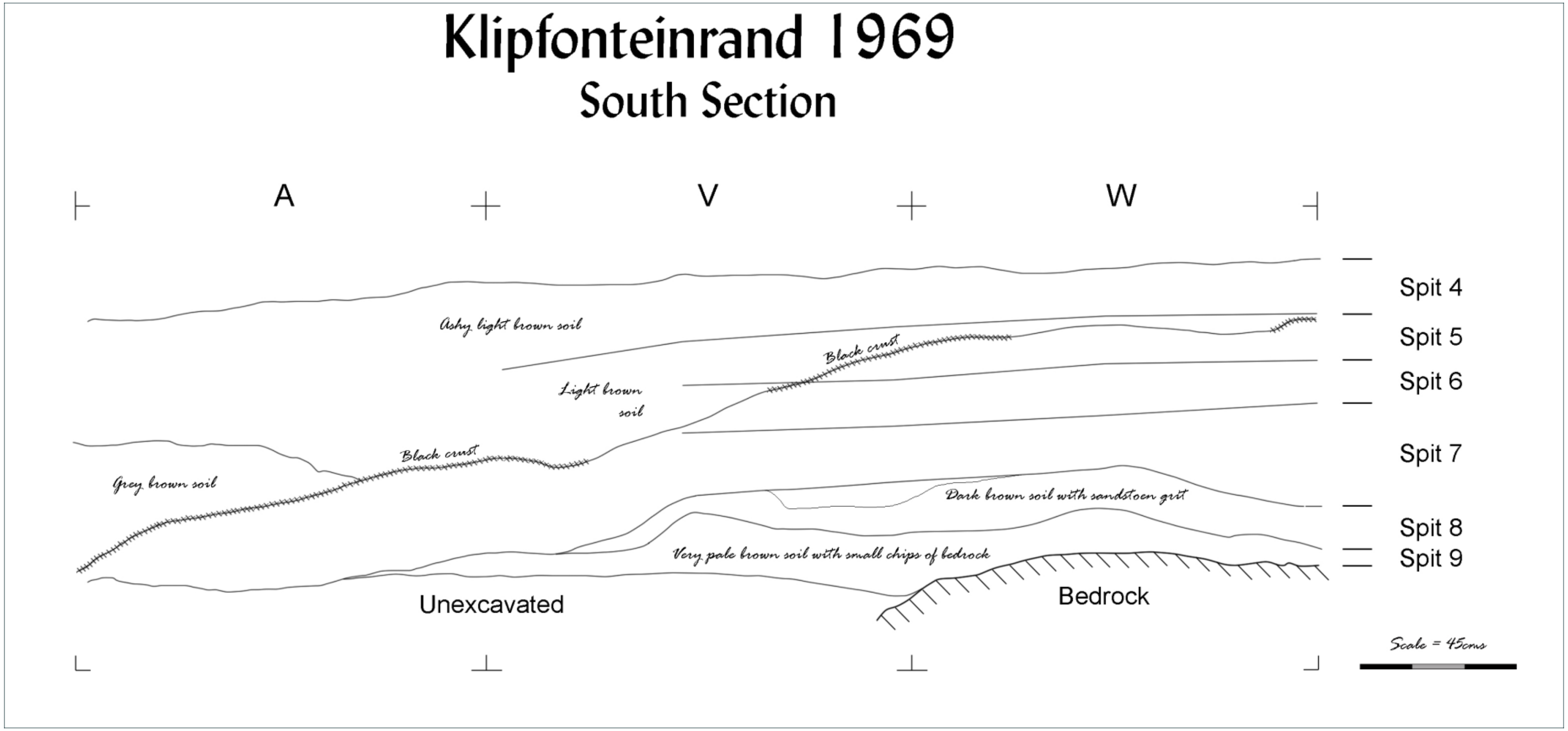


FIGURE 5.11 (a): KFR south section from 1969 excavation

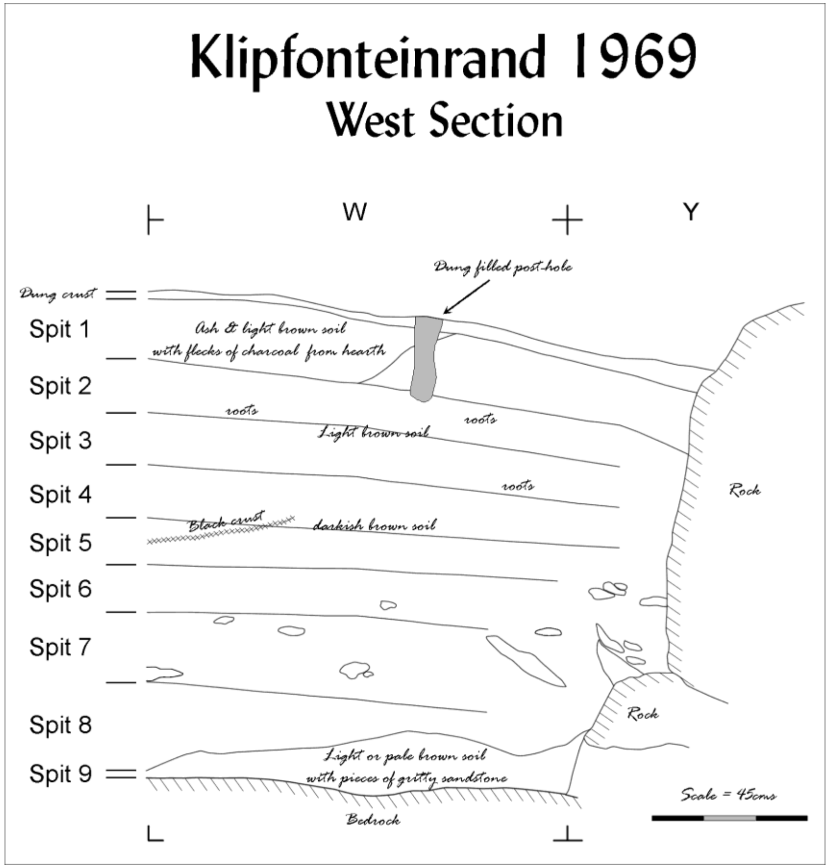


FIGURE 5.11 (b): KFR west section from 1969 excavation

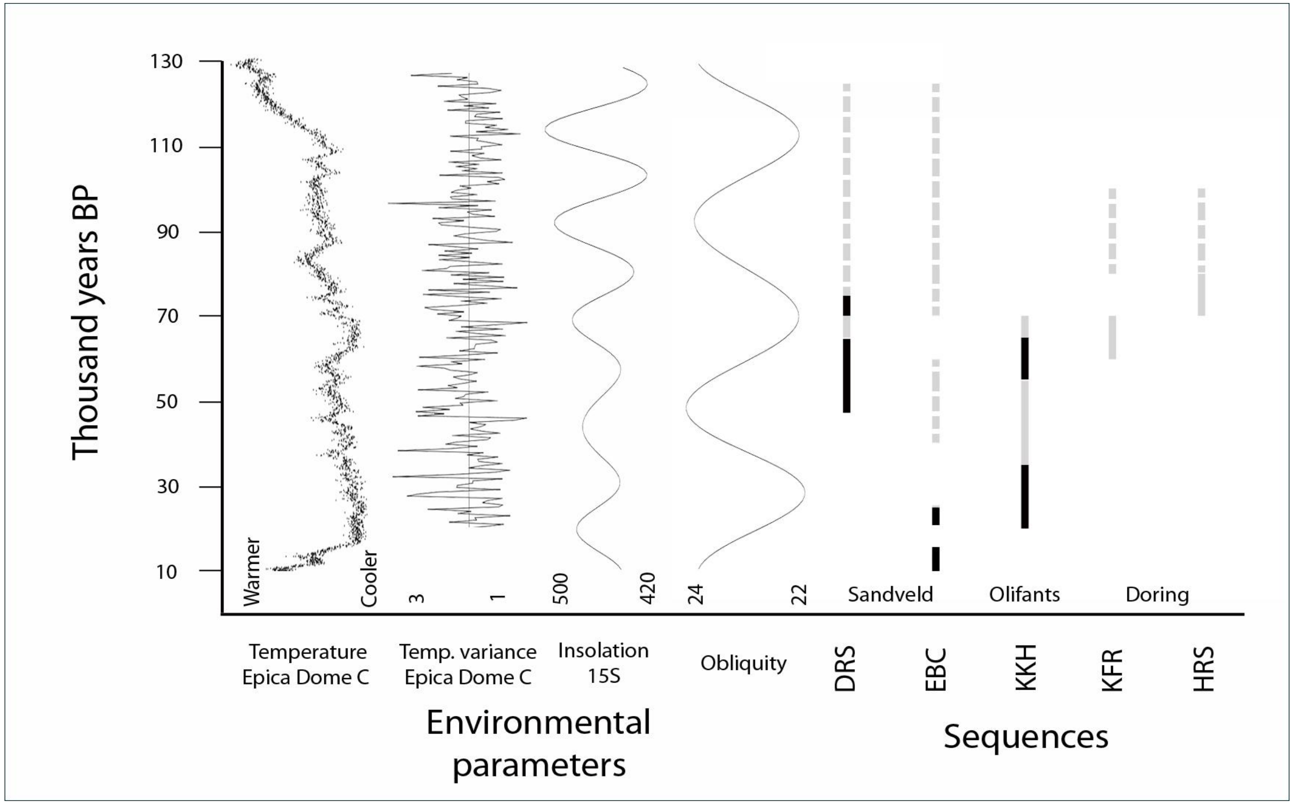


FIGURE 5.12: WRZ environmental parameters and suggested occupational sequences in the study area. Periods of occupation inferred from chronometric ages are shown as black lines; inferences from culture historic units are show as solid grey lines; inferences from stratigraphic position relative to chronometry and/or culture history are shown as dotted grey lines

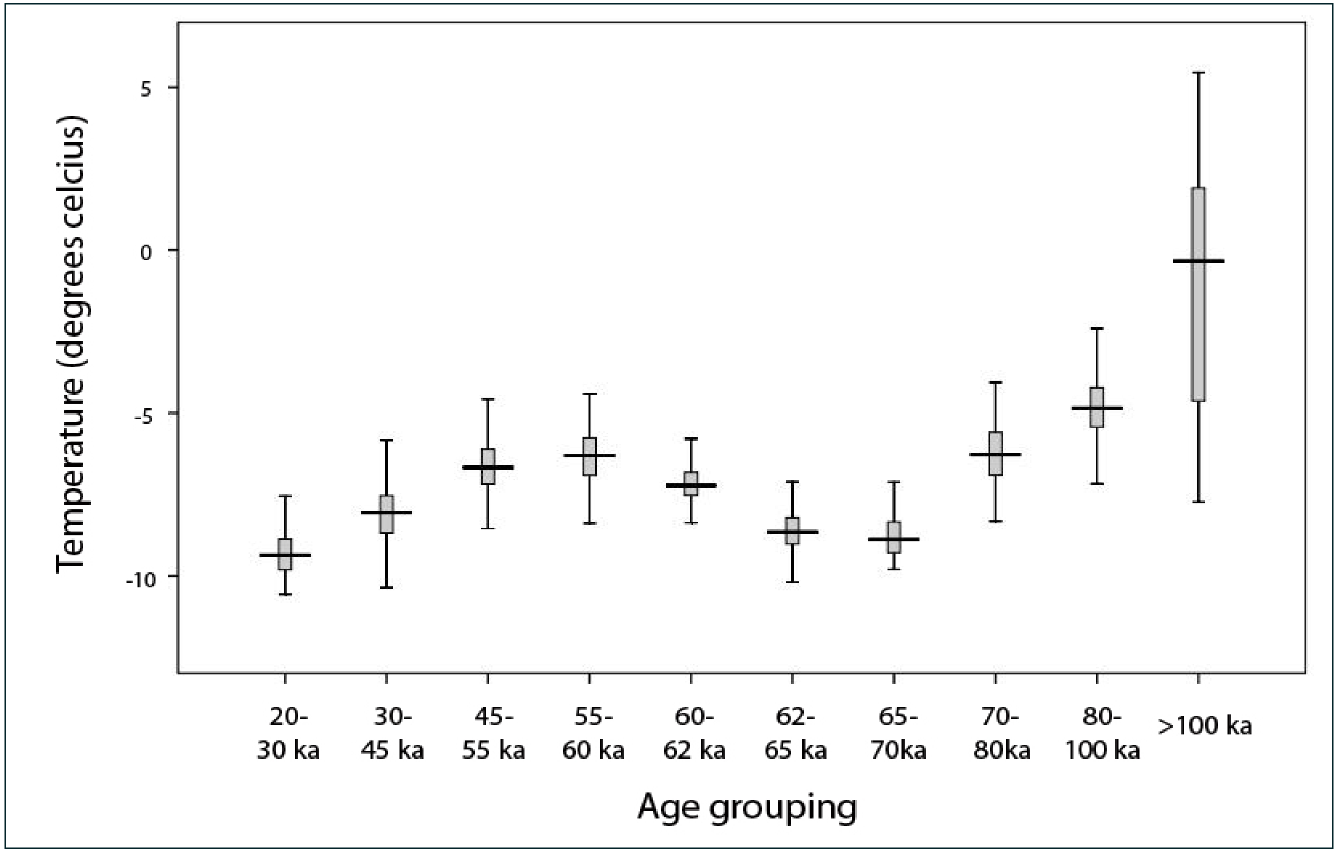


FIGURE 6.1: Boxplot of temperatures from Epica Dome C core organised into age groupings used for artefact analysis

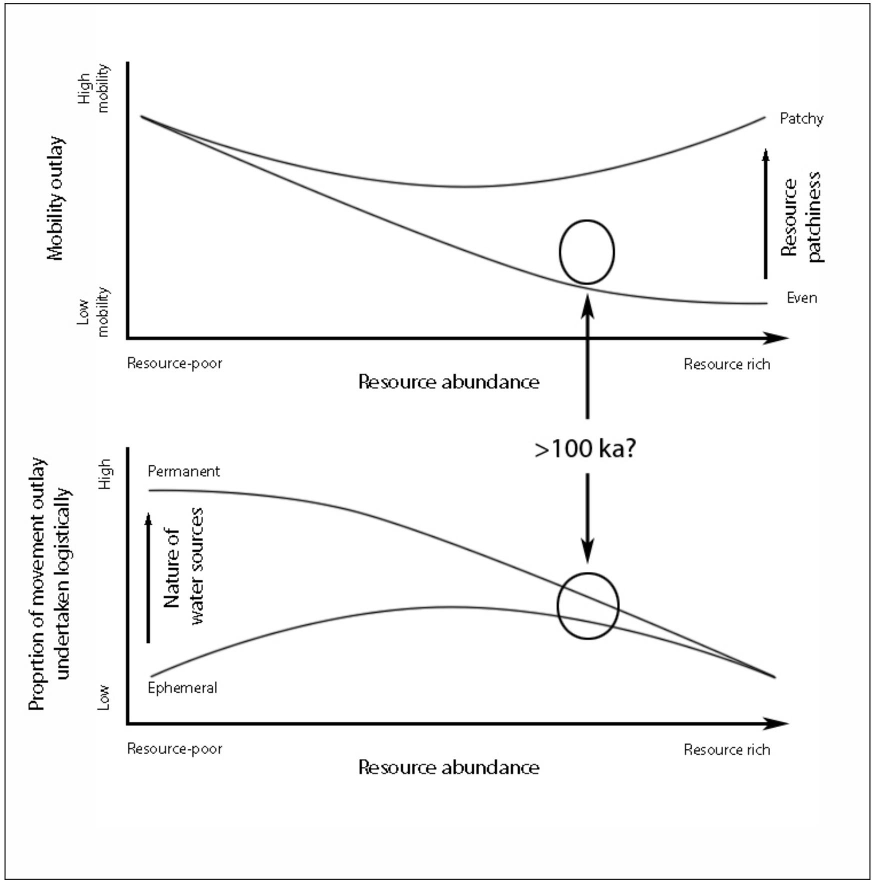


FIGURE 6.2: Hypothesised mobility magnitude and organization >100 ka

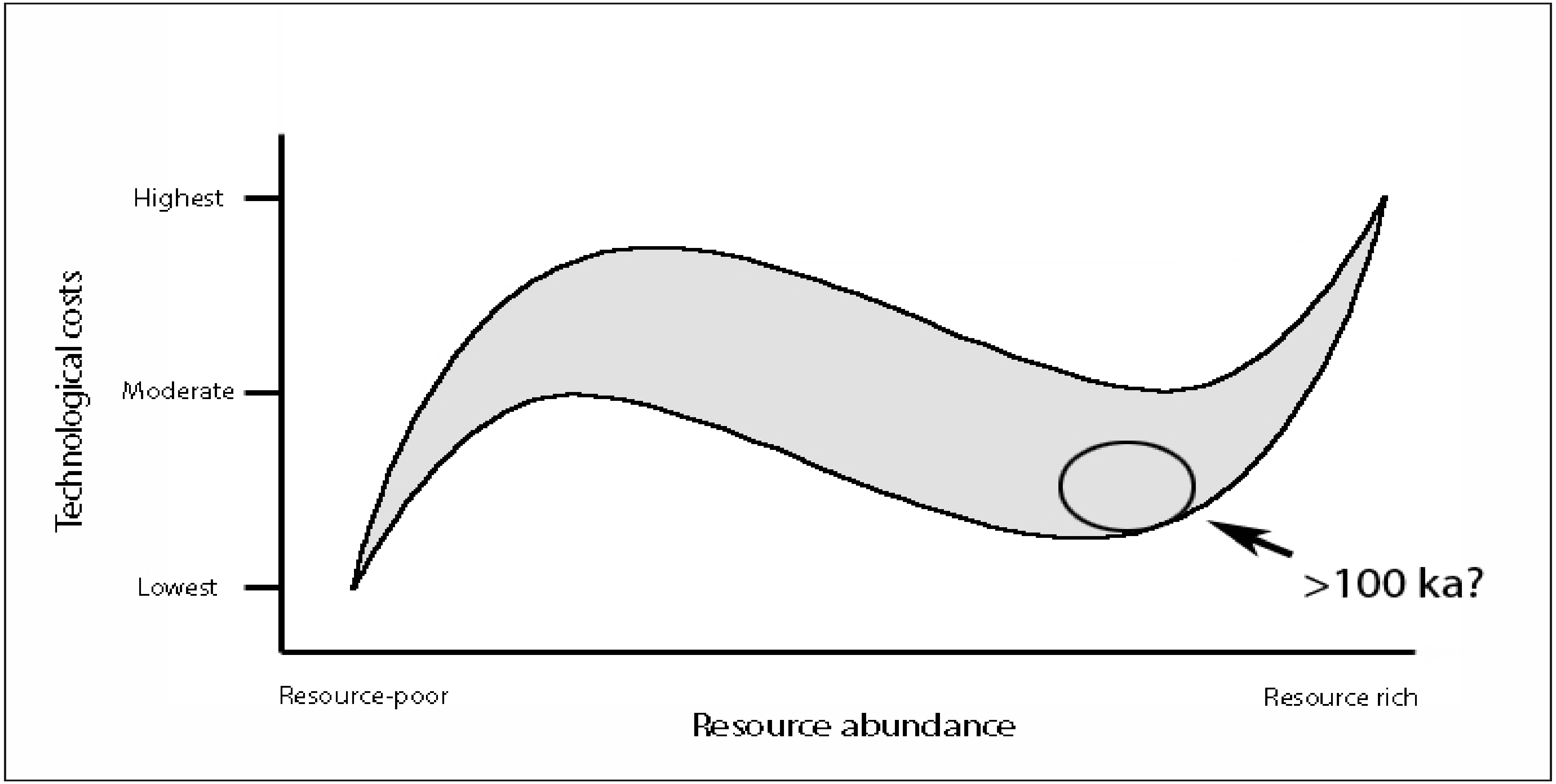


FIGURE 6.3: Hypothesised technological time cost and configuration >100 ka

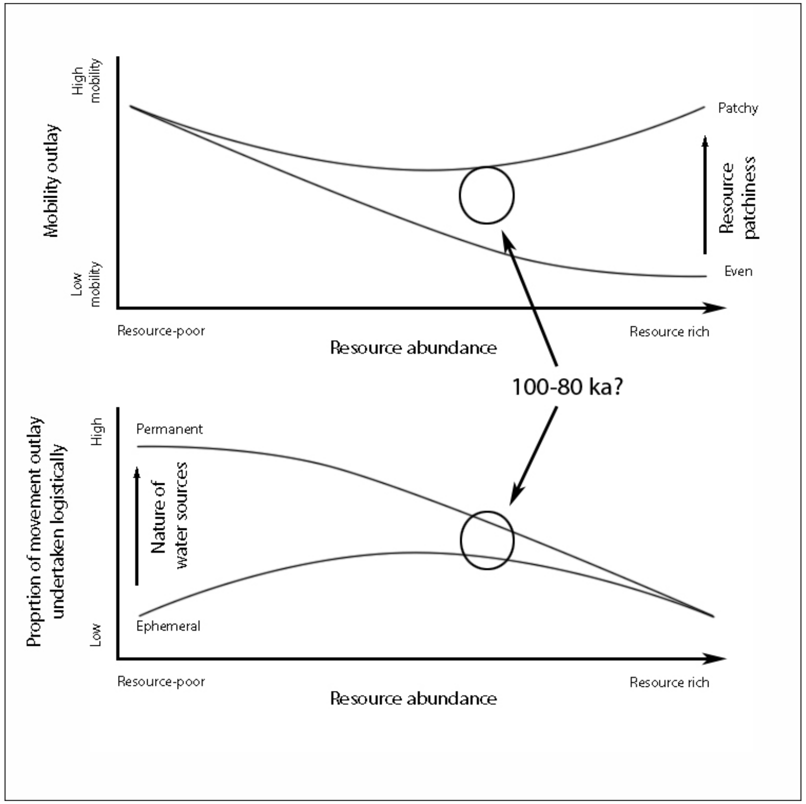


FIGURE 6.4: Hypothesised mobility magnitude and organization 100-80 ka

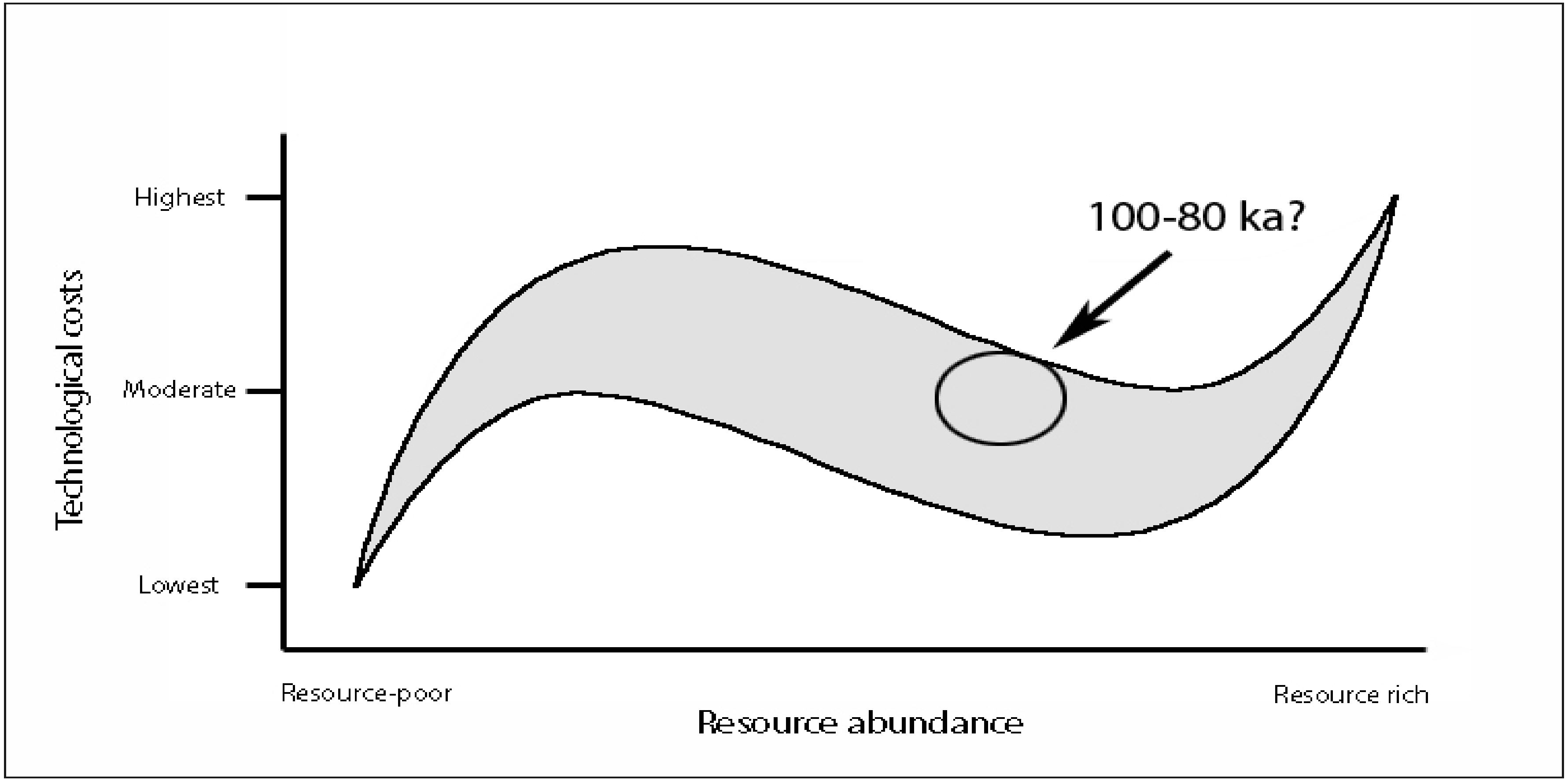


FIGURE 6.5: Hypothesised technological time cost and configuration 100-80 ka

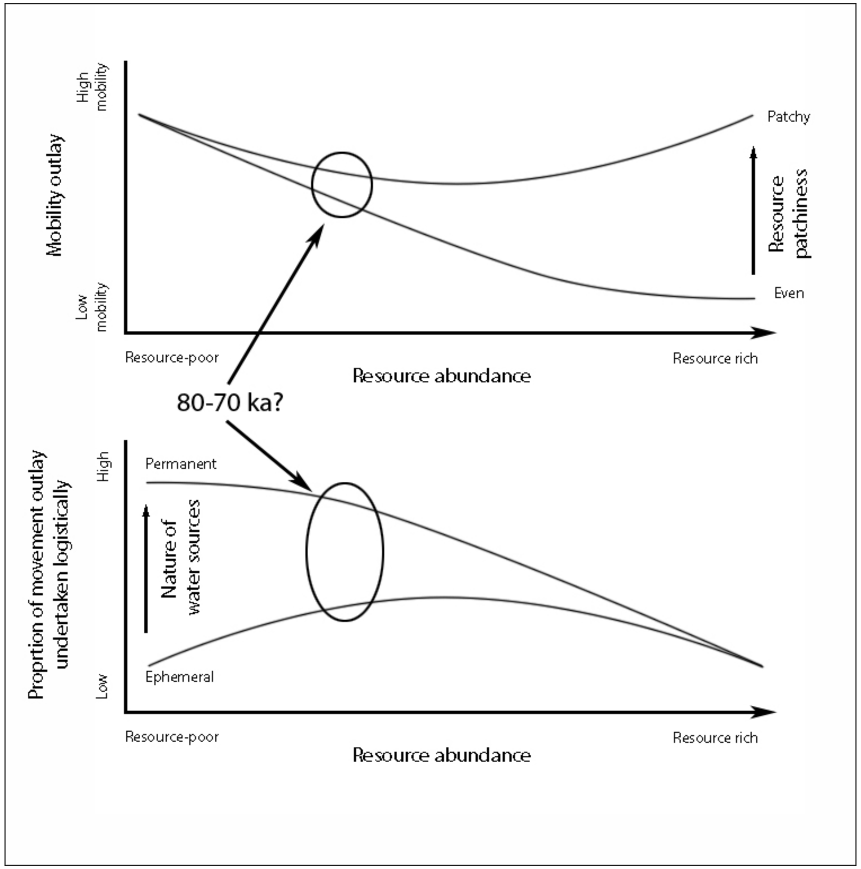


FIGURE 6.6: Hypothesised mobility magnitude and organization 80-70 ka

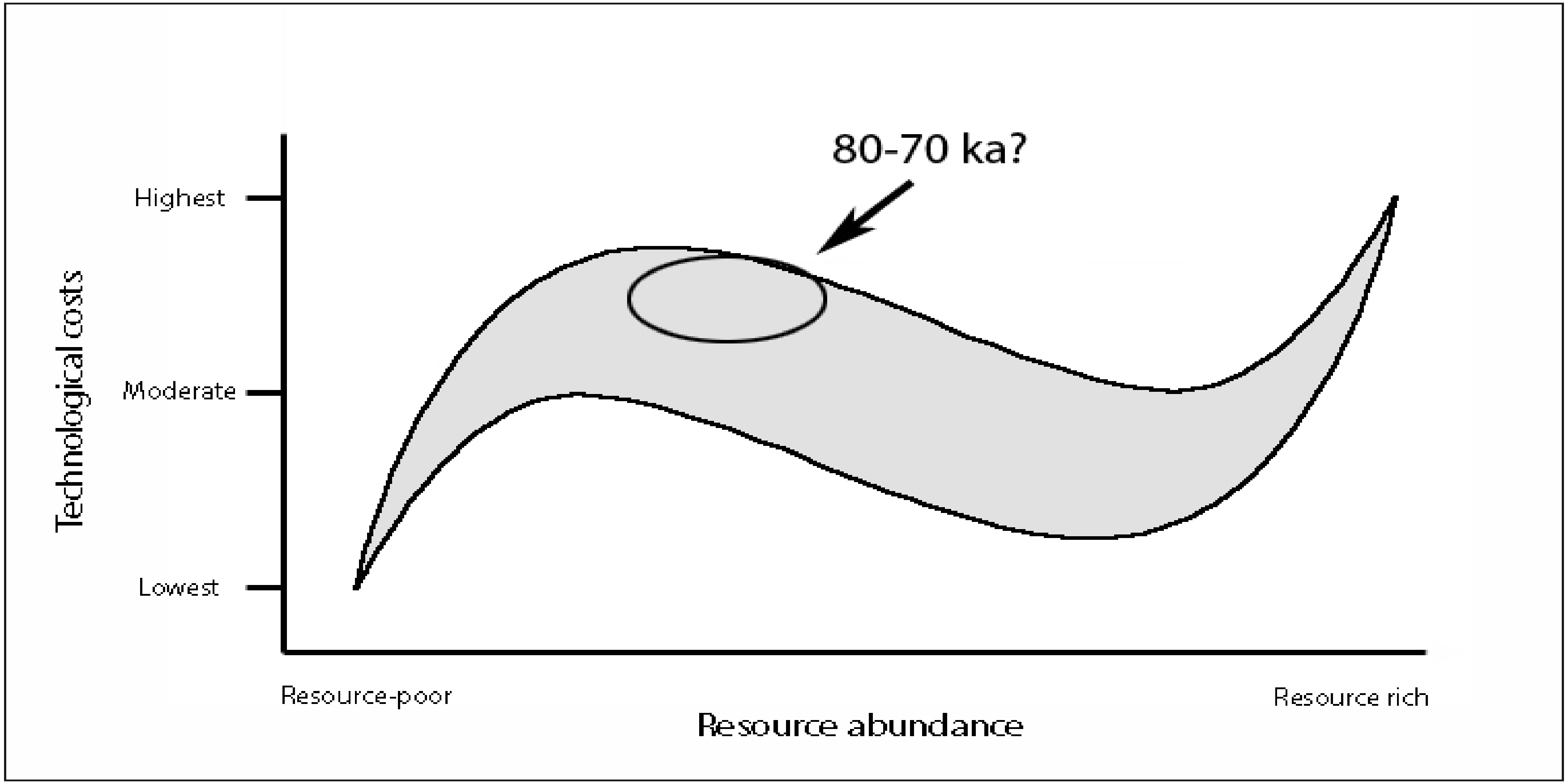


FIGURE 6.7: Hypothesised technological time cost and configuration 80-70 ka

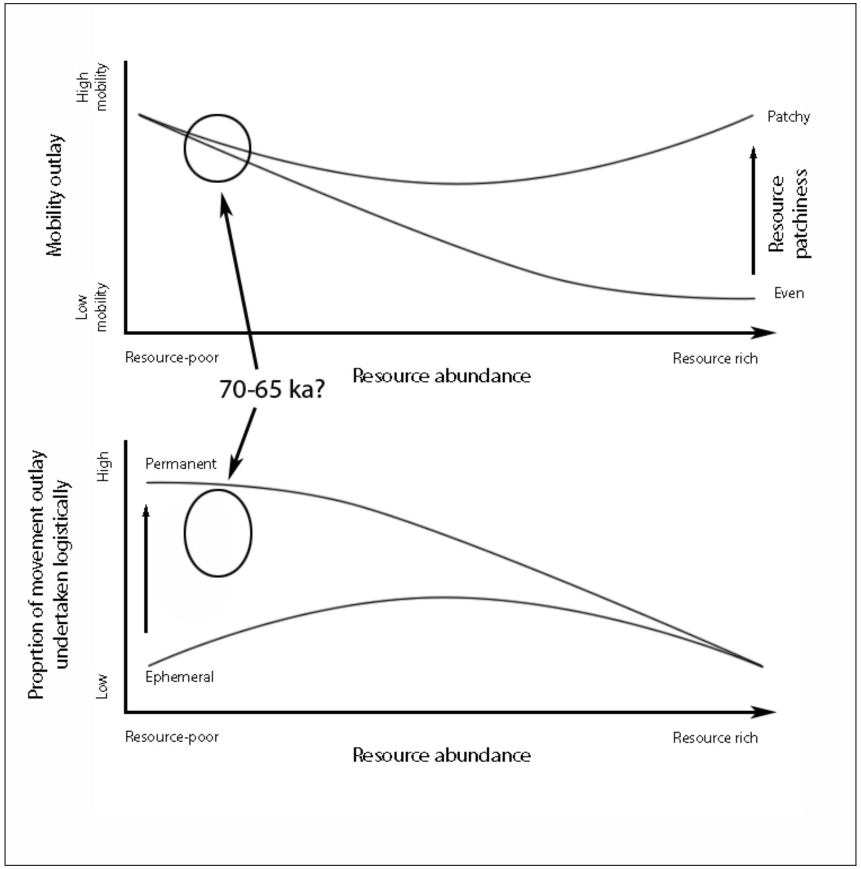


FIGURE 6.8: Hypothesised mobility magnitude and organization 70-65 ka

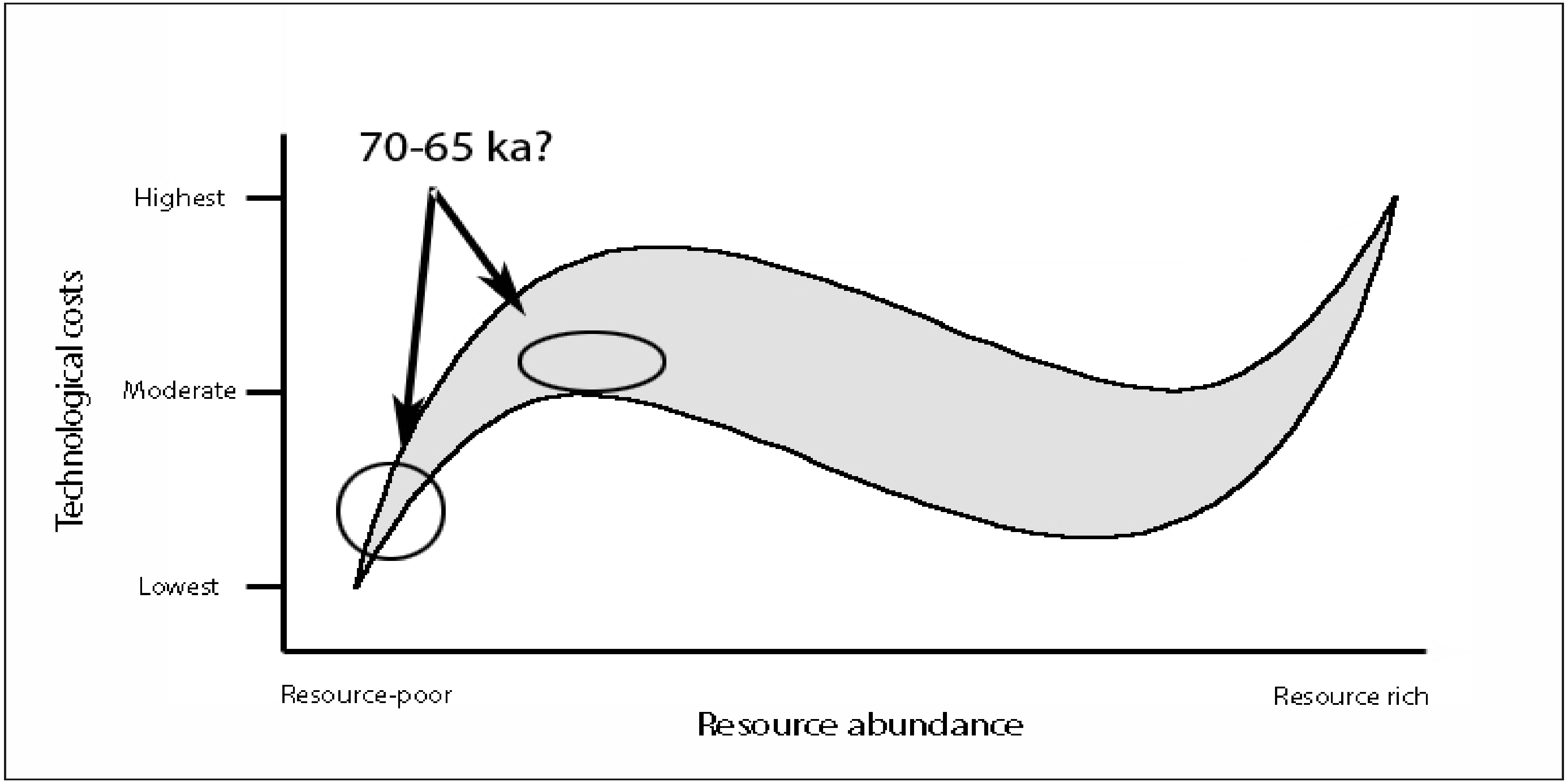


FIGURE 6.9: Hypothesised technological time cost and configuration 70-65 ka

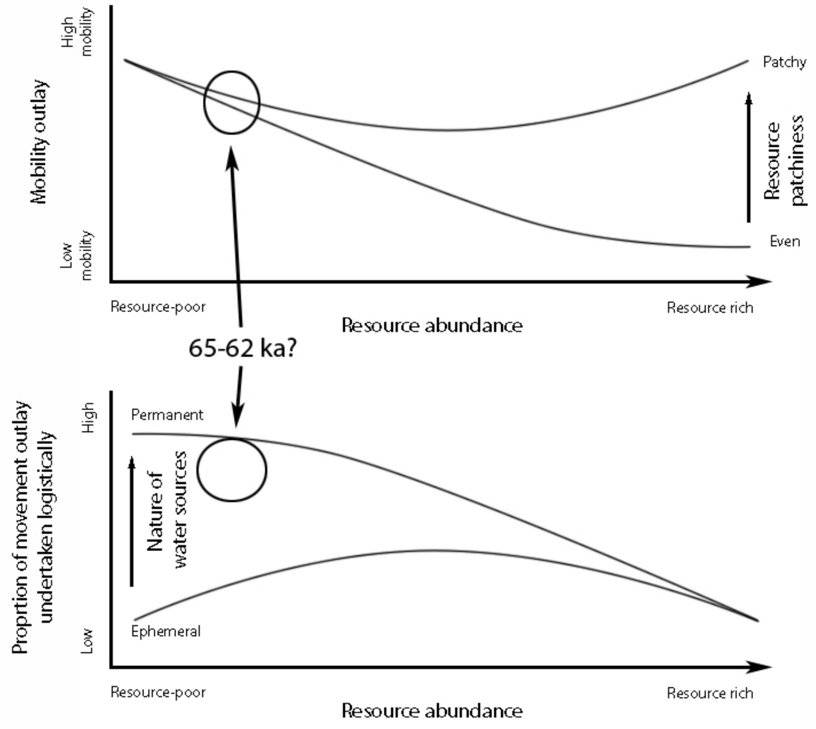


FIGURE 6.10: Hypothesised mobility magnitude and organization 65-62 ka

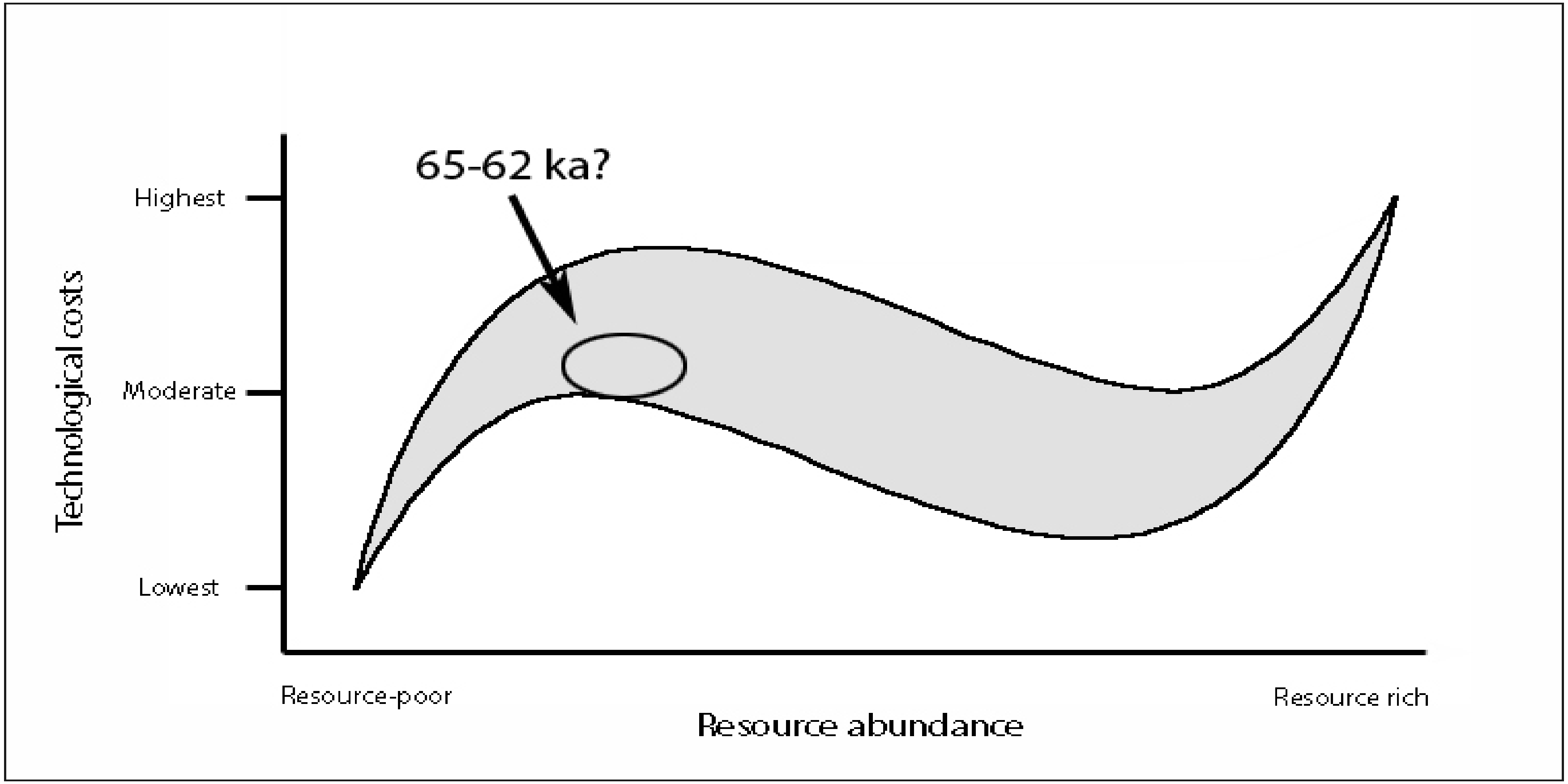


FIGURE 6.11: Hypothesised technological time cost and configuration 65-62 ka

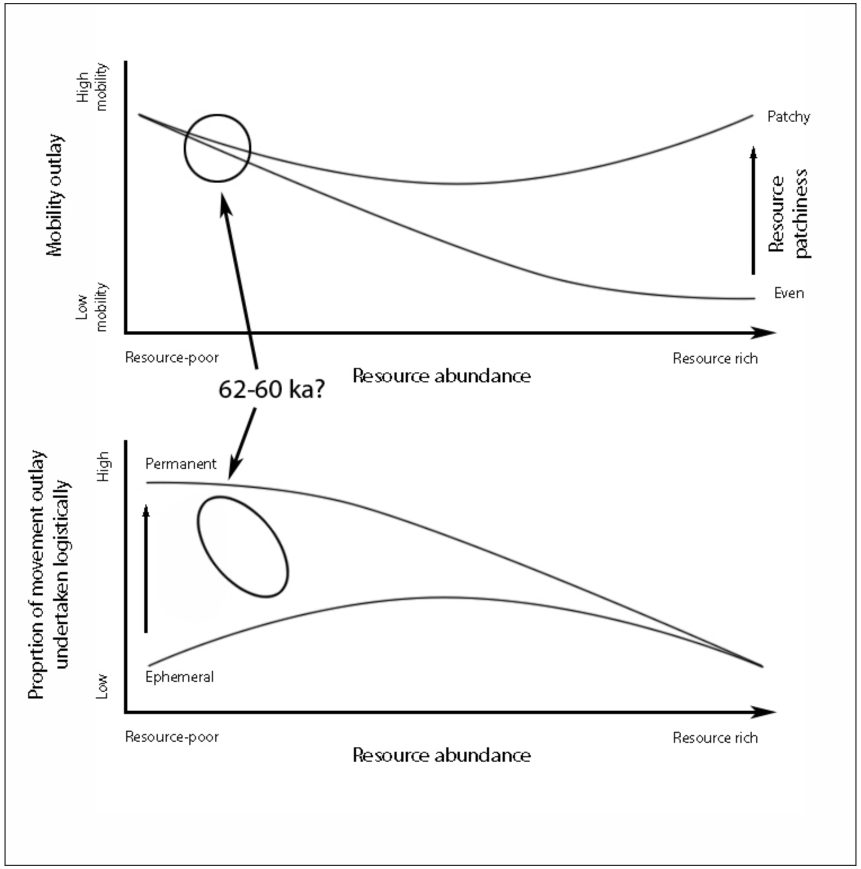


FIGURE 6.12: Hypothesised mobility magnitude and organization 62-60 ka

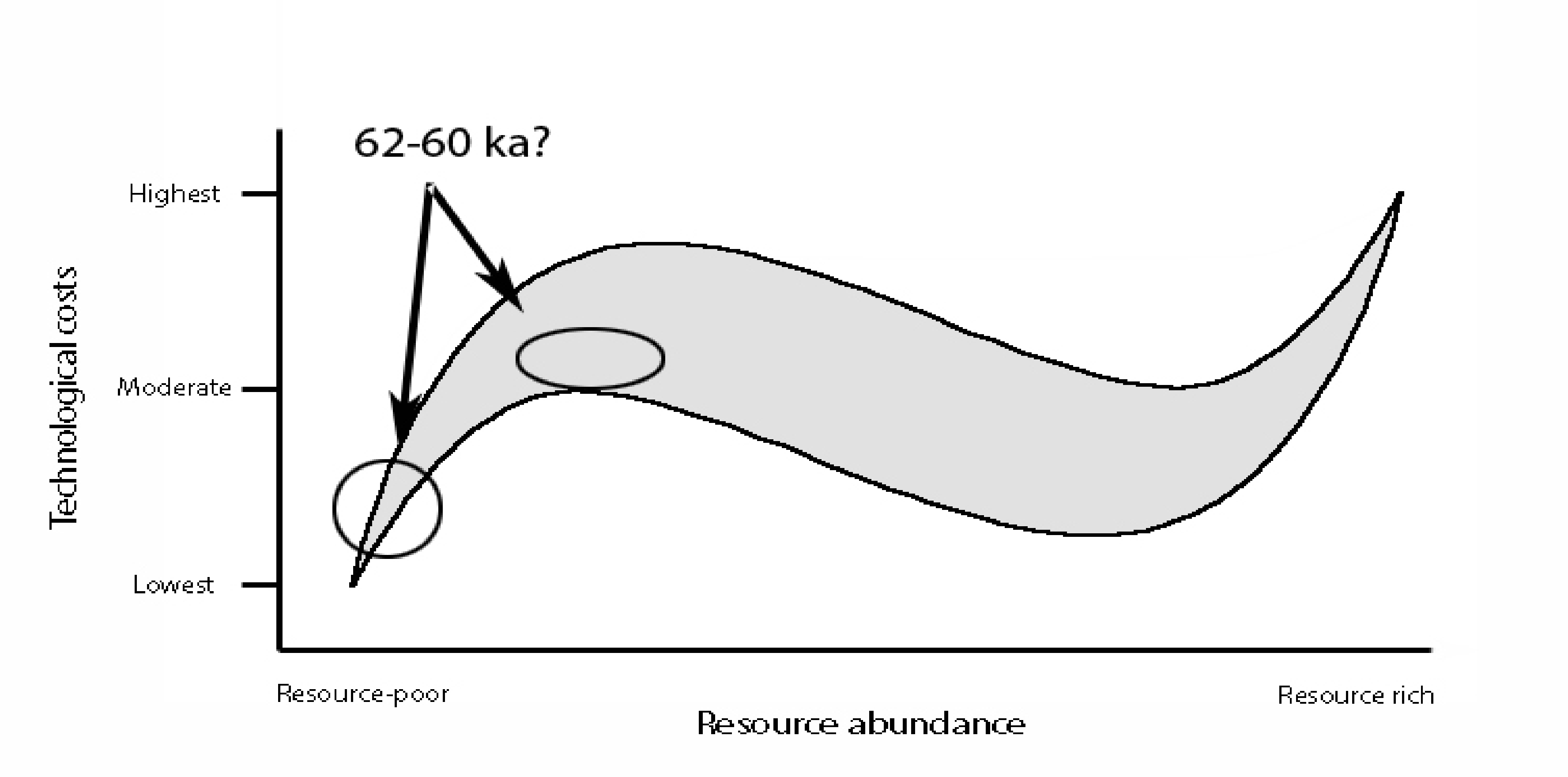


FIGURE 6.13: Hypothesised technological time cost and configuration 62-60 ka

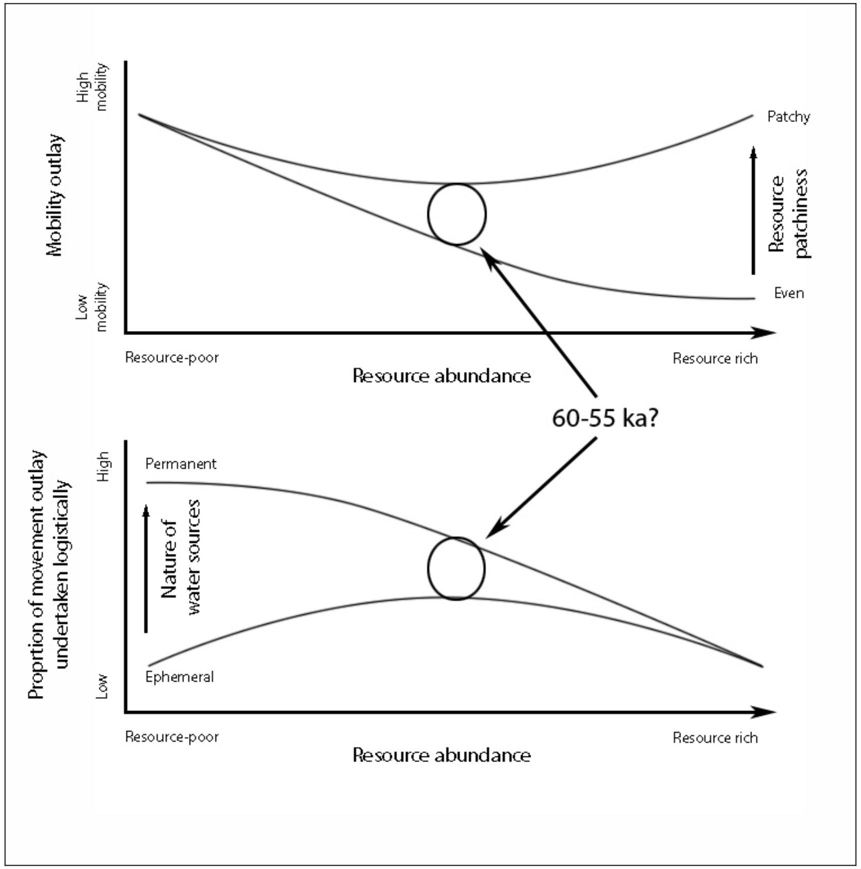


FIGURE 6.14: Hypothesised mobility magnitude and organization 60-55 ka

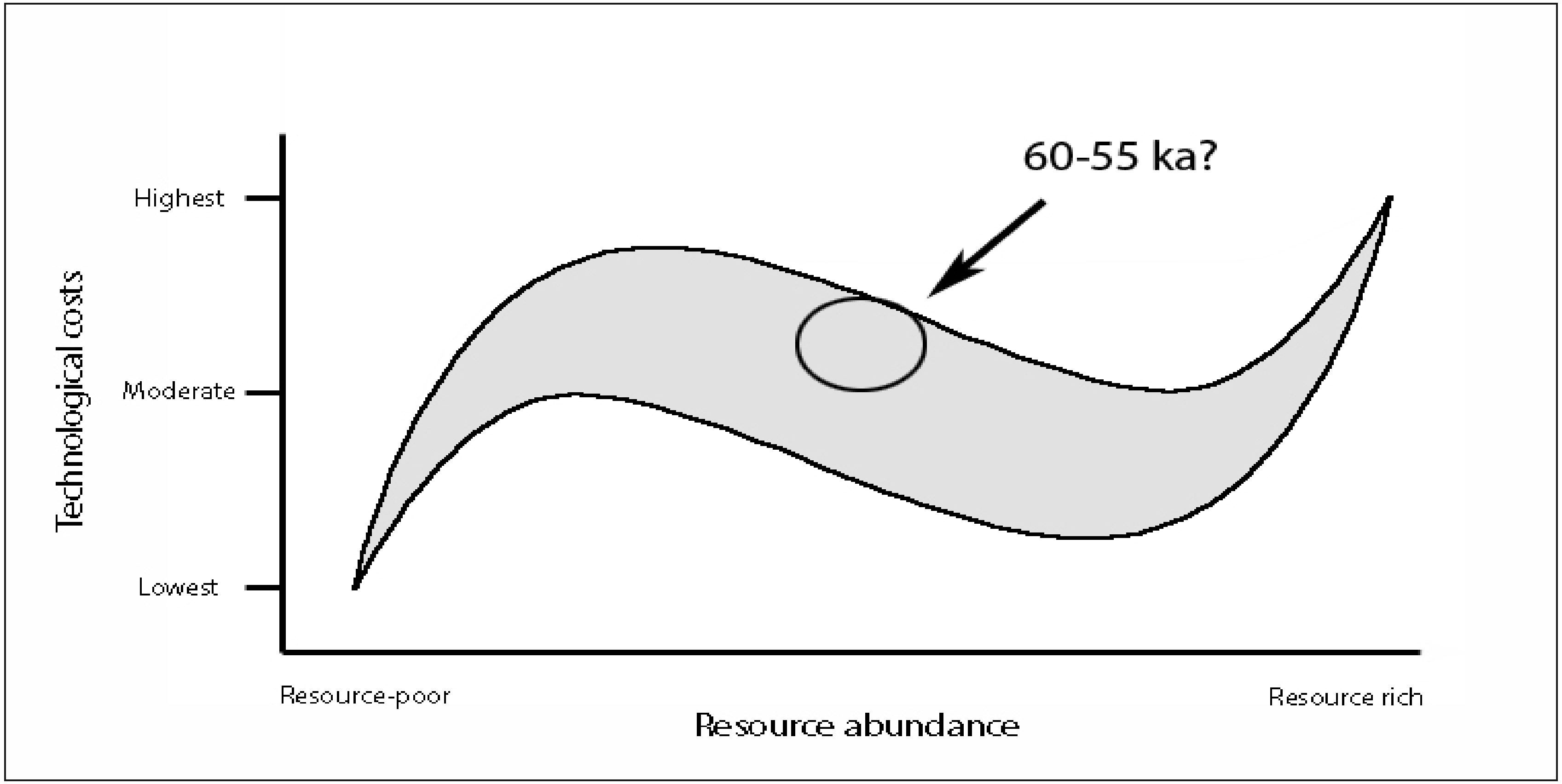


FIGURE 6.15: Hypothesised technological time cost and configuration 60-55 ka

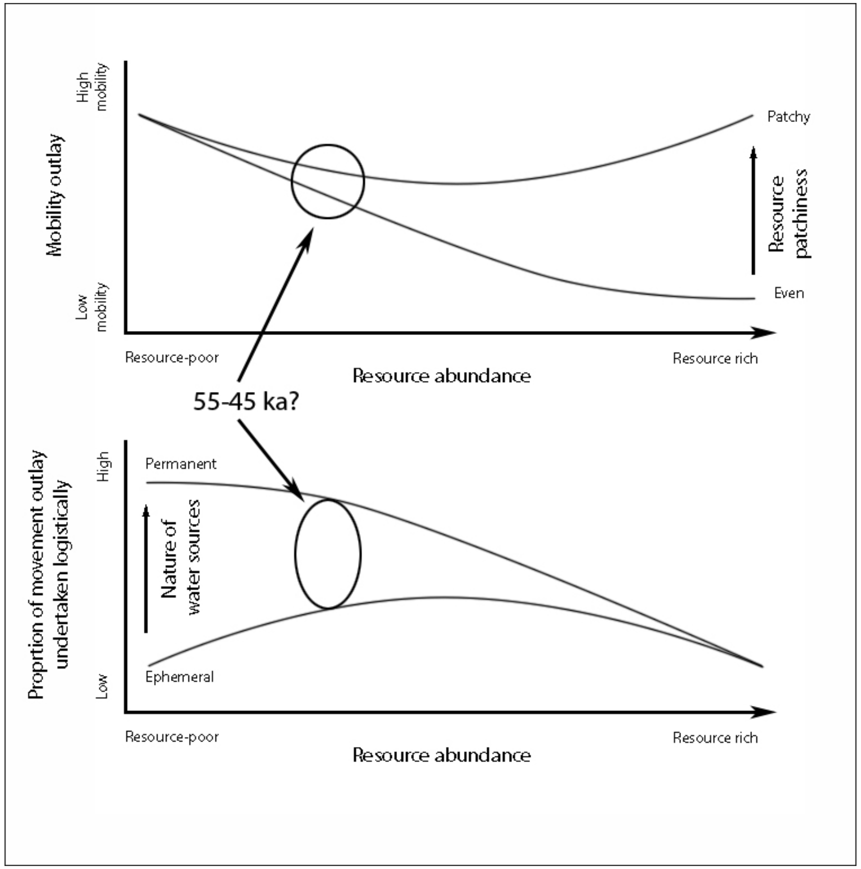


FIGURE 6.16: Hypothesised mobility magnitude and organization 55-45 ka

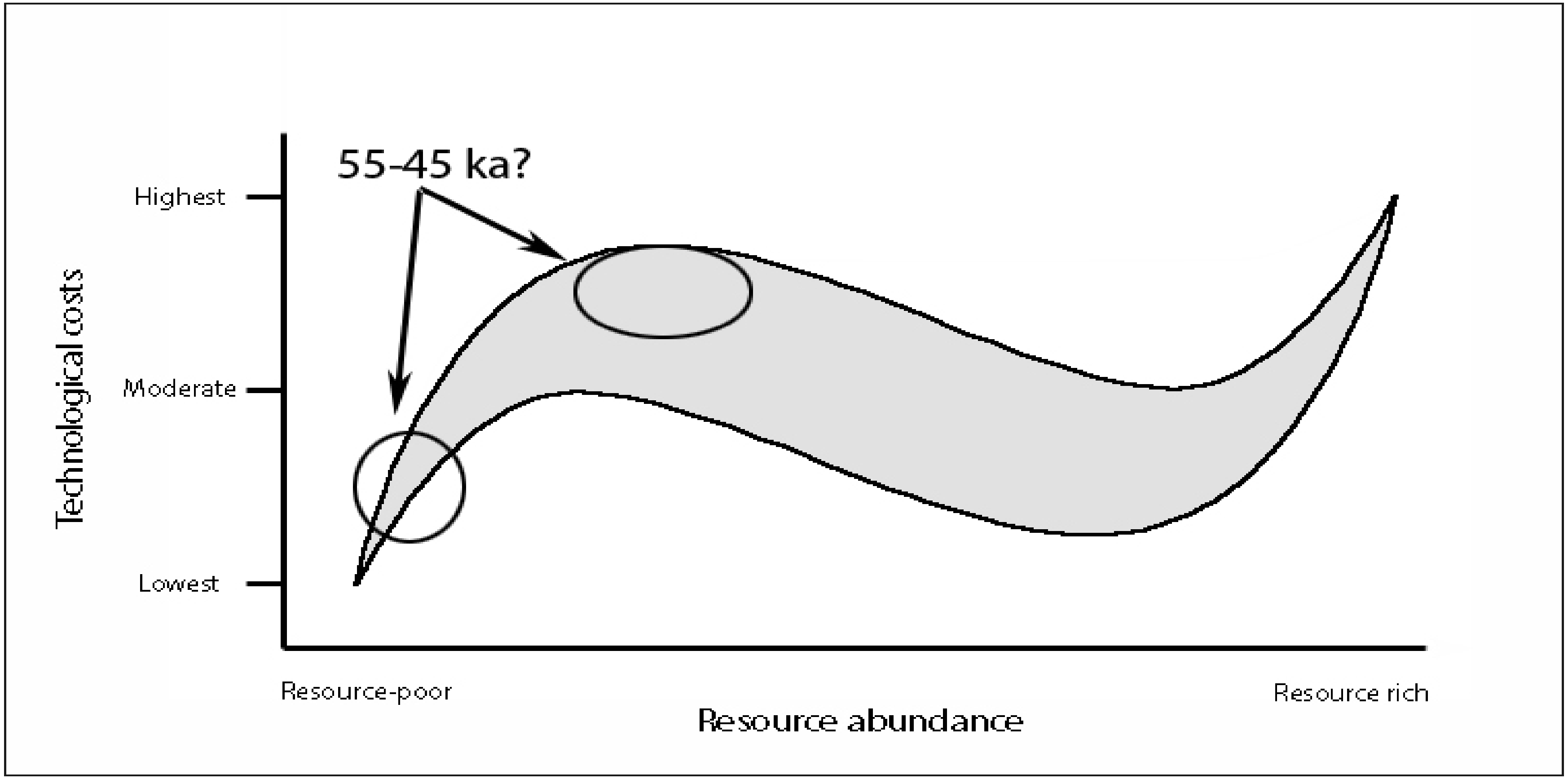


FIGURE 6.17: Hypothesised technological time cost and configuration 55-45 ka

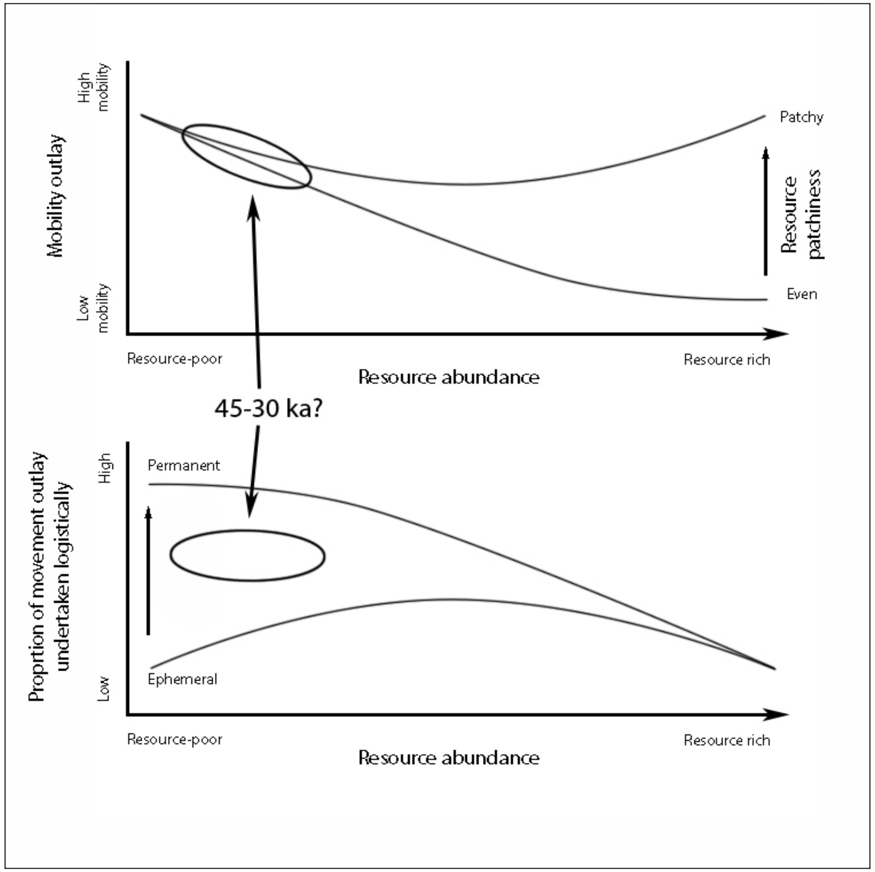


FIGURE 6.18: Hypothesised mobility magnitude and organization 45-30 ka

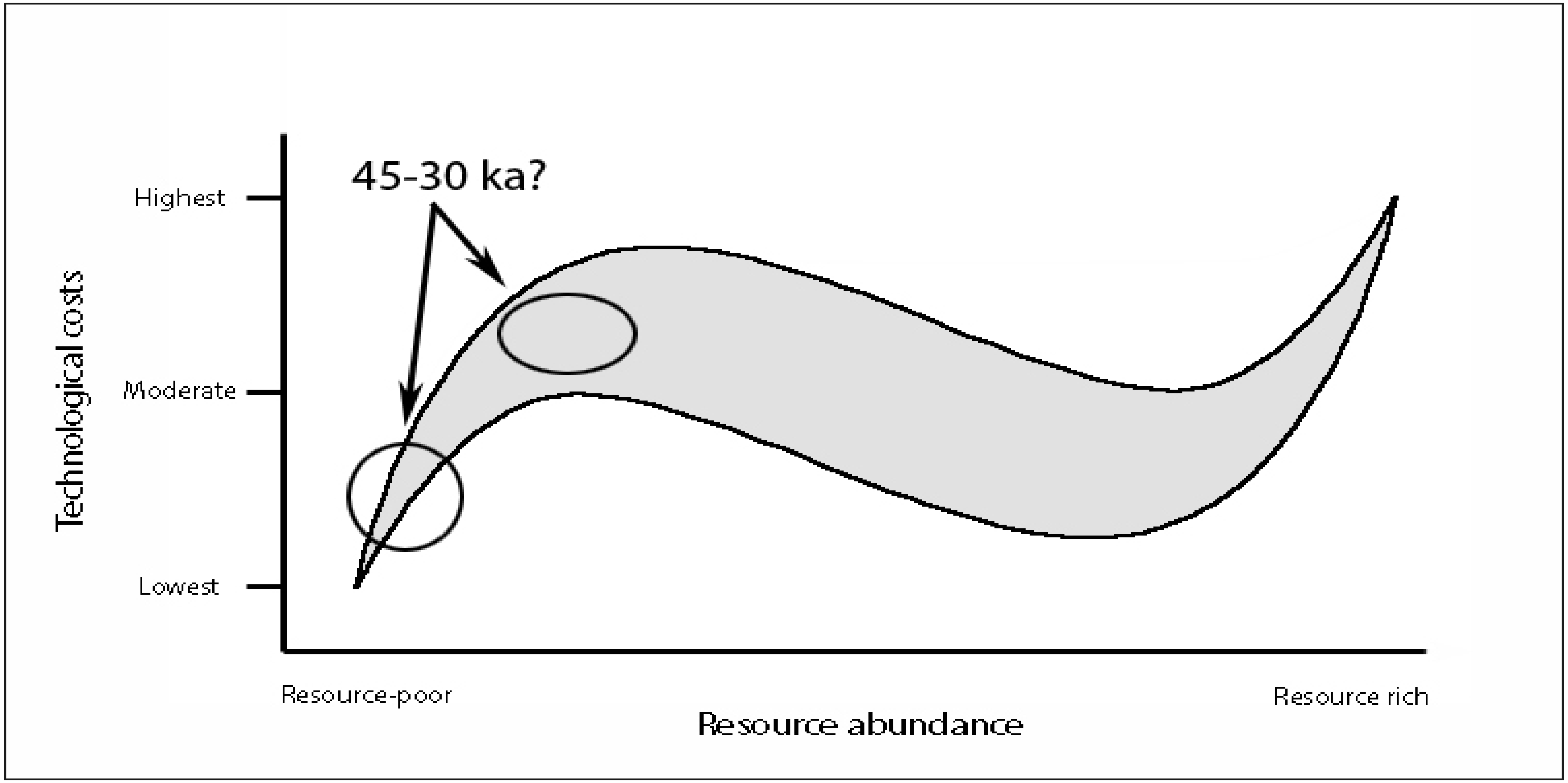


FIGURE 6.19: Hypothesised technological time cost and configuration 45-30 ka

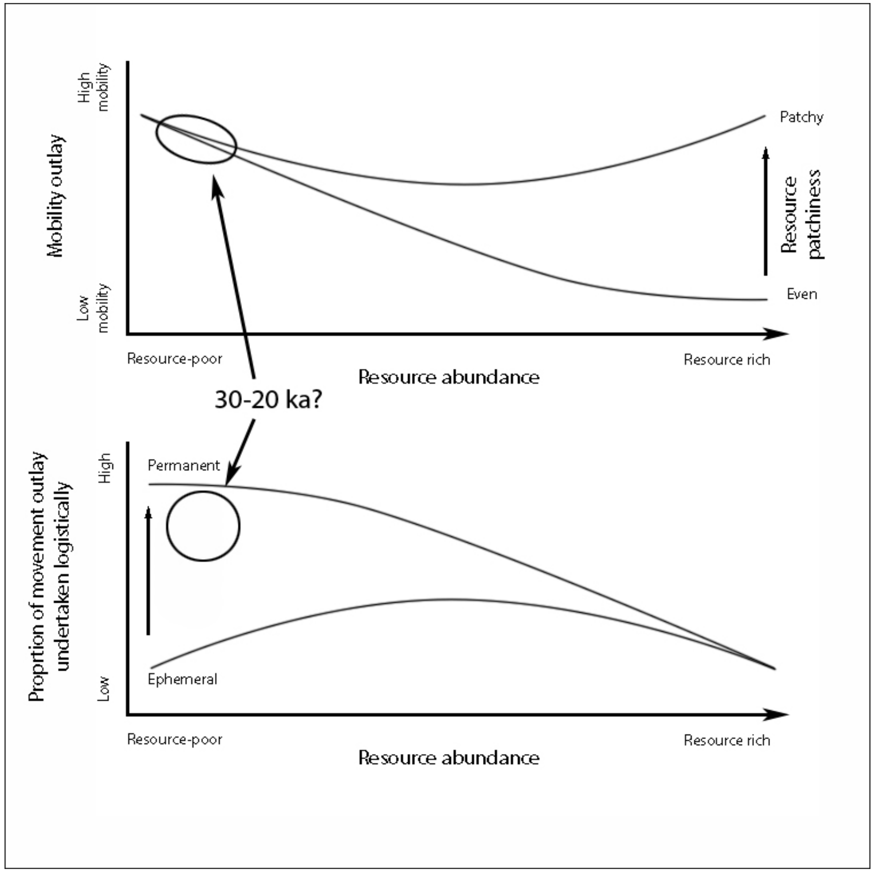


FIGURE 6.20: Hypothesised mobility magnitude and organization 30-20 ka

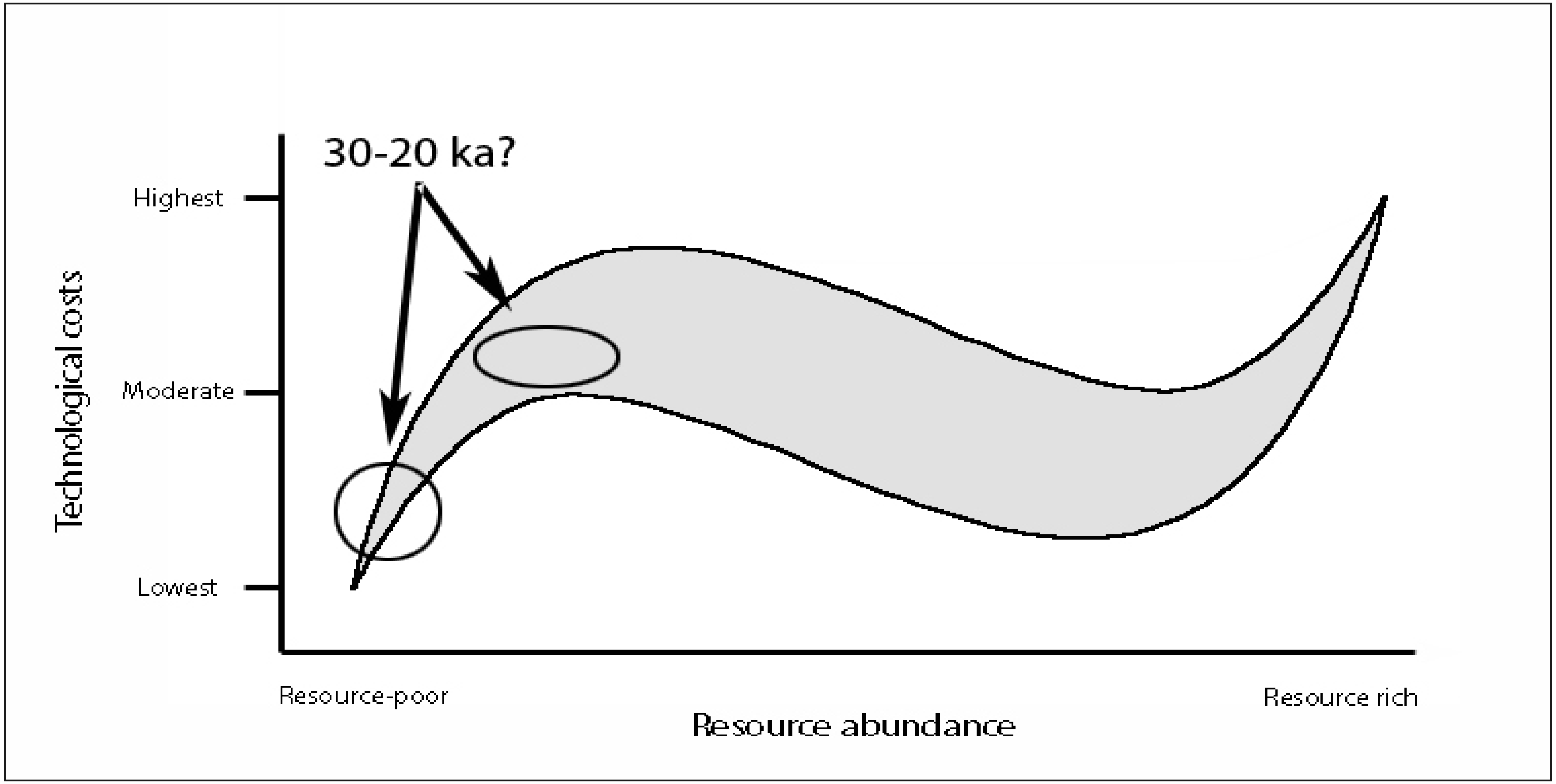


FIGURE 6.21: Hypothesised technological time cost and configuration 30-20 ka

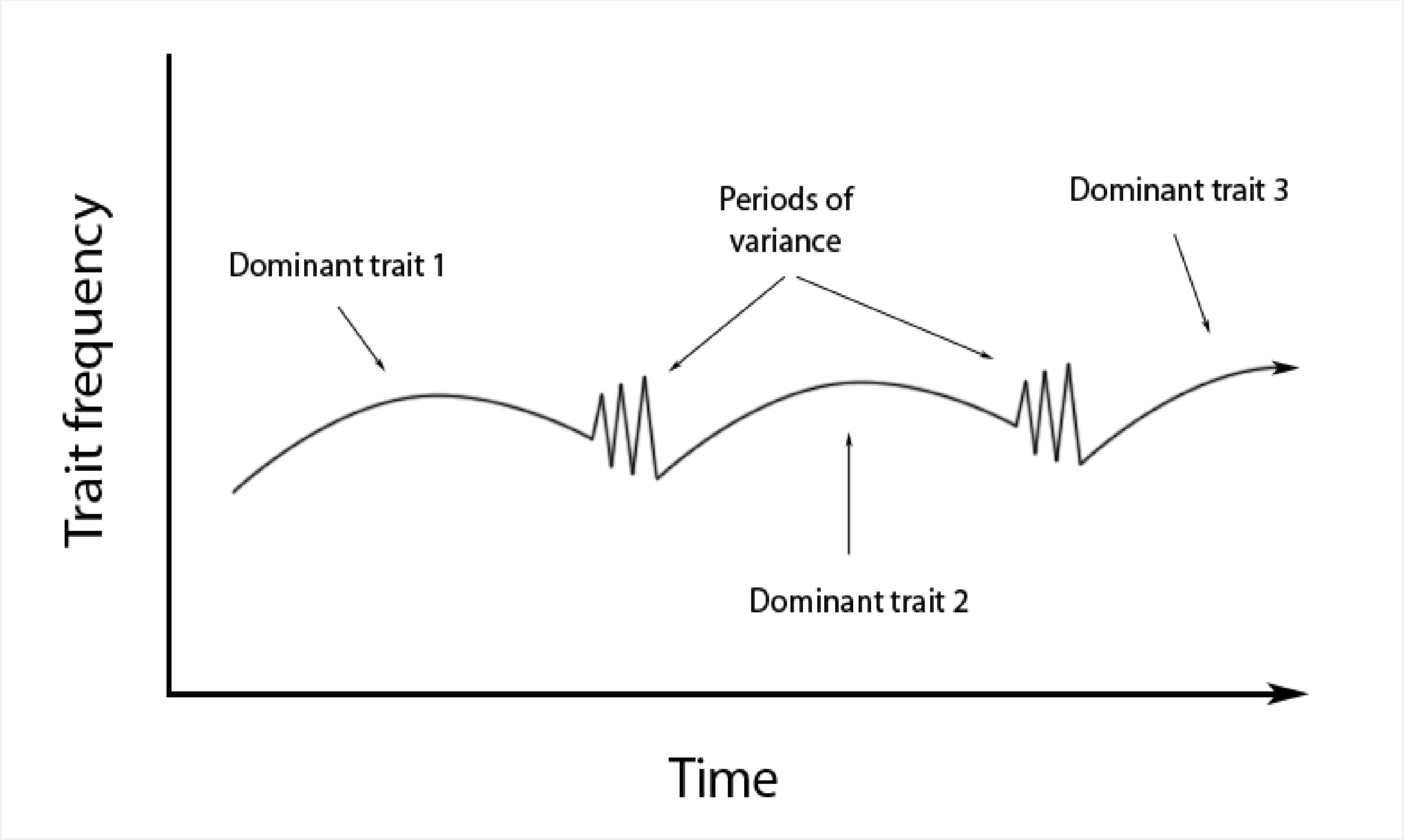


FIGURE 6.22: Trait frequency variation during technological turnover

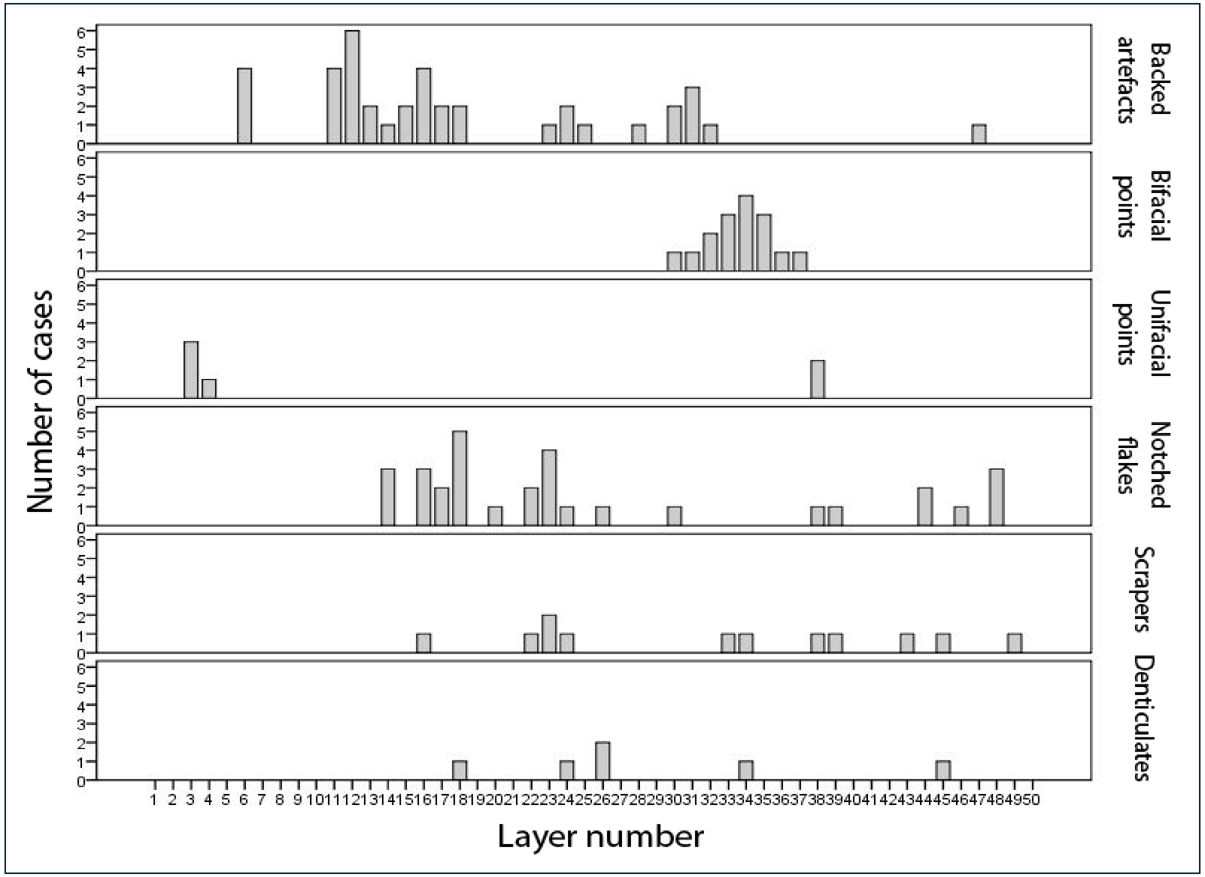


FIGURE 8.1: Implement type histograms, DRS

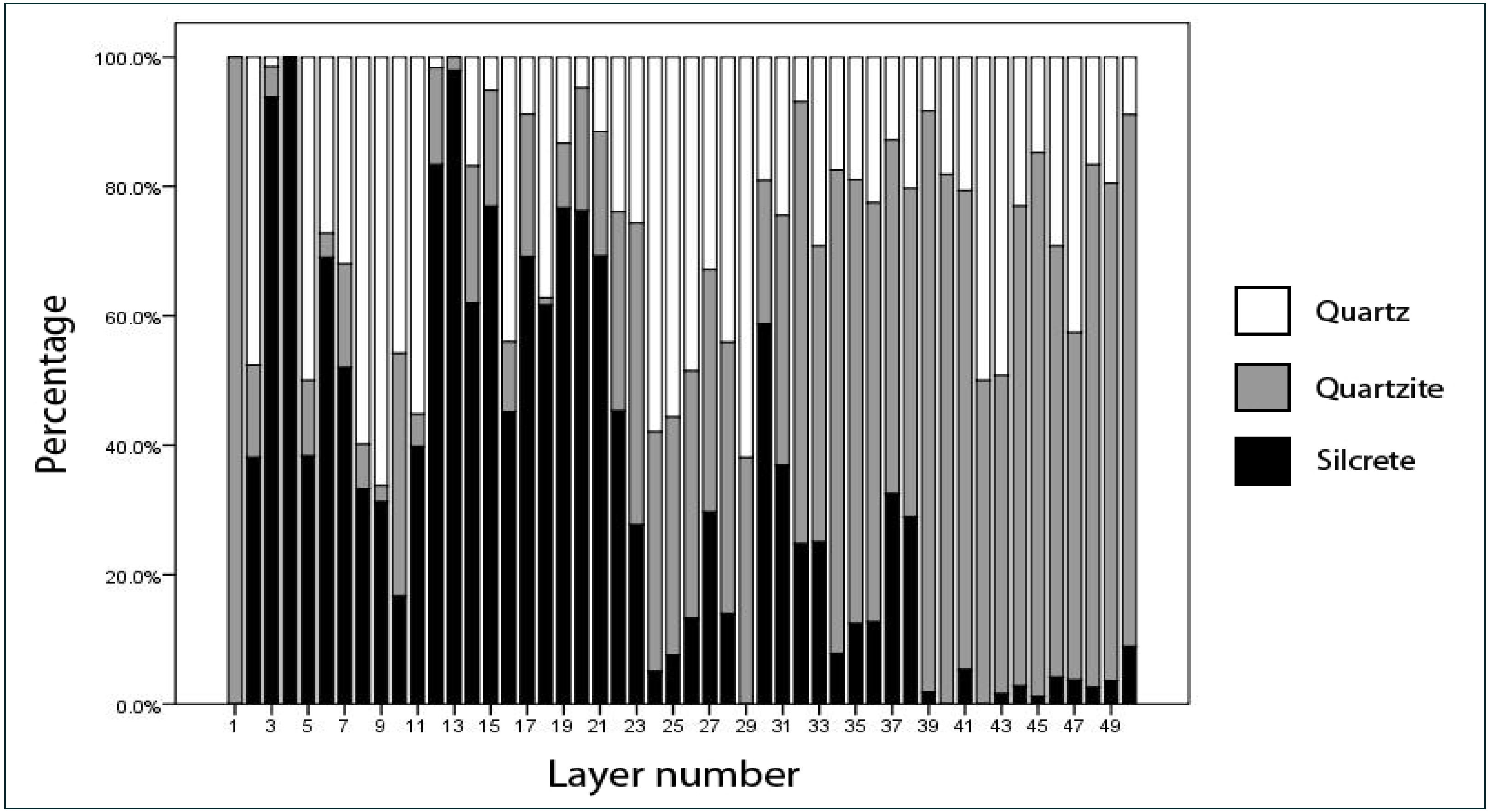


FIGURE 8.2: Material changes, DRS

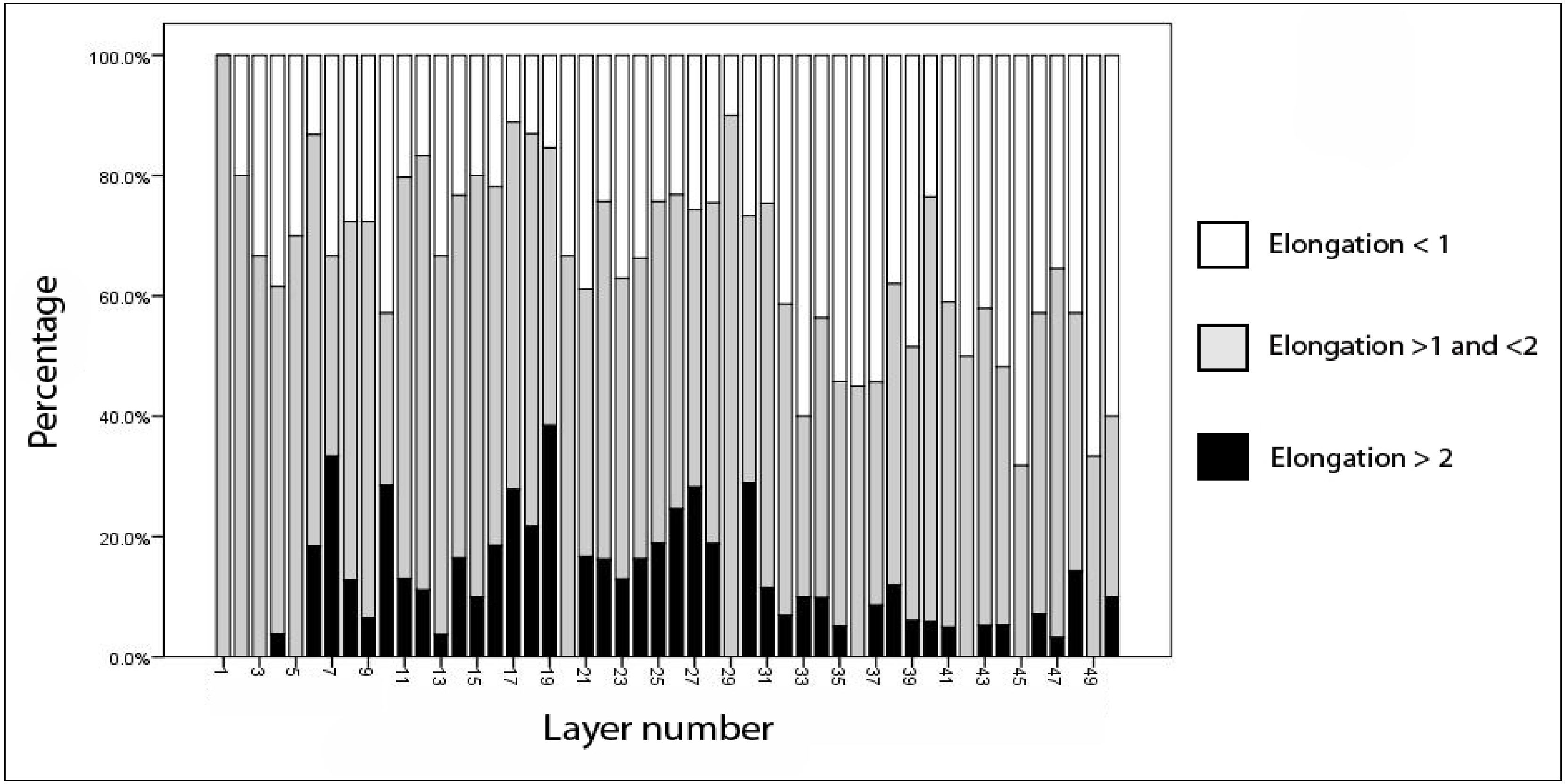


FIGURE 8.3: Flake elongation changes, DRS

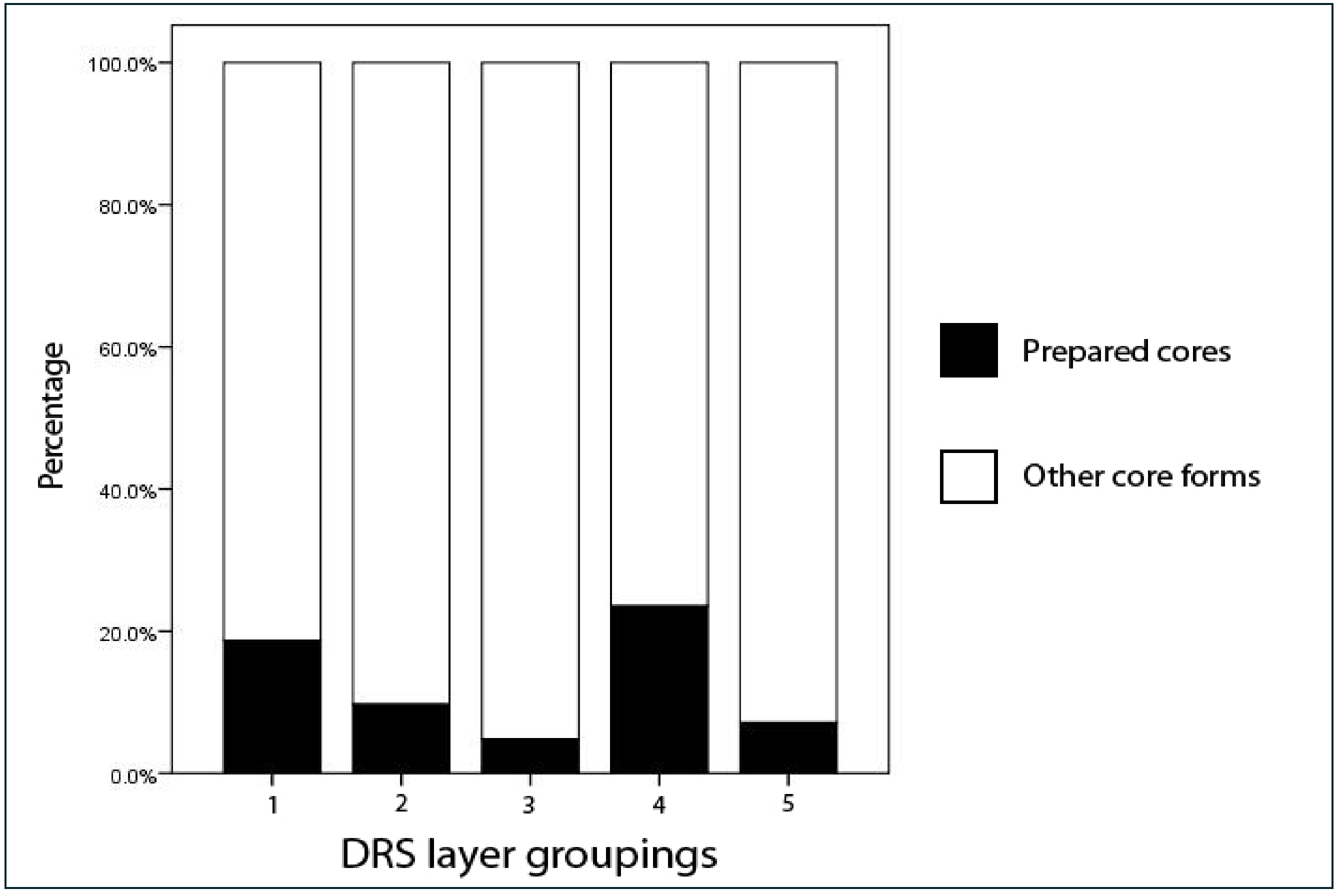


FIGURE 8.4: Changes in prepared core prevalence, DRS

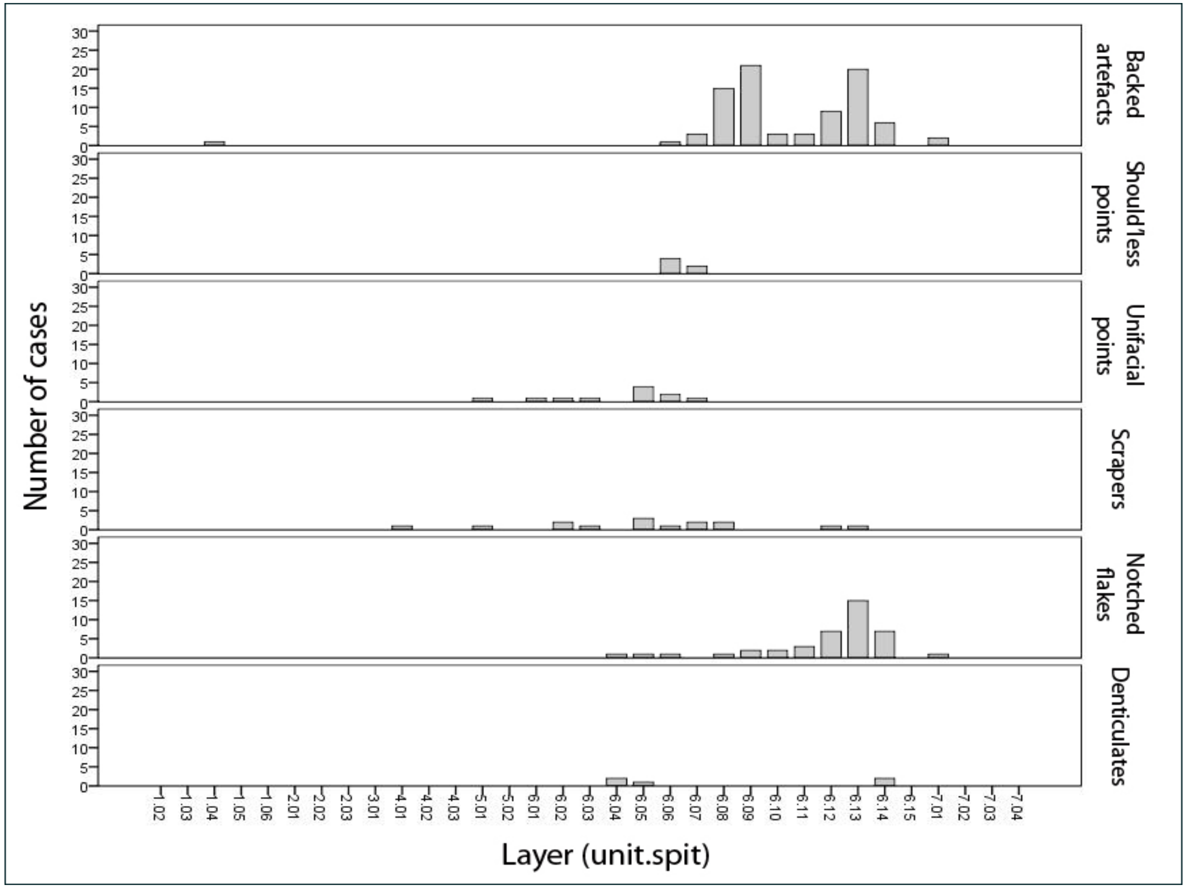


FIGURE 8.5: Implement type histograms, KKH

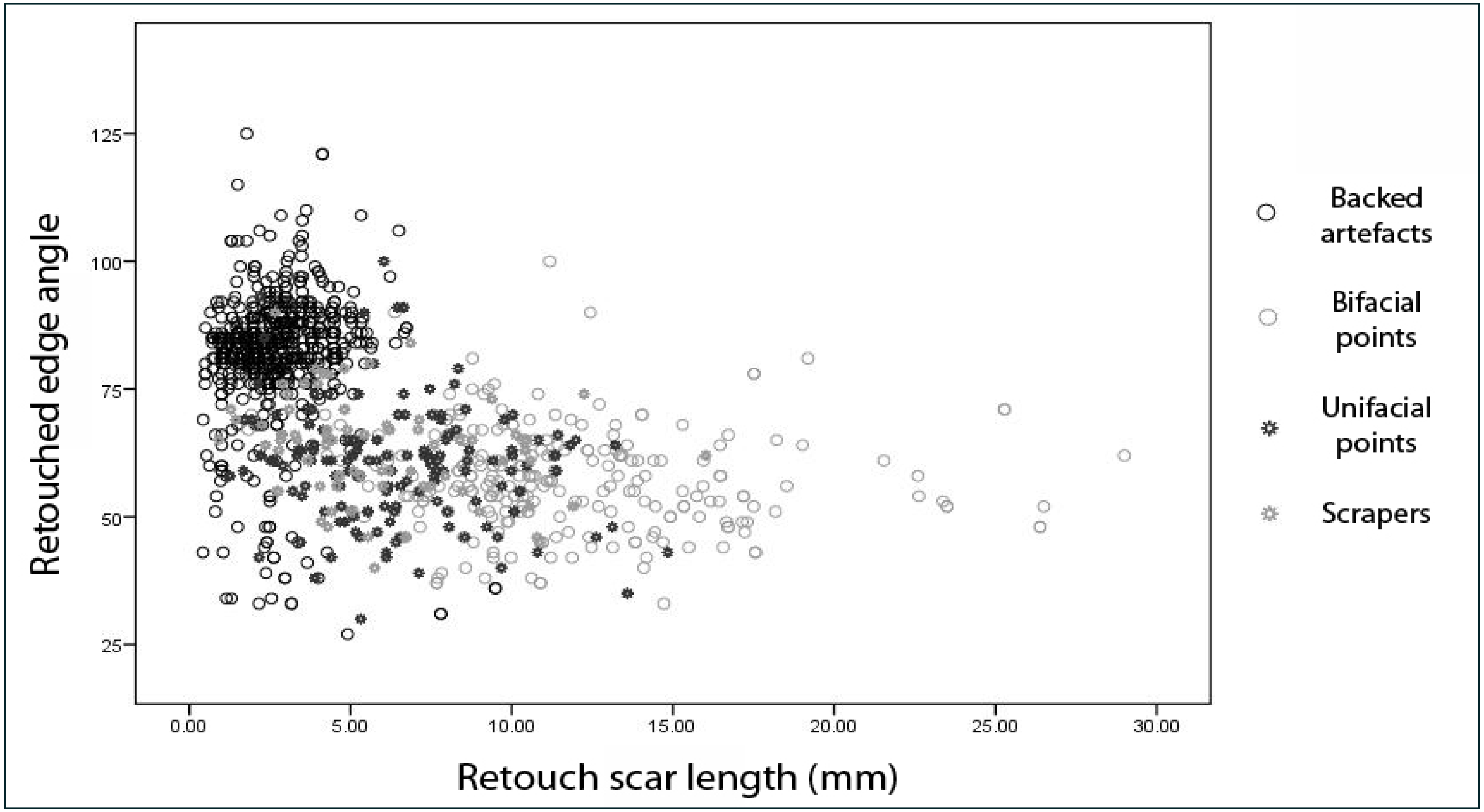


FIGURE 8.6: Scattergram of retouched edge angle and retouch scar length for major implement types

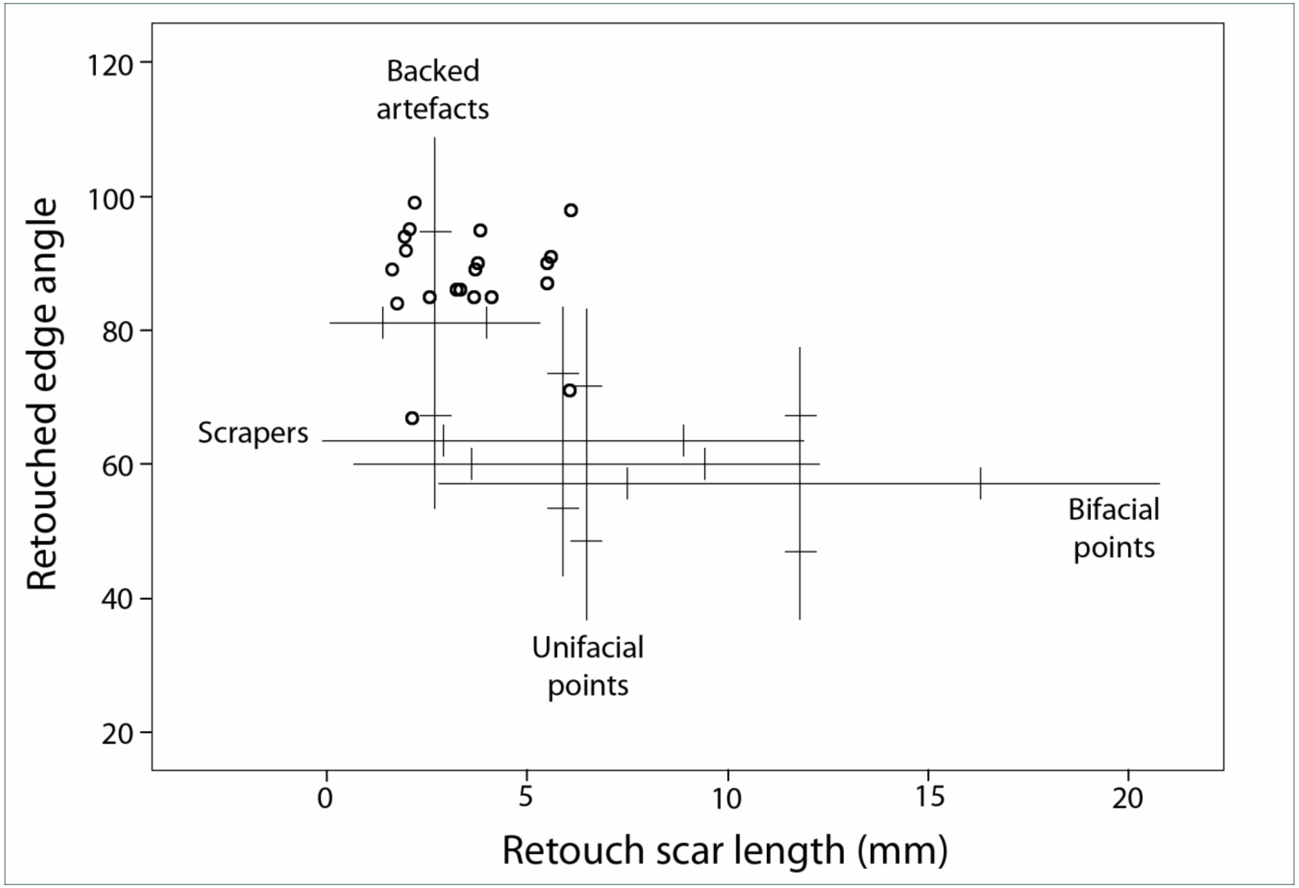


FIGURE 8.7: Scattergram of retouched edge angle and retouch scar length for 'shoulderless points' against major implement types

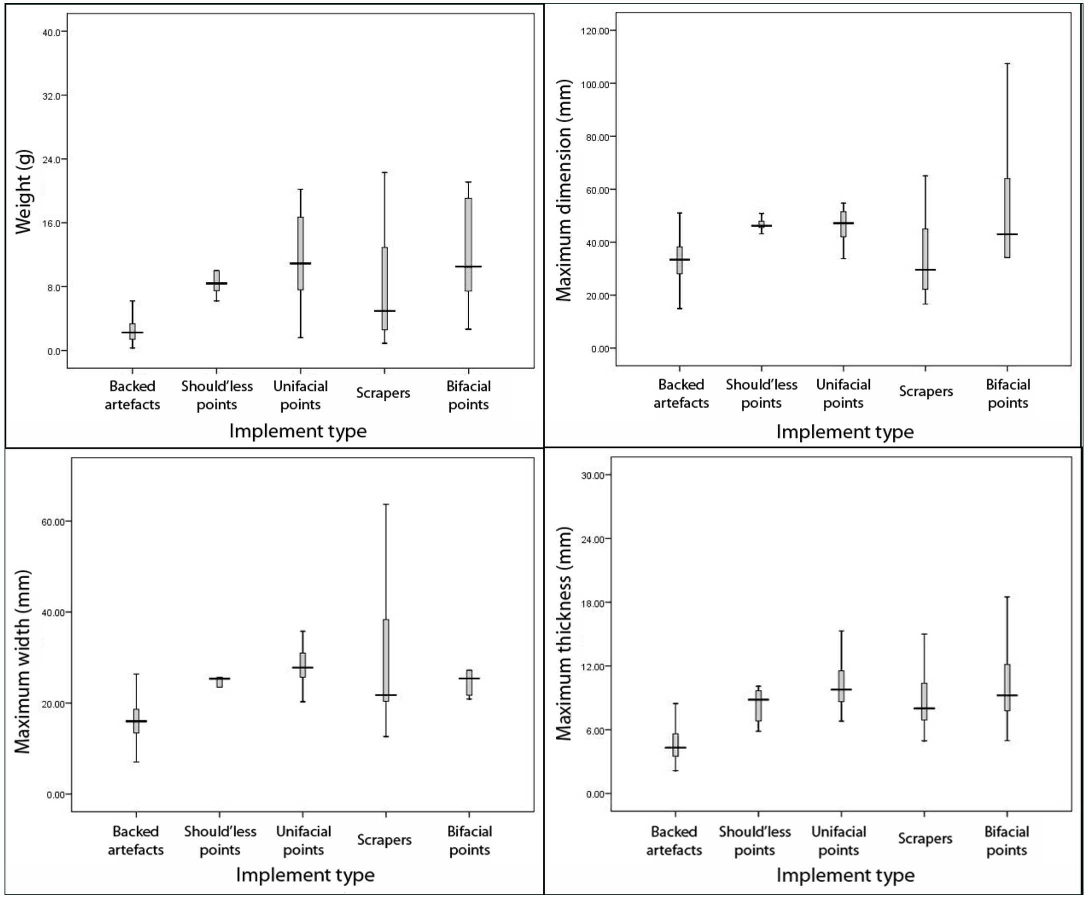


FIGURE 8.8: Weight and dimension data for 'shoulderless' points and major implement types

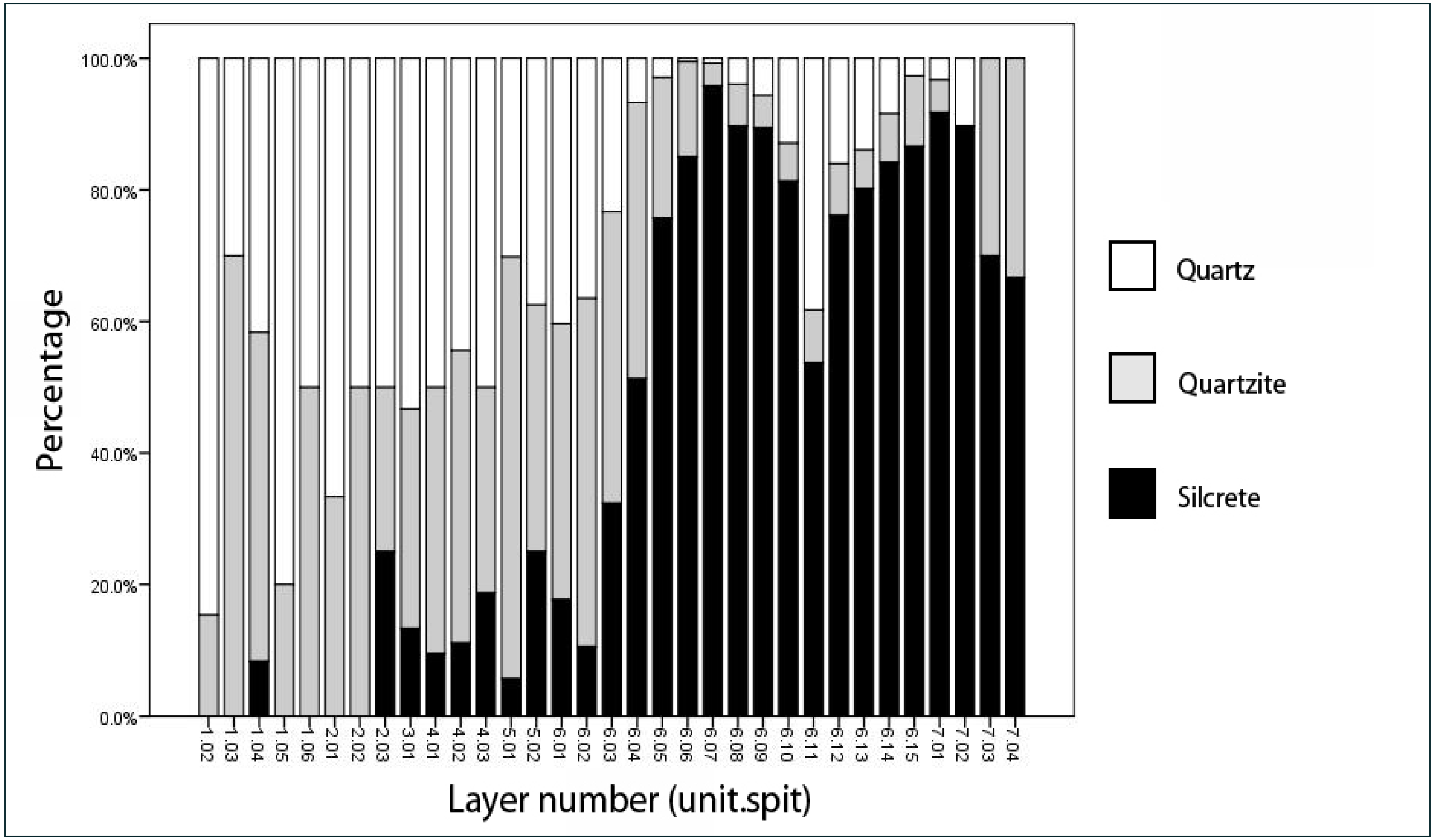


FIGURE 8.9: Material changes, KKH

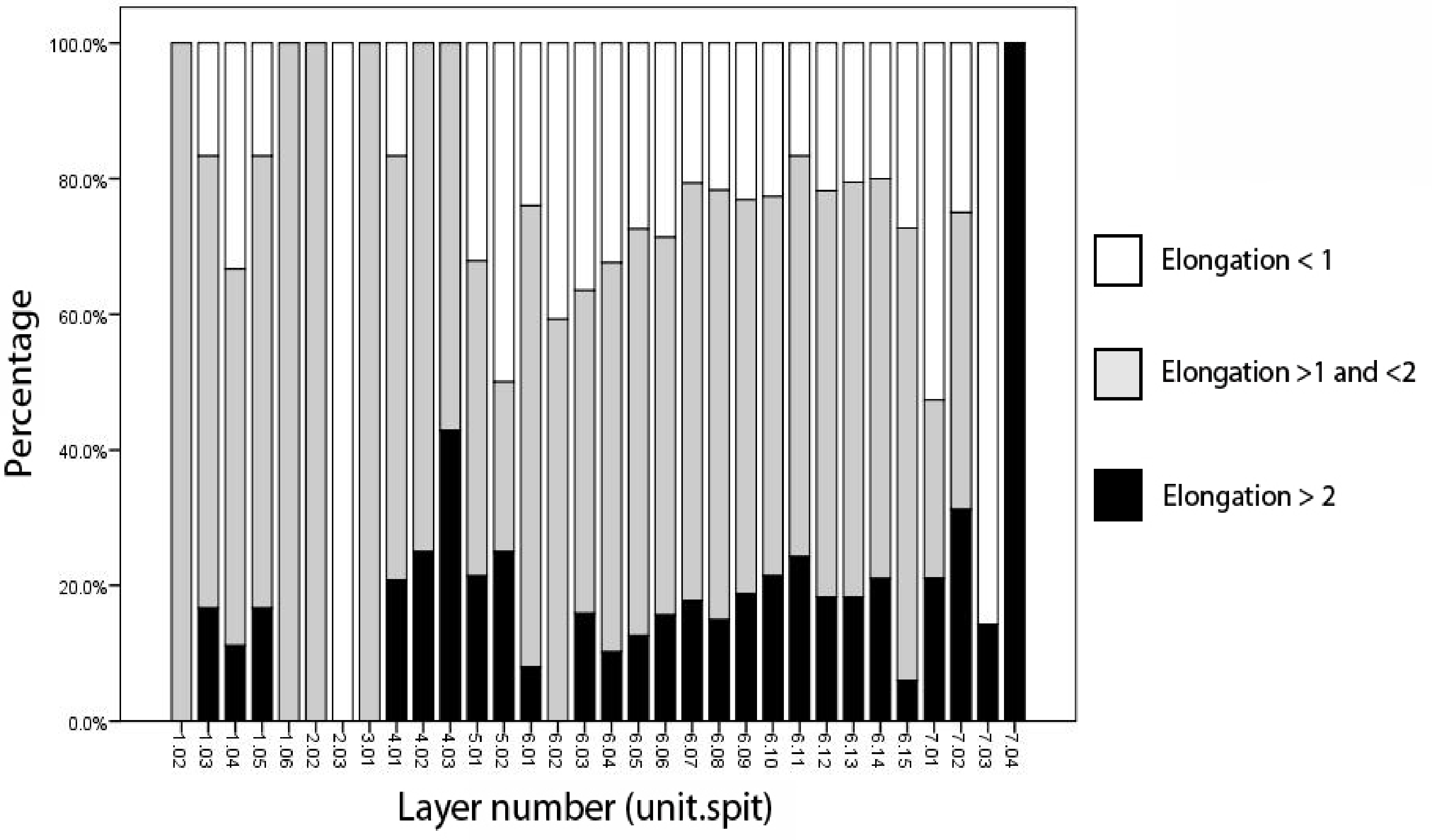


FIGURE 8.10: Flake elongation changes, KKH

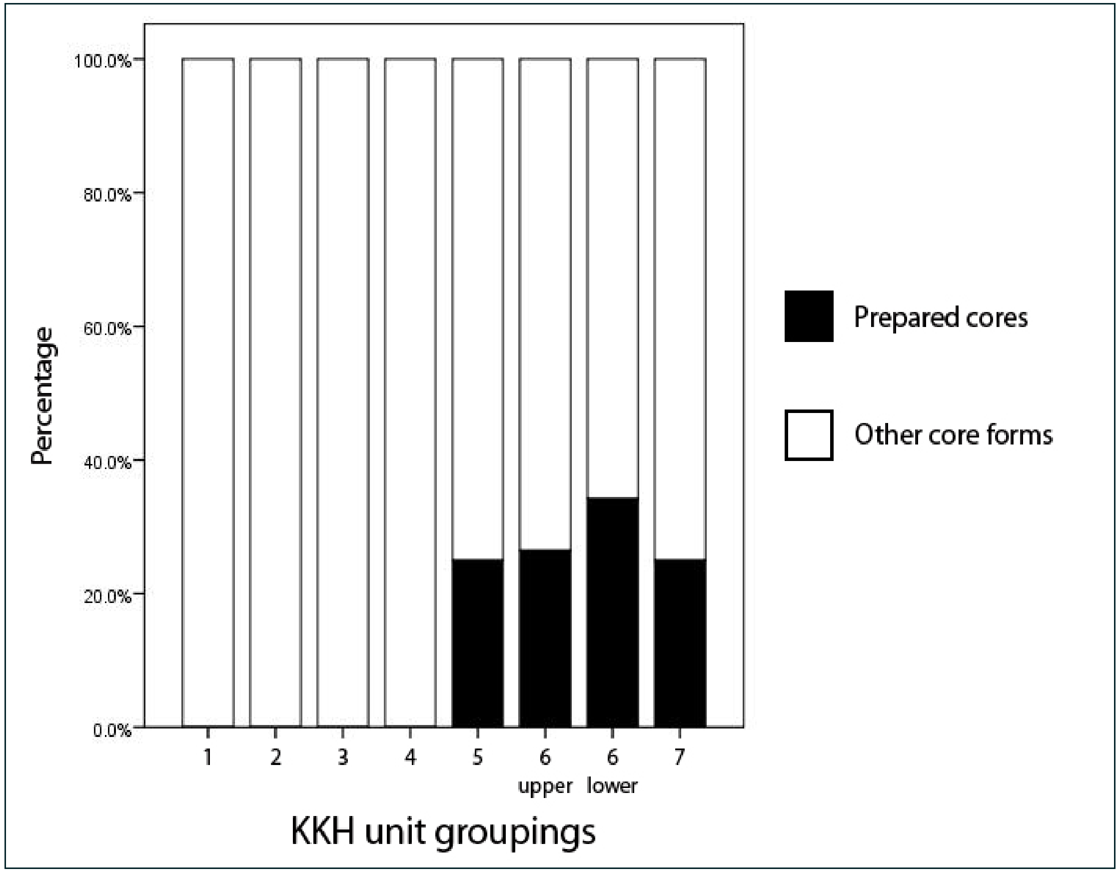


FIGURE 8.11: Changes in prepared core prevalence, KKH

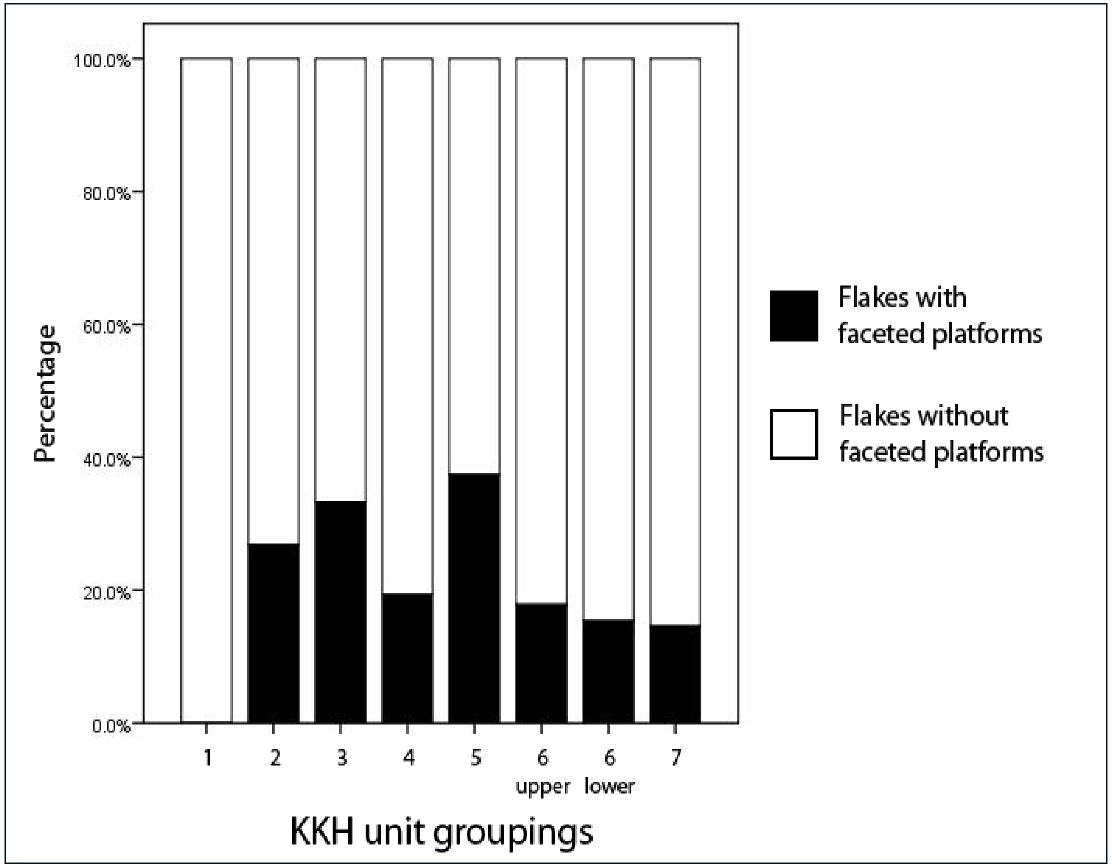


FIGURE 8.12: Changes in the prevalence of flakes with prepared platforms, KKH

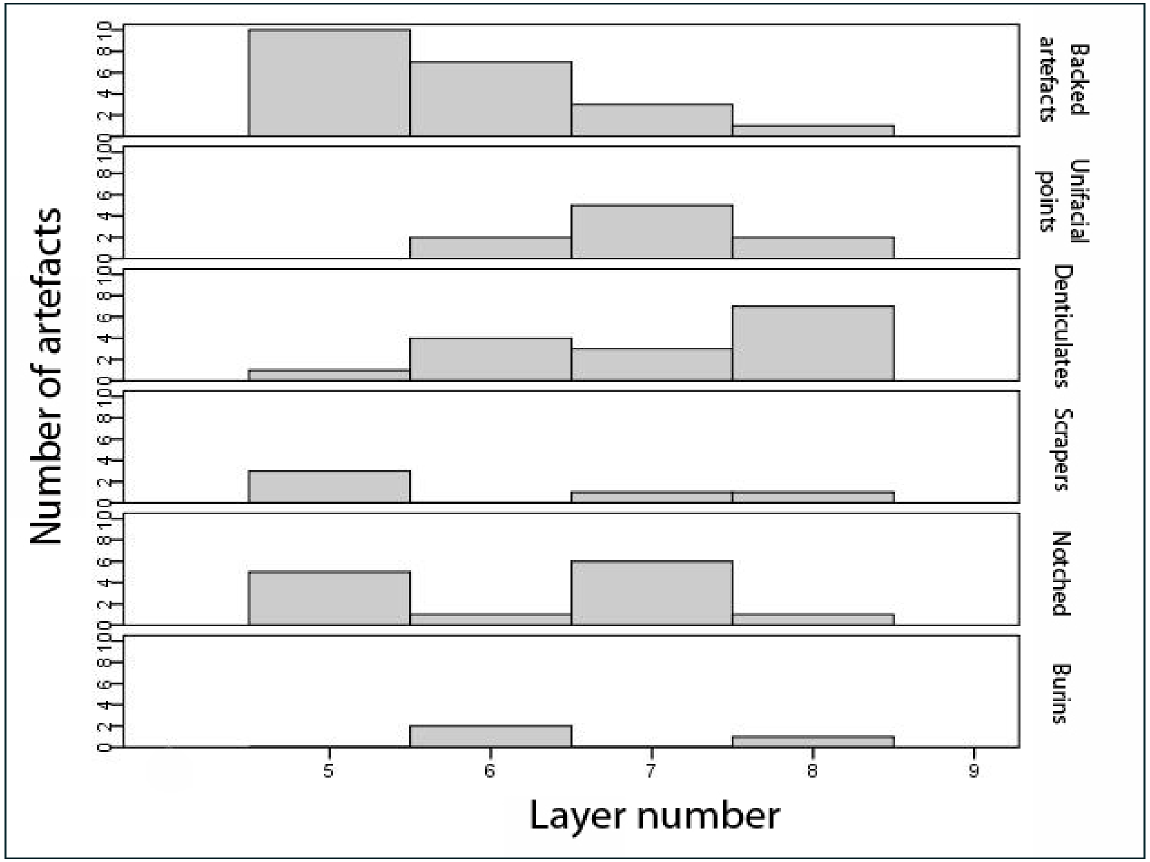


FIGURE 8.13: Implement type histograms, KFR

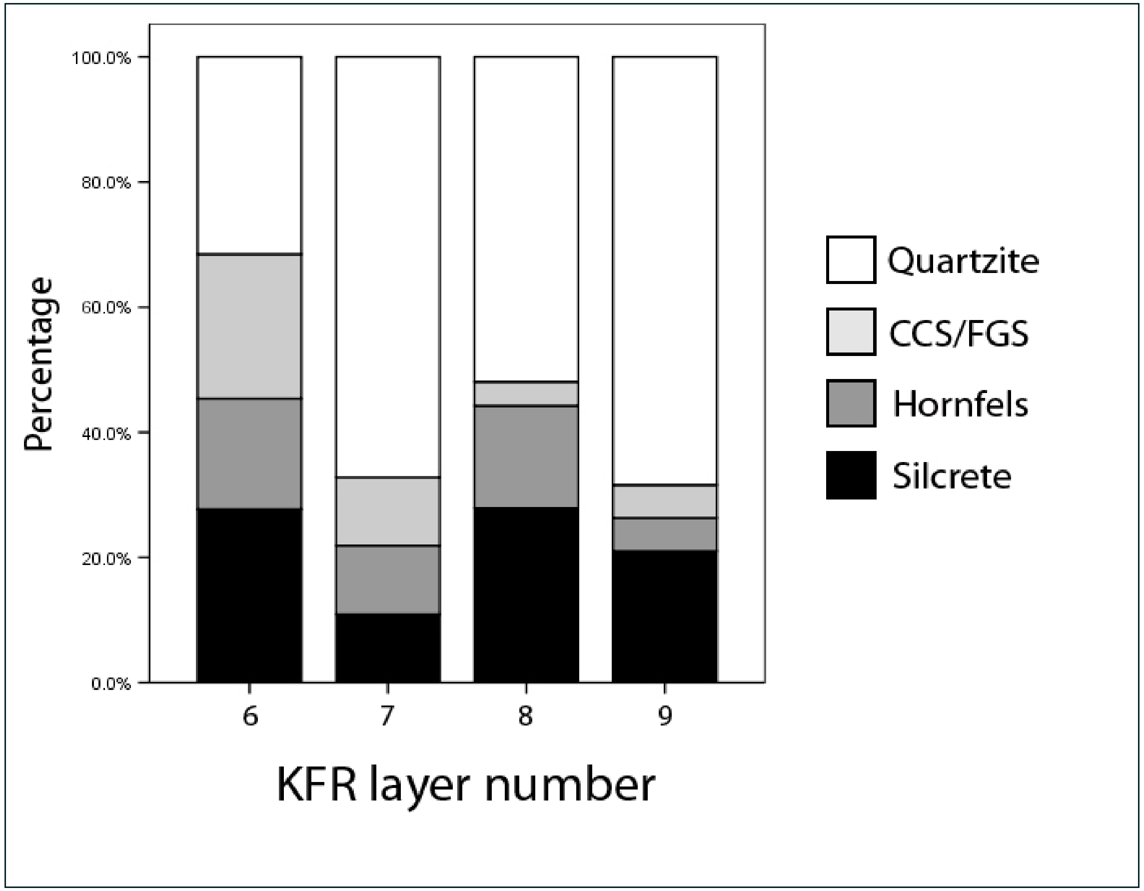


FIGURE 8.14: Material changes, KFR

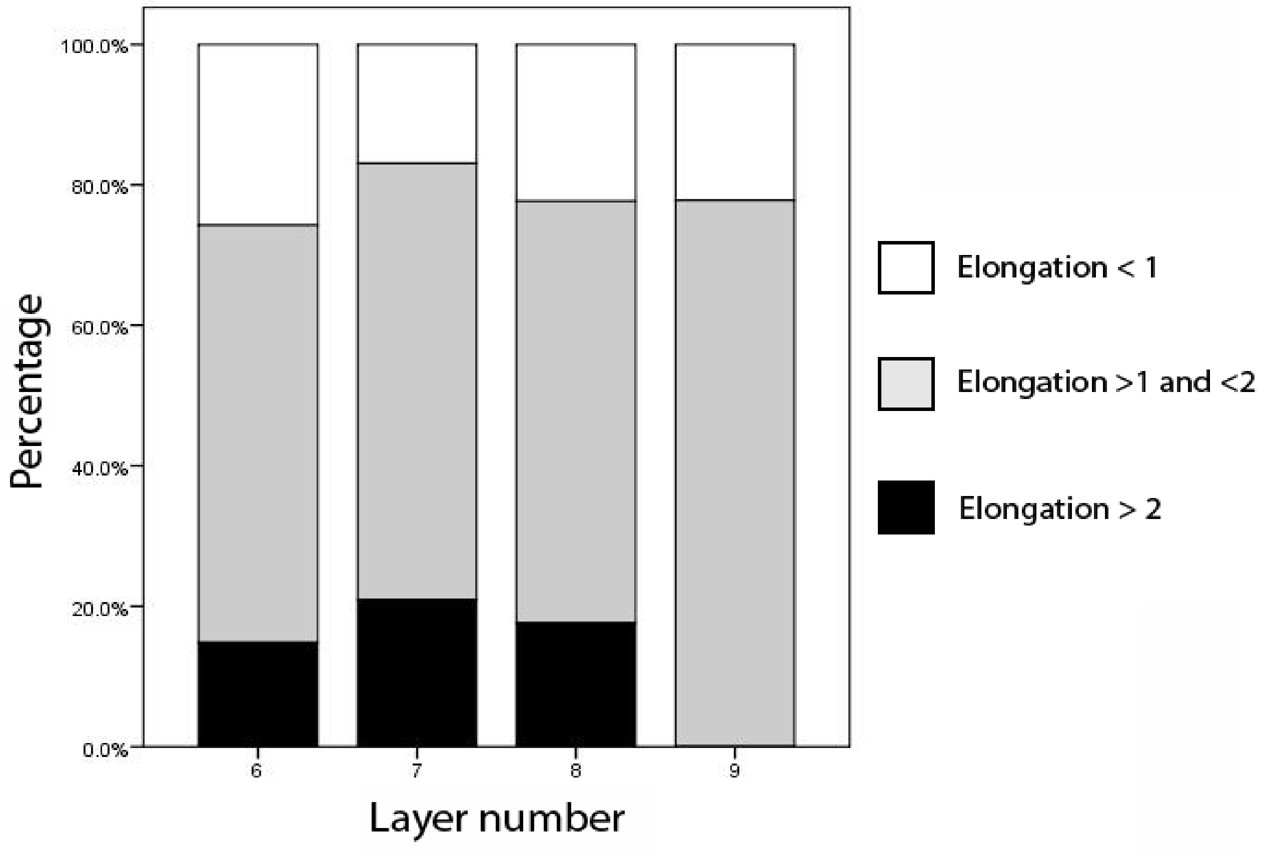


FIGURE 8.15: Flake elongation changes, KFR

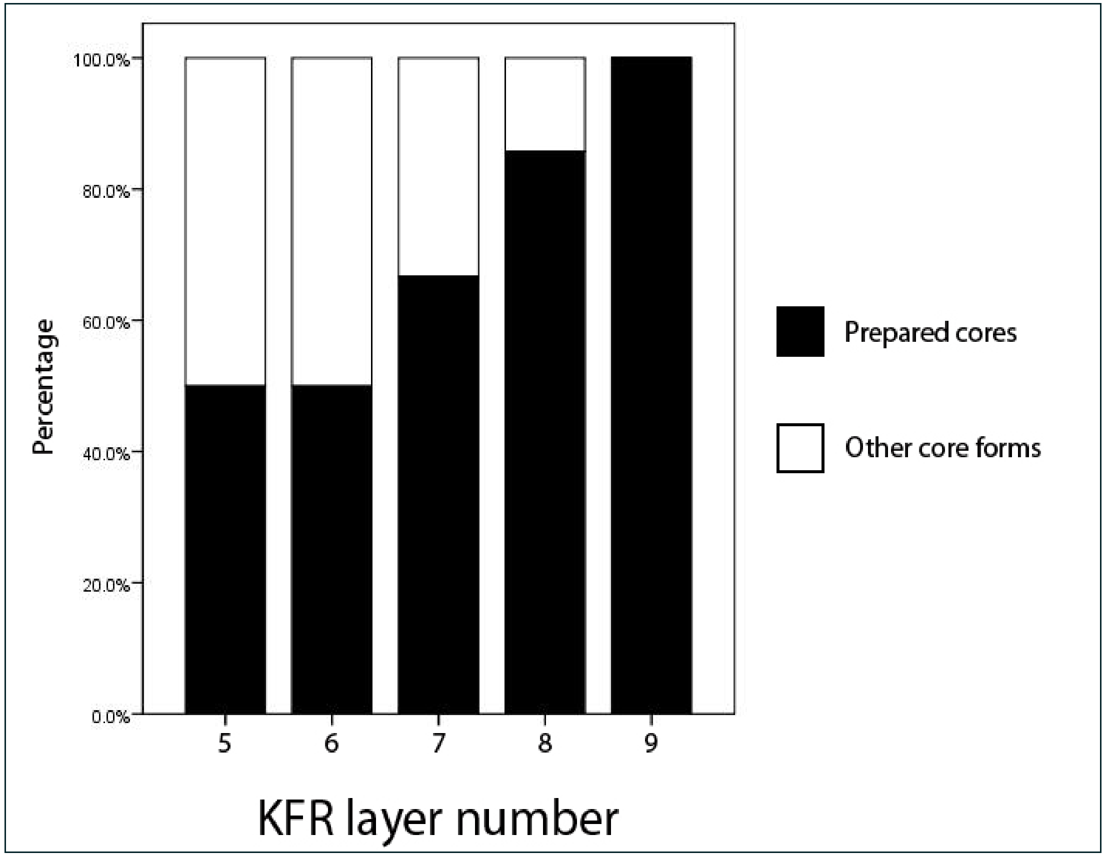


FIGURE 8.16: Changes in prepared core prevalence, KFR

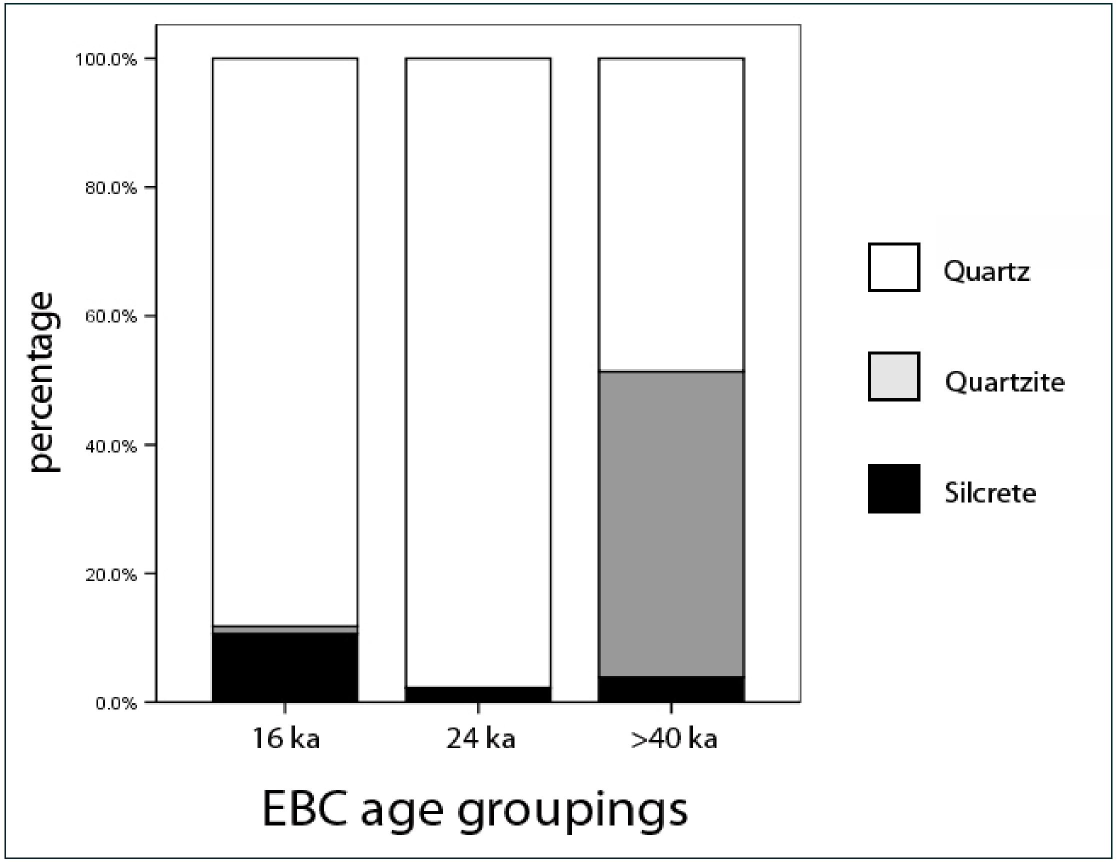


FIGURE 8.17: Material changes, EBC

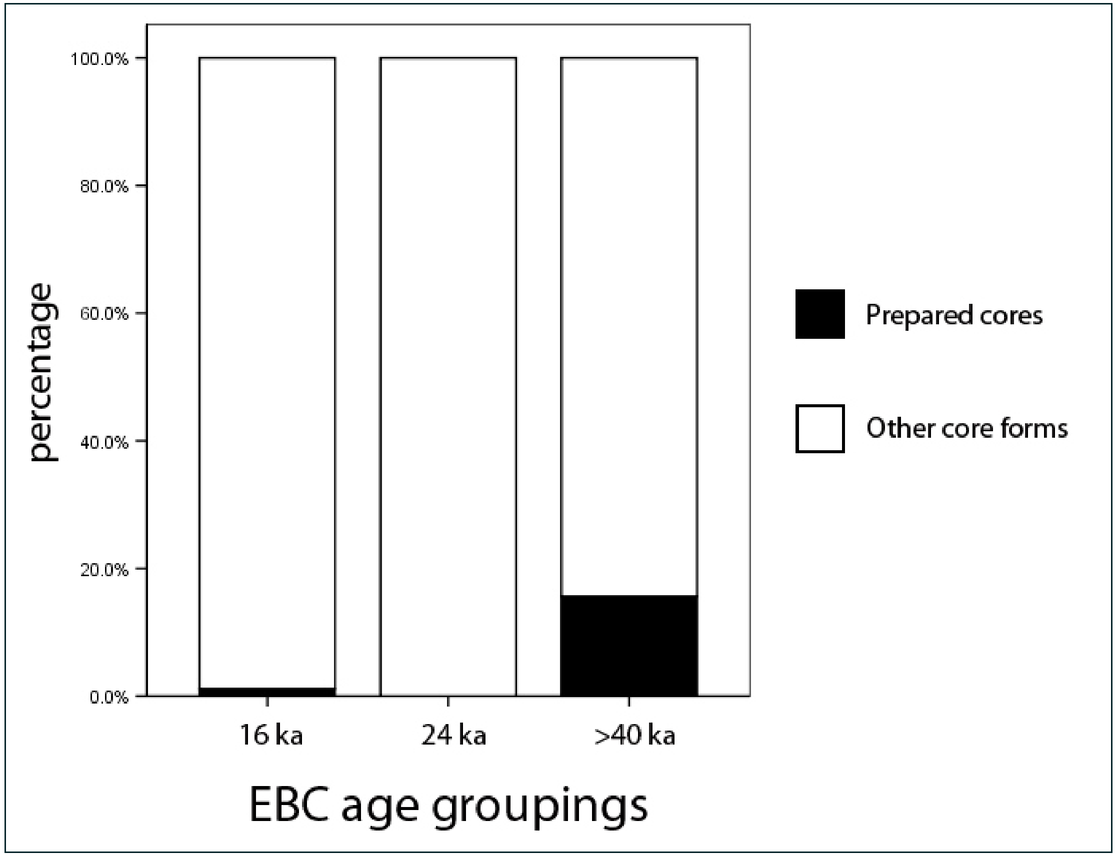


FIGURE 8.18: Changes in prepared core prevalence, EBC

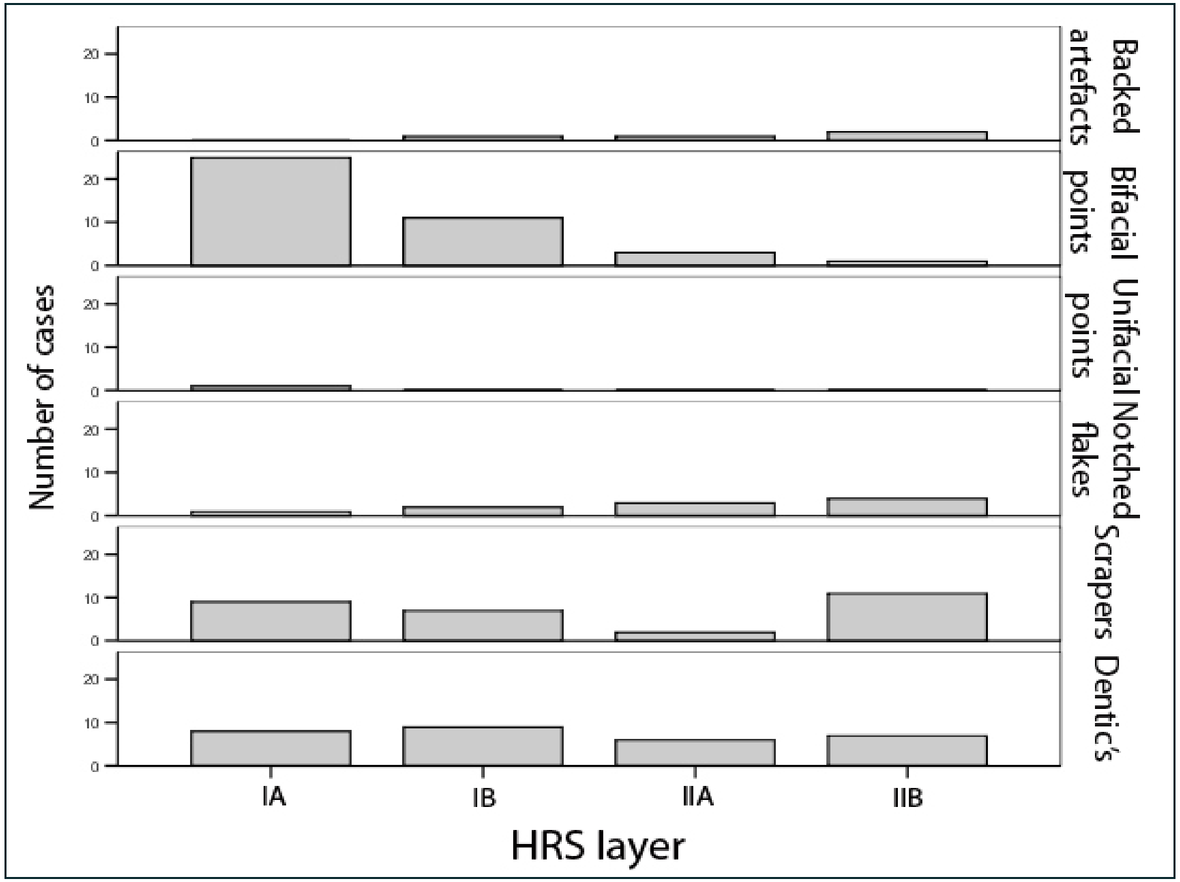


FIGURE 8.19: Implement type histograms, HRS

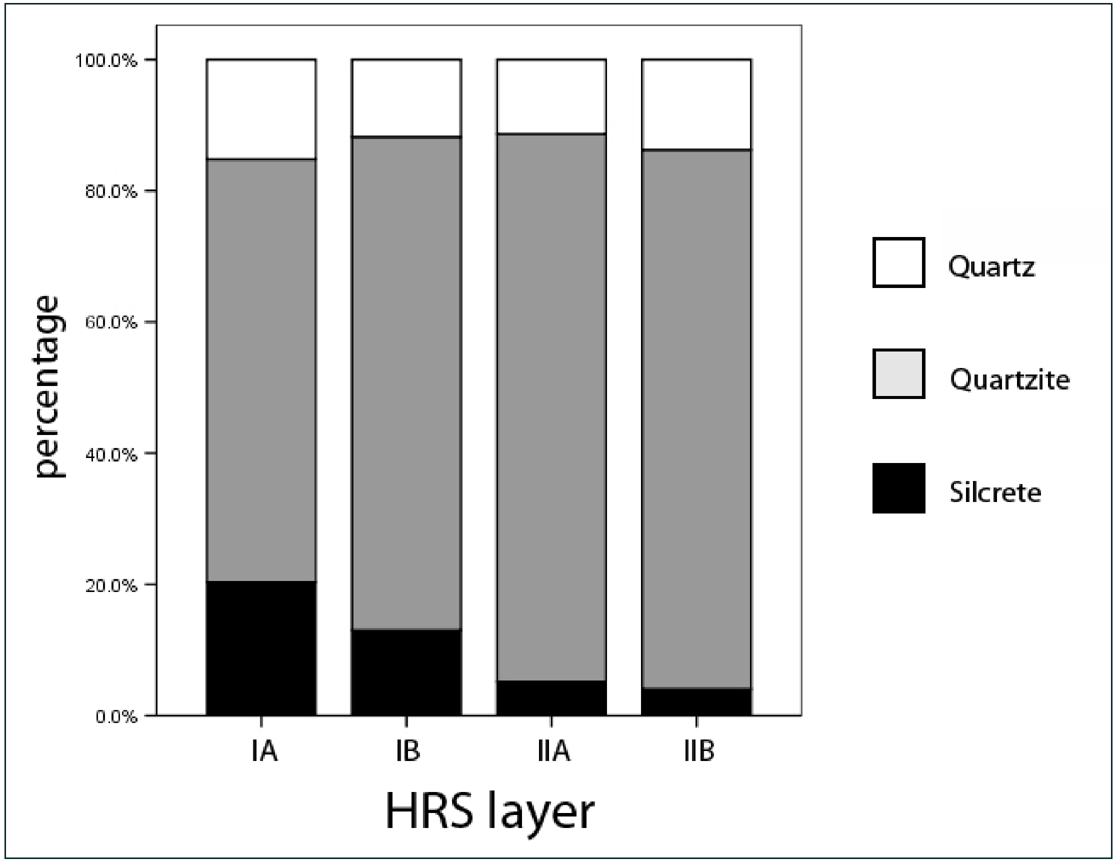


FIGURE 8.20: Material changes, HRS

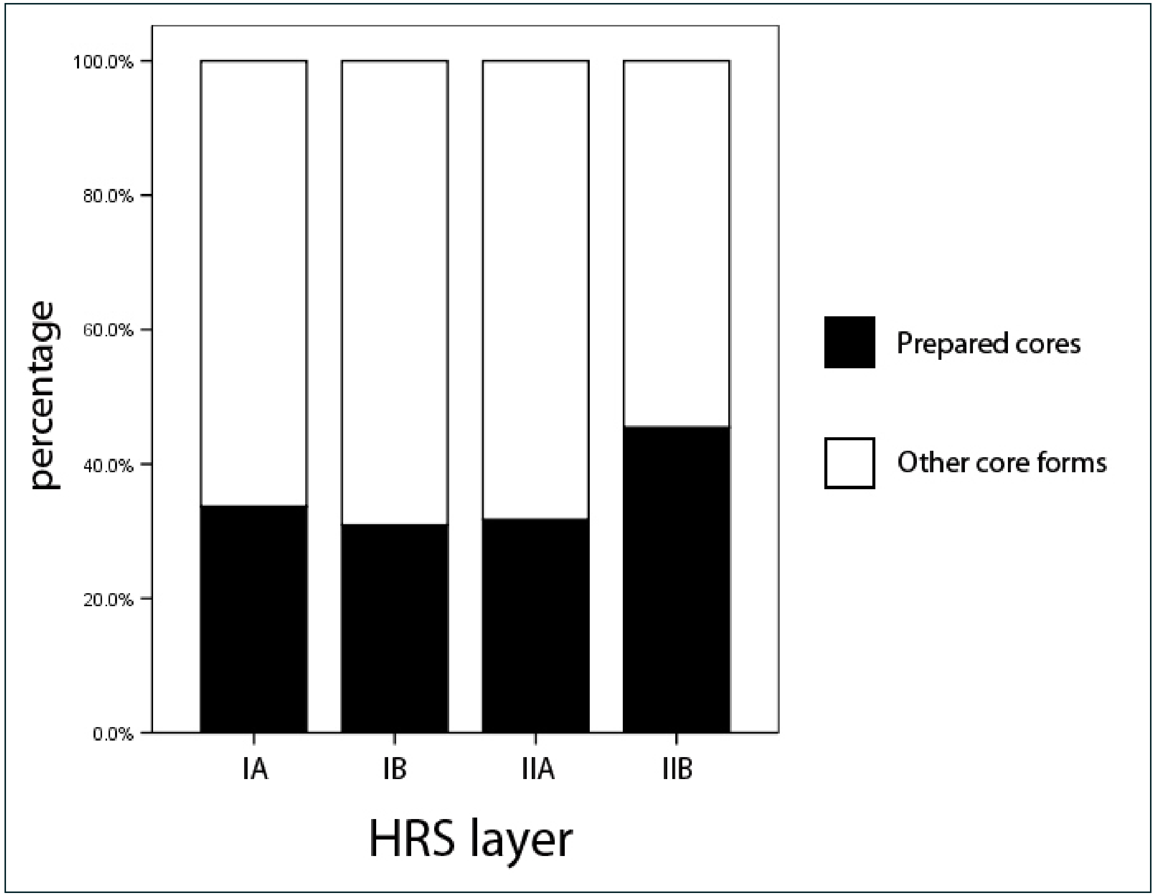


FIGURE8.21: Changes in prepared core prevalence, HRS

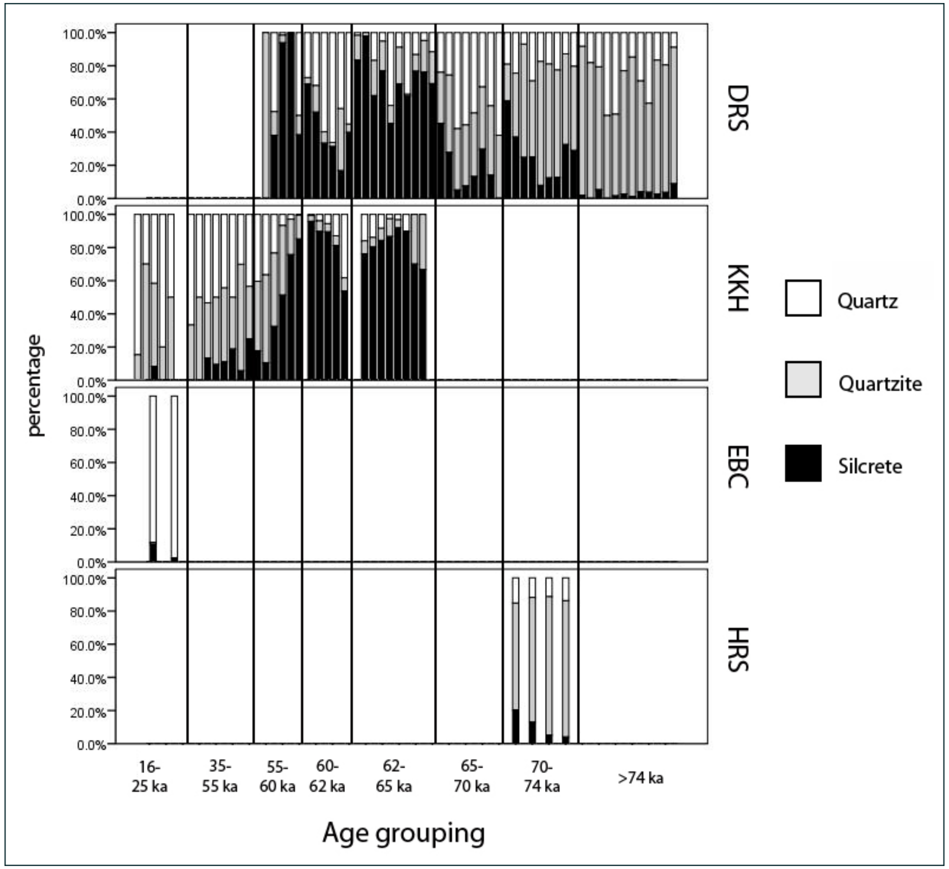


FIGURE 8.22: Age grouped material changes at DRS, KKH, EBC and HRS

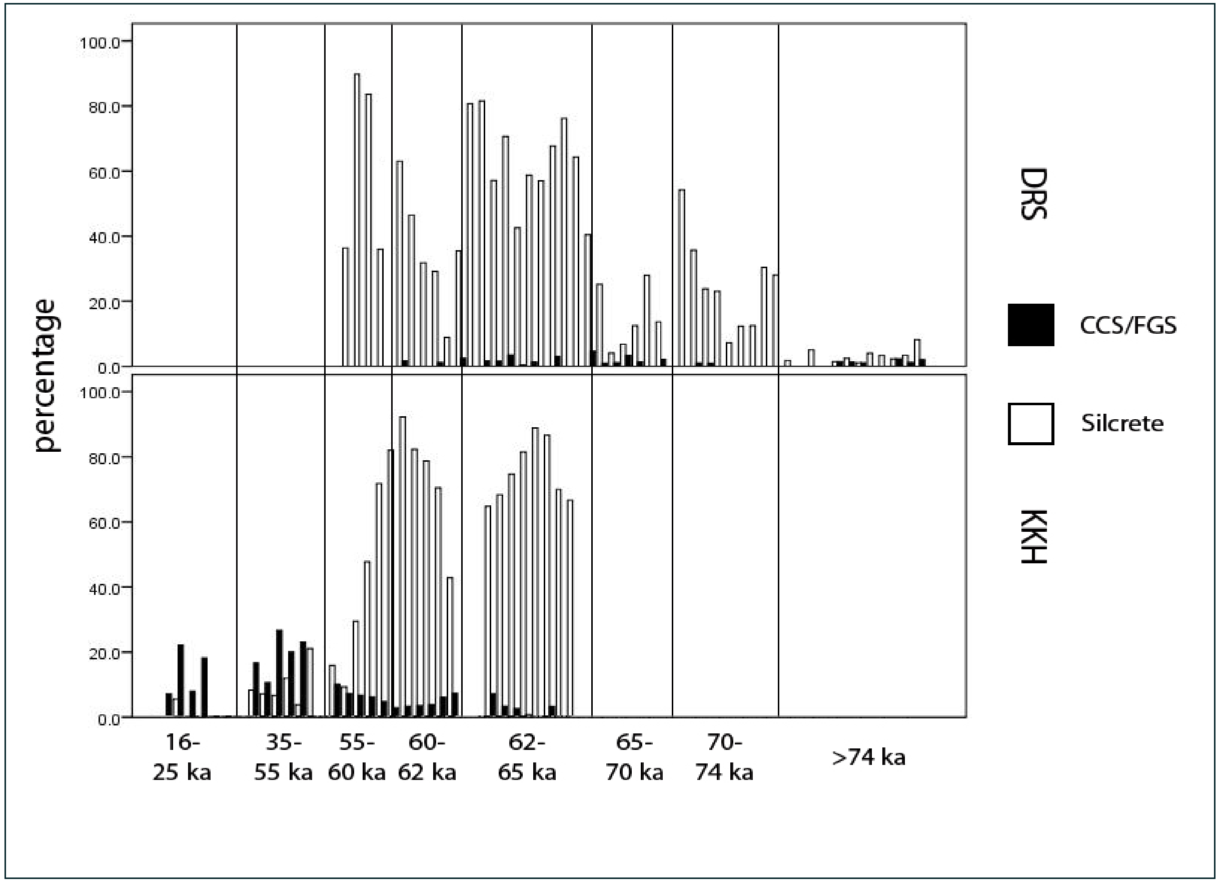


FIGURE 8.23: Age grouped changes in silcrete and CCS/FGS at DRS and KKH

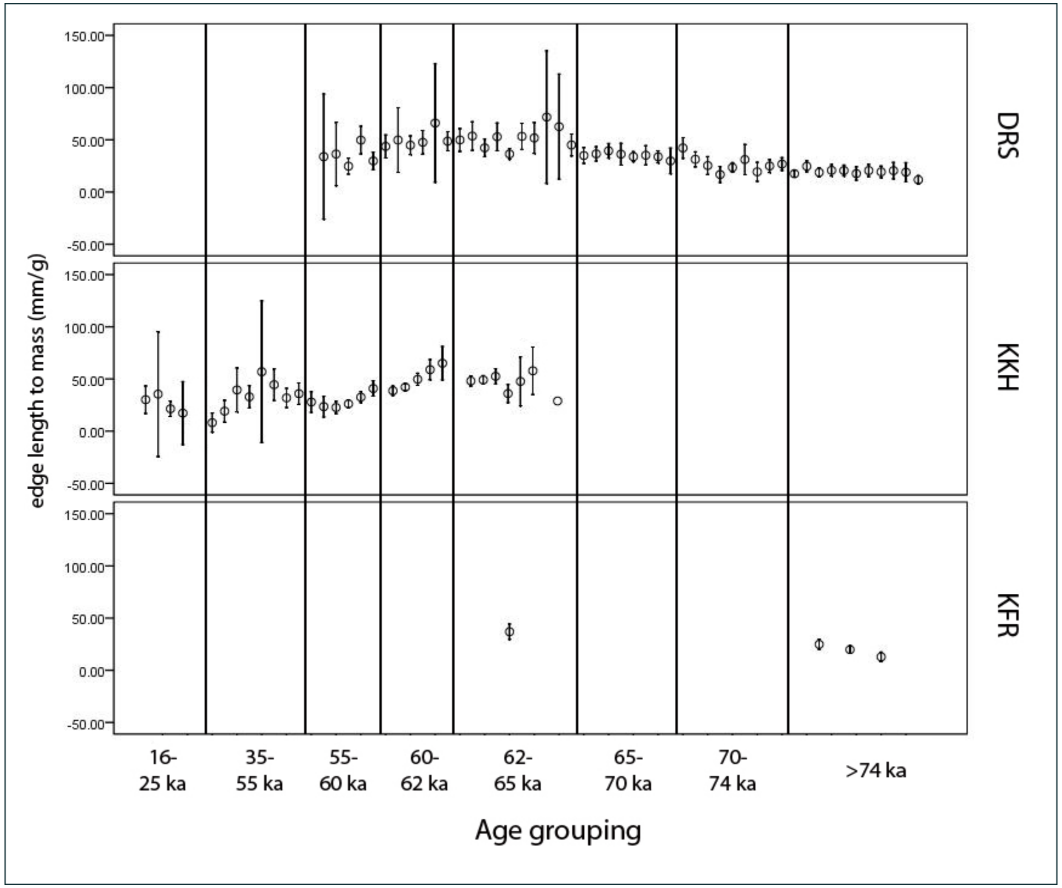


FIGURE 8.24: Age grouped changes in ELM at DRS, KKH and KFR

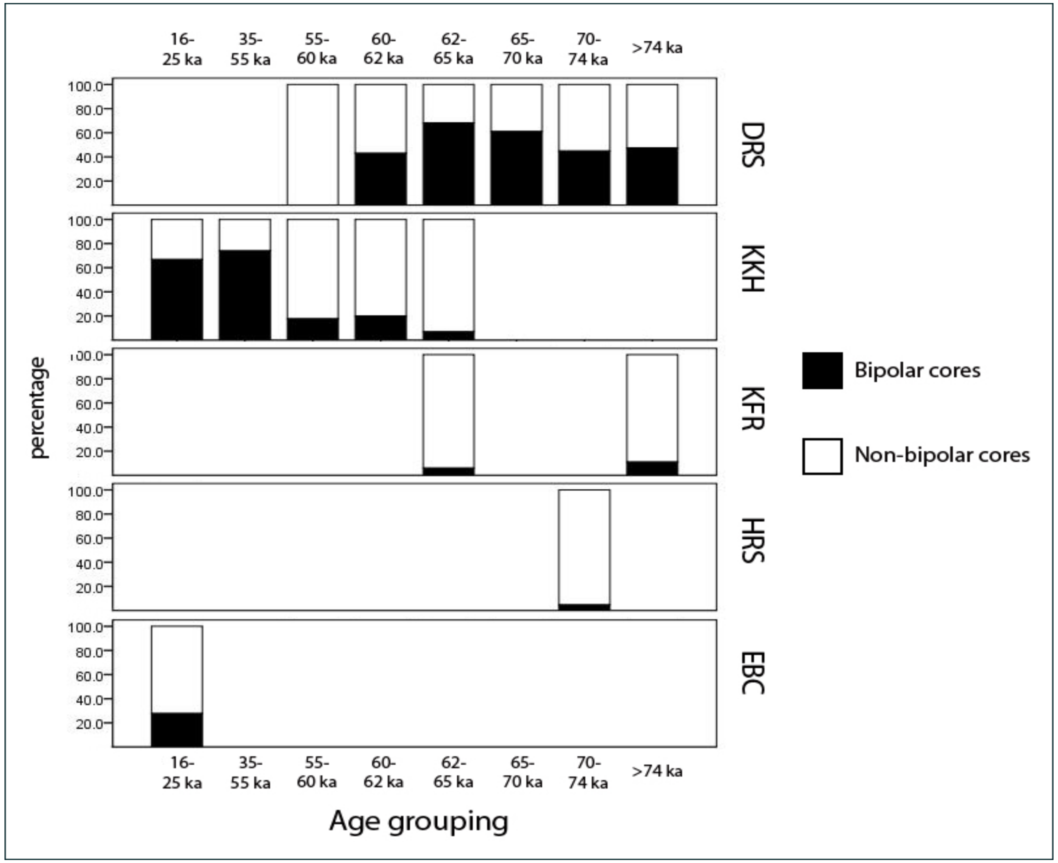


FIGURE 8.25: Age grouped changes in bipolar core prevalence at DRS, KKH, KFR, HRS and EBC

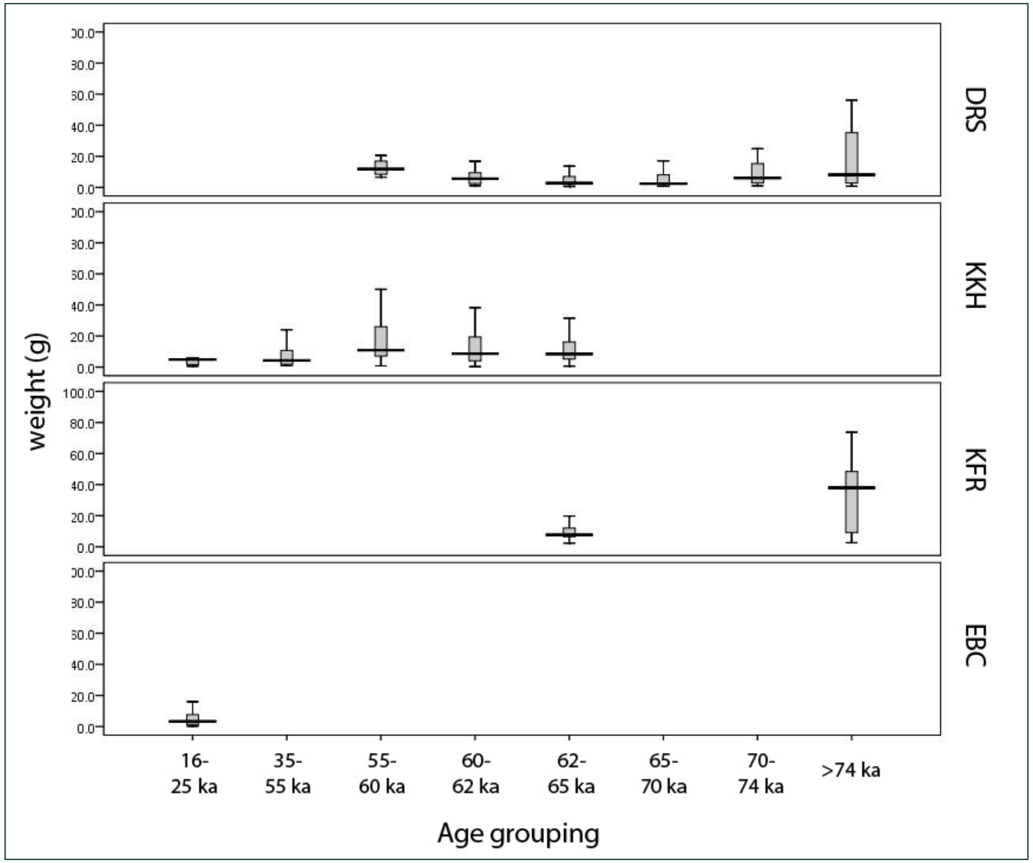


FIGURE 8.26: Age grouped changes in core weight at DRS, KKH, KFR and EBC

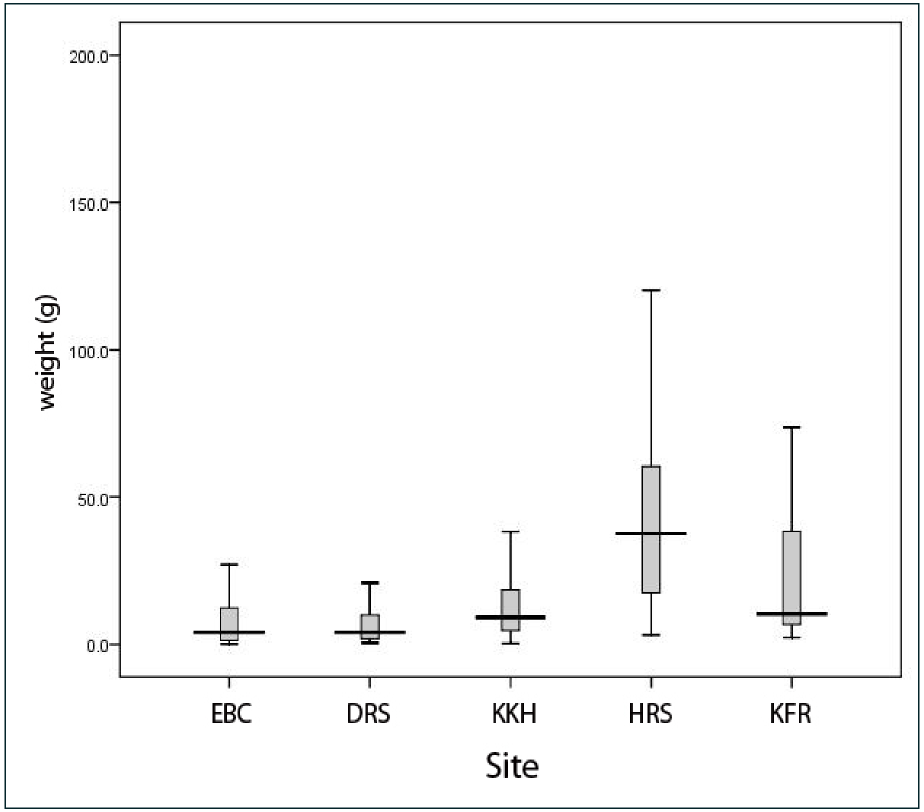


FIGURE 8.27: Comparison of core weights by site. Sandveld zone sites (EBC and DRS) are on the left, the Olifants zone site (KKH) is in the middle, and the Doring zone sites (HRS and KFR) are on the right.

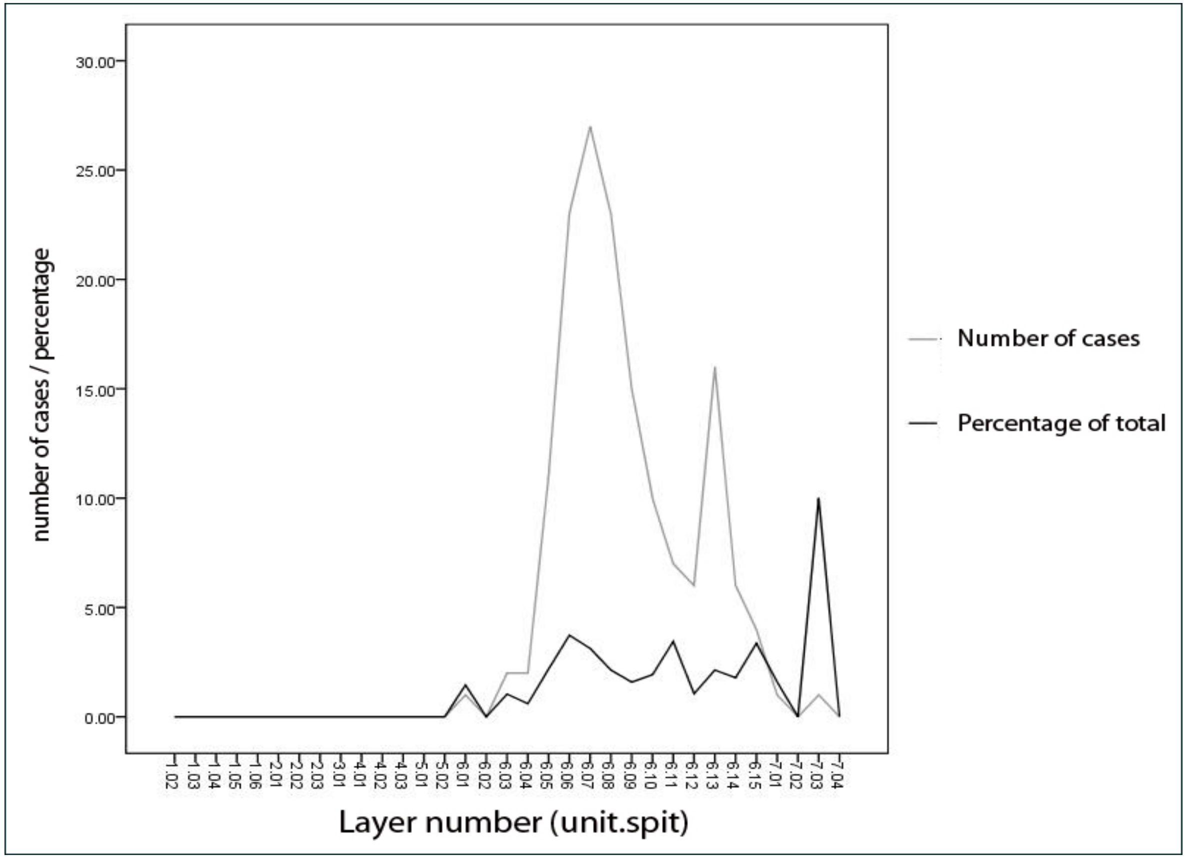


FIGURE 8.28: 'Heated then flaked' artefacts by number and as a percentages of layer assemblage total

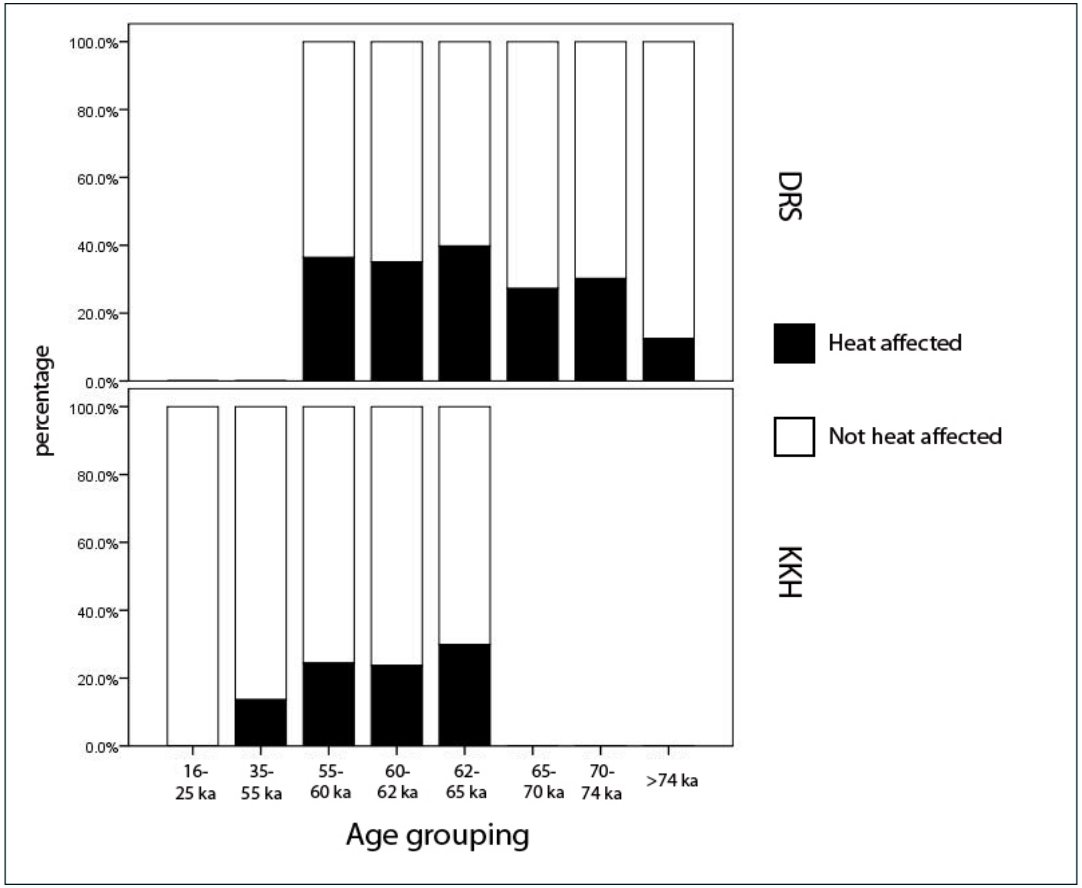


FIGURE 8.29: Age grouped changes in rates of heat affect among all complete flakes, DRS and KKH

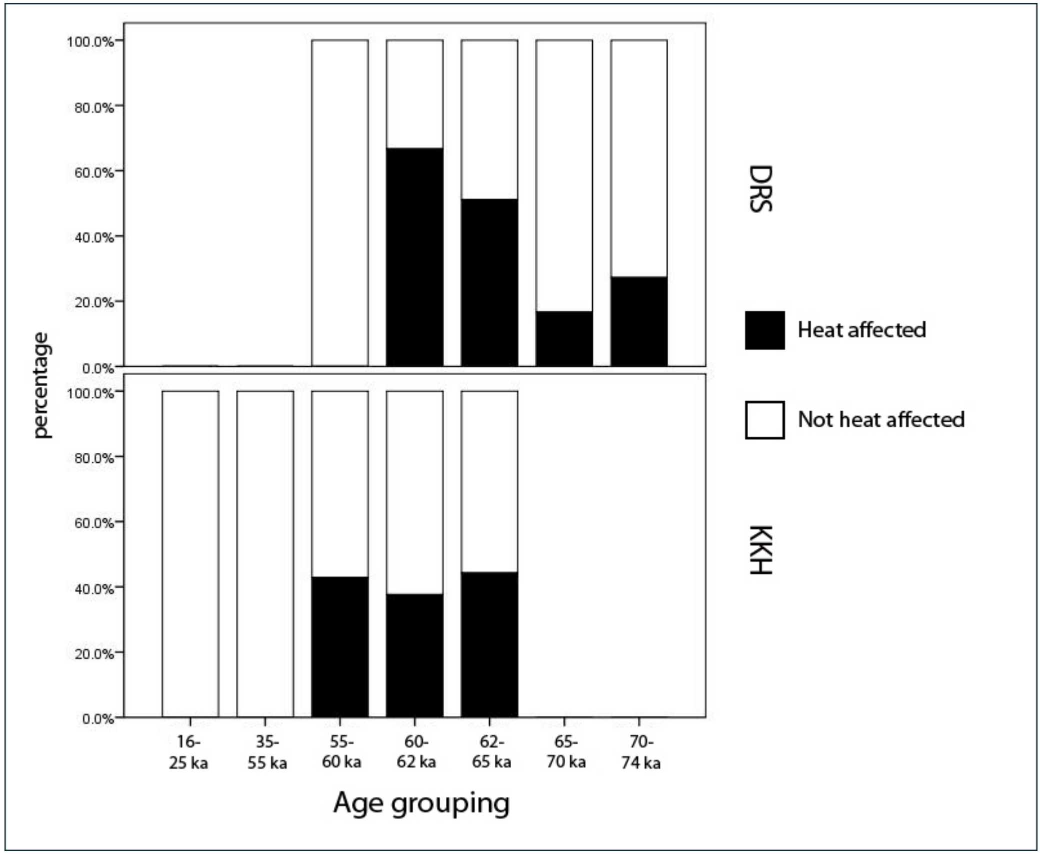


FIGURE 8.30: Age grouped changes in rates of heat affect among complete cores, DRS and KKH

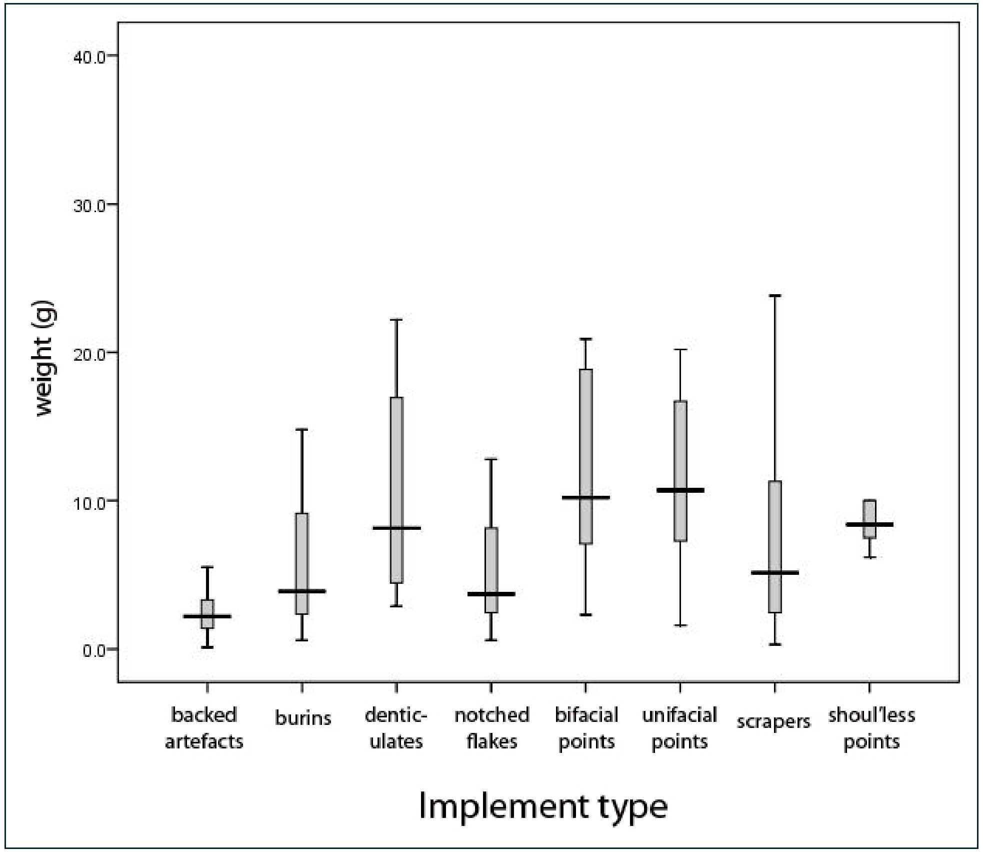


FIGURE 8.31: Boxplots of implement weights by type, complete implements only

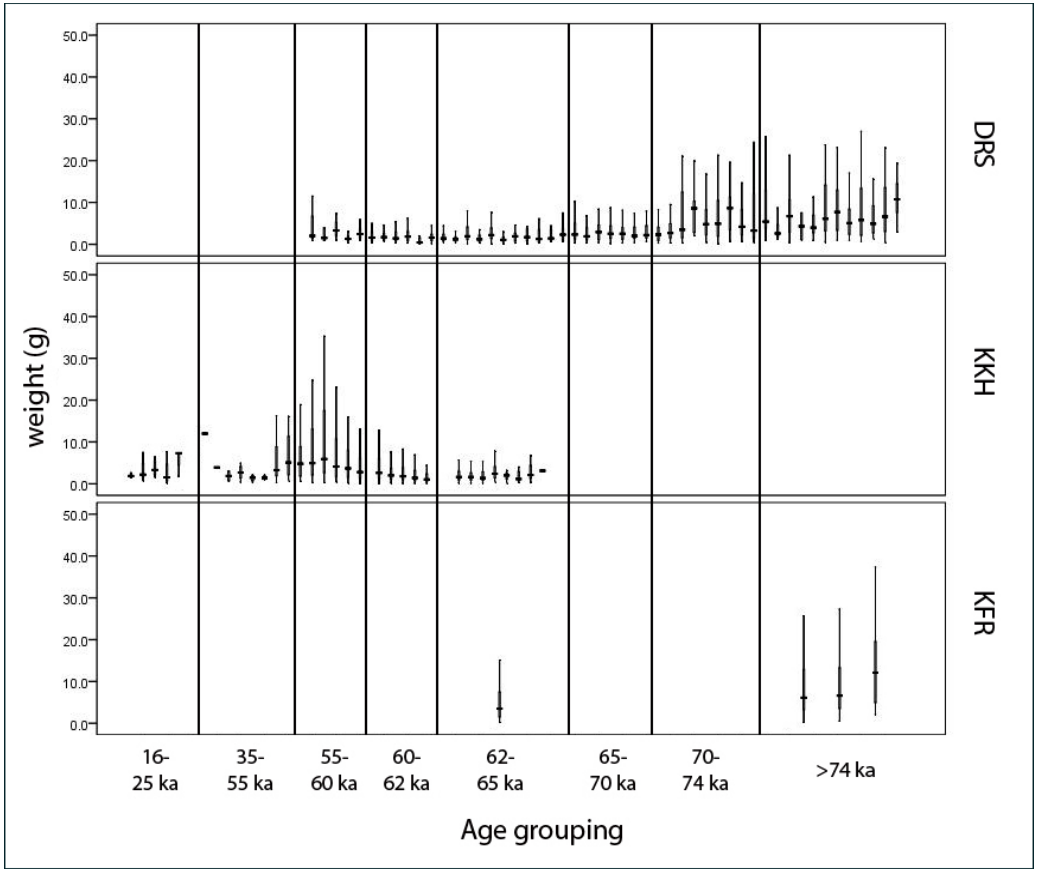


FIGURE8.32: Age grouped changes in flake weight, DRS, KKH and KFR

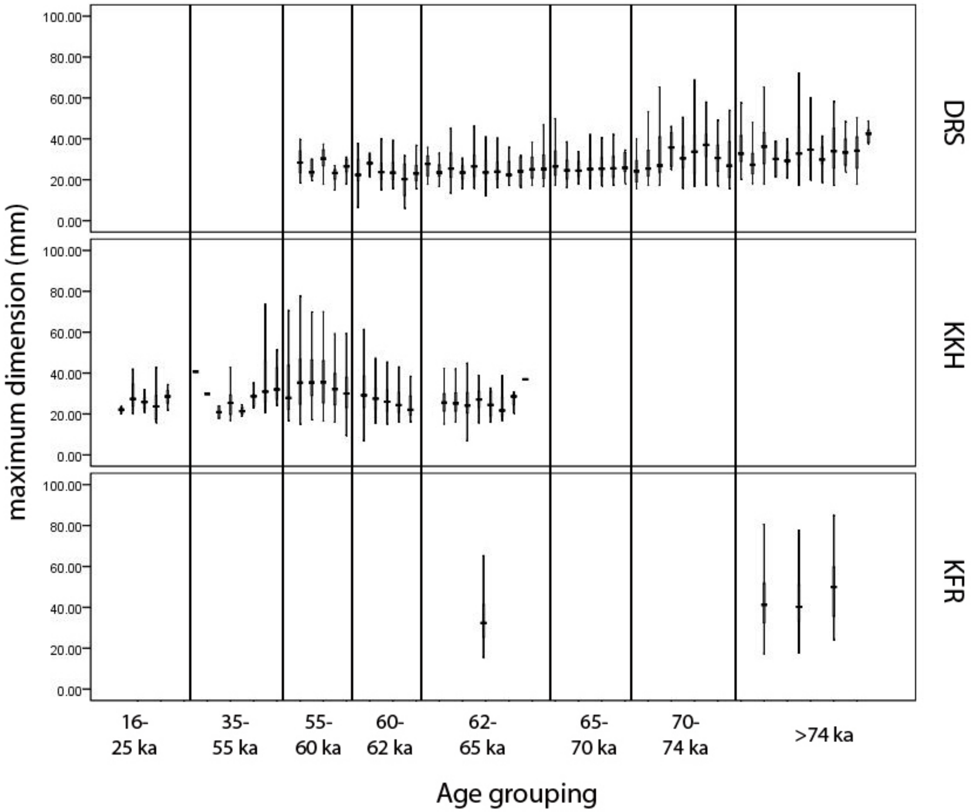


FIGURE 8.33: Age grouped changes in flake maximum dimension, DRS, KKH and KFR

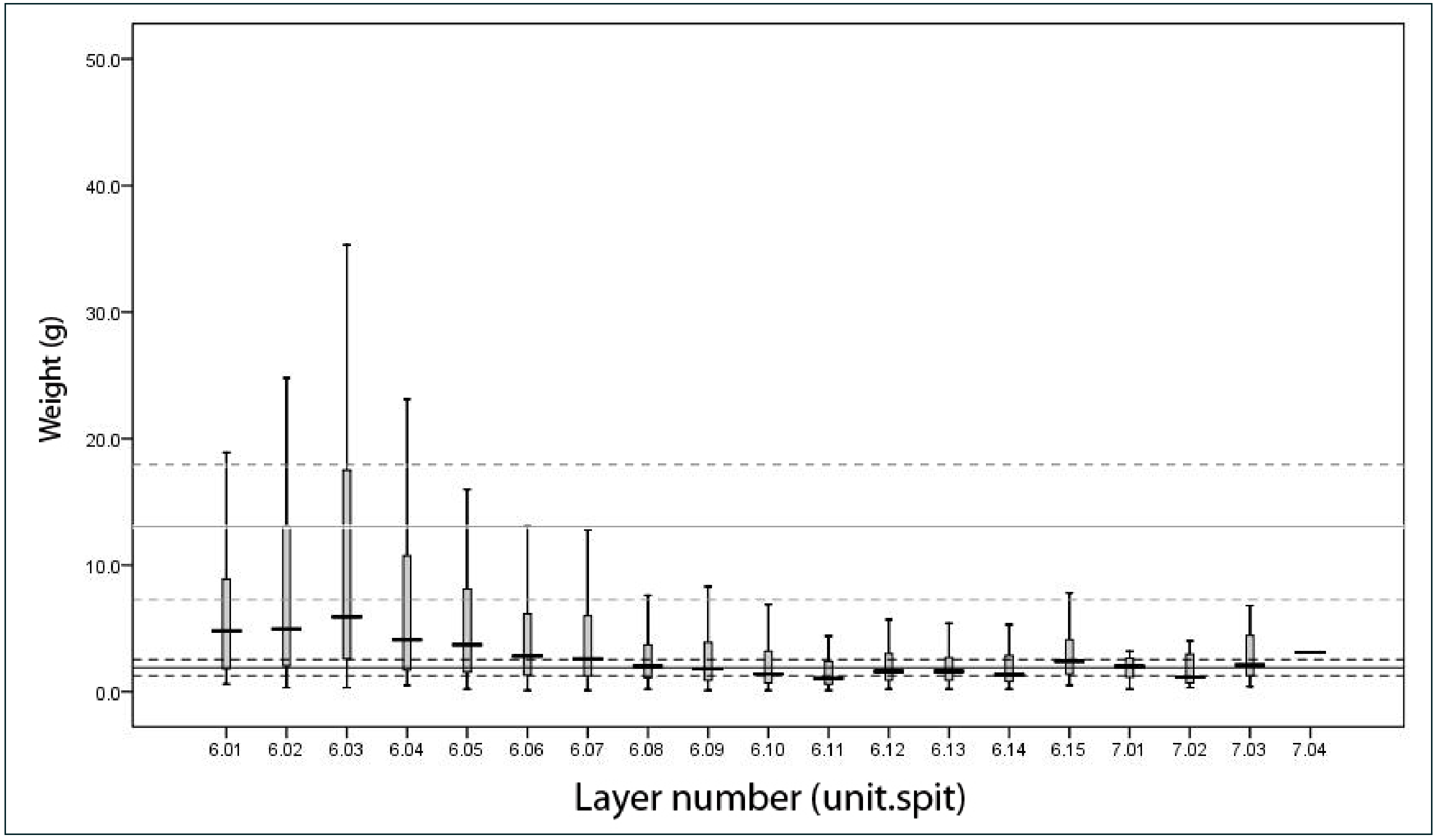


FIGURE 8.34: Changes in flake weight by layer at KKH (Units Dvi and Dvii only), with median (solid lines) and interquartile range values (dotted lines) for backed artefacts (black lines) and unifacial points (grey lines) shown

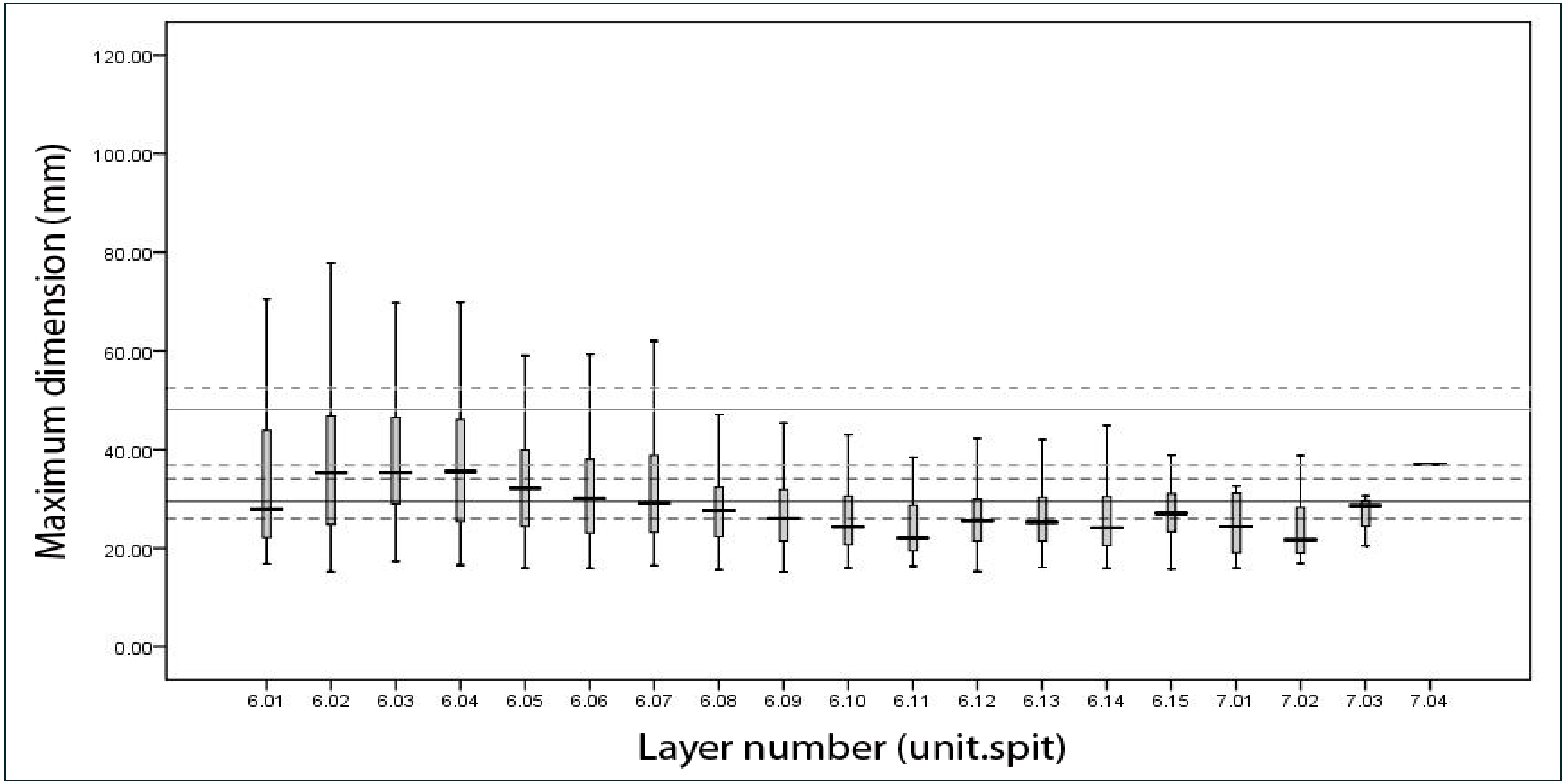


FIGURE 8.35: Changes in flake maximum dimension by layer at KKH (units Dvi and Dvii only), with median (solid lines) and interquartile range values (dotted lines) for backed artefacts (black lines) and unifacial points (grey lines) shown

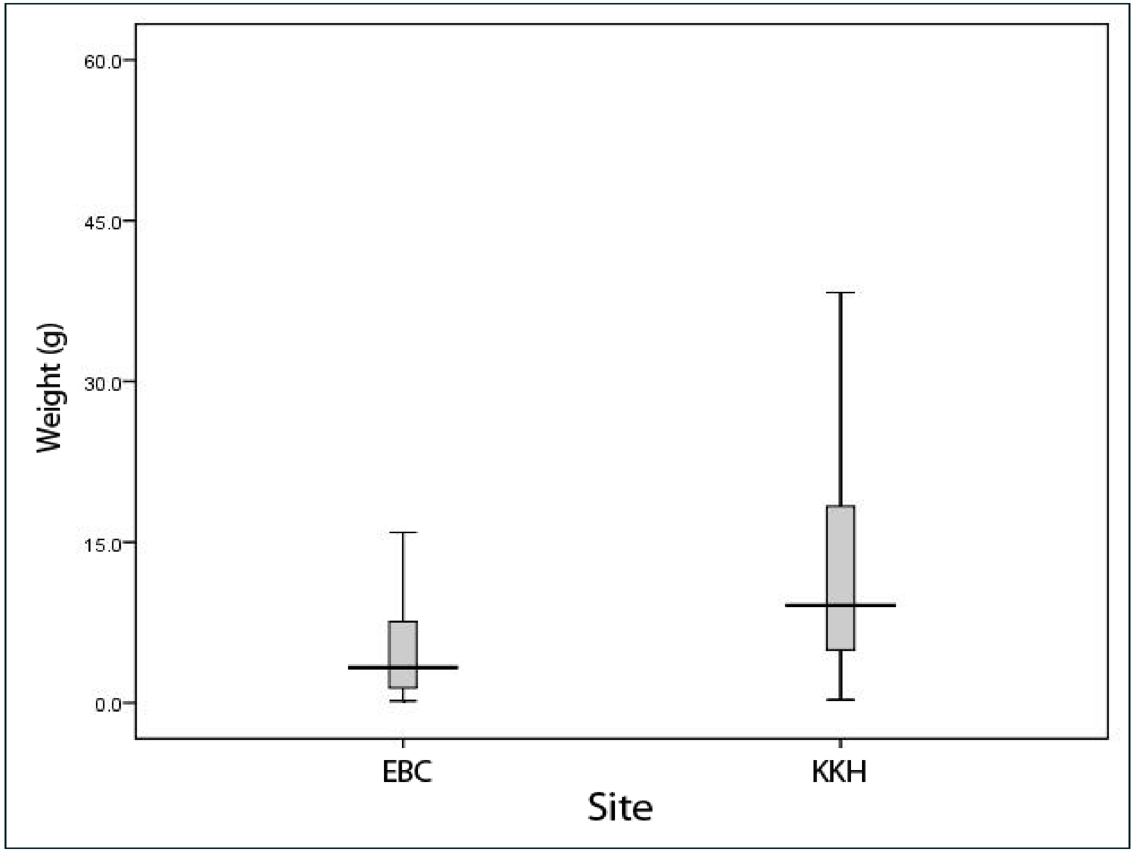


FIGURE 8.36: Boxplots of core weight, all complete cores, KKH and EBC

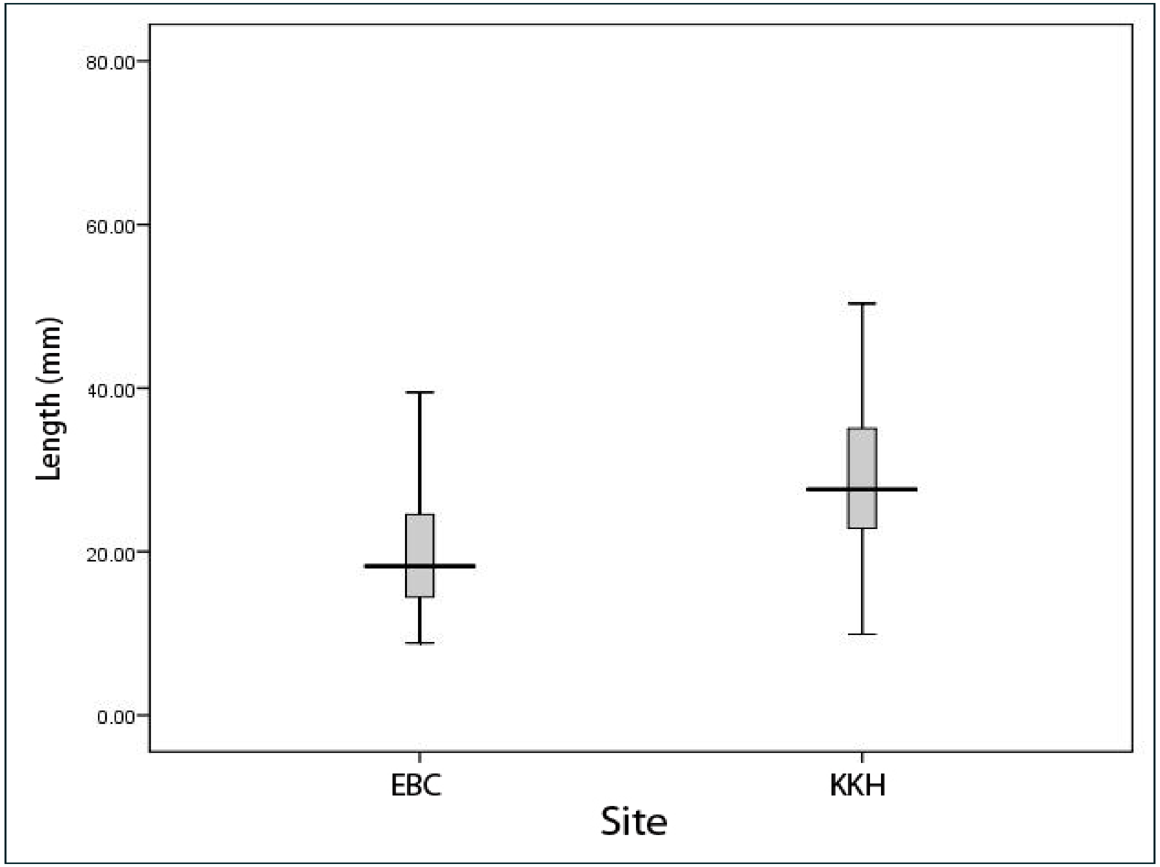


FIGURE 8.37: Boxplots of core length, all complete cores, KKH and EBC

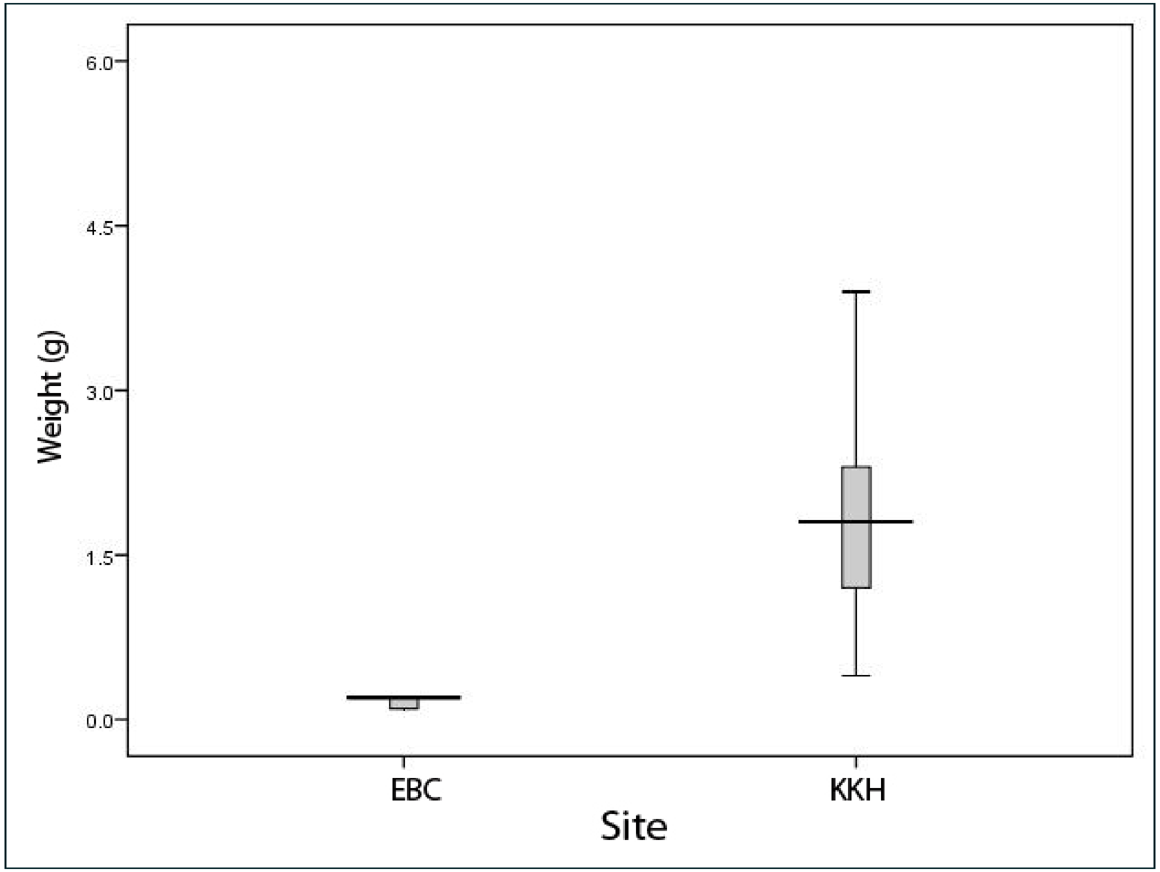


FIGURE 8.38: Boxplots of backed artefact weight, all backed artefacts, KKH and EBC

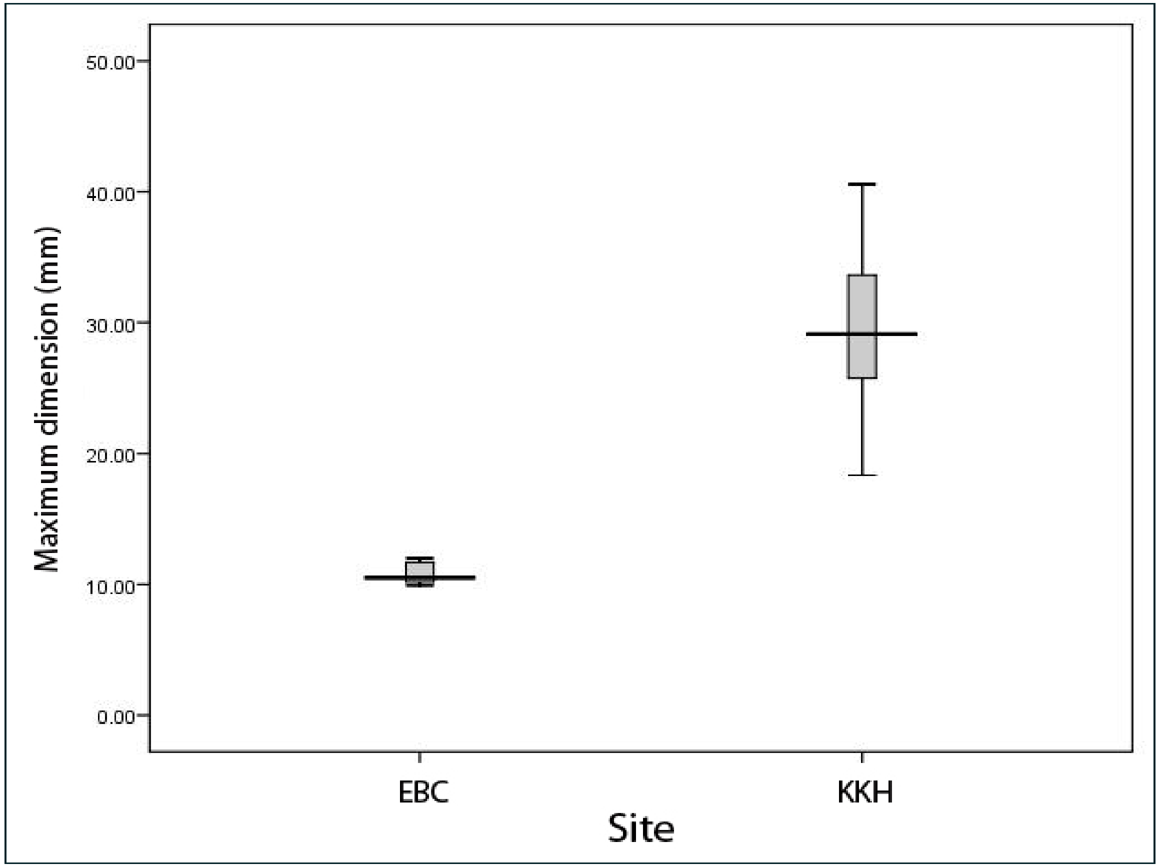


FIGURE 8.39: Boxplots of backed artefact maximum dimensions, all backed artefacts, KKH and EBC

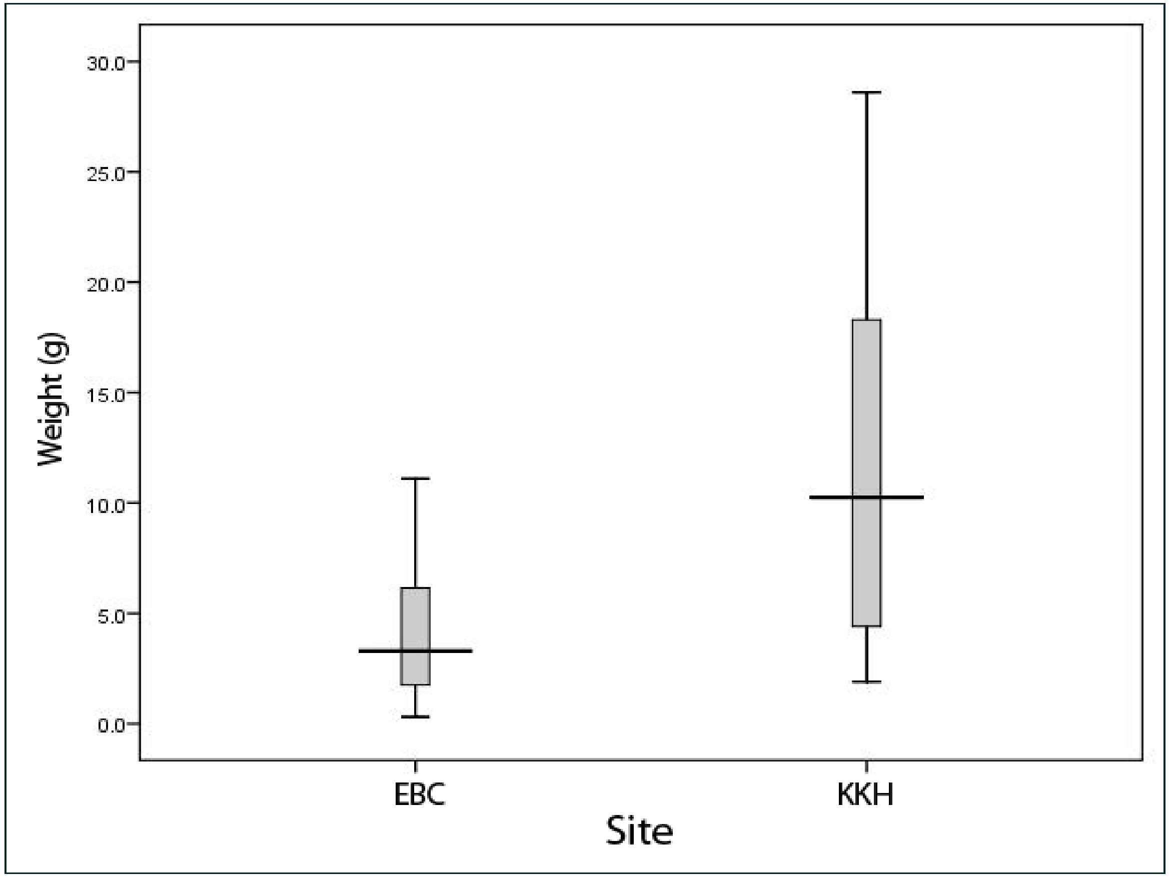


FIGURE 8.40: Boxplots of scraper weight, all scrapers, KKH and EBC

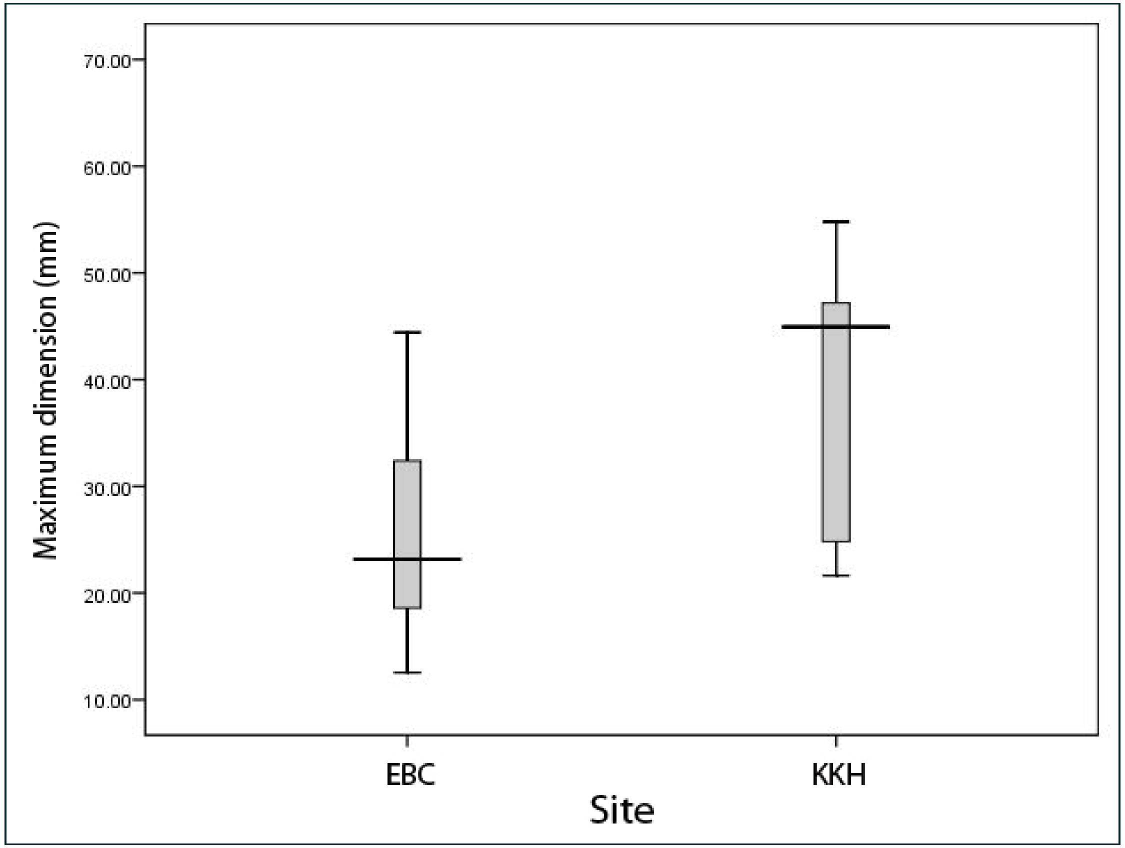


FIGURE 8.41: Boxplots of scraper length, all scrapers, KKH and EBC

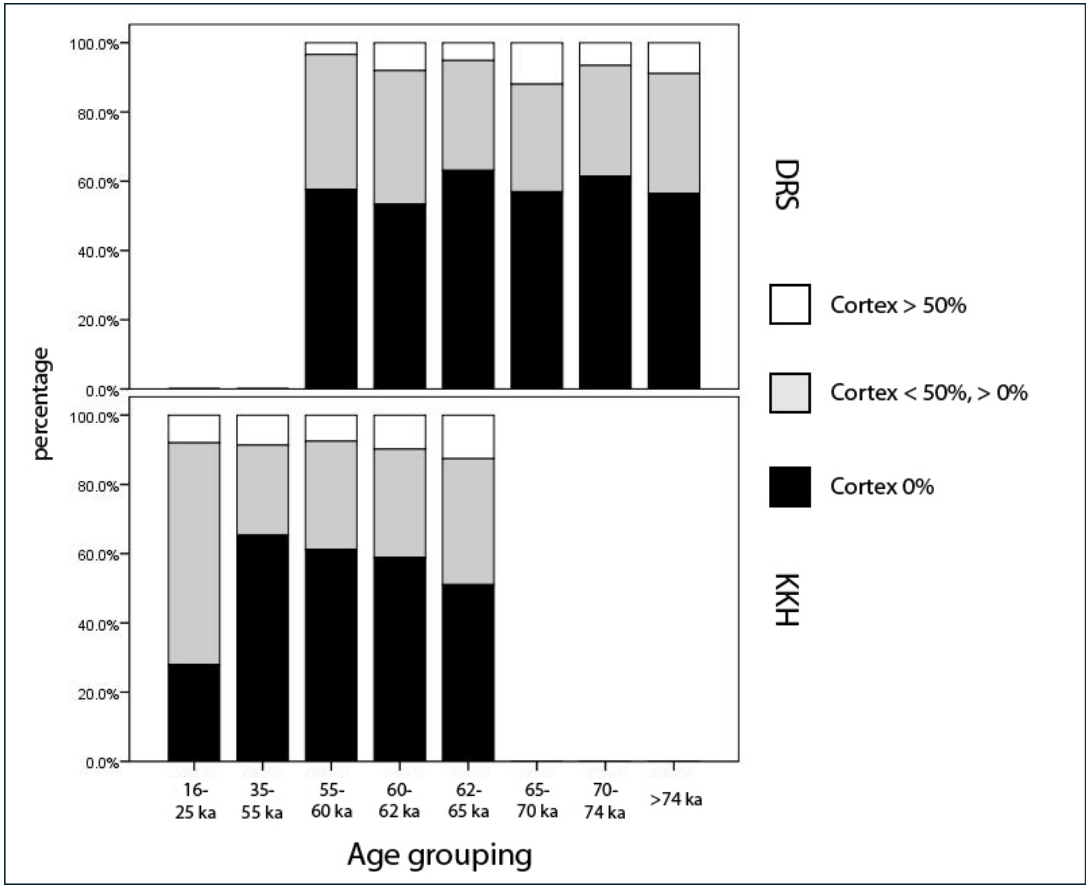


FIGURE 8.42: Age grouped changes in flake cortex, DRS and KKH

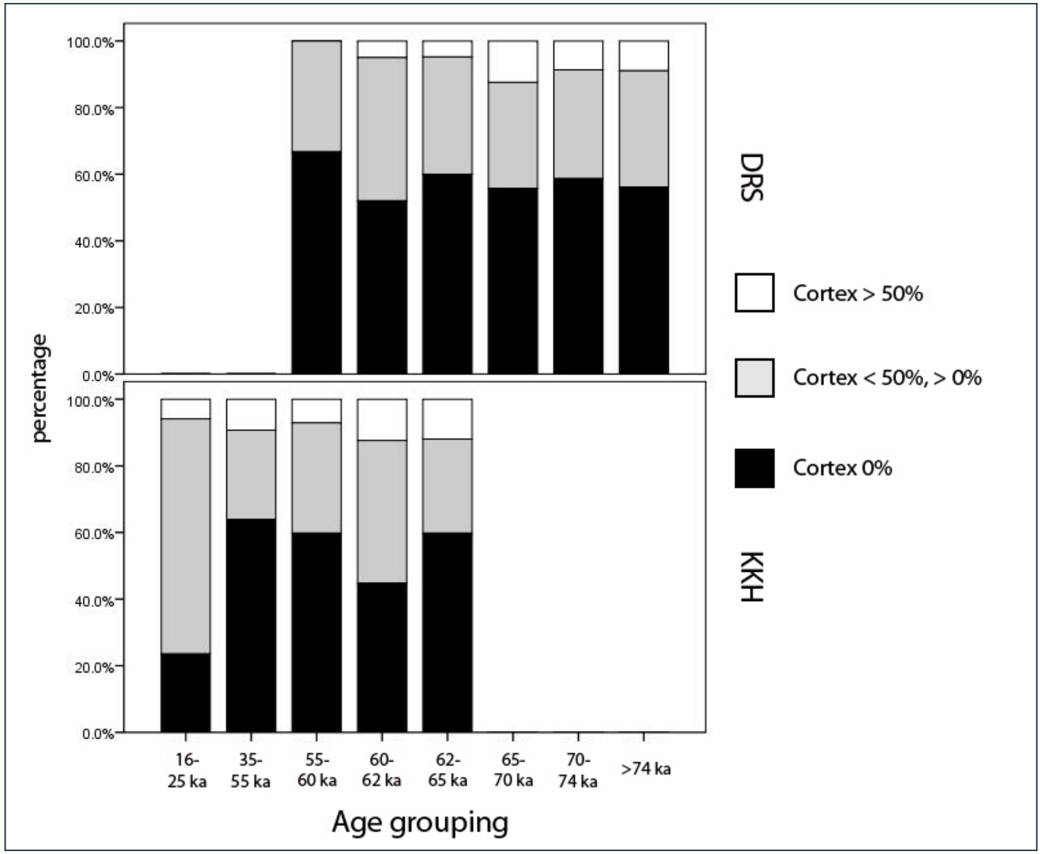


FIGURE 8.43: Age grouped changes in flake cortex, ‘local’ materials only, DRS and KKH

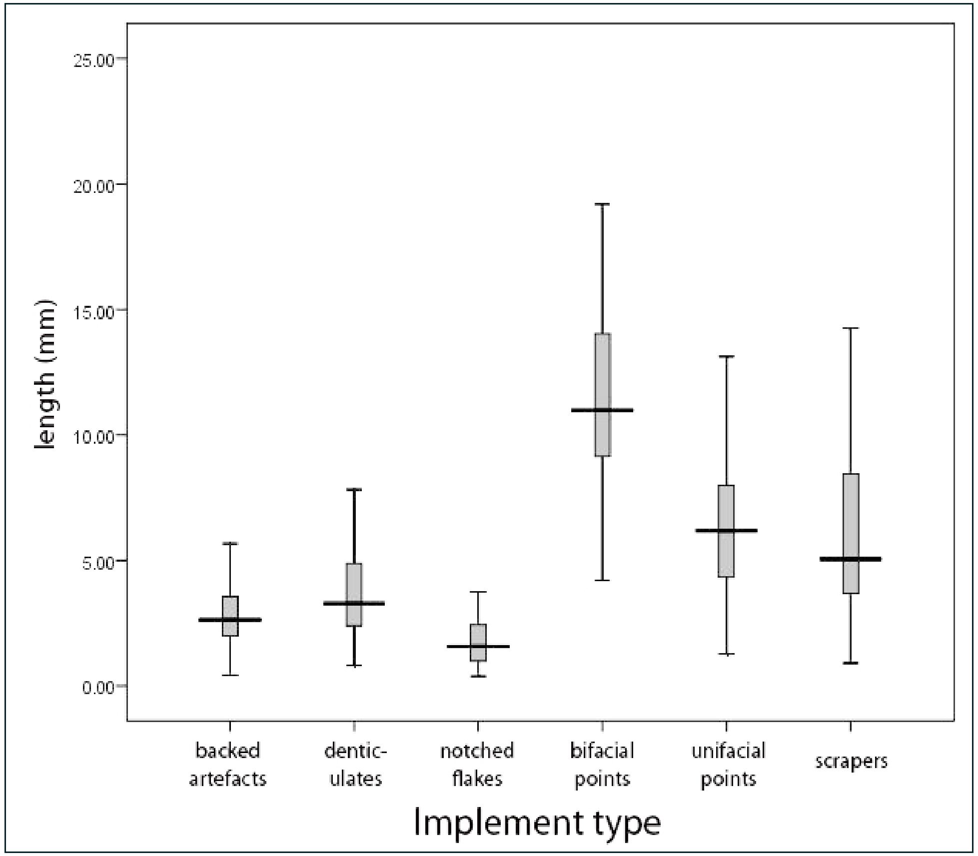


FIGURE 8.44: Boxplots of retouch scar length for major implement types

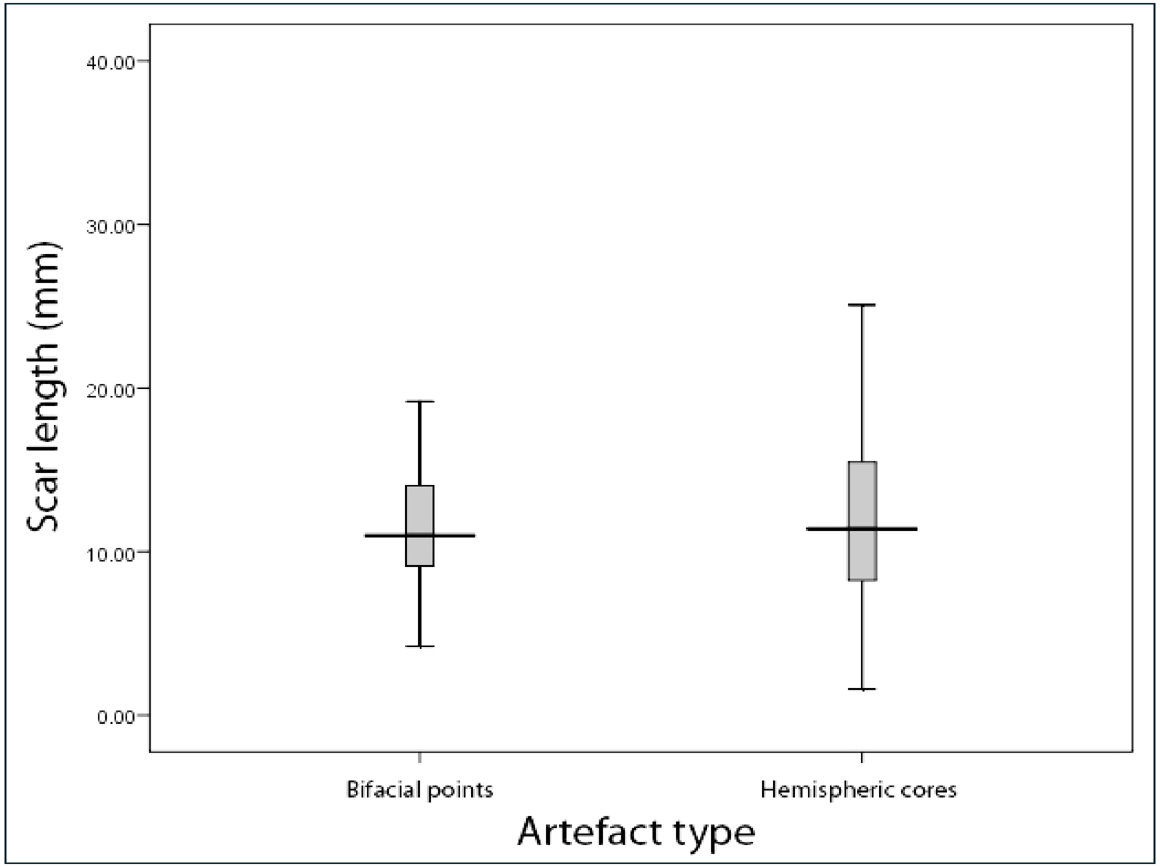


FIGURE 8.45: Boxplots of scar length for bifacial points and hemispheric cores

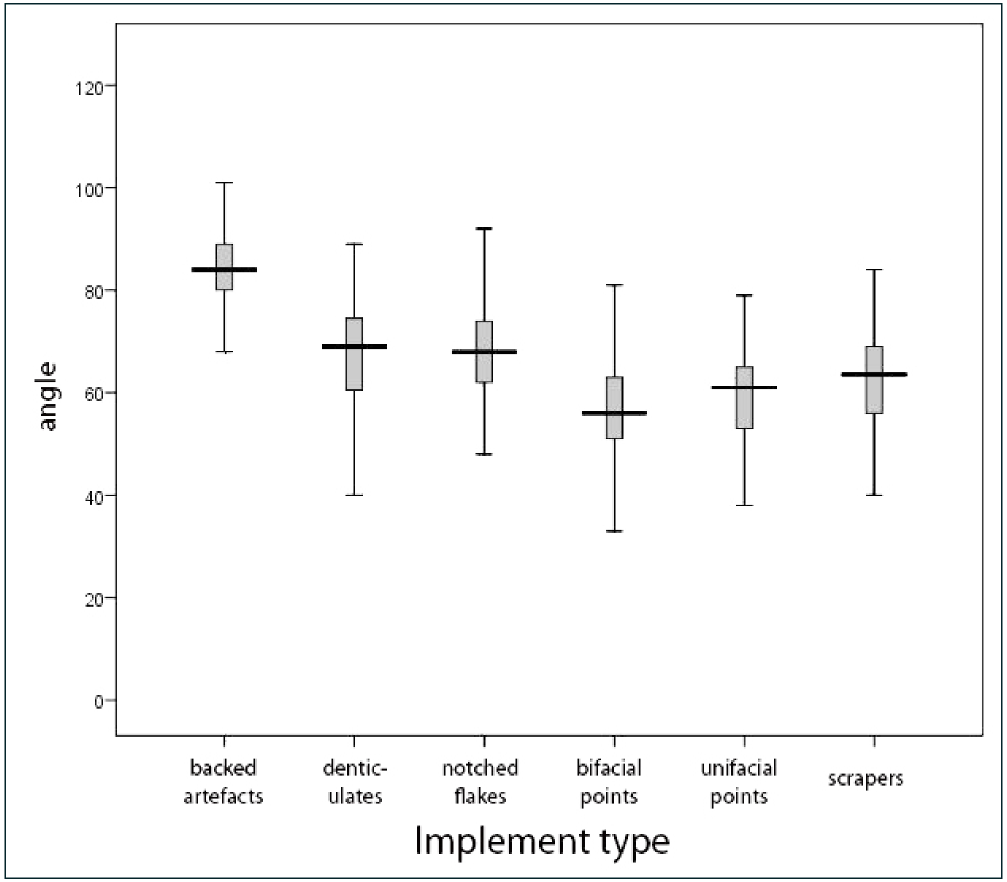


FIGURE 8.46: Boxplots of retouched edge angle for major implement types

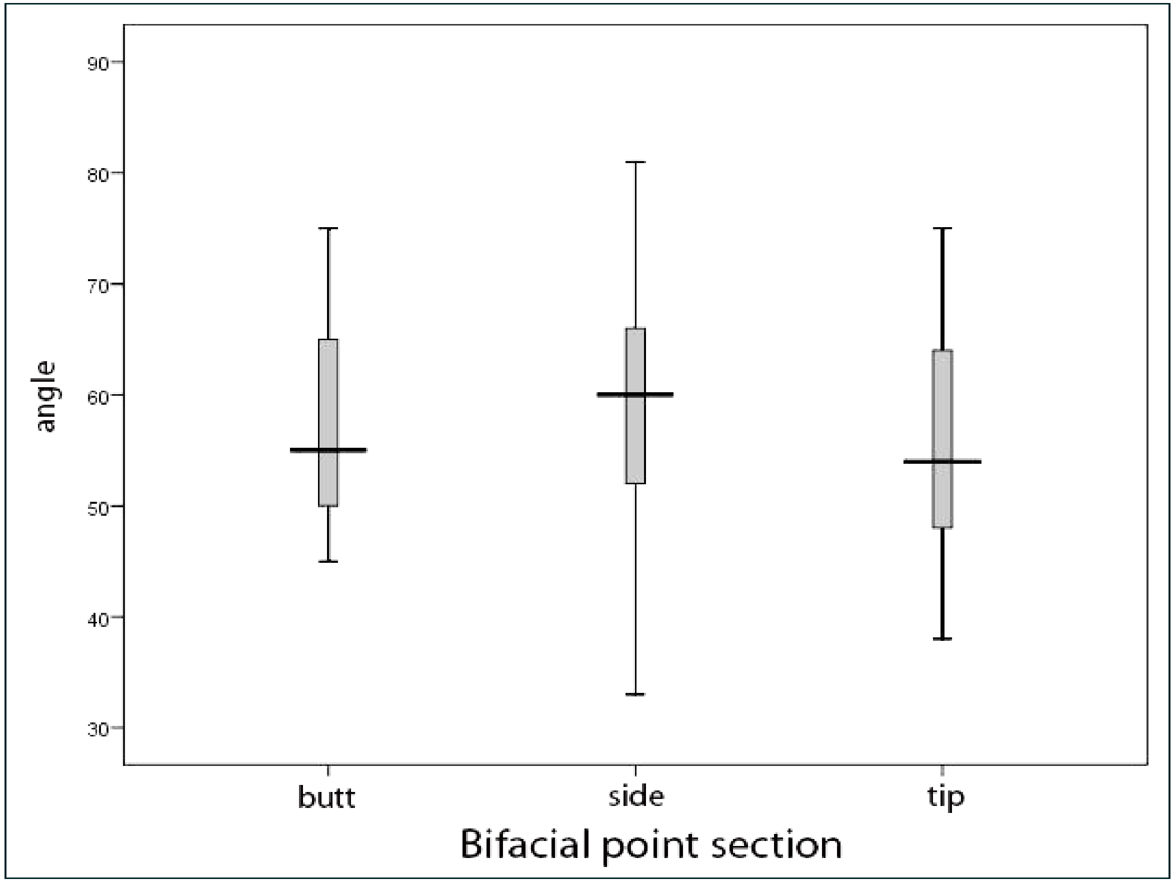


FIGURE 8.47: Boxplots of retouched edge angle at the butts, sides and tips of bifacial points

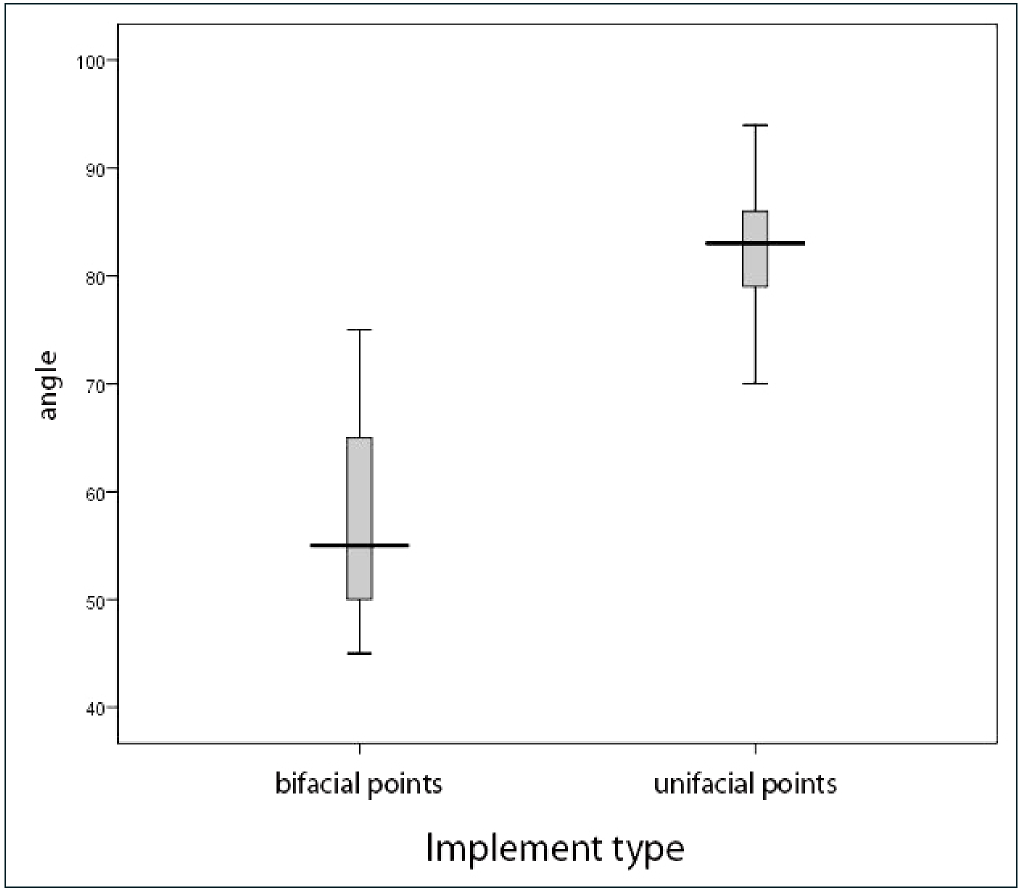


FIGURE 8.48: Boxplots of edge angle at the butts of bifacial points and unifacial points

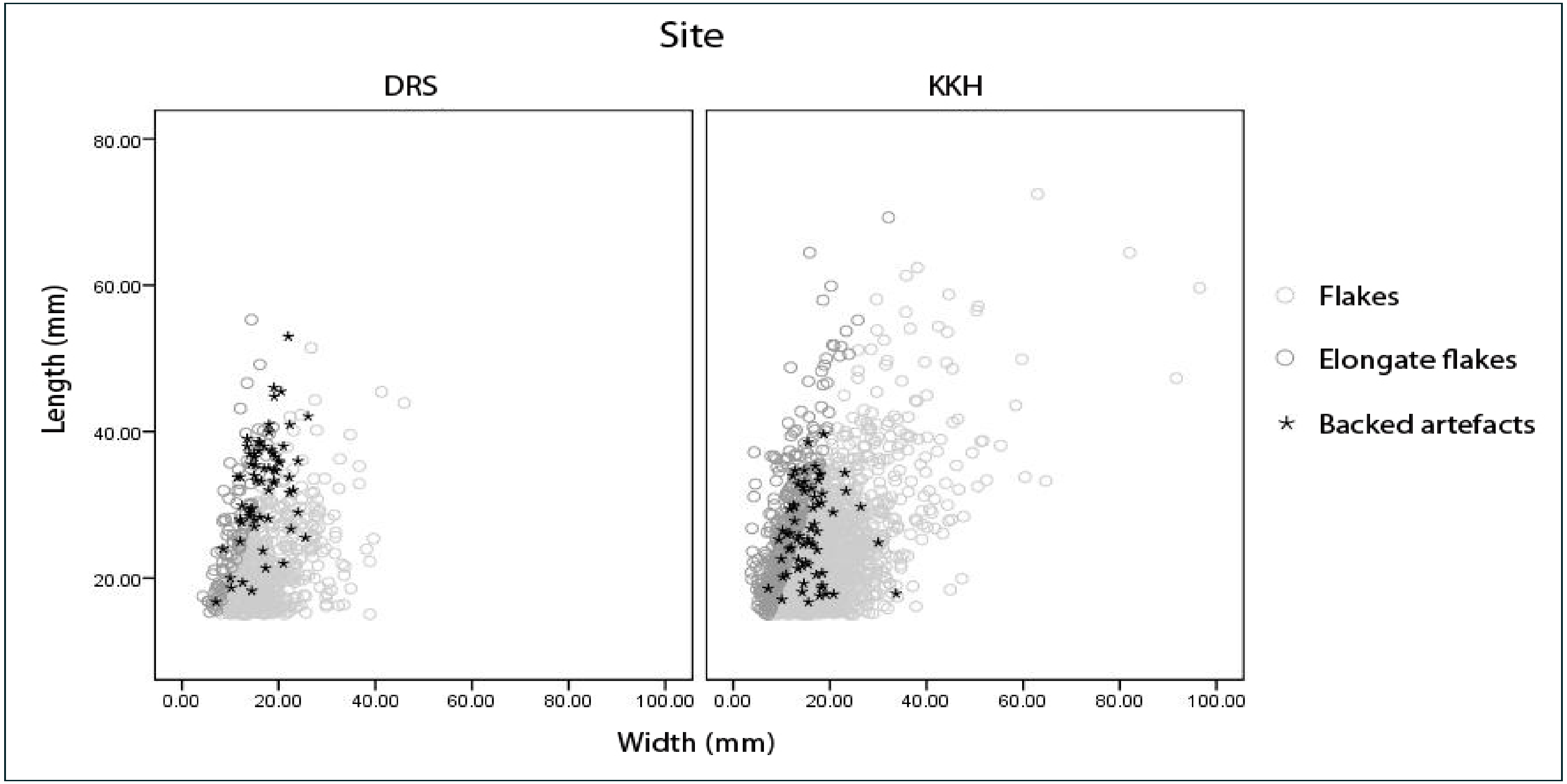


FIGURE 8.49: Scattergram of lengths and maximum widths for flakes, elongate flakes and backed artefacts at DRS and KKH

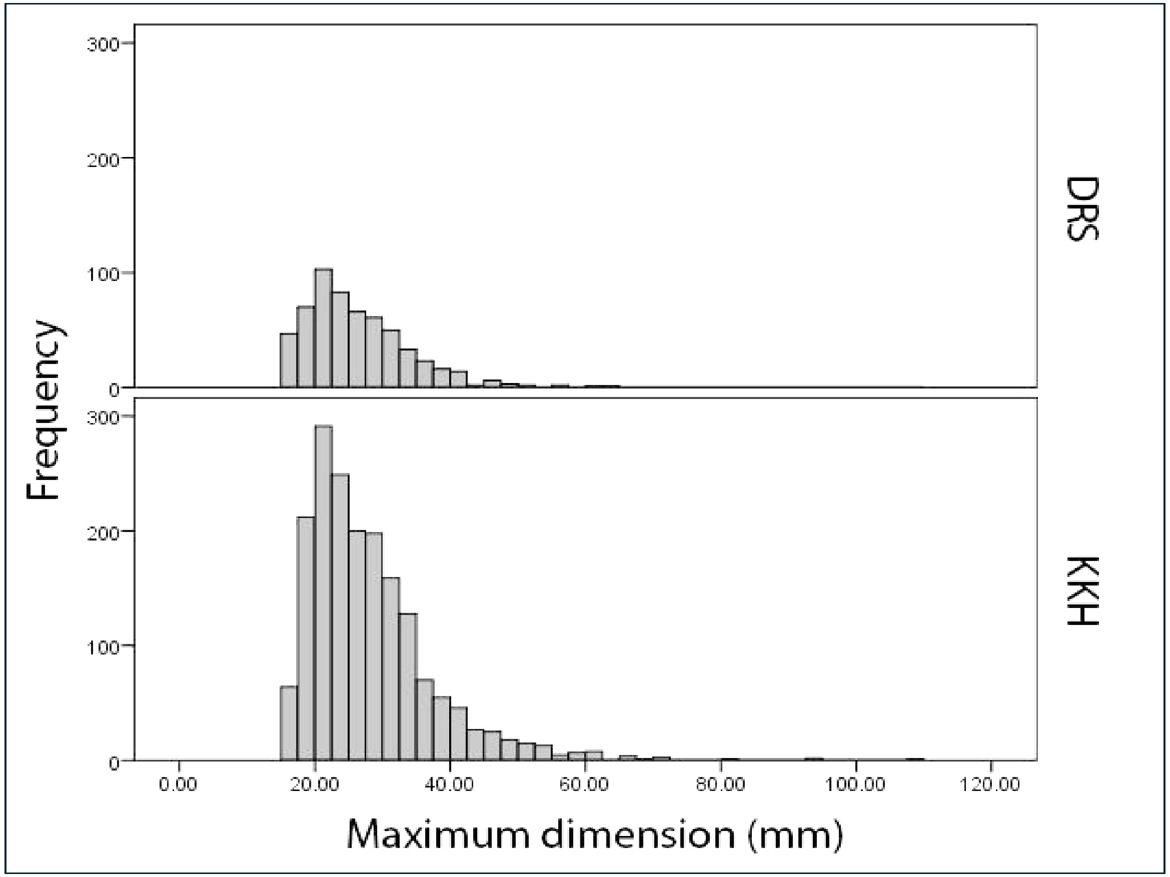


FIGURE 8.50: Histograms of maximum dimension for complete flakes at DRS and KKH

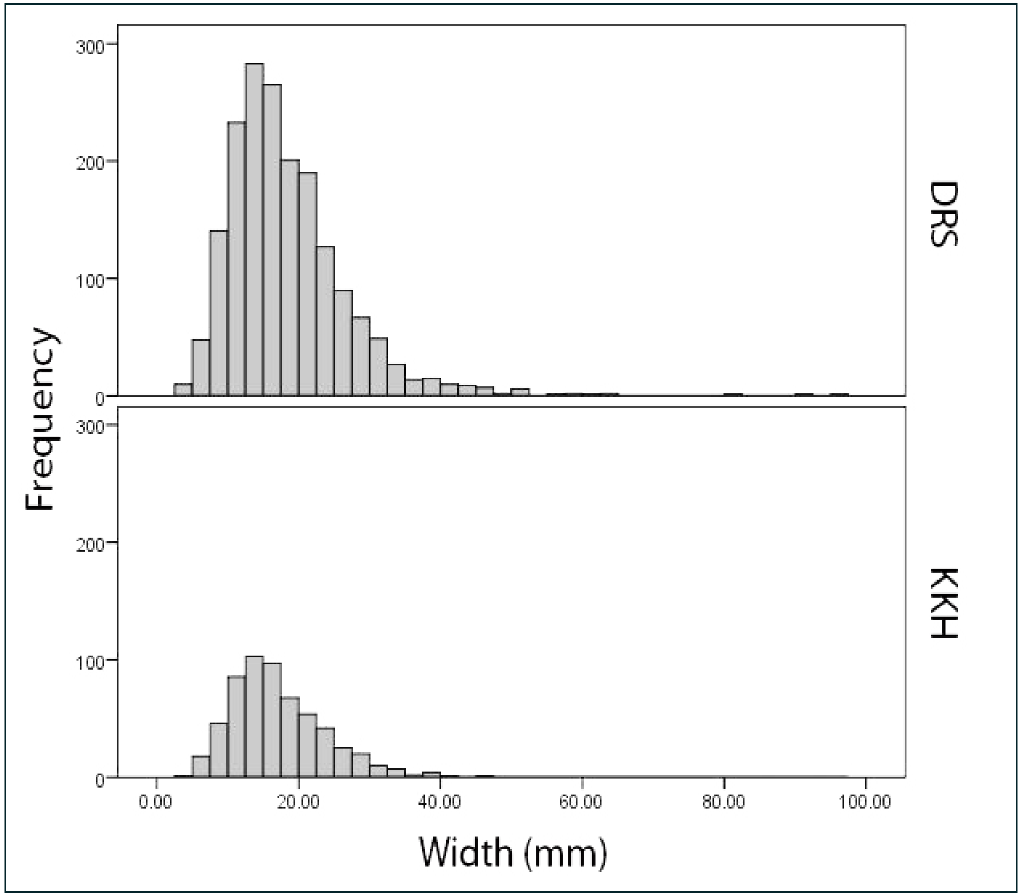


FIGURE 8.51: Histograms of maximum widths for complete flakes at DRS and KKH

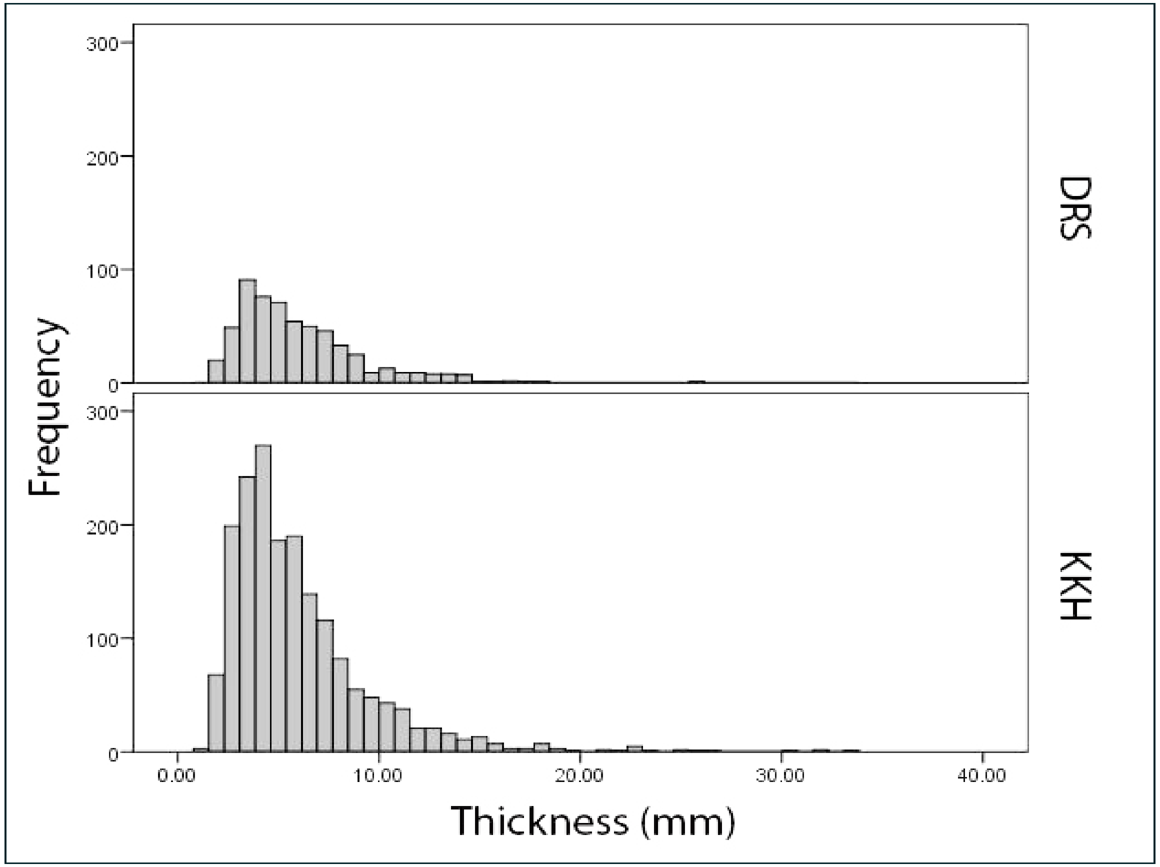


FIGURE 8.52: Histograms of maximum thickness for complete flakes at DRS and KKH

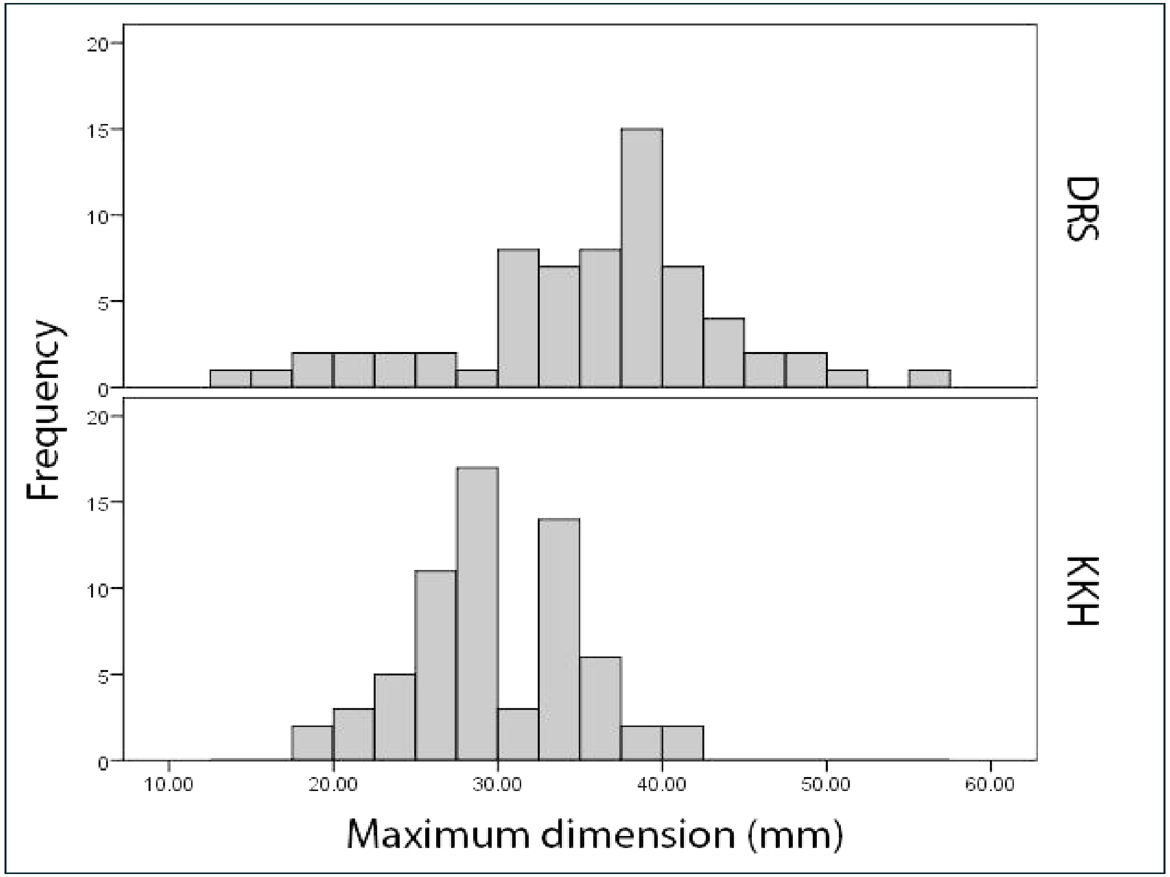


FIGURE 8.53: Histograms of maximum dimension for complete backed artefacts at DRS and KKH

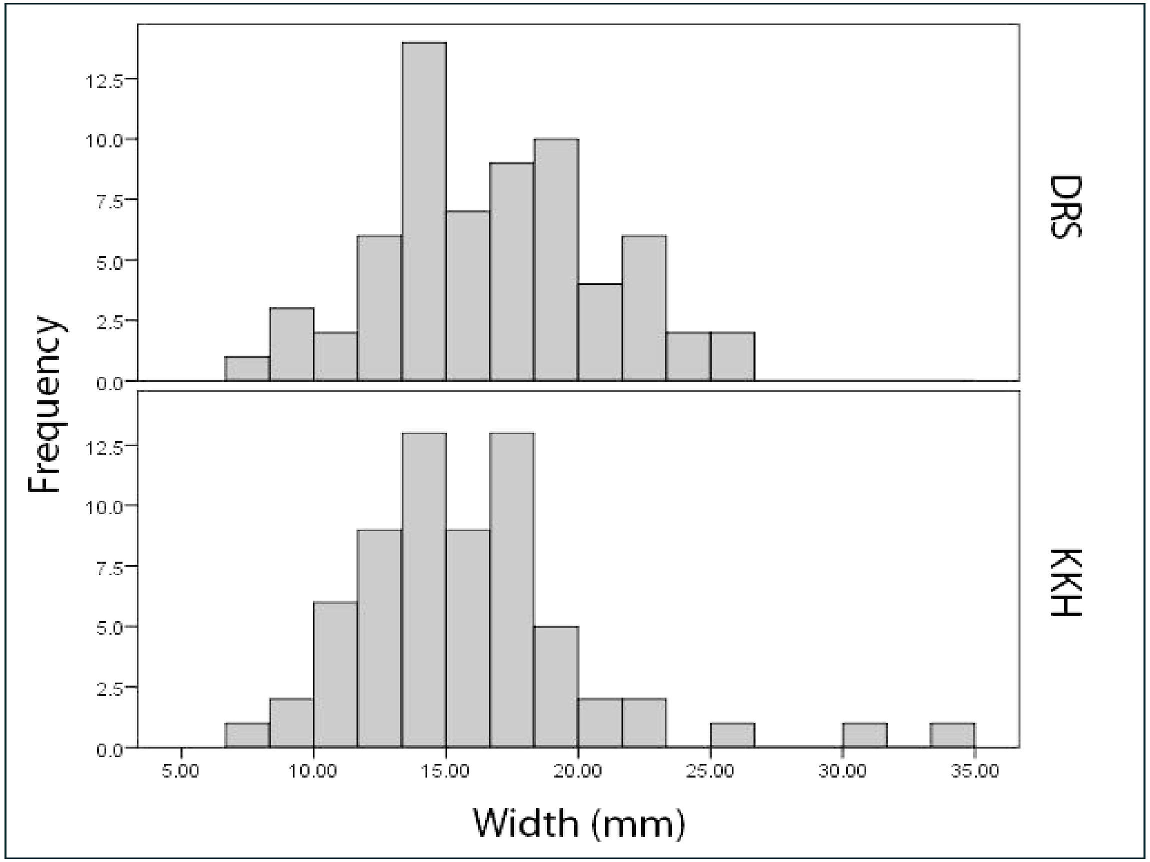


FIGURE 8.54: Histograms of maximum widths for complete backed artefacts at DRS and KKH

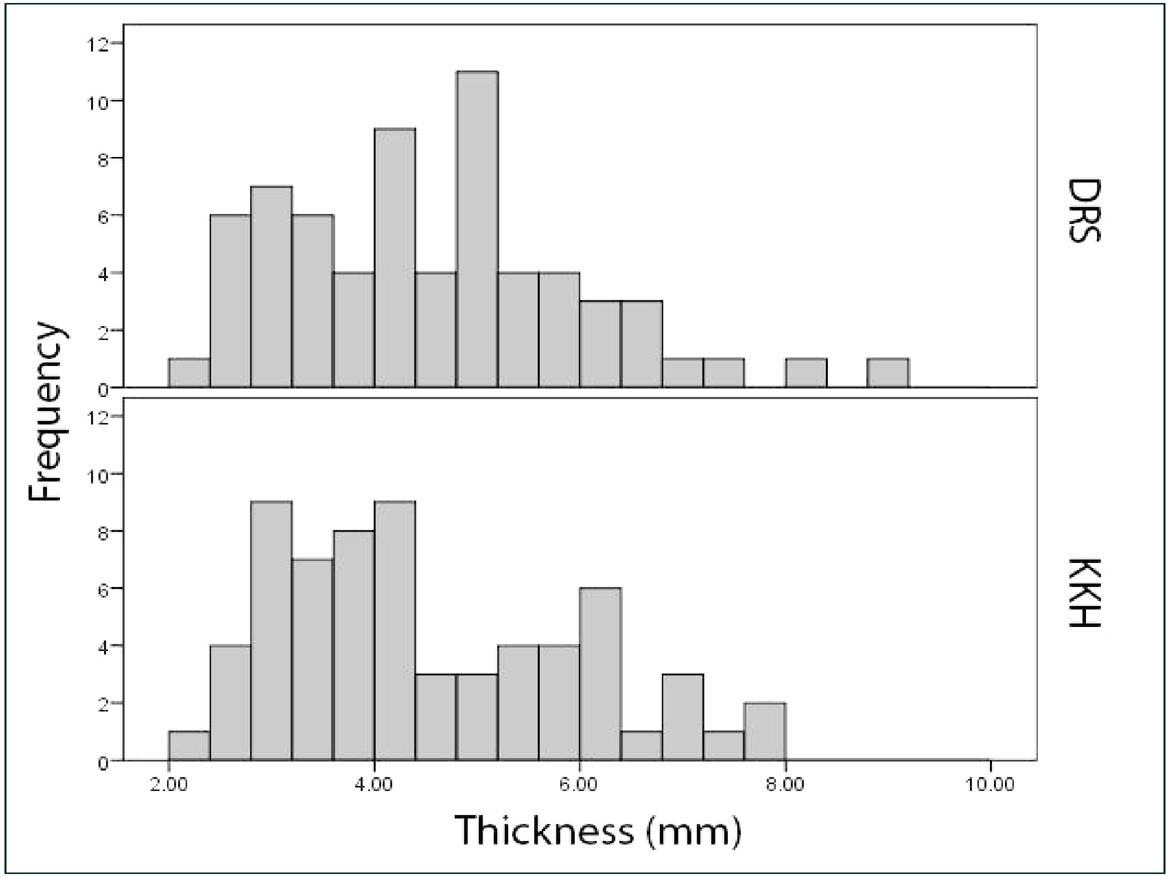


FIGURE 8.55: Histograms of maximum thickness for complete backed artefacts at DRS and KKH

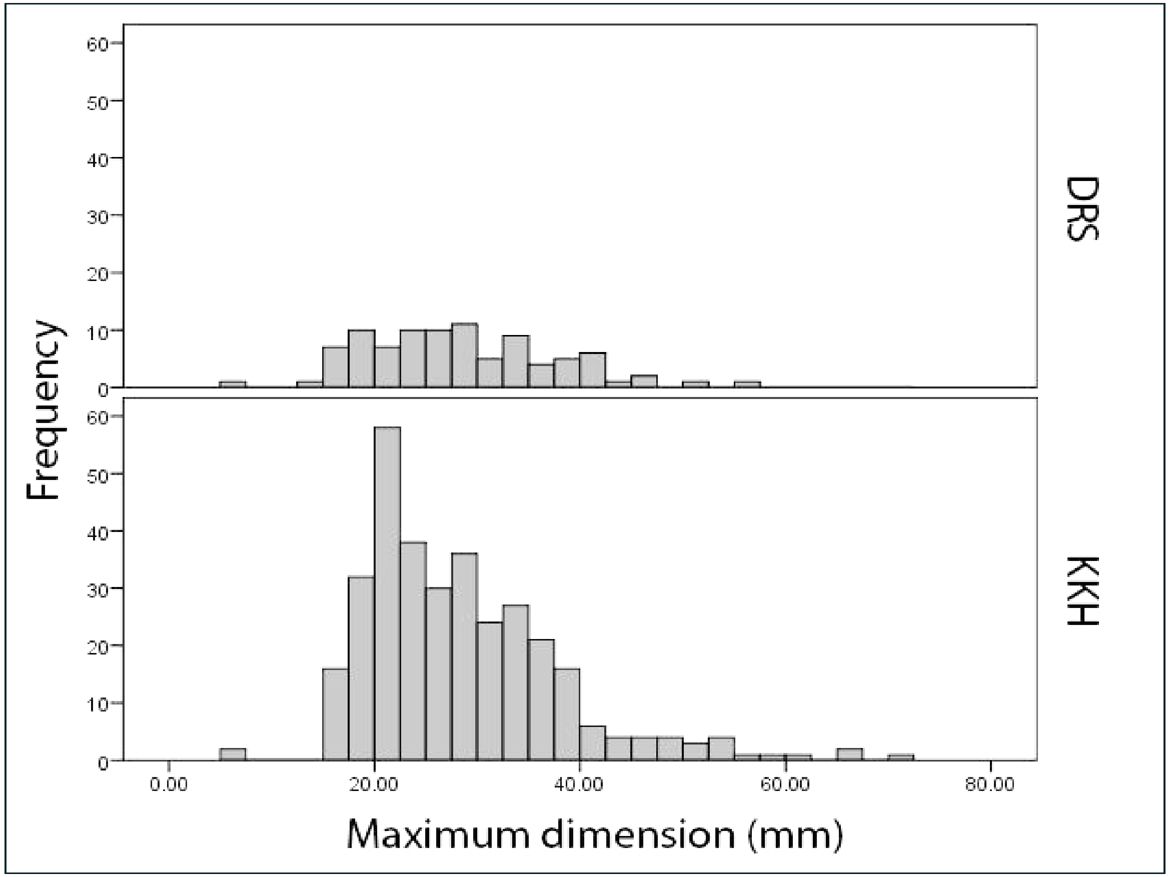


FIGURE 8.56: Histograms of maximum dimension for complete elongate flakes at DRS and KKH

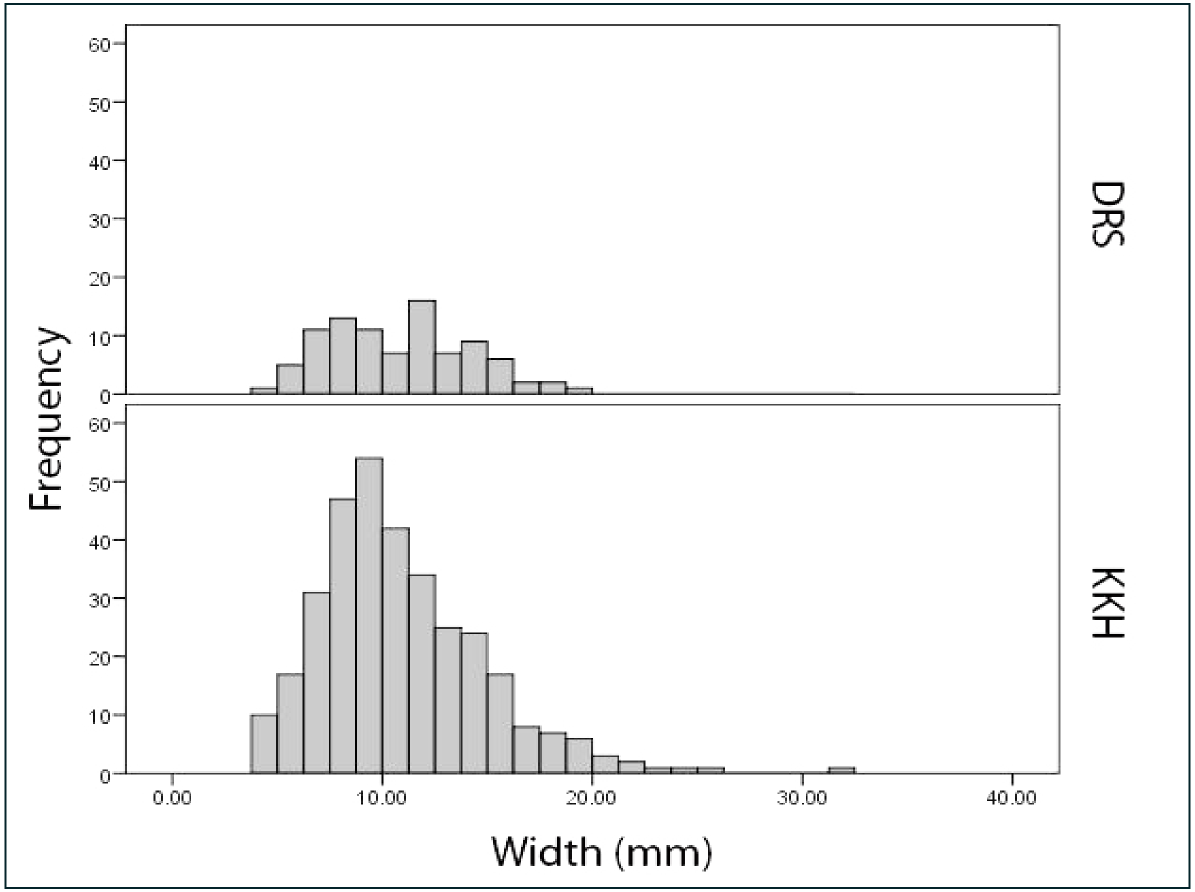


FIGURE 8.57: Histograms of maximum widths for complete elongate flakes at DRS and KKH

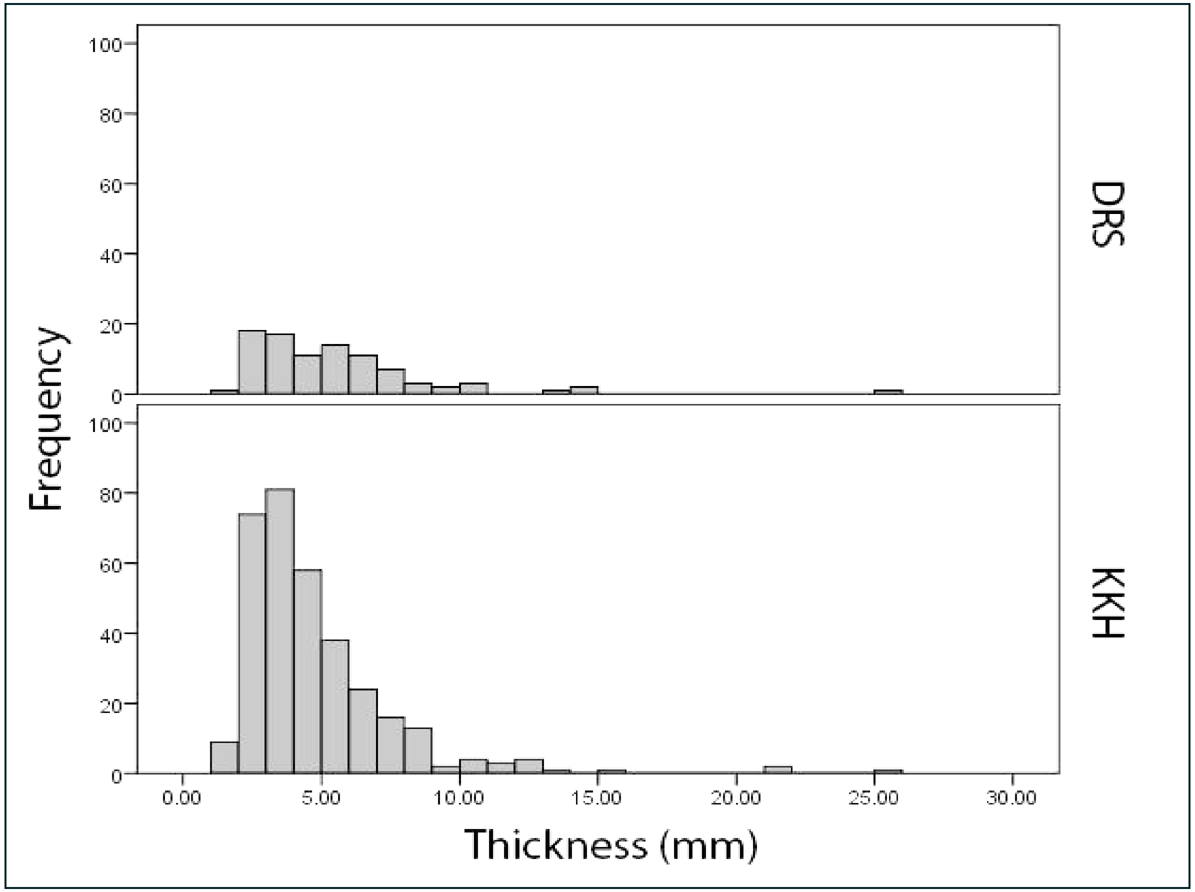


FIGURE 8.58: Histograms of maximum thickness for complete elongate flakes at DRS and KKH

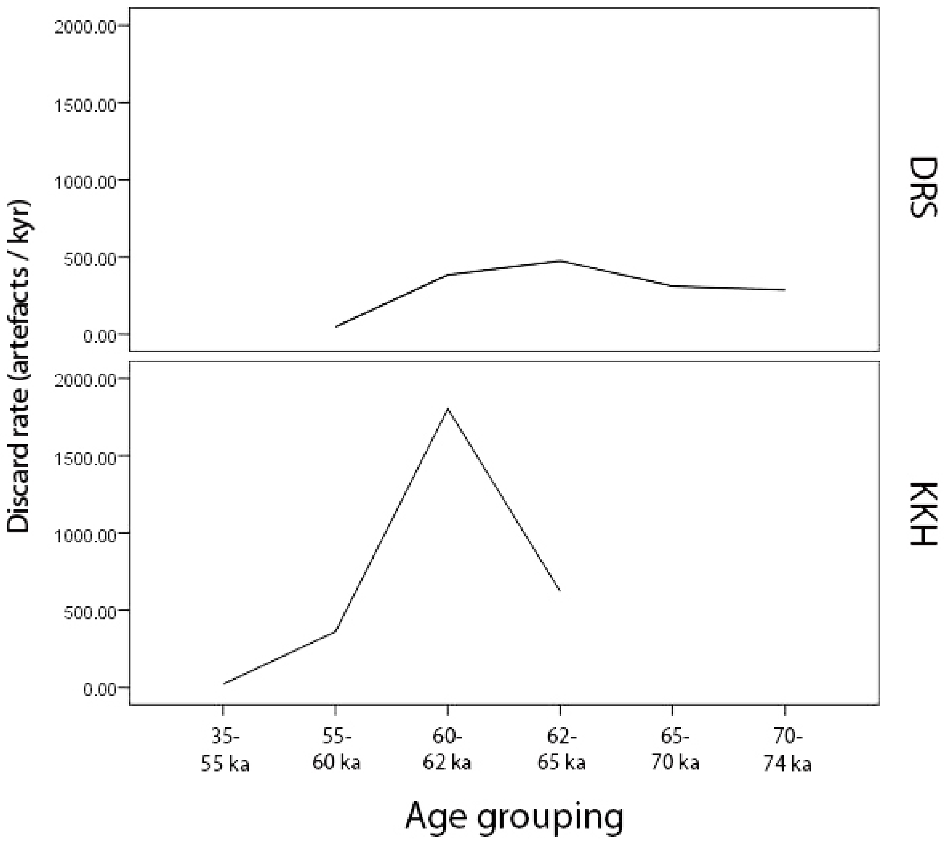


FIGURE 8.59: Age grouped discard rates at DRS and KKH

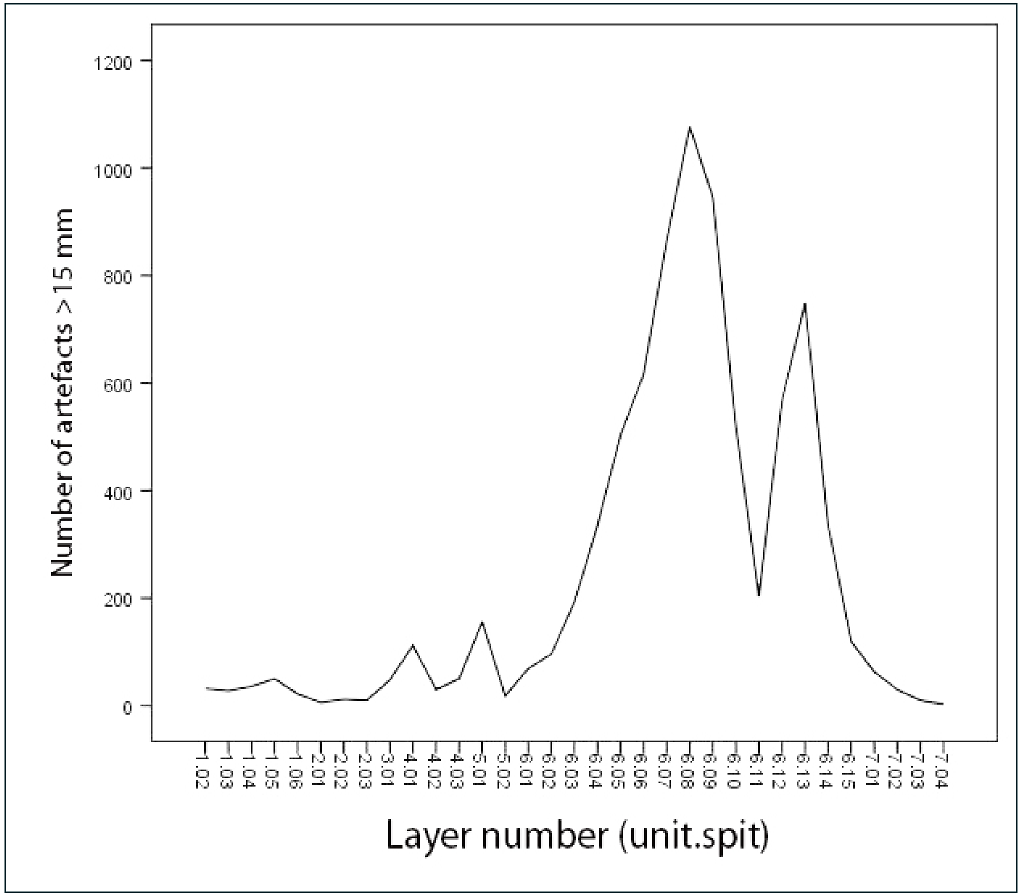


FIGURE 8.60: Artefact numbers by layer at KKH

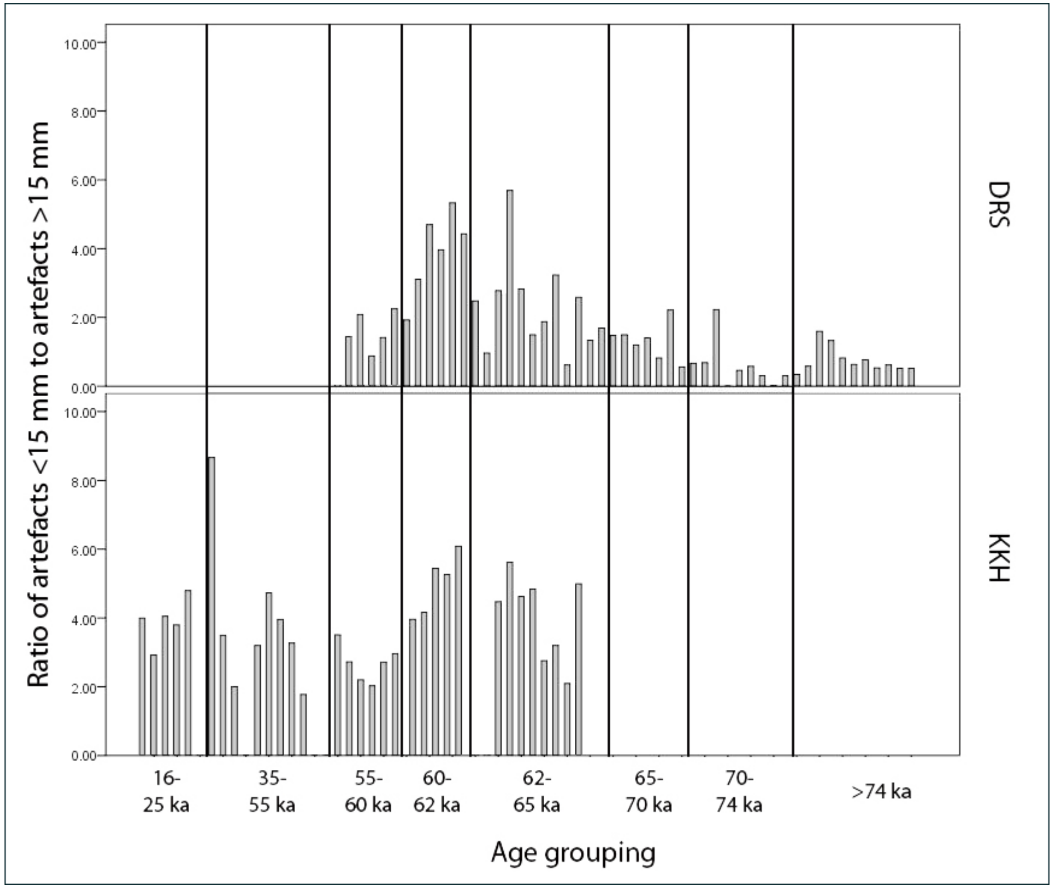


FIGURE 8.61: Age grouped ratios of artefacts <15 mm to artefacts >15 mm at DRS and KKH (all layers)

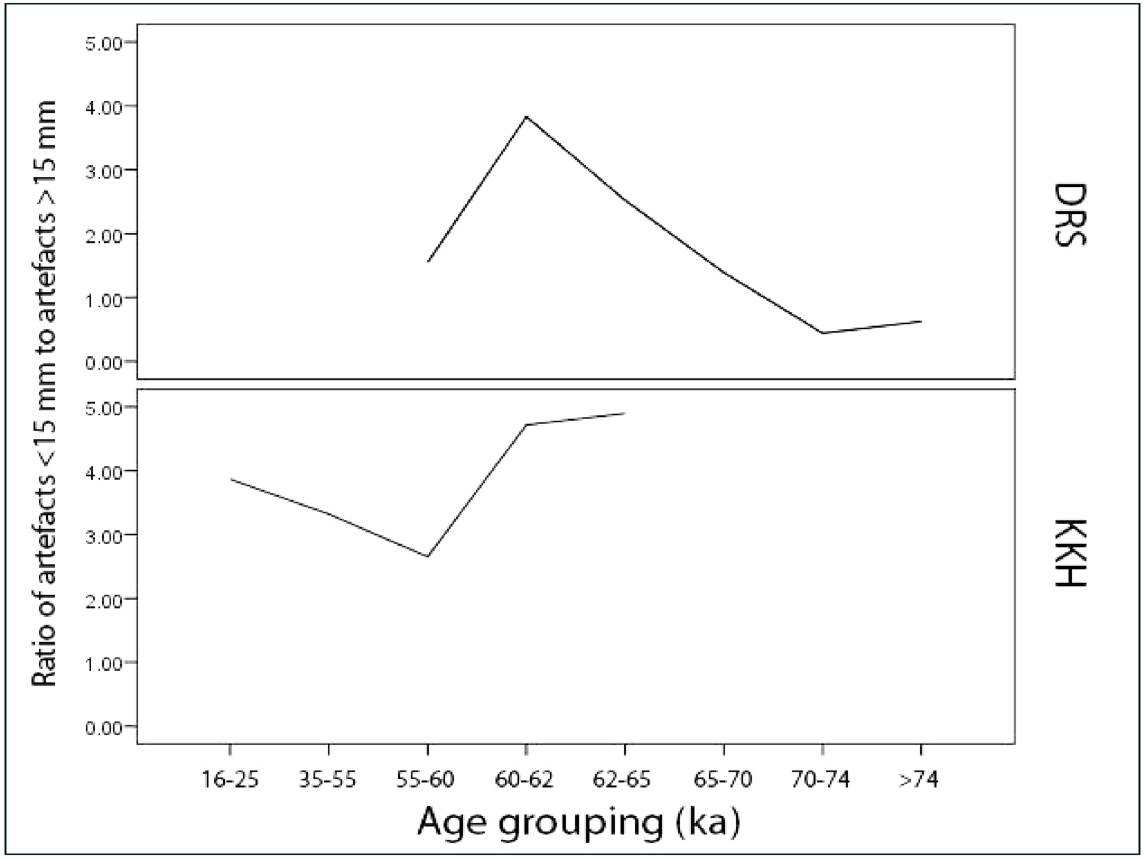


FIGURE 8.62: Age grouped ratios of artefacts <15 mm to artefacts >15 mm at DRS and KKH

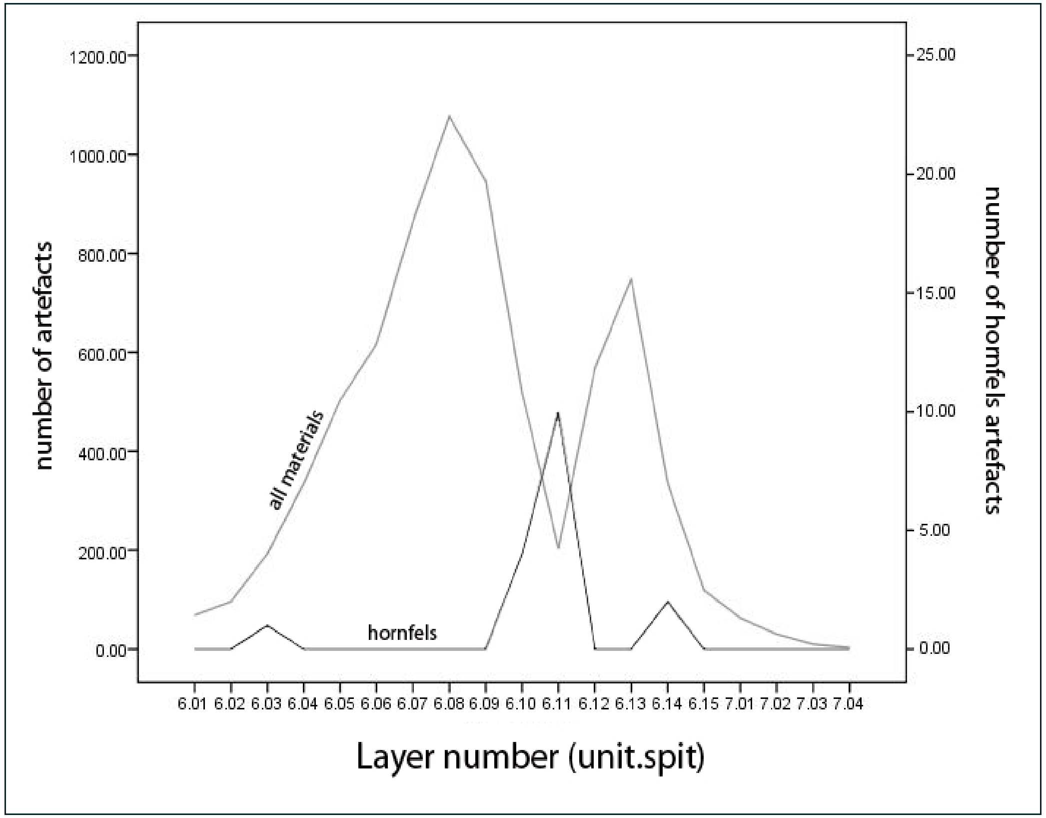


FIGURE 8.63: Relationship between number of artefacts and number of hornfels artefacts by layer at KKH (units Dvi and Dvii only)

FIGURE 9.1: Hypothetical territorial area around KKH, 65-60 ka

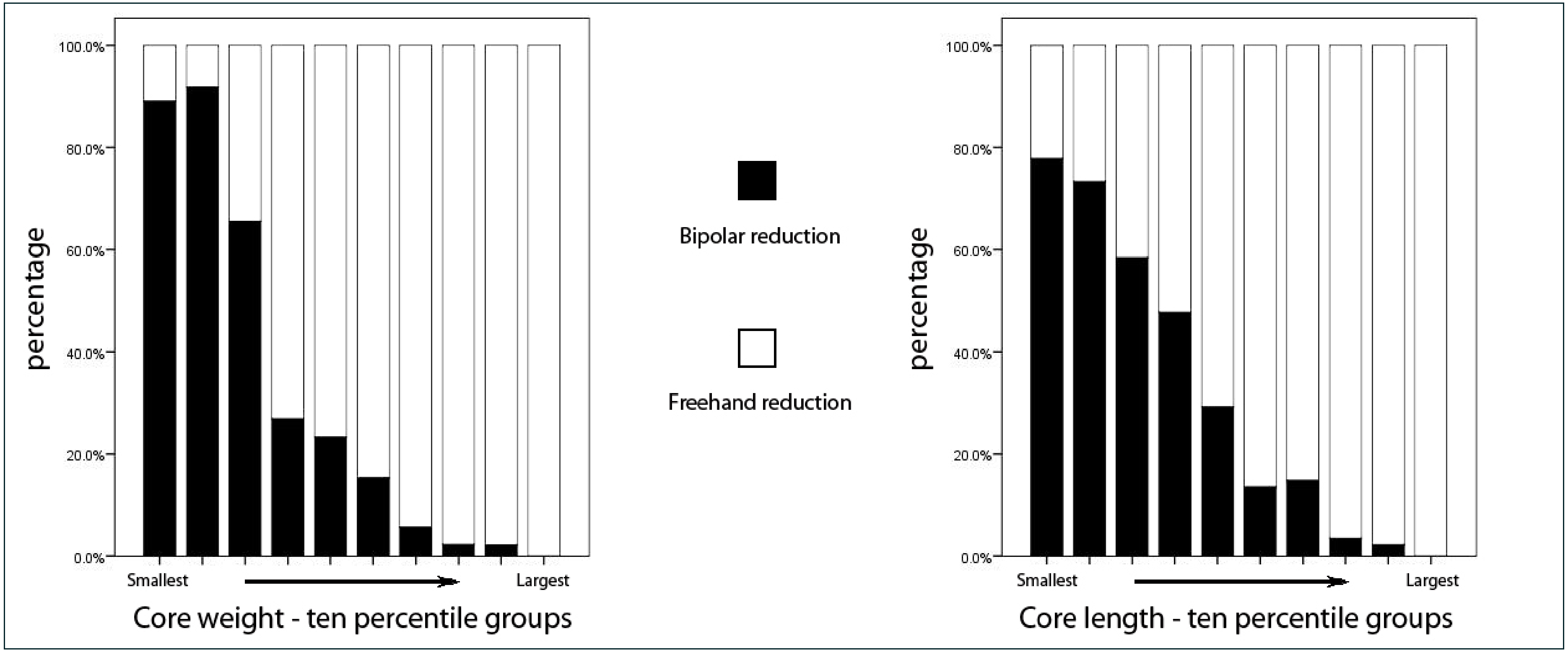


FIGURE 9.2: Relationship between core size and prevalence of bipolar reduction, all complete cores

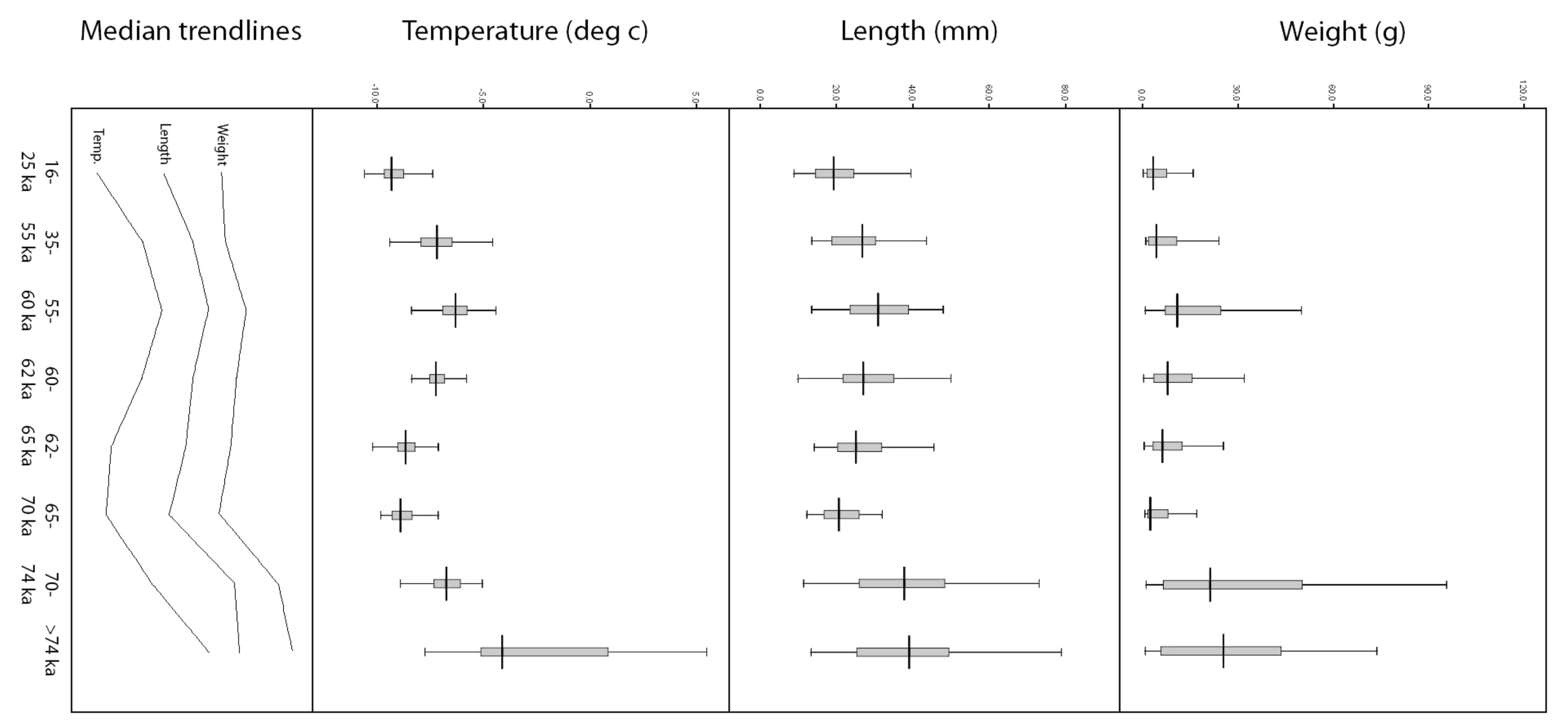


FIGURE 9.3: Relationship between changes in core size in the study area and temperature in the Epica Dome C core

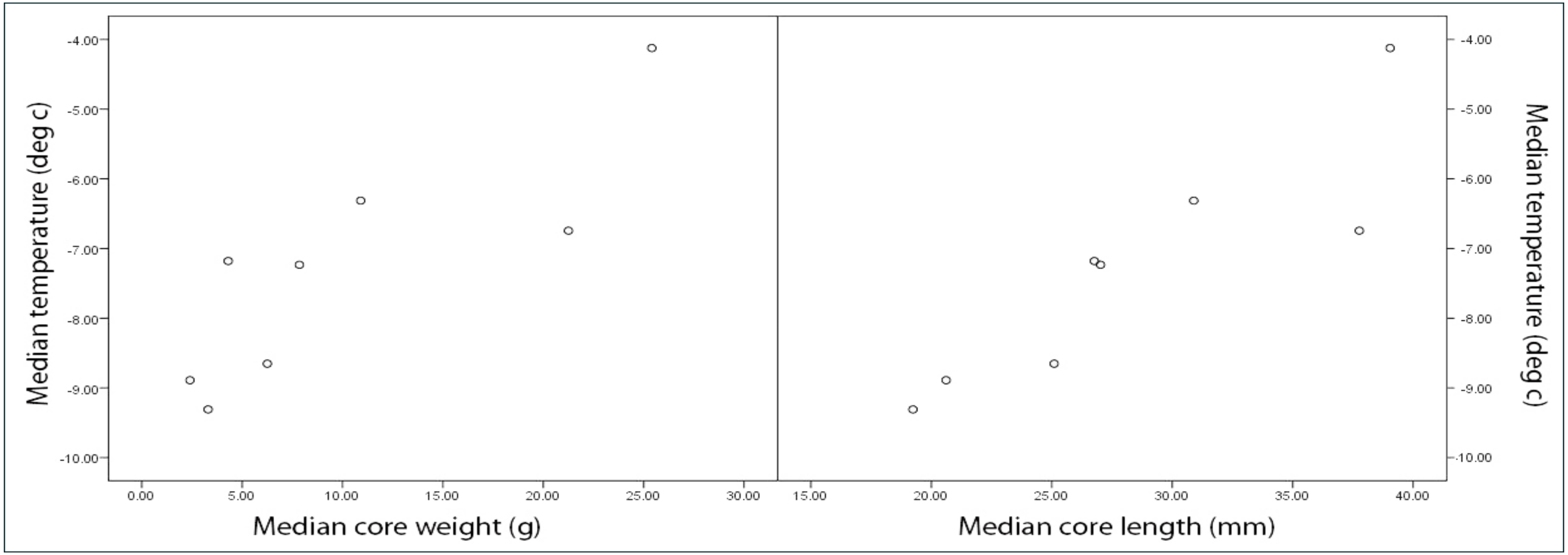


FIGURE 9.4: Scattergram of median values of core size and temperature

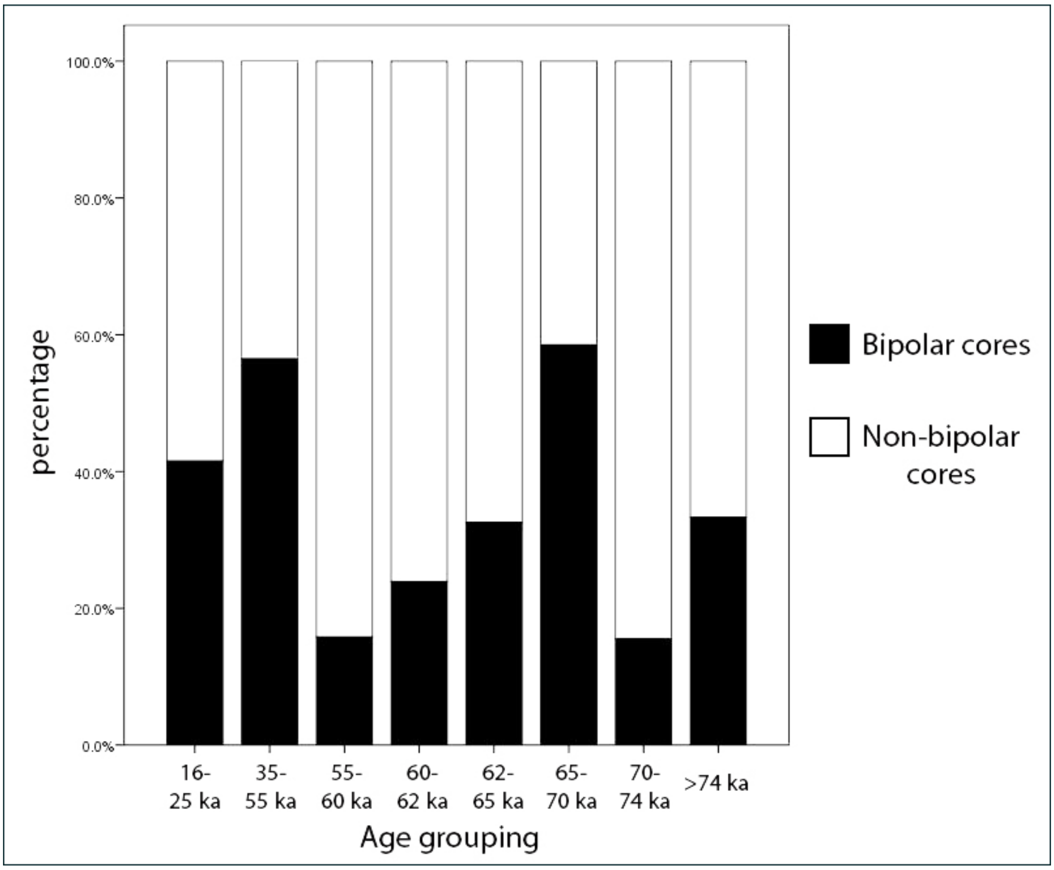


FIGURE 9.5: Age grouped changes in the prevalence of bipolar cores

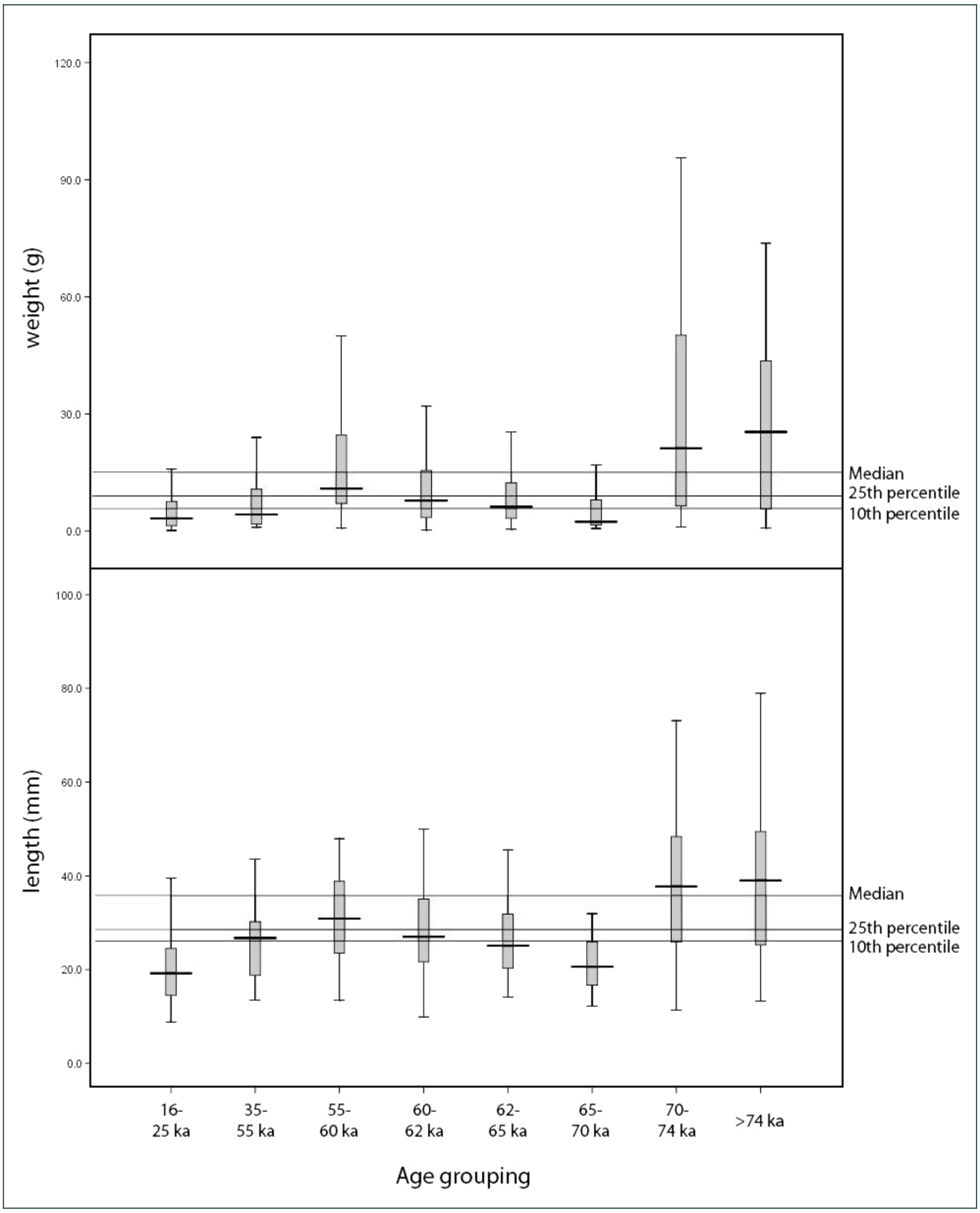


FIGURE 9.6: Age grouped changes in core size against median, 25th percentile and 10th percentile values for complete prepared cores

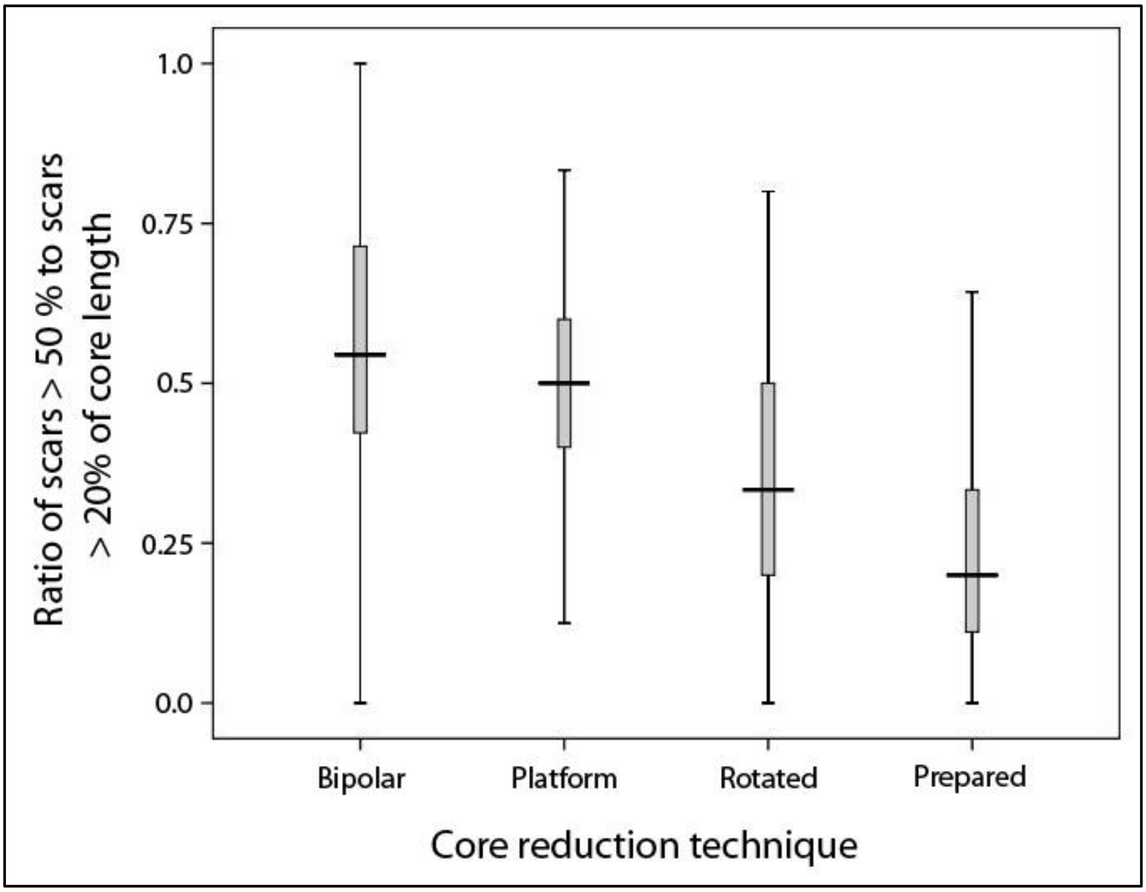


FIGURE 9.7: Ratio of core scars > 50% of length to scars > 20% of length

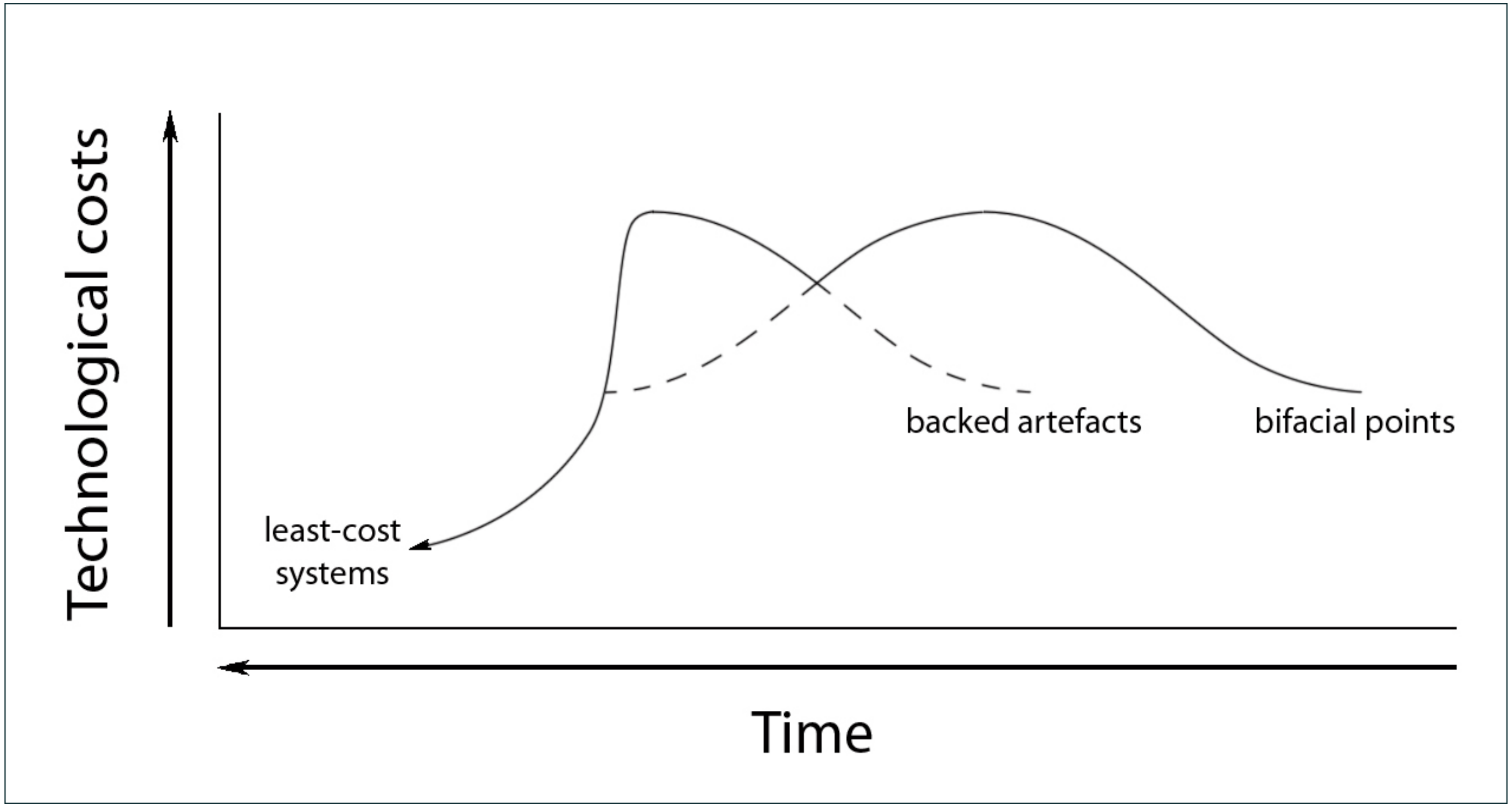


FIGURE 9.8: Hypothetical changes in the configuration and magnitude of technological costs 74-70 ka

TABLES

Original / high-order classification	**Variants and subgroupings**	**References**
Acheul		Fichardt 1957
	African Acheulean	Wayland 1950; van Riet Lowe 1955a; Malan 1956
	Later African Acheul	Malan 1956
African Hand-axe Culture		van Riet Lowe and van der Elst 1949; van Riet Lowe 1955a 1955b
	Pre-Hand-axe	van Riet Lowe 1955b
*Alexandersfontein variant**		Goodwin and van Riet Lowe 1929; Clark 1959
	Alexandersfontein Complex	Malan 1949a
Chelles-Acheul		Malan 1949a; Tobias 1949; Wayland 1950; van der Elst 1950; Mabbutt 1955; Power 1955; van Riet Lowe 1955a; Malan 1956; Viereck 1957; Clark 1958a, 1959; Mason 1958
	Final Chelles-Acheul	Malan 1949, 1956
	Later Chelles-Acheul	Mason 1958
	Pre-Chellean	Wayland 1950
	Pre-South African Chellean	Wayland 1950
	African Chelles-Acheul	van Riet Lowe and van der Elst 1949
	Evolved Chelles-Acheul	Clark 1959
Fauresmith		Goodwin and van Riet Lowe, 1929; Davies 1949; Malan 1949a; van der Elst 1950; Wayland 1950; Mabbutt 1955; Rudner and Rudner 1955; Malan 1956; Fichardt 1957; Mason 1957; Viereck 1957; Clark 1959
	Early Fauresmith	van Riet Lowe and van der Elst 1949; van der Elst 1950

TABLE 3.1: List of industry and variant types in use 1929-1962

Original / high-order classification	Variants and subgroupings	References
	Lowland fauresmith	Wayland 1950
Glen Grey Falls		Goodwin and Van Riet Lowe 1929
Hagenstad Variation		Goodwin and van Riet Lowe 1929; Clark 1959
Howiesonspoort		Goodwin and van Riet Lowe 1929; Jager 1949; Malan 1949; Wayland 1950; Mabbutt 1955; Rudner and Rudner 1955; Malan 1956
	Magosian	Malan 1949a,b; ; Schofield 1949; Wayland 1950; Wayland 1950; Mabbutt 1955; Malan 1956; Viereck 1957; Clark 1958a, b, 1959
	S.A.Magosian	Malan 1949
	Modderpoort variant	Clark 1959
Kafuan		Wayland 1950; Mabbutt 1955; Malan 1956
	Pre-Kamasi Kafuan	Malan 1956
Lupemban		Clark 1959
Mazelspoort		Malan 1949; Clark 1959
	Mazelspoort complex	Malan 1949
	Mazelspoort-Vlakkraal	Malan 1949
Mossel Bay		Goodwin and van Riet Lowe 1929; Malan 1949a; Clark 1959
Natchikufan		Clark 1955, 1958c; Mabbutt 1955
Oldowan		van der Elst 1950; Mabbutt 1955; van Riet Lowe 1955b
	Pre-Oldowan	van Riet Lowe 1955b
Pietersburg		Goodwin and van Riet Lowe 1929; Malan 1949a; Tobias 1949; Mason 1949, 1957; Clark 1959

TABLE 3.1 List of industry and variant types in use 1929-1962 (cont…)

Original / high-order classification	Variants and subgroupings	References
	Epi-Pietersburg	Malan 1949a; Clark 1959
	Early Pietersburg	Clark 1959
	Upper Pietersburg	Clark 1959
	Lower Pietersburg	Clark 1959
	Middle Pietersburg	Clark 1959
Sangoan		Wayland 1950; Mabbutt 1955; Davies 1957; Mason 1957; Hanisch 1958; Clark 1958a
	Transvaal Later Sangoan	Mason 1957
	Hill Sangoan	Wayland 1950
	Zambezi	Clark 1959
	Luangwa	Clark 1959
	Bembezi	Clark 1959
Smithfield		Goodwin and van Riet Lowe 1929; Jager 1949; Malan 1949, 1956; Mason 1949; Schofield 1949; Wayland 1950; Clark 1955; Mabbutt 1955; Rudner and Rudner 1955; Fichardt 1957
	Smithfield 'N'	van Riet Lowe 1936; Clark 1955, 1958b, 1959
	Smithfield-Wilton Complex	Malan 1956
	Smithfield 'C'	Jager 1949; Malan 1956; Clark 1958a, 1959
	Smithfield 'B'	Clark 1958a, 1959
	Early Smithfield	van Riet Lowe and van der Elst 1949
	Smithfield 'A'	Clark 1959
	Later Smithfield of the Transvaal	Mason 1962
	Smithfield Poort	Goodwin 1958

TABLE 3.1: List of industry and variant types in use 1929-1962 (cont…)

Original / high-order classification	Variants and subgroupings	References
Stellenbosch	Umlaas Variant of the Smithfield C	Schoute-Vanneck and Walsh 1961
Stellenbosch		Goodwin and van Riet Lowe, 1929; Davies 1949; Macfarlane 1949; van Riet Lowe and van der Elst 1949; Power 1955; Malan 1956; Viereck 1957
	Pre-Stellenbosch	Macfarlane 1949; Mason, 1949; Wayland 1950; Malan 1956
	Stellenbosch Stage I	van Riet Lowe and van der Elst 1949; van der Elst 1950
	Stellenbosch Stage III	van Riet Lowe and van der Elst 1949; van der Elst 1950
	Stellenbosch Stage IV	van der Elst 1950
	Stellenbosch Stage V	van der Elst 1950
	Upper Stellenbosch	Wayland 1950
Stillbay		Goodwin and van Riet Lowe 1929; Malan 1949, 1956; Schofield 1949; Wayland 1950; Mabbutt 1955; Rudner and Rudner 1955
	Natal Still Bay	Malan 1949
	Rhodesian Still Bay	Schofield 1949; Clark 1959
	Rhodesian Proto-StillBay	Clark 1959
	Proto-Stillbay	Jones 1949
Wilton		Goodwin and van Riet Lowe 1929; van Riet Lowe and van der Elst 1946; Mason 1949; Clark 1955, 1958a,b; Viereck 1957; Fichardt 1957; Malan 1956; Mabbutt 1955; Rudner and Rudner 1955
	North Rhodesia Wilton	Clark 1955
	Smithfield-Wilton Complex	Malan 1956
First and Second Intermediates		Clark 1957; Mabbutt 1955

*Terms coined by Goodwin and van Riet Lowe (1929) are shown in italics.

TABLE 3.1: List of industry and variant types in use 1929-1962 (cont…)

Outlay	High (3)	Moderate (2)	Low (1)
Magnitude	Targeted procurement of specific materials	Largely embedded, some targeted procurement	Entirely embedded
Frequency	High discard thresholds	Moderate discard thresholds	Low discard thresholds
Manufacture	Considerable investment in complex tools	Some complex tools	Largely expedient toolkit

TABLE 4.1: Technological time-cost table

Layer (if known)	**Square (L6 or other)**	**Culture historic unit**	**Technique**	**Age (ka) (^{14}C ages cal b.p.)**
OB* Complex	Other	HP	^{14}C	> 24.4
OB Complex	Other	HP	^{14}C	33.6 ± 0.6
-	Other	HP	^{14}C	44.5 ± 1.3
-	Other	HP	^{14}C	46.2 ± 1.8
OB3	Other	HP	OSL	44.0 ± 5.0
OB Complex	Other	HP	^{14}C	> 45.3
OB3	Other	HP	TL	46.0 ± 5.0
Anne	Other	Post-HP	OSL	47.7 ± 1.7
OB4	Other	HP	OSL	54.0 ± 5.0
-	Other	Post-HP	AMS	> 55.0
Allie	Other	Post-HP	OSL	55.4 ± 2.0
OB2	Other	HP	TL	56.0 ± 5.0
Gary	Other	HP	OSL	58.1 ± 1.9
Greg	Other	HP	OSL	60.3 ± 2.0
George	Other	HP	OSL	60.5 ± 1.9
OB5	Other	HP	TL	60.0 ± 6.0
Helen	Other	HP	OSL	61.3 ± 1.9
Edgar	L6	HP	OSL	61.8 ± 1.7
John	L6	HP	OSL	63.3 ± 2.2
OB5	Other	HP	TL	67.0 ± 7.0
-	Other	HP	TL	70.6 ± 8.1
-	Other	HP	TL	70.9 ± 8.9
Kerry	L6	SB	OSL	70.9 ± 2.3
OB5	Other	HP	TL	71.0 ± 11.0
John	Other	HP	TL	72.0 ± 7.0
Logan	L6	SB	OSL	73.6 ± 2.5
OB5	Other	HP	TL	74.0 ± 8.0
OB5	Other	HP	TL	77.0 ± 11.0
OB4	Other	HP	TL	78.0 ± 8.0
OB5	Other	HP	TL	79.0 ± 10.0
John	Other	HP	TL	83.0 ± 11.0
OB5	Other	HP	TL	87.0 ± 14.0
John	Other	HP	TL	96.0 ± 10.0
Kerry / Kate	Other	SB	TL	99.0 ± 10.0
Larry / Kim	L6	SB	TL	108.0 ± 9.0
Larry / Kim	Other	SB	TL	115.0 ± 12.0
Kerry / Kate	Other	SB	TL	118.0 ± 11.0
Larry / Kim	Other	SB	TL	121.0 ± 11.0
Larry / Kim	L6	SB	TL	127.0 ± 10.0
Larry / Kim	L6	SB	TL	129.0 ± 11.0

* OB= Orange Black

References: Jacobs *et al*. 2008; Parkington 1999, 1977; Parkington *et al*. 2006; Tribolo et al 2009

TABLE 5.1: Pleistocene ages, DRS

Layer	**Culture historic unit**	**Technique**	**Age (ka) (^{14}C ages cal b.p.)**
DS02	Late Pleistocene Microlithic	^{14}C	14.7 ± 0.5
GBS2	Late Pleistocene Microlithic	^{14}C	15.9 ± 0.4
SOSE	Late Pleistocene Microlithic	^{14}C	16.2 ± 0.4
SOSE	Late Pleistocene Microlithic	^{14}C	39.7 ± 1.4
MOS1	Late Pleistocene Microlithic	^{14}C	16.5 ± 0.4
SPIN	Late Pleistocene Microlithic	^{14}C	21.3 ± 0.4
OAKO	Late Pleistocene Microlithic	^{14}C	24.4 ± 0.4
DS06	Late Pleistocene Microlithic	^{14}C	24.1 ± 0.4
NORT	MSA	^{14}C	45.5 ± 1.8
DS11	MSA	^{14}C	46.6 ± 2.1
PATT	MSA	^{14}C	> 40.3
TAPT	MSA	^{14}C	> 44.6

TABLE 5.2: Pleistocene ages, EBC

Layer	Square	Technique	Age (ka) (^{14}C ages cal b.p.)
Di5	H2C	^{14}C	22.3 ± 0.3
Di5 (Dii?)	H2C	OSL	33.0 ± 1.0
Diii2	H1B	^{14}C	> 35.0
Div1	H2C	^{14}C	> 35.0
D1/D2 (Dv/Dvi?)	I1	OSL	55.0 ± 2.0
Dvi1	H2C	OSL	56.0 ± 3.0
Dvi3	H1C	OSL	58.0 ± 2.0
Dvi10	H2C	OSL	60.0 ± 3.0
Dvi13	H2C	OSL	64.0 ± 3.0
Dvi6	H2C	OSL	65.0 ± 3.0
D2/D3 (Dvi/Dvii?)	I1	OSL	66.0 ± 3.0

TABLE 5.3: Pleistocene ages, KKH

Zone	Drainage systems	Water reliability	Material types	Material abundance
Sandveld	Poor Not well defined	Generally unreliable	Quartzite Quartz Silcrete FGS/CCS Hornfels	Common Common Rare Some None (rare?)
Olifants	Effective Well defined	Reliable	Quartzite Quartz Silcrete FGS/CCS Hornfels	Abundant Common Common Some None
Doring	Effective Well defined	Seasonal	Quartzite Quartz Silcrete FGS/CCS Hornfels	Abundant Common Rare? Rare Common

TABLE 5.4: Characteristics of drainage and materials in the study area by zone

OIS	Age range (kya)	Temp. (Primary productivity?)	Temp. variance	Water abundance	Obliquity (Seasonality?)	Insolation (Primary productivity?)
5	>100	high	low	variable?	low	high / low
5	100-80	moderate	high	variable?	high	low / high
4	80-70	low	high	good?	high / low	low / high
4	70-65	lowest	low	good?	low	high / low
4	65-62	very low	low	v. good	low	low
4	62-60	low	low	poor-moderate?	low / high	low
3	60-55	low-moderate	high	moderate-good	high	low / high
3	55-45	low	high	moderate-good?	high	high
3	45-30	low	low	good?	high / low	high / low
2	<30	lowest	low	good	low / high	low / high

TABLE 5.5: Variance in climatic parameters in the study area

Period	Mobility magnitude	Mobility organization	Settlement structure	Patch use	Diet breadth	Technological investment	Technological organisation
> 100	Low	Residential	Dispersed	Generally brief	Low	Low	-
100-80	Moderate	Residential	~Clumped	Focus on DRS / KKH	Moderate	Low / moderate	Maintainable
80-70	High	Residential to logistical	~Clumped to ~dispersed	Increasing	High	High	Reliable / maintainable
70-65	High	Logistical	Dispersed	Longer	Highest	Highest / lowest	Reliable
65-62	High	Logistical	Dispersed	Longer	Very high	High	Reliable
62-60	High	Logistical	Dispersed	Focus on DRS / KKH	High / moderate	High	Reliable
60-55	Moderate	Residential	Clumped	Generally brief	Moderate	Moderate	Maintainable
55-45	High	Residential to logistical	Clumped	Moderate	High	High / lowest?	Reliable / maintainable
45-30	High	Logistical	Clumped to dispersed	Longer	High	High / lowest?	Reliable
< 30	Highest	Logistical	Dispersed	Longer	Highest (or low if risk prone)	Highest / lowest	Reliable

TABLE 6.1: Summary of hypotheses

Layer name	Layer number		Layer name	Layer number
Burnt crust	1		Jess	26
Claude	2		Julia	27
Denzil	3		Kate	28
Danny	4		Kerry	29
Debbie	5		Kenny	30
Darryl	6		Kegan	31
Deon	7		Keno	32
Eric	8		Kim	33
Ester	9		Larry	34
Edgar	10		Logan	35
Eve	11		Liz	36
Eben	12		Leo	37
Fred	13		Lynn	38
Frank	14		Lauren	39
Frans	15		Mike	40
Fanie	16		Mark	41
Fiona	17		Moses	42
Fox	18		Naggie	43
Glen	19		Miles	44
Governor	20		Mary	45
John	21		Noel	46
Jeff	22		Noah	47
Joy	23		Nina	48
Jack	24		Nel	49
Jude	25		Neva	50

TABLE 8.1: Relationship betweeb layer names and numbers at DRS

	Quartzite	**Quartz**	**Silcrete**	**CCS/FGS**	**Other**	**Total**
Absolute numbers						
Ret. flakes	78	120	214	8	30	450
Cores	36	126	109	3	10	284
All artefacts	2451	1881	1869	72	452	6725
Percentages						
Ret. flakes	17.3	26.7	47.6	1.8	6.6	100
Cores	12.7	44.4	38.4	1.1	3.6	100
All artefacts	36.4	28.0	27.8	1.1	6.7	100
Percentage deviance						
Ret. flakes	-19.1	-1.3	+19.8	+0.7	-0.1	-
Cores	-23.7	+16.4	+10.6	0	-3.1	-

TABLE 8.2: Material selection deviance for retouched flakes and cores, DRS

	Quartzite	**Quartz**	**Silcrete**	**CCS/FGS**	**Oth**	**Total**
Absolute numbers						
Ret. flakes	27	67	379	42	45	560
Cores	20	88	306	63	14	491
All artefacts	1260	858	6111	502	680	9411
Percentages						
Ret. flakes	4.8	12.0	67.7	7.5	8.0	100
Cores	4.1	17.9	62.3	12.8	2.8	99.9
All artefacts	13.4	9.1	64.9	5.3	7.2	99.9
Percentage deviance						
Ret. flakes	-8.6	+2.9	+2.8	+2.2	+0.8	-
Cores	-9.3	+8.8	-2.6	+7.5	-4.4	-

TABLE 8.3: Material selection deviance for retouched flakes and cores, KKH

	Quartzite	Quartz	Silcrete	CCS/FGS	Oth	Total
Original percentage						
Ret. flakes	0.6	75.6	11.6	2.4	9.8	100
Cores	1.5	87.2	3.8	1.5	6.0	100
Percentage deviance at DRS						
Ret. flakes	-19.1	-1.3	+19.8	+0.7	-0.1	-
Cores	-23.7	+16.4	+10.6	0	-3.1	-
Estimated range of percentage values for all artefacts at EBC based on DRS correction						
Min	18.5	70.8	-8.2	1.5	9.1	-
Max	22.2	76.9	-6.8	1.7	9.9	-

TABLE 8.4: Material selection and corrections, EBC

Age range (ka)	DRS layers	KKH units/layers	KFR layers	EBC layers	HRS layers
<30		Di1-6		16 ka & 24 ka units	
30-45		Dii1-Dv2		hiatus	
45-55				>40 ka unit	
55-60	1-5	Dvi1-6			
60-62	5-11	Dvi7-11	5?		
62-65	12-22	Dvi11-Dvii4	6 (&5?)		
65-70	23-29		hiatus?		
70-80	30-38				1-4
80-100	38-51		7-9		
100-120					

TABLE 8.5: Summary of layer synchronization

Site	Age grouping	Number of artefacts	Number of implements	Number of amorphous retouched	Implements per 100 artefacts	Implements / amorphous retouched
DRS	>74 ka	1347	16	52	1.2	0.3
	74-70 ka	1148	31	46	2.7	0.7
	70-65 ka	1554	14	55	0.9	0.3
	65-62 ka	1428	38	45	2.7	0.8
	62-60 ka	769	9	22	1.2	0.4
	60-55 ka	241	6	7	2.5	0.9
KKH	65-62 ka	1865	73	54	3.9	1.4
	62-60 ka	3605	72	75	2.0	1.0
	60-55 ka	1806	36	45	2.0	0.8
	55-35 ka	216 (432)	3 (6)	8 (16)	1.4	0.4
	25-16 ka	83 (166)	1 (2)	3 (6)	1.2	0.3
KFR	>74 ka	nd	31	21	-	1.5
	65-62 ka	nd	34	40	-	0.9
	Spit 6 only	nd	16	19	-	0.8
EBC	25-16 ka	nd	77	87	-	0.9

TABLE 8.6: Numbers of implements relative to amorphous retouched and all artefacts, DRS, KKH, KFR and EBC

Type	Number of specimens	Mean weight (g)	Standard deviation
Backed artefacts	163	2.7	2.2
Burins	47	9.1	17.7
Denticulates	8	14.5	17.1
Notched pieces	27	5.4	4.6
Points - bifacial	14	13.5	15.9
Points - unifacial	26	14.5	14.1
Scrapers	119	8.9	18.1
Shoulderless points	5	9.5	3.6

TABLE 8.7: Weight data, all implement types

Artefact type	Number of scars	Mean scar length (mm)	Standard deviation
Bifacial points	218	11.9	4.2
Hemispheric cores	183	12.4	6.2

TABLE 8.8: Scar length data, bifacial points and hemispheric cores

Site	Temporal grouping	Time elapsed (ky)	Implement type	Number of cases	Number per ky
DRS	74-70 ka	4	Bifacial points	15	4.3
	70-65 ka	5	Backed artefacts	7	1.4
	65-62 ka	3	Backed artefacts	21	7
	62-60 ka	2	Backed artefacts	8	4
	60-55 ka	5	Unifacial points	4	0.8
KKH	65-62 ka	3	Backed artefacts	37	12.3
	62-60 ka	2	Backed artefacts	49	24.5
	60-55 ka	5	Unifacial points	9	1.8
	55-35 ka	20	Scraper	3 (6)	0.3

TABLE 8.9: Implement discard rates, DRS and KKH

Implement class	Number of edges measured	Mean angle (°)	Standard deviation
Backed artefacts	481	84.7	8.9
Denticulates	23	66.9	12.0
Notched flakes	57	68.1	9.1
Points – bifacial	218	57.2	10.2
Points – unifaical	102	60.5	10.1
Scrapers	74	62.8	10.1

TABLE 8.10: Retouched edge angles, major implement types

Implement class	Number of edges measured	Mean angle (°)	Standard deviation
Bifacial points	110	58.9	10.5
Unifacial points	34	81.6	7.0

TABLE 8.11: Butt-end angles, bifacial points and unifacial points

Site	n	mean	s.d.	K-S Z	Sig.*
DRS	565	26.3	7.6	2.134	**0.000**
	565	17.1	6.6	2.027	**0.001**
	565	6.0	3.1	2.435	**0.000**
KKH	1797	28.1	9.5	4.272	**0.000**
	1795	18.4	8.7	3.908	**0.000**
	1794	6.0	3.6	5.479	**0.000**

* Results which depart from a normal distribution at $p<0.05$ are shown in bold.

TABLE 8.12: One-sample Kolmogorov-Smirnov tests for normal distribution among complete flakes at DRS and KKH

Site	n	mean	s.d.	K-S Z	Sig.*
DRS	66	35.7	8.0	0.858	0.453
	66	16.8	4.2	0.481	0.975
	66	4.5	1.4	0.935	0.346
KKH	65	29.9	5.2	0.739	0.646
	65	15.8	4.5	1.162	0.134
	65	4.5	1.4	1.090	0.185

* Results which depart from a normal distribution at $p<0.05$ are shown in bold.

TABLE 8.13: One-sample Kolmogorov-Smirnov tests for normal distribution among complete backed artefacts at DRS and KKH

Site	Dimension	Artefact class	n	mean rank	Mann-Whitney U	Sig.*
DRS	Max. dimension	Flakes	565	295.47	7046.0	**0.000**
		Backed	66	491.7		
	Max. width	Flakes	565	314.6	17830.0	0.559
		Backed	66	328.4		
	Max. thickness	Flakes	565	324.9	13640.5	**0.000**
		Backed	66	240.2		
KKH	Max. dimension	Flakes	1797	922.7	42640.0	**0.000**
		Backed	65	1173.9		
	Max. width	Flakes	1795	935.3	49670.0	**0.042**
		Backed	65	797.2		
	Max. thickness	Flakes	1794	938.0	43935.0	**0.001**
		Backed	65	708.9		

* Results which are significant at a cut-off of $p<0.05$ are shown in bold.

TABLE 8.14: Mann-Whitney tests for differences in the dimensions of backed artefacts and complete flakes at DRS and KKH

Site	n	mean	s.d.	K-S Z	Sig.*
DRS	92	28.2	9.1	0.706	0.701
	92	10.8	3.3	0.800	0.544
	92	5.5	3.4	1.505	**0.022**
KKH	336	28.4	9.5	1.678	**0.007**
	336	10.9	4.0	1.574	**0.014**
	336	4.8	2.9	2.982	**0.000**

* Results which depart from a normal distribution at $p<0.05$ are shown in bold.

TABLE 8.15: One-sample Kolmogorov-Smirnov tests for normal distribution among complete elongate flakes at DRS and KKH

Site	Dimension	Artefact class	n	mean rank	Mann-Whitney U	Sig.*
DRS	Max. dimension	Elong fl.	91	63.2	1562.0	**0.000**
		Backed	66	100.84		
	Max. width	Elong fl.	91	54.9	805.5	**0.000**
		Backed	66	112.3		
	Max. thickness	Elong fl.	91	83.1	2633.0	0.188
		Backed	66	73.4		
KKH	Max. dimension	Elong fl.	331	191.2	8348.0	**0.004**
		Backed	65	235.6		
	Max. width	Elong fl.	331	177.8	3907.5	**0.000**
		Backed	65	303.9		
	Max. thickness	Elong fl.	331	196.7	10165.5	0.483
		Backed	65	207.6		

* Results which are significant at a cut-off of p<0.05 are shown in bold.

TABLE 8.16: Mann-Whitney tests for differences in the dimensions of backed artefacts and complete elongate flakes at DRS and KKH

Artefact class	Dimension	Site	n	mean rank	Mann-Whitney U	Sig.*
Flakes	Max. dimension	DRS	565	1093.9	458200	**0.000**
		KKH	1797	1209.0		
	Max. width	DRS	565	1125.6	476100	**0.028**
		KKH	1795	1197.8		
	Max. thickness	DRS	565	1205.8	492200	0.302
		KKH	1794	1171.9		
Backed artefacts	Max. dimension	DRS	66	82.6	1046	**0.000**
		KKH	65	49.1		
	Max. width	DRS	66	71.9	1758.5	0.075
		KKH	65	60.1		
	Max. thickness	DRS	66	66.7	2101.5	0.841
		KKH	65	65.3		

* Results which are significant at a cut-off of p<0.05 are shown in bold.

TABLE 8.17: Mann-Whitney tests for differences between the dimensions of backed artefacts and complete elongate flakes at DRS and KKH

Site	Age grouping	Time elapsed (ky)	Number of artefacts	Discard rate (artefacts / ky)
DRS	74-70 ka	4	1148	287
	70-65 ka	5	1554	310.8
	65-62 ka	3	1428	476
	62-60 ka	2	769	384.5
	60-55 ka	5	241	48.2
KKH	65-62 ka	3	1865	621.7
	62-60 ka	2	3605	1802.5
	60-55 ka	5	1806	361.2
	55-35 ka	20	216 (432)	21.6

* Calculated using the doubled artefact total

TABLE 8.18: Changes in artefacts discard rates at DRS and KKH

Site	Temporal grouping	% hornfels (complete flakes)	% hornfels (all artefacts >15 mm)	% hornfels (site overall)
DRS	>74 ka	3.5	2.4	4.6
	74-70 ka	2.4	2.1	
	70-65 ka	5.8	6.6	
	65-62 ka	5.2	4.5	
	62-60 ka	8.1	6.7	
	60-55 ka	1.8	5.0	
KKH	65-62 ka	0.2	0.1	0.3
	62-60 ka	0.5	0.4	
	60-55 ka	0.0	0.1	
	55-35 ka	1.3	0.5	
	25-16 ka	0.0	2.4	
KFR	>74 ka	5.6	10.8	11.9
	65-60 ka	15.3	14.5	
HRS	74-70 ka	nd	7.0	7.0
EBC	25 ka	nd	5.1	5.1

TABLE 8.19: Hornfels percentages at all sites

Temporal grouping	Number of cases	% of assemblage total
65-62 ka	22	1.2
62-60 ka	43	1.2
60-55 ka	23	1.3
55-35 ka	16	7.2
25-16 ka	2	2.4

TABLE 8.20: Prevalence of brown shale, KKH

	Minimum	10th percentile	25th percentile	Median	Mean	s.d.
Weight	3.8	5.8	9.0	15.1	28.6	38.4
Length	19.0	26.1	28.6	35.8	38.6	13.1

TABLE 9.1: Descriptive statistics for the sizes of prepared cores

PLATES

PLATE 5.1 (a): View of the Sandveld, looking east along the Verlorenvlei

PLATE 5.1 (b): View of the Sandveld, south of Verlorenvlei looking east

PLATE 5.3 (a): View over Clanwilliam Dam (Olifants River) towards the Cederberg Mountains

PLATE 5.3 (b): View of Cederberg Mountains, Olifants catchment

PLATE 5.5: Temporary waterholes on Sandveld outcrops shortly after winter rains

PLATE 5.6: Conglomerates in the Table Mountain Sandstone, Sandveld

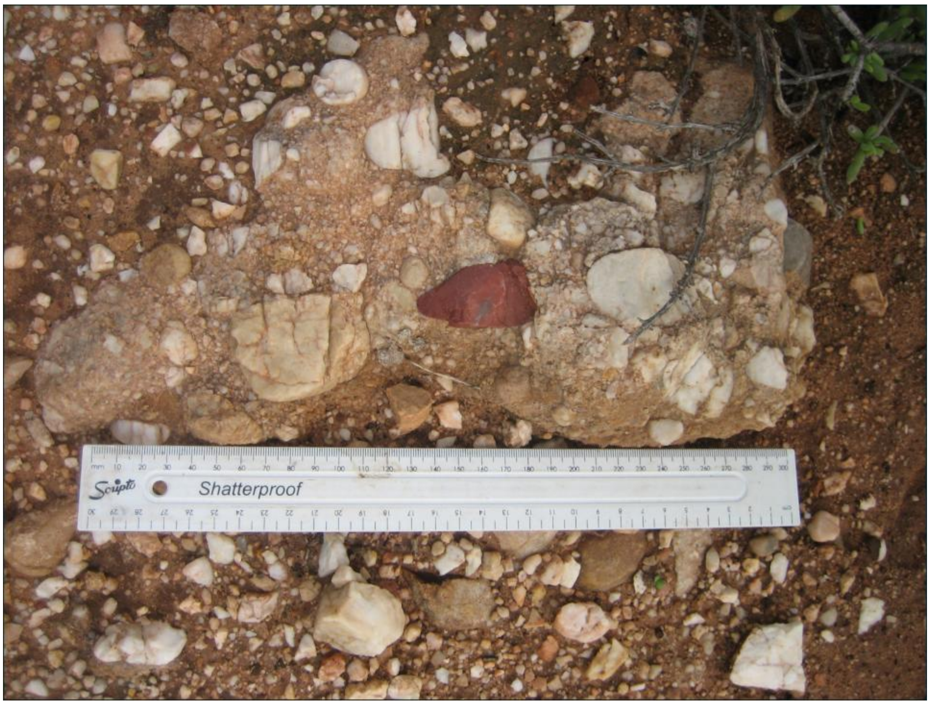


PLATE 5.7: Conglomerates in the Table Mountain Sandstone, Sandveld

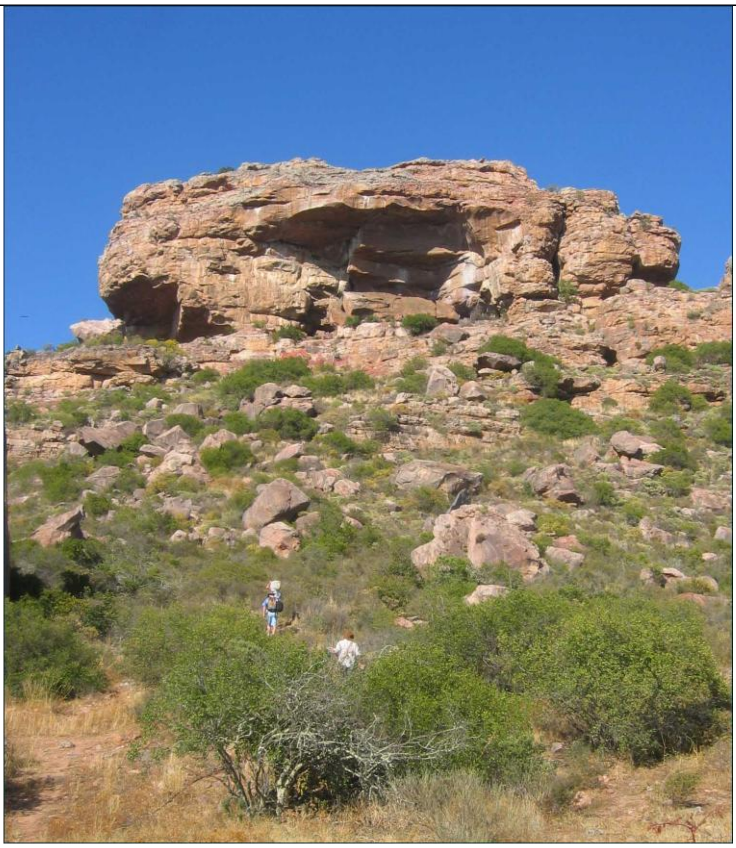


PLATE 5.8: View of DRS, facing south

PLATE 5.9: View of the eastern end of the Verlorenvlei from DRS

PLATE 5.10: Stratigraphic section, DRS

PLATE 5.11: Quartzite scree near KKH

PLATE 5.12: Conglomerates in the Table Mountain Sandstoneon, near KKH

PLATE 5.13: Silcrete outcrop in Olifants Valley

PLATE 5.14: Silcrete-rich boulder ~10 km south of KKH

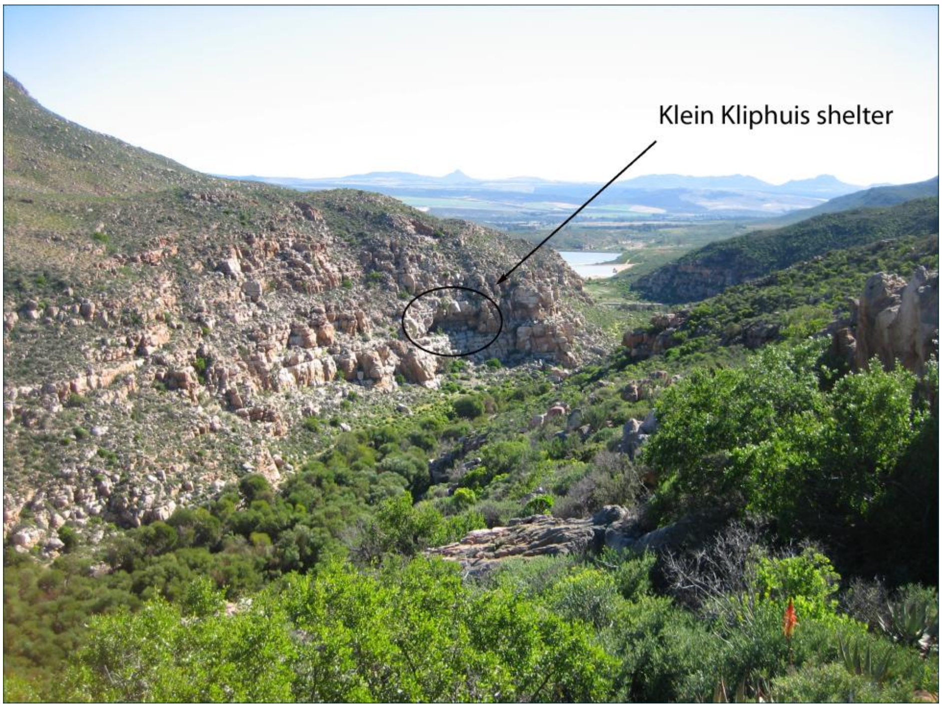


PLATE 5.15: View of KKH, facing west

PLATE 5.16 View of HRS, facing north west

PLATE 8.1: Layer 39 unifacial point tip (scale bar is 2 cm)

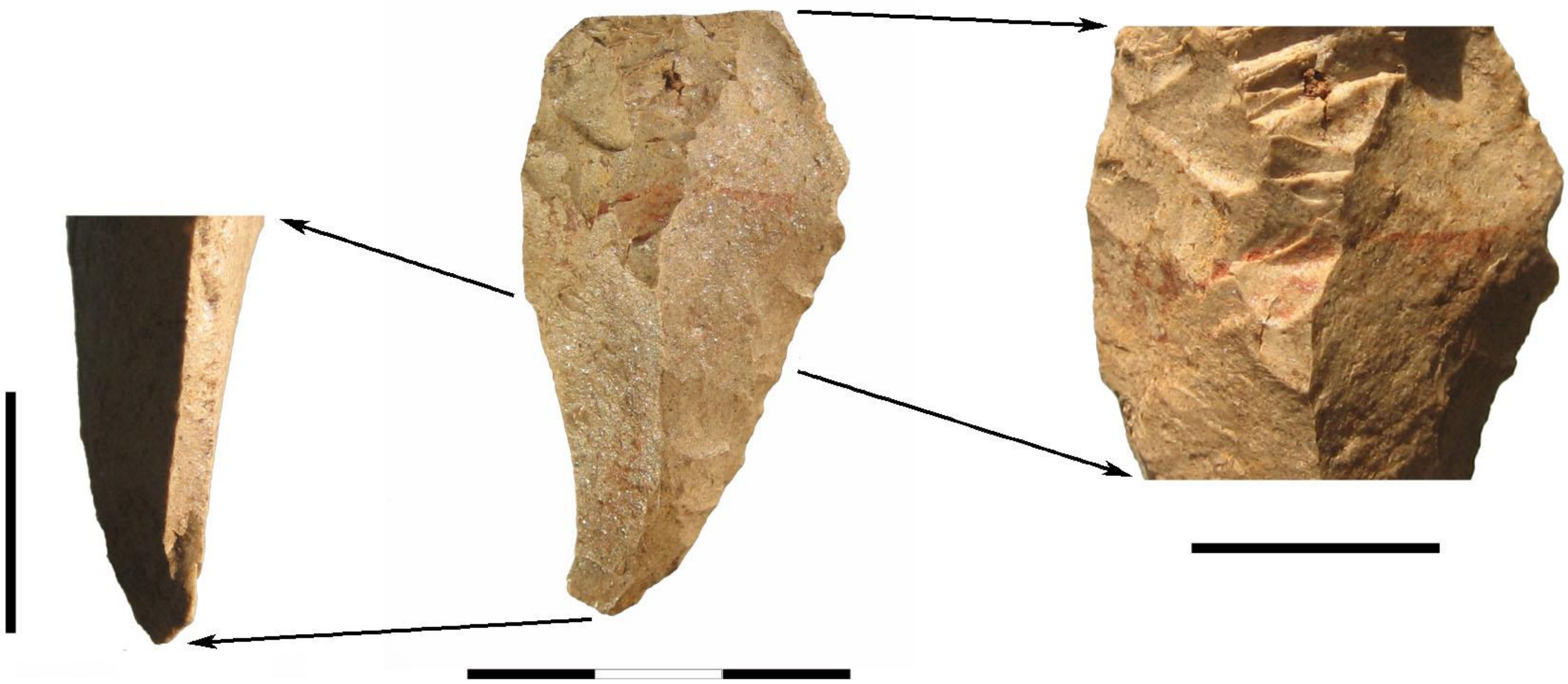


PLATE 8.2: Layer 39 unifacial point with spalling from the tip and discolouration at the proximal end (scale bar is 1 cm)

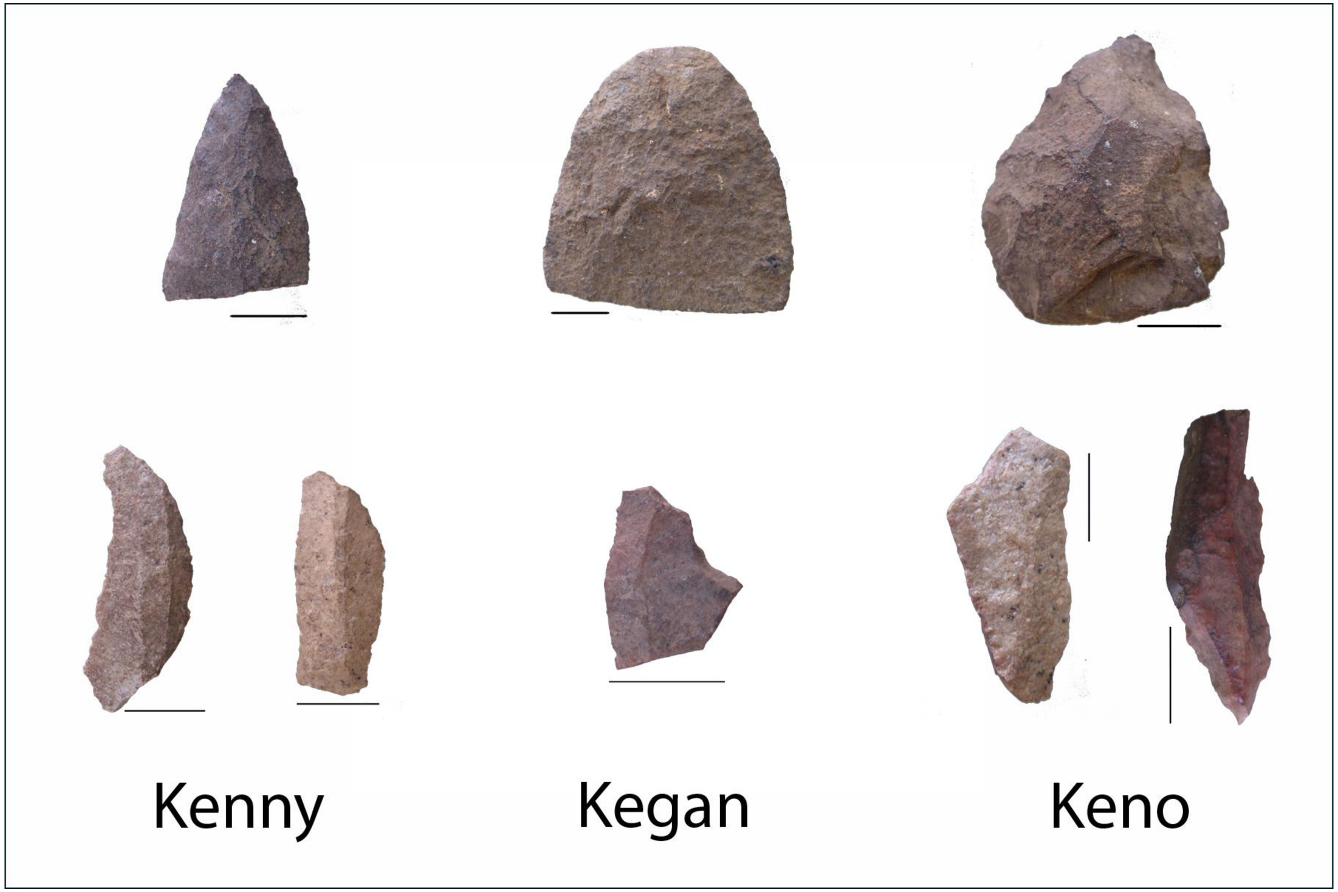


PLATE 8.3: Overlapping backed artefacts and bifacial points in layers 32-30 at DRS (scale bars are 1 cm)

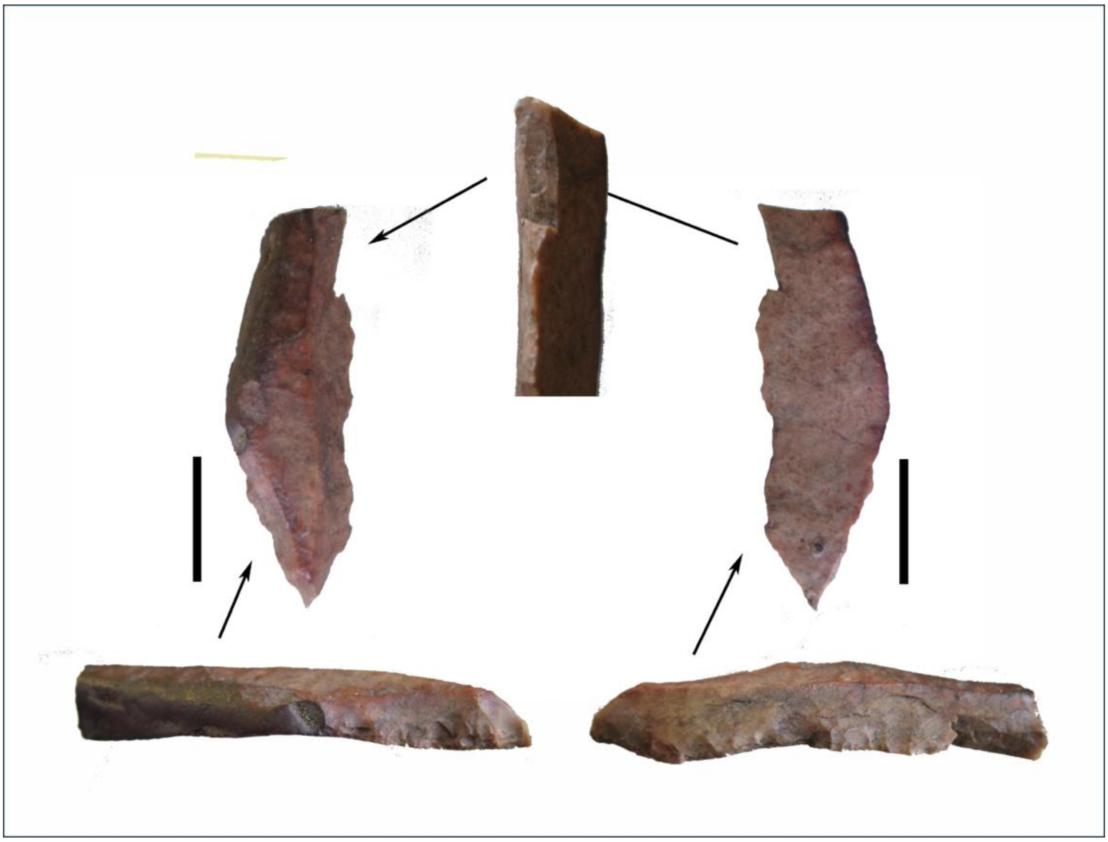


PLATE 8.4: Unusual retouched piece, layer 31 at DRS (scale bars are 1 cm)

PLATE 8.5: Shoulderless points, KKH (scale bars are 3 cm)

PLATE 8.6: Recycled bifacial point, DRS (scale bar is 1 cm)

PLATE 8.7 :Parti-bifacial point, KKH (scale bar is 1 cm)

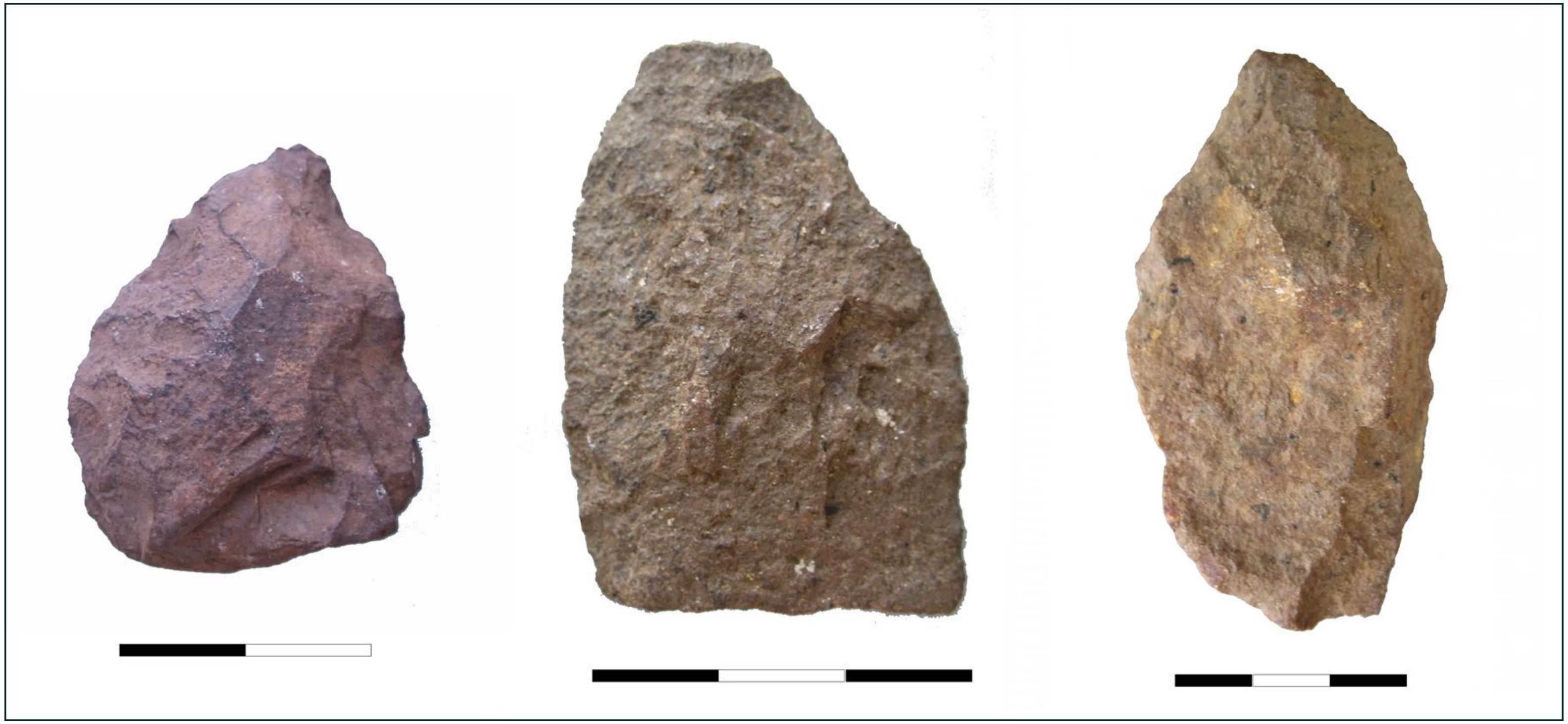


PLATE 9.1: ‘Roughouts’, or early stage reduction bifacial points at DRS

PLATE 9.2: Complete hornfels core from LGM layer at EBC

PLATE 10.1: Points and radially worked pieced from 'Clanwilliam Dam East' site, ~15 km south of KKH