Coalescence and fragmentation in the late Pleistocene archaeology of southernmost Africa

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A B S T R A C T

The late Pleistocene archaeological record of southernmost Africa encompasses several Middle Stone Age industries and the transition to the Later Stone Age. Through this period various signs of complex human behaviour appear episodically, including elaborate lithic technologies, osseous technologies, ornaments, motifs and abstract designs. Here we explore the regional archaeological record using different components of lithic technological systems to track the transmission of cultural information and the extent of population interaction within and between different climatic regions. The data suggest a complex set of coalescent and fragmented relationships between populations in different climate regions through the late Pleistocene, with maximum interaction (coalescence) during MIS 4 and MIS 2, and fragmentation during MIS 5 and MIS 3. Coalescent phases correlate with increases in the frequency of ornaments and other forms of symbolic expression, leading us to suggest that population interaction was a significant driver in their appearance.

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Introduction

The archaeological record of southernmost Africa during the late Pleistocene exhibits a number of atypically early signs of cultural complexity, giving rise to claims that it is one potential point of origin for the emergence of modern human behaviour (Parkington, 2003, 2010; Marean, 2010; though note; Bouzouggar et al., 2007; Bar-Yosef Mayer et al., 2009). Elements of this complexity include the early production of ornaments, motifs and abstract designs, the use of osseous technology, and the manufacture of lithic technologies that later become common in many other parts of the world (Henshilwood and Sealy, 1997; Henshilwood et al., 2001a, 2002, 2004; d’Errico et al., 2005; d’Errico and Henshilwood, 2007; Backwell et al., 2008; d’Errico et al., 2008; Jacobs et al., 2008a; Mackay and Welz, 2008; Henshilwood et al., 2009; Lombard et al., 2010; Mourre et al., 2010; Texier et al., 2010; Henshilwood et al., 2011; d’Errico et al., 2012a; Texier et al., 2013; Vanhaeren et al., 2013). The temporal distribution of many of these markers is variable and apparently non-directional, leading to speculation about the causes of their appearance and disappearance (Jacobs and Roberts, 2009; Powell et al., 2009; Villa et al., 2010; d’Errico and Stringer, 2011; Henshilwood and Dubreuil, 2011; Lombard and Parsons, 2011).

Much of the discussion of late Pleistocene lithic technologies has focused on methods of tool manufacture and the definition of culture-historic units (Volman, 1980; Thackeray, 1989; Wadley and Harper, 1989; Wadley, 1995, 2005; Wurz, 2002; Soriano et al., 2007; Wadley, 2007; Brown et al., 2009; Villa et al., 2009; Mourre et al., 2010; Villa et al., 2010; Brown et al., 2012; Wurz, 2012; Porraz et al., 2013a). Less explicit consideration has been given to the mechanisms underlying lithic technological change across the subcontinent, and more specifically to the causes of patterns of similarity and difference between spatially dispersed sites (Deacon, 1984a; Mitchell, 1988; Ambrose and Lorenz, 1990; Deacon and Wurz, 1996; Ambrose, 2002; McCall, 2007; Jacobs et al., 2008a; Mackay, 2008a; McCall and Thomas, 2012; Faith, 2013; Porraz et al., 2013b). Causes of technological change that have been inferred (either implicitly or in brief discussion) include adaptations to changes in the subsistence environment (Mackay, 2009; Villa et al., 2010; Hiscock et al., 2011; Lombard and Parsons, 2011; Mackay, 2011; Mackay and Marwick, 2011; McCall and Thomas, 2012; Ziegler et al., 2013) and responses to changing social
stimuli that are adaptively neutral with respect to environmental variation (sometimes called ‘fashions’) (Volman, 1980; Thackeray, 1989, 2000; Jacobs et al., 2008a). Viewed in extremis these two positions are equally unlikely. The frequent occurrence of similar technologies over large areas with diverse local environments is difficult to reconcile with optimally-adapted systems (Jacobs et al., 2008a); on the other hand, given that lithic technology was a component of human subsistence behaviour for more than two million years, it is unlikely that technological systems were always selectively neutral or maladaptive (though note Boyd and Richerson, 1985). We thus suggest that there were always some socially-mediated dimensions to environmental-mediated technologies and vice versa.

In this paper, we pursue a more nuanced understanding of technological change in late Pleistocene southernmost Africa. The objective is to understand the degree of fit between lithic technological systems and environmental variation through the period from 130 to 12 ka (thousands of years ago), and the extent to which transfer of information between interacting populations influenced the form of technological systems at different times. Changes in the extent of interaction between populations have implications not just for the forms of lithic systems, but also for the appearance of technological complexity, ornaments and other forms of social display. Large, interconnected populations may retain more complex variation in information, and are more likely to pursue signs of social identity through social symboling than isolated or fragmented populations (Henrich, 2001, 2004; Shennan, 2001; Stiner and Kuhn, 2006; Kuhn and Stiner, 2007; Powell et al., 2009; Henrich, 2010; Sterelny, 2011; Kuhn, 2012; Collard et al., 2013; Derex et al., 2013; Stiner, 2014). Consequently, variation in population interconnectedness through time may help to explain the temporally patchy distribution of behavioural markers (Jacobs and Roberts, 2009).

In this paper we pose the following questions:

1. To what extent are late Pleistocene technological changes in southernmost Africa consistent with the spatio-temporal structure of environmental variation?
2. Is there evidence for the transmission of technological systems between populations?
3. Is the extent of population interconnection variable through the late Pleistocene?

In order to answer these questions, we synthesise data from the archaeological record of southernmost Africa through the period from 130 ka to 12 ka, focussing on patterns of occupation and technological systems in the region’s different climatic zones. Before this, however, we introduce the elements of technological variation relevant to the study and present methods for their analysis in terms of technological organisation and information transmission.

Components of technological variability and information transfer

Numerous schemes exist that divide the late Pleistocene archaeological record of southernmost Africa into a series of sequential units, variously termed cultures, industries or technocomplexes (Goodwin and van Riet Lowe, 1929; Sampson, 1974; Volman, 1980; Deacon, 1984b; Thackeray, 1989; Wadley, 1993; Wurz, 2002; Minichillo, 2005; Lombard et al., 2012). Currently prevalent schemes differentiate nine units in the study period: MSA1 2a (Klasies River unit), MSA 2b (Mossel Bay unit), Still Bay, Howiesons Poort, post-Howiesons Poort, late MSA, final MSA, early LSA1 and Robberg. A range of characteristics are used to distinguish these units, the most common being material selection (the types of rocks chosen for tools), flaking systems (the ways in which those rocks are flaked) and implement types (also referred to as ‘tools’ where these are defined as morphologically-regular retouched flakes). We examine each of these factors separately, with the addition of a fourth factor, provisioning systems, and suggest that they have different potential for information transfer relative to resource structure, allowing us to differentiate the processes underlying technological change. We also give consideration to the processes underlying the transfer of information between individuals and how these may reflect variability in population interconnectedness.

Components of technological variability

Provisioning systems Rock types do not necessarily occur when and where they are needed to perform tasks. For that reason, stone tool users deployed systems to ensure that adequate tools were always on hand when needed (Kelly, 1988). These are referred to as provisioning systems, and following Kuhn (1995) we differentiate two forms: place provisioning and individual provisioning. Place provisioning involves the transportation of stone to a selected point in space for the manufacture of artefacts (Parry and Kelly, 1987). Place provisioning is a viable system only where extended occupancy of a location can be anticipated, and is thus necessarily tied to resource predictability (Kuhn, 1995). This approach to technological organisation can be identified archaeologically by the accumulation of large assemblages of artefacts through the on-site reduction of transported stone blocks (commonly as cores) and the on-site production of implements (Riel-Salvatore and Barton, 2004).

Individual provisioning, on the other hand, involves the ongoing transport and maintenance of tools that are used to undertake many of the tasks foragers encounter. Heavy reliance on transported tools heightens the risk of tool failure, a risk that can be offset by expedient manufacture and use of implements often from locally-available rocks (Binford, 1979; Kuhn, 1995; Mackay, 2005). Individual provisioning is expected to be emphasised where the spatial and temporal distribution of resources is difficult to predict (Clarkson, 2004). Design constraints on transported tools emphasise portability and maintainability, constraints that are less relevant when place provisioning (Kelly, 1988; Nelson, 1991; Kuhn, 1994). Archaeologically, diminished assemblage size may result from individual provisioning, given a principal focus on implement maintenance and repair (Riel-Salvatore and Barton, 2004). Because the efficacy of different provisioning systems is strongly tied to the spatial and temporal configuration of subsistence resources, these systems cannot readily be transferred between populations in areas without underlying environmental similarities. That is, provisioning systems are always expected to be adaptive responses to local environmental conditions.

Material selection Material selection involves making choices about what rocks to use when making stone artefacts. Different rocks have different flaking characteristics, and thus not all rocks are equivalent with respect either to the kinds of artefacts that can easily be made (Eren et al., 2011a), or the extent to which (and economy with which) they can be used and reduced (Goodyear, 1989; Mackay, 2008a; Braun et al., 2009). Furthermore, different rocks have different distributions, with implications for acquisition costs. In many regions, fine-grained rocks are

1 MSA = Middle Stone Age.
2 LSA = Later Stone Age.
uncommon and their regular acquisition necessitates either a greater magnitude of movement or deliberate procurement effort (Ambrose and Lorenz, 1990; Minichillo, 2006; Mackay, 2008a; Mackay and Marwick, 2011; Porraz et al., 2013a). Most importantly, however, due to geological differences at regional scales, similar rocks are not always available in all areas. Some rock types are nearly ubiquitous but many others often have restricted distributions. A preference for the use of specific types of rocks in artefact manufacture thus has a geologically-restricted capacity to be transferred between groups.

Flaking systems The term ‘flaking systems’ as used here refers principally to the means by which cores were reduced. Flaking systems are a complex process coupling general strategies with contingent responses to the outcome of specific actions within the reduction chain (Bleed, 2001). Because of this complexity, and because of the large number and diverse means of reducing stone, flaking was probably in most cases a taught skill involving extended periods of information transfer from skilled workers to novices (Stout, 2002; Eren et al., 2011b; Tostevin, 2012; Hiscock, 2014). We follow Derex et al. (2012) in referring to such information transfer through detailed instruction as process copying, and note its benefits in terms of transmission fidelity when compared with learning from sighted examples of the outcome of a manufacturing process (see also Tehrani and Riede, 2008; Tehrani and Collard, 2009; Tennie et al., 2009; Sterelny, 2011). Assuming conditions akin to apprenticeship, information transfer through process copying implies a strong degree of interconnectedness between individuals (Tehrani and Collard, 2009; Mace and Jordan, 2011), and for this reason, similarities in flaking systems between different assemblages have been argued to reflect shared traditions between spatially separated groups (e.g., Petraglia et al., 2007; Clarkson, 2010; Rose et al., 2011).

Implement type Implements are morphologically regular retouched artefacts, commonly but not always made from flakes and blades. As with flaking systems, implement manufacture can be a complex process but is not necessarily so. Some implements such as backed artefacts are usually small and can be produced in batches for relatively little cost in time and material (Hiscock, 2006). Similarly, unifacial points, scrapers and denticulates all rely on unifacial retouch of a blank margin whereby most of the steps in production can be discerned from the implements themselves (Högberg and Larsson, 2011; Hiscock, 2014). In these cases, and unlike flaking systems, transfer of the artefacts alone could provide sufficient information for the method of their manufacture to spread. Following Derex et al. (2012), we refer to this means of learning as product copying (note also Tehrani and Collard, 2009; Mace and Jordan, 2011). There are obvious exceptions to this simplification. For example, bifacial points may have multiple stages in manufacture, which, coupled with the complexity of reduction and attendant high failure rates, would make them less easily transferred without extended instruction (Villa et al., 2009; Högberg and Larsson, 2011; Porraz et al., 2013a). Overall, however, the transfer of the design of simple, unifacial implements would theoretically have been achievable through product copying alone, without requiring extended periods of learning or a strong degree of interconnectedness between individuals or populations (Högberg and Larsson, 2011; Hiscock, 2014).

Characteristics of information transfer

We have highlighted ways in which information transfer may occur as a learning process and its relationship to population connectedness; here we briefly discuss information transfer as a
spatio-temporal process using insights from literature on the diffusion of innovations and cultural transmission (Hagerstrand, 1967; Morrill, 1970; Rogers, 1983; Boyd and Richerson, 1985; Bettinger and Eerkens, 1999; Eerkens and Lipo, 2007). The objective is to facilitate the identification of different processes in the archaeological record. We make four points of relevance to the issues at hand.

First, the diffusion of innovations through populations is likely to result in sigmoid-shaped uptake curves, with slow initial uptake followed by rapid increase through to saturation (Henrich, 2001). In the case of adoption of adaptively neutral characteristics, frequency may subsequently decline, resulting in a "battleship" curve that often (but not always) identifies a characteristic under drift (Nieman, 1995; though see Shennan and Wilkinson, 2001). Second, people in some areas will not be receptive to the uptake of new technologies, even when they are adaptively beneficial, resulting in zones of non-uptake (Rogers, 1983). Third, assuming a regular rate of information mutation through copying errors and misremembering (Eerkens and Lipo, 2005), and given that the number of individual information transfers increases with distance, we expect that the degree of information fidelity will decay with distance. Thus, at the furthest point from the origin of an innovation it should look most unlike its form at source. Finally, we expect greater variability of tool form and/or production processes in locations where innovations are either initially generated or adapted to local conditions rather than simply adopted (Boyd and Richerson, 1985; Bettinger and Eerkens, 1999).

Expectations

These various propositions allow us to generate some expectations relative to the questions posed in the Introduction.

1. Where technological changes are chiefly guided by environmental conditions we expect technologies to be more similar where environments are more similar, and to be more different where environments are more different.

2. Where technological systems are transferred between populations, maximum diversity of forms will occur at or near the source of an innovation. Where diffusing technologies are mostly neutral with respect to environments, similarities in technology will be a product of spatial proximity rather than environmental context (Jordan and Shennan, 2003). Consequently, technologies will become increasingly unlike their source form with distance from source. Where transferred technologies are environmentally-adaptive, their form will track environmental variation as per the previous point. Uptake of diffusing innovations will exhibit sigmoid-shaped curves, and where selectively neutral, their disappearance may result in battleship curves.

3. Where populations are strongly interconnected they will share similarities in flaking systems, implement form, and material selection within the constraints of the underlying geology. If underlying provisioning systems are similar, similarities in the predictability of subsistence resources are also implied. Weakly-connected populations may share similarities in implement form where implements are simple to copy, but other elements of the technological systems will differ. Disconnected populations will
not share characteristics, except where these can be explained by underlying environmental similarities (convergence).

**Spatial and chronological structure of data**

**Spatial structure**

In the analysis presented here, we discuss sites across southernmost Africa in terms of modern climate regions (Table 1, Fig. 1). Southern African climates are dominated by two primary atmospheric circulation systems: 1) frontal systems embedded in the westerly storm track to the south of the continent that bring rainfall to south-western Africa during the winter, and 2) tropical easterly flow, which brings moist air from the warm Indian Ocean to the subcontinent during the summer months (Tyson, 1986). These systems do not operate entirely independently of one another, and interactions between them bring significant moisture to southern Africa both throughout the annual cycle (Tyson, 1986) and perhaps as a result of large-scale reorganizations of circulation systems over multi-millennial timescales (Tyson, 1986; Chase, 2010). The relative annual influence of these systems can be considered in terms of the average annual precipitation during a given season. Chase and Meadows (2007) distinguish three broad units based on the percentage of precipitation received between the winter months of April–September. These are 1) the winter rainfall zone (WRZ; >66%), 2) the year-round rainfall zone (YRZ; 66–33%), and 3) the summer rainfall zone (SRZ; <33%). These rainfall zones presently support different biomes with grasslands and savanna communities more common in the SRZ, and shrubland, succulent and thicket communities common in the WRZ and YRZ (Mucina and Rutherford, 2006).

The extent of these rainfall zones and the climatic conditions within them have not remained constant over the time periods considered here (Chase and Meadows, 2007). With expansions of Antarctic sea-ice during periods of globally cooler conditions, the zone of westerly influence is believed to have expanded further north, resulting in an increase in the geographical extent of winter rains, and the duration and impact of its rainy season (Nicholson and Flohn, 1980; Chase and Meadows, 2007; Toggweiler and Russell, 2008; Chase, 2010; Mills et al., 2012; Stager et al., 2012; Chase et al., 2013; Truc et al., 2013). Summer rains in contrast are dependent on the formation of robust convection cells in the Indian Ocean. These cells result from high sea surface temperatures, and their formation is likely to have been impaired under generally cooler conditions (Nicholson and Flohn, 1980; Tyson and Preston-Whyte, 2000; Chase, 2010; Stager et al., 2012; Truc et al., 2013). Under many (but not all; Chase, 2010) circumstances it is predicted that a coeval inverse relationship existed between the winter and summer rainfall zones, with more humid conditions in one occurring when drier conditions existed in the other (Tyson, 1986; Cockcroft et al., 1987). As a transition zone, the modern YRZ would have probably fallen under the dominance of the intensifying climate region, and its rainfall regime would have evolved accordingly (Cockcroft et al., 1987).

While recognizing that the spatial extent of the region’s rainfall zones almost certainly shifted over the course of the time periods considered, insufficient evidence currently exists to reliably reconstruct the extent or nature of these variations, with some authors having proposed substantial shifts in tropical and temperate systems over the last glacial–interglacial cycle (van Zinderen Bakker, 1967; van Zinderen Bakker, 1976; Butzer et al., 1978; Cockcroft et al., 1987; Stuut et al., 2002), while others have suggested that only minor changes occurred (van Zinderen Bakker, 1983; Lee-Thorp and Beaumont, 1995; Sealy, 1996). In lieu of adequate evidence to reliably determine the past extent and timing of shifts in these rainfall zones, we employ the modern rainfall zones as a climatic framework for our study, but highlight that it is generally accepted (though see Bar-Matthews et al., 2010) that during relatively warm periods the SRZ is likely to have become wetter and more extensive (Cockcroft et al., 1987; Peeters et al., 2004; Chase and Meadows, 2007) and references therein; Caley et al., 2011; Dupont et al., 2011; Truc et al., 2013), while cooler periods are likely to have favoured the intensification and areal influence of winter rain systems (Cockcroft et al., 1987; Stuut et al., 2002; Peeters et al., 2004; Chase and Meadows, 2007 and references therein; Stager et al., 2012; Chase et al., 2013). Due to these differences in their underlying controls and in the vegetation communities they commonly support, the climate regions provide a framework against which to assess mechanisms of change. If technological changes are responsive to environmental variation then we would expect, considering the anti-phase relationship that

<table>
<thead>
<tr>
<th>Zone</th>
<th>Site</th>
<th>Dated?</th>
<th>Unit</th>
<th>Dominant material</th>
<th>Dominant flaking products</th>
<th>Dominant implements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Quartz</td>
<td>Blades</td>
<td>Points</td>
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<tr>
<td>WRZ</td>
<td>DK</td>
<td>Y</td>
<td>None</td>
<td></td>
<td></td>
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<tr>
<td>DRS</td>
<td>Y</td>
<td></td>
<td>MSA 2b</td>
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<tr>
<td>HRS</td>
<td>Y</td>
<td>None</td>
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<tr>
<td>HDP</td>
<td>N</td>
<td>None</td>
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<tr>
<td>KFR</td>
<td>N</td>
<td>MSA 2b</td>
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<tr>
<td>YFT</td>
<td>Y</td>
<td>None</td>
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<tr>
<td>YRZ</td>
<td>AXI</td>
<td>N</td>
<td>MSA 2b</td>
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<tr>
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<td>None</td>
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<tr>
<td>CSB</td>
<td>N</td>
<td>MSA 2b</td>
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<tr>
<td>KRM</td>
<td>Y</td>
<td>MSA 2a</td>
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<tr>
<td>KRM</td>
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<td>MSA 2b</td>
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<tr>
<td>NCB</td>
<td>Y</td>
<td>MSA 2a</td>
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<td>BBC</td>
<td>Y</td>
<td>None</td>
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<tr>
<td>SRZ</td>
<td>PP</td>
<td>Y</td>
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<tr>
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<tr>
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<td>None</td>
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</table>

Included are sites dated to MIS 5, assigned to MSA 2a or MSA 2b, and coastal sites, which would have been inundated during the MIS 5e high stand and which thus cannot antedate ~124 ka. Note that the data for provisioning systems in this period are sufficiently scarce that it is not included in the summary. Note also that the absence of a ‘check’ does not denote the absence of that material, flaking system or tool type, only that these are not considered among the dominant materials/systems/types by the assemblage analysts. The abbreviations (u) and (b) after the checks denote unifacial and bifacial points, respectively.
exists between the SRZ and WRZ, within-region systems to be more similar than between-region systems. When changes are mostly adaptively neutral with respect to environments, we should expect to see no such pattern.

**Chronological structure**

Recent years have seen dramatic improvements in dating southernmost Africa’s late Pleistocene archaeological record, but a robust chronological framework remains elusive. While the terminal Pleistocene falls within the range of radiocarbon,\(^3\) luminescence chronologies for the age range beyond 50 ka have been contested (Jacobs et al., 2008a; Tribolo et al., 2009, 2012; Guérin et al., 2013; Jacobs et al., 2013). Of particular note are two discordant chronologies for the important Winter Rainfall Zone site of Diepkloof (Jacobs et al., 2008a; Tribolo et al., 2012). While these chronologies overlap in layers younger than \(\sim 65\) ka, the discrepancy reaches \(\sim 50\%\) in the deeper part of the sequence, before becoming concordant again in the earlier MSA towards the sequence base. Necessarily, at least one of these chronologies is wrong. While Porraz et al. (2013b) provide an excellent interpretation of southernmost African technological change predicated on the Tribolo chronology, this paper assumes the greater accuracy of the Jacobs chronology (Jacobs et al., 2008a), which has the advantage of being replicated at multiple sites, including those proximate to Diepkloof (e.g., Högberg and Larsson, 2011).

In addition to site-specific problems, the large errors associated with luminescence age estimations make exploration of leads and lags in technological patterning problematic, if not impossible in many cases. Finally, while there have been concerted efforts to understand the timing of certain technological changes (most notably the appearance and disappearance of the Still Bay and Howiesons Poort units), the bulk of the later Pleistocene has received considerably less attention. The through-time distribution of ages is consequently uneven in ways that do not necessarily reflect occupational patterning. The basic temporal structure here follows the Marine Isotope Stage (MIS) system. While local environmental responses to global climatic variations remain here follows the Marine Isotope Stage (MIS) system. While local environmental responses to global climatic variations remain

![Figure 2. MIS 5 sites. MSA sites with chronometric ages (circles) or inferred occupation (squares) in MIS 5.](image)

**Results**

**MIS 5 (130–74 ka)**

We start by presenting the archaeological evidence from MIS 5 in terms of flaking systems, material selection and implement types. Data are currently insufficient at most sites to discuss provisioning systems in this period in any detail. Our results are summarised in Table 2. The prevailing scheme, which differentiates two units in this period, MSA 2a (Klasies River unit) and MSA 2b (Mossel Bay unit), is used as a baseline as the dating is weak in many cases. The older unit (MSA 2a) is distinguished by the production of long, standardised blades; the younger unit (MSA 2b) is distinguished by the production of large convergent flakes with blades being more irregular. Denticulates are common in MSA 2a and rare in MSA 2b, while infrequent unifacial and bifacial points occur in the latter (Volman, 1980). In both cases, quartzite is the dominant material and radial (here subsuming disc and discoidal) or Levallois reduction accounts for most core forms. Dates place the MSA 2a at between \(\sim 115\) and \(90\) ka and the MSA 2b between \(\sim 100\) and \(80\) ka (Wurz, 2002; Lombard et al., 2012).

The MSA 2a/2b scheme was originally designed to describe technological variation in the sequences at two Year-round Rainfall Zone (YRZ) sites: Klasies River and Nelson Bay Cave. Detailed consideration suggests that the scheme applies fairly weakly both within the YRZ and beyond, in the Winter- and Summer Rainfall Zones (WRZ, SRZ) (Fig. 2).

In the YRZ, the site of Blombos has flaking systems oriented towards the production of flakes rather than blades or convergents in its M3 unit, and as such matches neither MSA 2a nor 2b despite an age overlap with MSA 2b (Henshilwood et al., 2001b; Jacobs et al., 2013). Cape St Blaize has undifferentiated blades typical of MSA 2b but lacks the production of convergents (Thompson and Marean, 2008), while there is no clear separation of blade and convergent flake production in the extensive MIS 5 sequence documented by Thompson et al. (2010) at Pinnacle Point 13b. Of Die Kelders (DK), another south-coast YRZ site, Thackeray (2000: 164) states: “DK MSA artefacts are not comparable with the Klasies River Mouth MSA I [equivalent to MSA 2a] ... as the DK collections are not characterized by the long flake-blades typically associated with this stage. Also, quantities of short triangular convergent flake-blades like those found in the upper part of the MSA II at Klasies River Mouth (MSA 2b) were not found”.

In the WRZ, flaking systems at Ysterfontein (Halkett et al., 2003; Wurz, 2012) and Hoedjiespunt (Will et al., 2013) are directed towards the production of flakes, with few blades or convergents. At Hoedjiespunt, bipolar cores outnumber radial or Levallois cores. Klipfonteinrand matches the typical characteristics of MSA 2b with respect to flaking systems (Volman, 1980), however, recent re-excavation by one of us (AM) suggests some mixing in the deeper deposits. The site also has numerous denticulates (Fig. 3), which were not reported during Volman’s (1980) analysis. Only at Diepkloof has a (currently tentative) case been made for a WRZ expression of flaking systems consistent with MSA 2b (Porraz et al., 2013a). At Apollo 11, situated on the northern margins of the current WRZ-YRZ the production of large blades occurs in pre-MIS 4 levels though convergents are not noted to be a significant assemblage component (Vogelsang et al., 2010).

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\(^3\) All radiocarbon ages are presented as calibrated ages using the SHCal13 curve following Hogg et al. (2013).
Figure 3. Selected artefacts from MIS 5-aged archaeological deposits arranged by rainfall zone. 1–3: denticulates from Apollo II Cave (Vogelsang et al., 2010: Fig. 11); 4–6: denticulates from Varsche River 3 (Mackay’s images); 7–9: denticulates from Klipfonteinkrantz (Mackay’s images); 10–12: points from Diepkloof, ‘MSA-Mike’; 13–14: points from Diepkloof, ’Pre-Still Bay type Lynn’ (Porraz et al., 2013b: Figs. 4 and 5); 15: denticulate from Hoedjiespunt, level AH I; 16: point from Hoedjiespunt, level AH II; 17: denticulate from Hoedjiespunt, level AH III (Will et al., 2013: Figs. 4, 7 and 8); 18–20: denticulates from Ysterfontein (Halbert et al., 2003; courtesy R. Klein); 21–23: cores from Diepkloof, ‘MSA-Mike’ (Porraz et al., 2013b: Fig. 4); 25–26: cores from Hoedjiespunt levels AH II (25) and AH III (26) (Will et al., 2013: Figs. 5 and 8); 27–29: blades (27–28) and a point (29) from Pinnacle Point 13b (Thompson et al., 2010: Fig. 4); 30–33: points (30–31) and scrapers (32–33) from Nelson Bay Cave (Mitchell, 2002: Fig. 4.5; after Volman, 1980: Figs. 16, 17, 22, 23); 34–36: blades (34–35) and a point (36) from Klasies River, MSA I; 37: a point from Klasies River, MSA II (Wurz, 2002: Fig. 4); 38–39: cores from Pinnacle Point 13b (Thompson et al., 2010: Fig. 4); 40–41: cores from Klasies River, MSA I; 42: a core from Klasies River, MSA II (Wurz, 2002: Fig. 3); 43–50: points from Rose Cottage Cave, Malan excavation, pre-Hoëviesons Poort levels (Wadley and Harper, 1989: Fig. 5); 51–53: notched blades from Melkane (Stewart’s images); 54: a point from Sibudu (Wadley, 2012: Fig. 2); 55–61: points (55–57, 60–61), a blade (58) and a scraper (60) from Border Cave (Beaumont, 1978: Fig. 88).
The data covering MIS 5 flaking systems in the SRZ are presently quite weak, though Melikane presents an interesting example. The earliest layers at this site contain numerous regular, large blades, which are the defining feature of MSA 2a. However, the relevant layers date within the range of MSA 2b. Different researchers have assigned these layers to both MSA 2a and MSA 2b depending on whether the technologies or the ages are accorded preference, highlighting the problems inherent in these units (Lombard et al., 2012; Stewart et al., 2012).

Consistent with expectations, quartzite accounts for most artefacts at most YRZ-WRZ sites, including Klases River, Nelson Bay Cave, Cape St Blaize, Pinnacle Point, Peers Cave, Diepkloof and Klipfonteinrand. However, most of these sites are situated in geological contexts dominated by Table Mountain Sandstones where quartzite is usually the most abundant locally-available, flakeable rock. In coastal sites where quartzite is not available close to hand, knappers show no obvious preference for its acquisition, instead preferring quartz (Hoedjiespunt) or silcrete (Ysterfontein). As Thompson and Marean (2008) suggest, material selection in the region was probably more strongly influenced by local availability than by preference.

Material selection patterns are more difficult to gauge in the SRZ, where there appears to be little dramatic sequential change, possibly because fine-grained rocks are more often locally available than in the WRZ-YRZ (Wadley and Harper, 1989; Wadley, 2005, 2007; Soriano et al., 2009; Conard et al., 2012). Border Cave provides an exception, with fine-grained chaledony sourced from ~15 km, thus providing insights into the relative frequency of non-local rock use. Border Cave conforms to the pattern of highly local procurement in the earlier MSA, with the ISM layers having lower frequencies of non-local rocks than those above them.

While variability in flaking systems and highly localised patterns of rock procurement seem characteristic of most sites across southernmost Africa in MIS 5, there are also spatial patterns in implement type that appear to track climate regions (Table 2, Fig. 3). Notably, most WRZ-YRZ sites are linked in at least some period of their MIS 5 occupation by the occurrence of denticulates. This does not seem to hold for the SRZ. While many SRZ sites remain undated beyond MIS 4 (if at all), in dated instances at Border Cave, Rose Cottage Cave and Sibudu, denticulates are outnumbered by bifacial and/or unifacial points in late MIS 5 (Pienaar et al., 2008; Wadley, 2012). At Border Cave bifacial point manufacture plausibly begins in MIS 6 and extends through MIS 5 to MIS 4 (Beaumont, 1978; Grün and Beaumont, 2001). Bifacial and unifacial points are also characteristic of the undated, earlier MSA layers at Bushman Rock Shelter, Cave of Hearths, Mwulu's Cave and Olifboompoort (Tobias, 1949; Elloff, 1969; Louw, 1969; Beaumont, 1978; Volman, 1980; Mason and Brain, 1988). Points are not characteristic of all MIS 5 SRZ assemblages, however; such implements appear to be persistently absent in the higher elevation sites of Lesotho (Jacobs et al., 2008a; Stewart et al., 2012).

Table 3
Summary of results from MIS 4, using only dated sites with detailed assemblage descriptions.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Site</th>
<th>Age range (unit)</th>
<th>Provisioning</th>
<th>Dominant material</th>
<th>Dominant flaking products</th>
<th>Dominant implements</th>
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</thead>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>DRS</td>
<td>75–70 ka</td>
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<td>Quartzite</td>
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<td>None</td>
</tr>
<tr>
<td></td>
<td>HRS</td>
<td></td>
<td>Individual</td>
<td>Silcrete</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>YRZ</td>
<td></td>
<td>n/d</td>
<td>Other</td>
<td>Flakes</td>
<td>Backed</td>
</tr>
<tr>
<td></td>
<td>AXI</td>
<td></td>
<td>Individual</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>SRZ</td>
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</tr>
<tr>
<td></td>
<td>RCC</td>
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<td>Individual</td>
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<tr>
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<td>n/d</td>
<td>Silcrete</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>AXI</td>
<td></td>
<td>Place</td>
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<td></td>
<td>Place</td>
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<td></td>
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</tbody>
</table>

The abbreviations (u) and (b) after the checks denote unifacial and bifacial points, respectively. There is likely some inconsistency in typological assessment which affects the summary. For example, unifacial points and convergent scrapers may be conflated or differentiated by different analysts.

4 In many parts of southernmost Africa, sources of stone used in artefact manufacture are difficult to isolate, particularly where these occur as outcrops of variable quality at variable distances from sites (e.g., quartzites around Apollo 11) or as gravels in fluvial systems (e.g., opalines in the Maloti-Drakensberg). Identifying behavioural patterns through material selection works best where isolated point-sources of stone (e.g., silcrete outcrops) show variable prevalence through space and time.

MIS 4 (74–58 ka)

Like MIS 5, two sequential units are generally identified in MIS 4: the Still Bay and the Howiesons Poort (Table 3). The former is identified by the presence of bifacial points, and the latter by the production of backed artefacts and small blades from unipolar prepared cores. Available dates generally place the Still Bay from ~75 to 70 ka and the Howiesons Poort from ~65 to 58 ka (Jacobs et al., 2008a; though see; Tribolo et al., 2012).

While dated, stratified Still Bay sites remain few, the starting ages are similar in the Winter (WRZ), the Year-round (YRZ) and the Summer Rainfall Zones (SRZ) with some SRZ examples extending into MIS 5 as noted above. Still Bay technologies do not appear at high elevations in the Maloti-Drakensberg areas of the SRZ (Stewart et al., 2012), and dated occurrences currently available thus form a rough arc around the southern perimeter of South Africa, broadly tracking the plains coastward of the Cape Fold Belt (Fig. 4).

The production of flakes from radial cores provides the most common flaking system in most dated Still Bay assemblages, with
Apollo 11 in the YRZ perhaps the exception (Vogelsang et al., 2010). Apollo 11 is also characterised by large blades in this period, which other Still Bay assemblages generally lack. More typical of Still Bay assemblages across southernmost Africa is the small number of cores (Henshilwood et al., 2001b; Wadley, 2007; Mackay, 2009; Porraz et al., 2013a). This contrasts with both earlier and later assemblages at the same sites and implies a difference in technological organisation, perhaps one more closely focussed on individual provisioning given the maintainable design of the dominant implements (Kelly, 1988; Mackay, 2009; McCcall and Thomas, 2012).

Material acquisition in the Still Bay differs from that in preceding occupations at most WRZ sites but perhaps not as clearly at sites in the YRZ and SRZ. At Hollow Rock Shelter and Diepkloof in the WRZ, the proportion of non-local rocks increases dramatically into the YRZ and SRZ. At Hollow Rock Shelter, but occupation there appears to cease at the peak of bifacial point frequency (Evans, 1994). Though the requisite data are as yet unavailable for Sibudu, it can be inferred that a more complex pattern pertains than at the WRZ examples cited here (Wadley, 2012).

The termination of bifacial point production appears broadly synchronous at most sites at ~70 ka (Jacobs et al., 2008a). In many cases, this heralds the start of a period of non-occupation (Minichillo, 2005; Jacobs et al., 2008a; Vogelsang et al., 2010) (Fig. 6). Recently, however, Brown et al. (2012) have presented evidence for backed artefact production at the YRZ site of Pinnacle Point 5/6 extending back to 71 ka. Though they are reluctant to classify these assemblages as Howiesons Poort, they argue for continuity in implement type and form through to 61 ka.

Of further interest here is Diepkloof in the WRZ, which includes both Still Bay and Howiesons Poort layers (Rigaud et al., 2006; Porraz et al., 2013a). Jacobs et al. (2008a) suggest a gap between the Still Bay and Howiesons Poort at Diepkloof of ~6 kyr (thousand years) based on upper ages for the former at ~71 ka and lower ages for the latter of ~65 ka. However, the upper Still Bay-assigned age of 70.9 ± 2.3 ka derives from layer Kerry, which although it contains bifacial points is better characterised by the production of small blades, pièces esquillées, and backed artefacts (Mackay, 2009). The backed artefacts here include at least two classic crescentic forms (Mackay, 2009), generally considered typical of the Howiesons Poort (Thackeray, 1992; Wurz, 2002). Porraz et al. (2013a), and classify Kerry and the layers above it as ‘early Howiesons Poort’.

Given that backed artefacts are present from Kerry at ~71 ka through to layers dated ~61.8 ka (Mackay, 2009; Porraz et al., 2013a), the duration of the backed artefact sequence at Diepkloof would seem strongly similar to that at Pinnacle Point 5/6. The repeated occurrence of backed artefacts in the latest bifacial point-bearing layers further implies that the Howiesons Poort at Diepkloof was foreshadowed by, if not rooted in, the Still Bay at that site. This is consistent with the fact that the 71–65 ka layers at Diepkloof also witness the first sustained appearance of blade and bladelet production in the sequence. In general, core reduction is unidirectional with exploitation of a single surface in a manner similar to that documented in the Howiesons Poort at Klasies River (YRZ) (Villa et al., 2010; Porraz et al., 2013a). Porraz et al. (2013b) suggest that, aside from some changes in blade size, the basic rules guiding flaking systems after 71 ka persist through to the end of the Howiesons Poort around 60 ka. Similar systems also appear at the site of Rose Cottage Cave in the SRZ, though these appear to have been adapted to the form and small size of local opaline numbers of bifacial points from dated and undated contexts (Minichillo, 2005; Villa et al., 2009; Mackay et al., 2010; Höögberg and Larsson, 2011). At the maximum distance from Umhlatuzana, Vogelsang et al. (2010) have questioned on morphological grounds whether the points from Apollo 11 should be considered ‘Still Bay’, though the assemblage dates are coherent with those elsewhere. Unifacial points are more common than bifacial points in the Apollo 11 sample, something which is also atypical for a Still Bay assemblage. Vogelsang et al. (2010) also note basal end scrapers at Apollo 11 in this period, something which they suggest to be typical of the Namibian Still Bay (cf. Vogelsang, 1998), but which seem to be absent elsewhere.

Assessing the diachronic distribution of bifacial pieces within sites is complicated by a tendency to present sequence data as culture historic units, which obscures within-unit trends (Mitchell, 1994; Mackay, 2008a, in press). These data are available for some sites, however. At Diepkloof, bifacial pieces exhibit a sigmoid-shaped increase in frequency followed by a comparable decline, resulting in a battleship curve (Mackay, 2009; Porraz et al., 2013a). A sigmoid uptake curve also describes the pattern at Hollow Rock Shelter, but occupation there appears to cease at the peak of bifacial point frequency (Evans, 1994). Though the requisite data are as yet unavailable for Sibudu, it can be inferred that a more complex pattern pertains than at the WRZ examples cited here (Wadley, 2012).

Figure 4. Early MIS 4 sites. Bifacial point-bearing ‘Still Bay’ sites with chronometric ages for occupation layers ~74–70 ka (circles); undated bifacial point-bearing MSA sites (squares).
Figure 5. Selected artefacts from early to mid MIS 4-aged archaeological deposits arranged by rainfall zone. 1–8: points from Apollo 11, Still Bay levels (Vogelsang et al., 2010: Fig. 10); 9–11: points from Hollow Rock Shelter, Still Bay levels (Mackay’s images); 12–15: points from Diepkloof, ‘Still Bay type Larry’; 16–20: backed artifacts from Diepkloof, ‘Early Howiesons Poort’, including two crescentic pieces (19 and 20); 21–23: points from Diepkloof, ‘Early Howiesons Poort’ (Porraz et al., 2013b; Figs. 6 and 7; Mackay, 2009: Plate 8.3); 24–33: points from Blombos, Still Bay levels (Villa et al., 2005; Fig. 1; Henshilwood, 2012: Fig. 3); 34–40: backed artefacts from Pinnacle Point 5/6 (Brown et al., 2012, Fig. 3); 41–45: points from Sibudu, Still Bay levels (Wadley, 2007: Figs. 4 and 5); 46–49: serrated points from Umhlatuzana, Still Bay levels (Lombard et al., 2010: Fig. 3).
The backed pieces at Klasies River (YRZ) are suggested to have been made almost exclusively on blades, while those at Diepkloof and Klein Kliphuis (WRZ) appear to make more use of flake blanks (Wurz, 1997; Mackay, 2008b; Porraz et al., 2013a). This patterning is matched by Clarkson’s (2010) analysis of core forms, which groups Diepkloof and Klein Kliphuis but differentiates them from Klasies River. Backed artefacts are generally produced on blades at Rose Cottage Cave in the SRZ (Soriano et al., 2007), but at Melikane the abundant blades and bladelets are rarely backed (Stewart et al., 2012). Further spatial patterning has been noted in the prevalence of notched or strangulated blades, which are components of the Howiesons Poort at WRZ-YRZ sites including Diepkloof, Klasies River, Klein Kliphuis, Nelson Bay Cave, and Pinnacle Point, but not of SRZ Howiesons Poort assemblages at Rose Cottage Cave, Sibudu or Umhlatuzana (Porraz et al., 2013a). In contrast, bifacial points are noted in the later Howiesons Poort at Sibudu (de la Pena et al., 2013) and possibly also at Umhlatuzana and Rose Cottage Cave (Wadley and Harper, 1989; Kaplan, 1990), but not at Diepkloof, Klasies River, Klein Kliphuis or Nelson Bay Cave (de la Pena et al., 2013).

Despite these differences, there are broad inter-regional consistencies in:

1. The basic form of implements (backed pieces including crescentic morphologies);
2. The production of small blades using similar flaking systems (Soriano et al., 2007; Villa et al., 2010; Porraz et al., 2013a);
3. Assemblage sizes either proportionally very large (total numbers of artefacts) or very dense (numbers of artefacts per unit volume) relative to other industries (cf. Mackay, 2010);
4. The on-site reduction of cores and production of implements.

Data on the diachronic distribution of backed pieces within the Howiesons Poort are available for some sites. Battleship curves can be observed in backed artefact frequencies in the SRZ sites of Border Cave and Rose Cottage Cave (Beaumont, 1978; Wadley and Harper, 1989). Patterns appear more complex in the WRZ-YRZ at Diepkloof, Klein Kliphuis and possibly Klasies River, with periods of increase, decrease, increase and rapid disappearance (Singer and Wymer, 1982; Mackay, 2010; Porraz et al., 2013a).

The increase in assemblage sizes, coupled with widespread evidence for on-site core reduction and implement production, is consistent with an increased emphasis on place provisioning (Mackay, 2009; McCall and Thomas, 2012; Porraz et al., 2013a). While faunal assemblages differ between sites (Faith, 2013), consistency in provisioning only implies consistency in the predictability of subsistence conditions rather than in the specifics of the resources harvested. There may be attendant implications for greater logistical organisation in movements at this time, and concomitant extended durations of site occupation (Mackay, 2009; McCall and Thomas, 2012). This matches micromorphological evidence at sites where such studies have been undertaken (Goldberg et al., 2009; Miller et al., 2013). Similar systems of provisioning thus appear to pertain across different climate regions in late MIS 4.
Figure 8. Selected artefacts from late MIS 4-aged archaeological deposits arranged by rainfall zone. 1–10: backed artefacts (1–7) and blades (8–10) from Apollo 11, Howiesons Poort levels (Vogelsang et al., 2010: Fig. 9); 11–15: backed artefacts from Varsche River 3, Howiesons Poort levels; 16: backed artefact from Putslaagte 8, Howiesons Poort levels (Mackay’s images); 17–19: backed artefacts from Klein Kliphuis, Howiesons Poort levels (Mackay’s images); 20–25: backed artefacts (20–22) and blades (23–25) from Diepkloof, ‘Intermediate Howiesons Poort’ (Porraz et al., 2013b: Fig. 9); 26–29: backed artefacts from Diepkloof, ‘Late Howiesons Poort’ (Porraz et al., 2013b: Fig. 10); 30–35 cores from Klein Kliphuis, Howiesons Poort levels (Mackay’s images); 36–38: cores from Diepkloof, ‘Intermediate Howiesons Poort’; (Porraz et al., 2013: Fig. 9); 39–41: cores from Diepkloof, ‘Late Howiesons Poort’ (Porraz et al., 2013b: Fig. 10); 42–48: backed artefacts from Nelson Bay Cave, Howiesons Poort levels (Mitchell, 2002: Fig. 4.6; after Volman, 1980; Figs. 27, 28, 30, 32); 49–56: backed artefacts (49–53) and blades (54–56) from Klasies River, Howiesons Poort levels (Villa et al., 2010: Fig. 7; Wurz, 2002: Fig. 5); 57–60: cores from Klasies River, Howiesons Poort levels (Villa et al., 2010: Fig. 15; Wurz, 2002: Fig. 3); 61–69: backed artefacts from Rose Cottage Cave, Howiesons Poort levels (Soriano et al., 2007: Fig. 15); 70–76: backed artefacts from Sibudu, Howiesons Poort levels (Lombard and Parfitt, 2008: Fig. 6; Lombard and Philippe, 2010: Fig. 4; Wadley, 2008: Fig. 4); 77–81: backed artefacts from Umhlaluzana, Howiesons Poort spits (Kaplan, 1990: Fig. 14); 82–89: backed artefacts (82–86) and blades (87–89) from Border Cave, Howiesons Poort levels (Beaumont, 1978: Fig. 88); 90–95: cores from Sibudu, Howiesons Poort levels (Soriano et al., 2007: Fig. 8).
Porraz et al., 2013a). In WRZ and YRZ sites the prevalence of sites in the Winter (WRZ), Year-round (YRZ) and Summer Rainfall (SRZ) zones has been described as gradual at Bay Cave, occupation directly after the Howiesons Poort ceases from the post-Howiesons Poort MSA levels at sites towards the northern limits of the modern WRZ (Vogelsang et al., 2010; Dewar and Stewart, 2012; Steele et al., 2012). At other WRZ-YRZ sites, such as Sibudu, the site has a deep Middle Stone Age (MSA) component at the site. As with MIS 5, Die Kelders appears not to match the typical characteristics of other regional sites in MIS 4.

**MIS 3 (58–24 ka)**

Lithic assemblages in MIS 3 are notably more heterogeneous than those in MIS 4 (Volman, 1980; Mitchell, 2008; Conard et al., 2012), with post-Howiesons Poort, late MSA, final MSA and early LSA units noted at various sites (Table 4). The post-Howiesons Poort industry immediately follows the Howiesons Poort industry both temporally and stratigraphically at numerous sites. The change is marked by the disappearance or frequency decline in backed artefacts and their replacement by unifacial points and scrapers. The emphasis on blade production decreases and flakes tend to be wider and thicker. These changes have been described as gradual at sites in the Winter (WRZ), Year-round (YRZ) and Summer Rainfall Zones (SRZ) (Soriano et al., 2007; Villa et al., 2010; Mackay, 2011; Porraz et al., 2013a). In WRZ and YRZ sites the prevalence of fine-grained rock also declines, something not noted in SRZ sites for reasons discussed above. As with the Still Bay and Howiesons Poort, the defining characteristics of the post-Howiesons Poort can be recognised in sites across all climate regions (Figs. 9 and 10).

While consistencies in early MIS 3 assemblages are numerous and widespread, there is spatial patterning to the occurrence of counter-examples. For example, typical unifacial points are absent from the post-Howiesons Poort MSA levels at sites towards the northern limits of the modern WRZ (Vogelsang et al., 2010; Dewar and Stewart, 2012; Steele et al., 2012). At other WRZ-YRZ sites, including Boomplaas, Klipfonteinrand, Montagu Cave and Nelson Bay Cave, occupation directly after the Howiesons Poort ceases altogether (Volman, 1980). Where occupation does persist in the WRZ-YRZ, assemblage size generally decreases dramatically (Singer and Wymer, 1982; Mackay, 2009, 2010; Porraz et al., 2013a).

In the SRZ, by contrast, few sites seem to be abandoned at the end of the Howiesons Poort and several appear to have been occupied for the first time, including Driekoppen, Holley Shelter, Sehonhong, Sibebe and Siphiso (Cramb, 1952, 1961; Davies, 1975; Price-Williams, 1981; Wallsmith, 1990; Jacobs et al., 2008a). The decrease in artefact numbers also appears more muted in the SRZ than in the WRZ. Indeed, the post-Howiesons Poort at Sibudu is notably rich, comprising 28 layers that span some 0.85 m (Jacobs et al., 2008a) and prompting Conard et al. (2012: 181) to describe the site as having been occupied “intensely” in this period (note also Goldberg et al., 2009; Wadley et al., 2011). This contrasts with sites such as Diepkloof, Klasies River and Klein Kliphuis in the WRZ, where Howiesons Poort deposits are far more extensive than those

Figure 9. Early MIS 3 sites. Unifacial point-bearing ‘post-Howiesons Poort’ sites with chronometric ages for occupation layers – 60–50 ka (circles); dated and undated post-Howiesons Poort assemblages with few or no unifacial points (triangles); undated unifacial point-bearing post-Howiesons Poort occurrences (squares).

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**Table 4**

Summary of results from MIS 3, using only dated sites with detailed assemblage descriptions.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Site</th>
<th>Age range</th>
<th>Provisioning</th>
<th>Dominant material</th>
<th>Dominating flaking products</th>
<th>Dominant implements</th>
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<tbody>
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<td>WRZ</td>
<td>DRS</td>
<td>60–50 ka</td>
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<td>None</td>
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<td>n/d</td>
<td>Opaline</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>SC</td>
<td>n/d</td>
<td>Opaline</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>UMH</td>
<td>Place?</td>
<td>Hornfels</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>YRZ</td>
<td>AXI</td>
<td>~ 31 ka</td>
<td>Individual?</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>(Final MSA, early LSA)</td>
<td>n/d</td>
<td>Hornfels</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

The abbreviations (u) and (b) after the checks denote unifacial and bifacial points, respectively.

Before concluding this section, the site of Die Kelders requires specific discussion. The site has a deep Middle Stone Age (MSA) sequence with ages suggesting that some or much of it accumulated in MIS 4 (Feathers and Bush, 2000; Schwarcz and Rink, 2000). The site also has a spike in silcrete towards the top of the deposit suggestive of a YRZ Howiesons Poort component. Yet, in contrast to sites ascribed to the Howiesons Poort in this period, the layers with high silcrete percentages in all samples tend to have lower frequencies of artefacts (Thackeray, 2000). Furthermore, while two backed artefacts were found, Thackeray (2000: 164) describes them as “idiosyncratic” and not representative of a Howiesons Poort component at the site. As with MIS 5, Die Kelders appears not to match the typical characteristics of other regional sites in MIS 4.
Figure 10. Selected artefacts from early MIS 3-aged archaeological deposits arranged by rainfall zone. 1–9: points from Klein Kliphuis, post-Howiesons Poort levels (Mackay's images); 10–15: points (10–13), a retouched backed artifact (14) and a blade (15) from Dieplkloof, 'post-Howiesons Poort type Claude' (Porraz et al., 2013b: Fig. 11); 16–19: cores from Klein Kliphuis, post-Howiesons Poort levels (Mackay's images); a core from Dieplkloof, 'post-Howiesons Poort type Claude' (Porraz et al., 2013b: Fig. 11); 21–29: convergent flakes/points (21–23), scrapers (24–27), and cores (28–29) from Klasies River, MSA III levels (Villa et al., 2010: Figs. 21 and 22); 30–32: points from Rose Cottage Cave, post-Howiesons Poort levels (Soriano et al., 2007: Fig. 6); 33–40: points from Ntloana Tsoana, post-Howiesons Poort levels (Mitchell and Steinberg, 1992: Fig. 7); 41–46: points from Sibudu, post-Howiesons Poort levels (Conard et al., 2012: Figs. 7 and 11); 47–53 points from Sibudu, Late MSA levels (Villa et al., 2005: Fig. 10; Villa and Lenoir, 2006: Fig. 7); 54–64: points from Holley Shelter, ‘Lower Strata’ (Cramp, 1961:46); 65–68: cores from Rose Cottage Cave, post-Howiesons Poort levels (Soriano et al., 2007: Fig. 13); 69–73: cores from Ntloana Tsoana, post-Howiesons Poort levels (Mitchell and Steinberg, 1992: Fig. 4); 74–77: cores from Sibudu, post-Howiesons Poort levels (Conard et al., 2012: Fig. 4); 78–86: cores from Sibudu, Late MSA levels (Villa et al., 2005: Figs. 6 and 8).
in the post-Howiesons Poort, the latter presumably reflecting an attenuated occupational signal (Singer and Wymer, 1982; Mackay, 2010; Miller et al., 2013; Porraz et al., 2013b). While Mackay (2009) has argued for an eventual return to individual provision-

ergising the post-Howiesons Poort at Klein Kliphuis, the intensive occupation at Sibudu suggests this may not be a widespread component of technological/settlement organisation.

After 50 ka, the cessation of occupation encompasses rock shelter sites across the WRZ-YRZ (Fig. 11). Few if any sites in these regions have robust ages in the range from 50 to 25 ka, and where these do occur assemblage sizes are small and difficult to characterise (Mackay, 2009, 2010; Jacobs, 2010; Thompson et al., 2010; Höberg and Larsson, 2011). Klein et al. (2004) have suggested potential abandonment of the region at this time (though note Mitchell, 2008). Apollo 11 and Boomplaas on the fringes of the modern WRZ-YRZ are presently the only two sites in the region to have produced convincing, finite radiocarbon ages for sizable assemblages between 50 and 25 ka (Wendt, 1976; Deacon, 1979; Vogelsang et al., 2010). This stands in marked contrast to the SRZ, where robust occupation is documented at numerous sites between 50 and 25 ka (Carter and Vogel, 1974; Opperman, 1987; Kaplan, 1990; Wallsmith, 1990; Wadley, 1993; Opperman, 1996; Wadley and Jacobs, 2004; Tribolo et al., 2005; Pienaar et al., 2008; Jacobs et al., 2008a,b; Mitchell and Arthur, 2010; Stewart et al., 2012). Unfortunately, in many cases the relevant assemblages remain poorly described, making it difficult to assess inter-site patterning in technological systems.

Defining characteristics are provided for a distinct final MSA industry dating around 39 ka at Sibudu (Wadley, 2005; Jacobs et al., 2008b) (Fig. 11). Points (both bifacial and unifacial) are common and a distinctive morphology (hollow based points) appears (Fig. 12). Such implements are also present in comparably-aged deposits at nearby Umlhlatuzana (Kaplan, 1990; Mohapi, 2013). Presently this morphology is specific to these two sites, though a decontextualized example has been reported from Kleinmonde at the southern edge of the SRZ (Clark, 1959). Wadley (2005) notes the paucity of cores in the ~39 ka assemblages at Sibudu, with those that are present typically bipolar. In this respect, Sibudu contrasts with Umlhlatuzana, where cores are well represented and platform cores are more common than bipolar cores (though these are also prevalent). The highland SRZ sites of Melikane and Ha Soloja have broadly similar aged-deposits to Sibudu and Umlhlatuzana, though as seems typical of Lesotho sites, points are absent and instead blade-based reduction with little retouch defines these assemblages (Carter and Vogel, 1974; Stewart et al., 2012).

A subsequent pulse of occupation associated with final MSA technology centres on ~31 ka. This is represented at Rose Cottage Cave, Sehonghong and Strathalan B (Opperman, 1996; Clark, 1999; Jacobs et al., 2008a), all situated quite close together in the SRZ, as well as Apollo 11 on the northern YRZ margin (Wendt, 1976; Deacon, 1979) (Fig. 11). While little detail is available for the Apollo 11 assemblage, there is evidence for similarities in technological systems between SRZ sites. Retouched points occur at Rose Cottage Cave, but these are not typical of the retouched component, which is dominated by straight sided scrapers or ‘knives’ (Clark, 1999) (Fig. 12). Cores are common and feature a mix of rotated and bipolar techniques, while bladelets and flakes are both present. Sehonghong exhibits very similar technological characteristics in this period, though cores are mostly irregular and flat, and retouched flakes uncommon (Carter, 1978; Carter et al., 1988). At Strathalan B, the hornfels-dominated assemblage contains scrapers with similar morphologies to those at Rose Cottage Cave and Sehonghong (Opperman, 1987). The ~32–35 ka component at Umlhlatuzana but the extent to which this can be understood as a coherent assemblage or the product of mixing is unclear, given stratigraphic problems with the site and the fact that artefacts similar to those in the subsequent MIS 2 Robberg unit are found in this latest MSA at the site.

Umlhlatuzana notwithstanding, MSA artefacts occur in this pulse at several sites, with MSA flake forms suggested to persist at Strathalan B through to ~24 ka. In contrast, LSA technologies are found in SRZ sites north of 27°S from >30 ka (Fig. 11). At Border Cave, dates of ~40 ka have been presented for the appearance of the LSA, based on the presence of organic artefacts taken to be typical of modern San material culture, including poisons, bone points and ostrich eggshell beads (d’Errico et al., 2012b). Organic preservation at Border Cave is exceptional, however, and consequently using these organic finds to define the technology of the period presents problems. The 40 ka lithic technology at Border Cave seems best characterised in terms of the bipolar reduction of quartz pebbles with the production of few implements; something shared with Cave James, Heuningneskran, Jubilee Shelter and Kathu Pan, which have all been claimed as examples of LSA assemblages antedating 30 ka, though the dating remains weak (Wadley, 1993). Melikane is presently the only SRZ site beyond this cluster with potentially LSA-aligned technologies from ~40 ka (Stewart et al., in Press).

MIS 2 (24–12 ka)

MIS 2 includes two sequential units, a poorly-defined early LSA and the subsequent Robberg industry, and is marked by the re-emergence of occupation across the Winter (WRZ) and Year-round (YRZ) Rainfall Zones. Like-aged deposits also occur across the SRZ (Davies, 1975; Deacon, 1979, 1982; Kaplan, 1990; Manhire, 1993; Wadley, 1993; Mitchell, 1995; Orton, 2006; Mackay, 2010; Vogelsang et al., 2010; Orton et al., 2011; Dewar and Steward, 2012) (Fig. 13). All assemblages in all climate regions are classified as LSA from the start of MIS 2, reflecting the disappearance of radial and Levallois techniques throughout southernmost Africa (Table 5). Beyond this similarity, the earliest technologies in this period do exhibit some spatial patterning. Flaking systems emphasise bladelet production with some additional use of bipolar technique in early LSA assemblages ~22 ka at the SRZ sites of Sehonghong (Mitchell, 1995) and Rose Cottage Cave (Clark, 1959).
At Melikane, located only 24 km from Sehonghong (40 km following the Senqu River Valley), early MIS 2 sees bladelet production phased out in favour of extremely heavy bipolar reduction. At Kathu Pan and Shongweni, early LSA assemblages are small and appear difficult otherwise to characterise (Wadley, 1993). In the WRZ-YRZ at Elands Bay Cave and Boomplaas, assemblages dating to the early LSA tend to be bladelet-poor, with a more marked emphasis on bipolar reduction (Deacon, 1982; Orton, 2006).

Figure 12. Selected artifacts from late MIS 3-aged archaeological deposits in the Summer Rainfall Zone (SRZ). 1–5: hollow-based (1–2), bifacial (3) and unifacial (4–5) points from Sibudu, final MSA levels (Villa and Lenoir, 2006: Fig. 6); 6–12: unifacial points from Umhlutuzana, final MSA spits 23–19 (Mohapi, 2013: Figs. 5a and 5b); 13–19: hollow-based (13–17) and unifacial (18–19) points from Umhlutuzana, final MSA spits 18–16 (Mohapi, 2013: Figs. 4a and 4b); 20: a hollow-based point from Kleinmonde (Clark, 1959: Fig. 32); 21–30: bladelets from Melikane, final MSA levels (Stewart’s images); 31–34: bipolar cores from Melikane, final MSA levels (Stewart’s images); 35–40: bipolar cores (35–37), a backed artifact (38) and bladelets (39–40) from Border Cave, Early Later Stone Age levels (Breammont, 1978: Fig. 8); 41–44: scrapers including two ‘knives’ (41–42) from Sehonghong, MSA/LSA transitional levels (Mitchell, 2002: Fig. 5.3); 45–48: ‘knives’ (45–47) and a point (48) from Strathalan B, terminal MSA level (Floor VIIb) (Opperman, 1996: Fig. 8); 49–60: ‘knives’ from Rose Cottage Cave, MSA/LSA transitional levels (Clark, 1999: Fig. 6); 61–65: cores from Sehonghong, MSA/LSA transitional levels (Carter et al., 1988: Fig. 4.30).
With respect to timing, while terminal dates for the Robberg are as late as 12–13 ka at Ravenscraig, Rose Cottage Cave, Sehonghong, Siphiso and Umhlatuzana in the SRZ (Kaplan, 1990; Wadley, 1993; Mitchell, 1995), alternative non-microlithic industries seem to be in place in some WRZ and YRZ sites by 14 ka (Manhire, 1993; Orton, 2006). Mitchell et al. (1998) have previously noted that asynchronous technological and occupational responses characterised patterns between vegetation biomes at the Pleistocene/Holocene boundary, a pattern accounted for by the different controls on rainfall regimes.

**Discussion**

Despite the uneven data, there are clear patterns in the late Pleistocene archaeological sequence of southernmost Africa (Table 6). In MIS 5, heterogeneity in flaking systems seems to characterise assemblages, while material selection is generally highly responsive to local availability. To that extent, broadly-applied schemes such as MSA 2a/2b appear to have limited value. However, there are climate region consistencies that distinguish the WRZ-YRZ from the SRZ: denticulates are common to sites in the former while points of various types are typical of those in the latter, particularly in dated assemblages. Assuming that unifacially-retouched implement types transfer more easily than flaking techniques, and given the prevalence of local-scale stone procurement and within-climate region heterogeneity in core reduction and flake production in MIS 5, these patterns most plausibly reflect information transfer between loosely interacting groups whose technological systems were strongly locally-adapted. The evidence for this is currently clearest for sites in the WRZ-YRZ. This interpretation assumes some degree of contemporaneity of assemblage formation in these climate regions. If, alternatively, we assume that the observed differences arise from different periods of assemblage formation, this in turn implies asynchronous occupation of the SRZ and WRZ-YRZ regions in MIS 5. Where dating allows consideration of this possibility it is non-supportive; sites with similar ages in the SRZ and YRZ have different technologies.

In either case, the weakness of denticulates as a spatio-temporal marker (e.g., Steele et al., 2012; Wurz, 2012) is probably overstated. While they may not be discrete markers to the same extent as hollow-based points or backed crescents, denticulates in concert with a paucity of other retouch types appear to characterise WRZ-YRZ sites antedating MIS 4. With perhaps minor exceptions they do not recur in large numbers in later periods, and the extent that they

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**Table 5**

Summary of results from MIS 2, using only dated sites with detailed assemblage descriptions.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Site</th>
<th>Age range</th>
<th>Dominant material</th>
<th>Dominant flaking products</th>
<th>Dominant implements</th>
</tr>
</thead>
<tbody>
<tr>
<td>WRZ</td>
<td>EBC</td>
<td>22–24 ka</td>
<td>Quartz</td>
<td>Flakes</td>
<td>Backed</td>
</tr>
<tr>
<td>YRZ</td>
<td>BMP</td>
<td>Early LSA</td>
<td>Silcrete</td>
<td>Blad/let's</td>
<td>Points</td>
</tr>
<tr>
<td>SRZ</td>
<td>SHH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WRZ</td>
<td>EBC</td>
<td>~22–14 ka</td>
<td>Quartzite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>YRZ</td>
<td>AXI</td>
<td></td>
<td>Quartzite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>YRZ</td>
<td>BMP</td>
<td></td>
<td>Quartzite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>YRZ</td>
<td>BNK</td>
<td></td>
<td>Silcrete</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRZ</td>
<td>MKL</td>
<td></td>
<td>Quartzite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRZ</td>
<td>RCC</td>
<td></td>
<td>Quartzite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRZ</td>
<td>SHH</td>
<td></td>
<td>Quartzite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRZ</td>
<td>UMH</td>
<td></td>
<td>Quartzite</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 14. Selected artefacts from MIS 2-aged archaeological deposits arranged by rainfall zone. 1–18: blades and bladelets (1–8, 12–18) and backed artefacts (9–11) from site AK2006/001G (Orton, 2008: Figs. 3 and 4); 19–30: blades and bladelets from Putslaagte 8, Robberg levels (Mackay’s images); 31–37: blades and bladelets from Byneskranskop 1, Robberg levels (courtesy J. Pargeter); 38–40: cores from site AK2006/001G (Orton, 2008: Fig 2); 41–45: cores from Putslaagte 8, Robberg levels (Mackay’s images); 46–52: bladelets from Nelson Bay Cave, Robberg levels (courtesy J. Pargeter); 53–57: backed artefacts (53–57), scrapers (58–61) and cores (62–68) from Nelson Bay Cave, Robberg levels (Deacon, 1978: Figs. 8 and 9); 69–99: blades and bladelets (69–90), backed artefacts (91–93) and scrapers (94–99) from Rose Cottage Cave, Robberg levels (Wadley, 1993: Fig. 5); 100–110: blades and bladelets (100–104), backed bladelets (105–106), a retouched blade (107), and scrapers (108–110) from Sehonghong, Robberg levels (Mitchell, 1995: Fig. 8); 111–121: cores from Rose Cottage Cave, Robberg levels (Wadley, 1993, Fig. 6); 122–130: cores (122–127) and pièces esquillées (128–130) from Sehonghong, Robberg levels (Mitchell, 1995: Fig. 5).

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do is probably less than bifacial points, unifacial points or backed artefacts.

Bifacial and unifacial points appear in parts of the WRZ-YRZ around the start of MIS 4. The morphology of these pieces is strongly similar to like-aged points in the SRZ. Given this and the complexity of point production as outlined by Villa et al. (2009), it seems unlikely that the appearance of these implements is entirely a consequence of convergence (independent invention in different locations). The more plausible alternative is that the advent of the Still Bay reflects the interaction of populations across southernmost Africa. While product copying may account for the spread of this technology, the similarity in form across >1000 km implies high fidelity transmission that is more likely to reflect process copying, and thus learning from individuals through extended periods of transmission. The sequence noted by Porraz et al. (2013a) at Diepkloof in which bifacial points appear immediately before a dramatic change in flaking systems around the start of MIS 4 may reflect initial population interaction followed by greater integration.

The most likely source for this technology was in the SRZ. While dating is often poor, several sites in the SRZ have bifacial points antedating MIS 4 and other, undated sites in the region have bifacial points extending down to their deepest levels. This is in contrast to the WRZ and YRZ where bifacial points have only been encountered either as isolated instances or in discrete bands, which are invariably not the oldest sequence component. Sites in the WRZ also tend to exhibit sigmoid-shaped uptake curves where that can be discerned. Sibudu, Border Cave and possibly Rose Cottage Cave are presently the only sites in southernmost Africa that preserve distinct phases of bifacial point production antedating 76 ka. MIS 5-aged bifacial points may occur at Blombos, but Jacobs et al. (2013) preclude a start for the Still Bay earlier than 75.5 ka. Further supporting an eastern origin is the diversity of forms in that region, including serrated examples, and the non-Still Bay-like form of Still Bay-aged points at Apollo 11, which is the maximum distance, and thus the maximum number of transfers, from the eastern SRZ assuming movement along the southern coastal arc.

These observations should not be taken to mean that the Still Bay was strictly a socially-mediated phenomenon, but rather that its spread probably had a socially-mediated component. At the same time, there are marked consistencies between climate regions in other elements of technological organisation at this time, most clearly in the paucity of cores. This observation in combination with the maintainable design of bifacial points (Bleed, 1986; Kelly, 1988), suggests widespread use of individual provisioning, attendant on some consistency in subsistence conditions, most likely in their predictability rather than the specifics of the fauna and flora harvested.

One other notable issue here is the apparent non-uptake of bifacial point technology in Lesotho. While bifacial points occur throughout many late Pleistocene sequences in the SRZ, there is currently no evidence of periods of concerted bifacial point manufacture in the highlands of Lesotho either in MIS 4 or earlier (Carter et al., 1988; Stewart et al., 2012). This may reflect non-occupation of the region in early MIS 4 (Stewart et al., in press) though it does not explain the distinction in MIS 5 or the later absence of points in MIS 3. Local zones of non-uptake are consistent with expectations for the diffusion of innovations.

From ~71 to 65 ka, and broadly coincident with the coolest period of MIS 4 in Antarctic records (Jouzel et al., 2007), the clearest occupational signal is in the WRZ-YRZ. The technological characteristics of assemblages from the two sites occupied at this time (Diepkloof and Pinnacle Point) are similar to those which follow across southernmost Africa dating ~65–60 ka. At Diepkloof, elements of this system have their roots in the preceding period. Provisioning systems at this time are difficult to assess with the available data, but given the apparently distinct regional patterning it seems plausible that the production of blades and backed artefacts at this time was a local innovation.

After 65 ka, comparable technological systems are found across southernmost Africa. Similarities in assemblage structure consistent with place provisioning suggest underlying similarities in the unpredictability of subsistence conditions, though these do not readily account for noted consistencies in core reduction and blade production systems across different climate regions. These consistencies in flaking systems seem more likely to arise from process copying, again implying strong interaction between populations across southernmost Africa. Besides these similarities are continued climate-region differences in the blank form used for the production of backed artefacts (flakes and blades in the WRZ; blades only in the YRZ and SRZ) and in the forms of secondary implements. The WRZ and YRZ sites often seem to have numerous notched pieces along with backed artefacts at times within the Howiesons Poort, while several SRZ sites have bifacial points, which are uncommon or absent in this period outside the region. Most plausibly these differences reflect continuing regional traditions over-printed by similarities arising from interaction. The tradition of bifacial point manufacture in the SRZ appears to begin before MIS 4 and extend well into MIS 3; the presence of such implements in the WRZ-YRZ appears much more temporally constrained.

Significant occupational changes occur at the transition from MIS 4 to MIS 3. These are most apparent in the WRZ-YRZ, where numerous sites are abandoned. No comparable changes are noted in the SRZ, where instead there are some indicators of increases in site use. Occupation of sites on the north-eastern edge of the WRZ – Klipfonteinrand, Boomplaas and Montagu Cave – show cessation of occupation immediately after the Howiesons Poort (though Boomplaas shows brief later reoccupation in mid-MIS 3). Where documented, flaking systems appear to document greater...
Coalescence and fragmentation in the late Pleistocene archaeology of southernmost Africa

The data presented here suggest a complex set of coalescent and fragmented technological relationships across southernmost Africa through the period 130–12 ka. In this depiction, coalescence is largely restricted to but not entirely coeval with cooler conditions in MIS 4 and MIS 2, with non-conforming patterns in MIS 5, MIS 3 and potentially the onset of MIS 1. Coalescence through much of MIS 4 is also consistent with Chase’s (2010) hypothesis of an expansion of westerly influence across southernmost Africa during glacial peaks, though as noted the archaeological pattern is more complex than singular. As an aside, we can note that the suggestion of coalescence and fragmentation post–70 ka is not affected by our choice of chronologies for Diepkloof. Both the Jacobs et al. (2008a) and Tribolo et al. (2012) chronologies allow for an early Howiesons Poort in the WRZ-YRZ antedating 65 ka and are broadly in-phase thereafter.

The suggestion of variable coalescence/fragmentation has implications for the way we understand the occurrence of cultural complexity in southernmost Africa through the late Pleistocene (Jacobs and Roberts, 2009; Powell et al., 2009; Richerson et al., 2009; d’Errico and Stringer, 2011; Ziegler et al., 2013). Prior to discussing this, the point needs to be made that characterising MIS 4 industries like the Still Bay and Howiesons Poort as complex based on flaked stone artefacts is inappropriate (Mackay, in press). Bifacial points and backed artefacts have deep antiquity in Africa and do not first appear in MIS 4 (Beaumont, 1978; McBrearty, 1988; Barham, 2002; Yellen et al., 2005; Barton et al., 2009). Nor, as has been discussed, do they disappear in MIS 3. Pressure flaking may first be in evidence in MIS 4 but heat treatment extends into MIS 6 (Brown et al., 2009; Mourre et al., 2010). Ornaments, abstract engravings and evidence for paint kits also all antedate MIS 4 in Africa (Bouzouggar et al., 2007; Henshilwood et al., 2009, 2011). What is unusual about MIS 4 in southernmost Africa, and the Still Bay and Howiesons Poort in particular, is less the presence than the frequency of symbolic items, bone tools and ornaments (Henshilwood and Sealy, 1997; Henshilwood et al., 2001a, 2002; d’Errico et al., 2005; Backwell et al., 2008; d’Errico et al., 2008; Teixier et al., 2010, 2013; Vanhaeren et al., 2013).

The data presented here suggest a complex set of coalescent and fragmented technological relationships across southernmost Africa through the period 130–12 ka. In this depiction, coalescence is largely restricted to but not entirely coeval with cooler conditions in MIS 4 and MIS 2, with non-conforming patterns in MIS 5, MIS 3 and potentially the onset of MIS 1. Coalescence through much of MIS 4 is also consistent with Chase’s (2010) hypothesis of an expansion of westerly influence across southernmost Africa during glacial peaks, though as noted the archaeological pattern is more complex than singular. As an aside, we can note that the suggestion of coalescence and fragmentation post–70 ka is not affected by our choice of chronologies for Diepkloof. Both the Jacobs et al. (2008a) and Tribolo et al. (2012) chronologies allow for an early Howiesons Poort in the WRZ-YRZ antedating 65 ka and are broadly in-phase thereafter.
MIS 3. This does not necessitate population decline, though such is suggested in the WRZ-YRZ by the weak occupational evidence there. Any local population extinctions associated with fragmentation might further have accelerated the process of information loss (Premo and Kuhn, 2010).

Encouragingly, there is evidence for the recurrence of ornamentation in the later coalescent phase of early MIS 2. This evidence includes: engraved ostrich eggshell at Boomplaas, Byneskrankop and Melkhoutboom (Deacon et al., 1976; Deacon, 1979; Schweitzer and Wilson, 1983), bone and ostrich eggshell beads at Boomplaas, Buffelskloof, Faraoskop, Kathu Pan, Nelson Bay Cave, Rose Cottage Cave, Sehonghong and possibly also Elands Bay Cave (Opperman, 1978; Deacon, 1982; Manhire, 1993; Wadley, 1993; Mitchell, 1995; John Parkington, Personal communication), bone ornaments from Buffelskloof (Opperman, 1978), and a marine shell pendant and Nassarius kraussianus shell bead at Sehonghong (Mitchell, 1995). The early MIS 2 layers at Rose Cottage Cave contain fragments of marine shell, implying contacts with the coast 330 km south-east across the Maloti-Drakensberg Mountains (Wadley, 1995), as does the marine shell pendant at Sehonghong, derived from a minimum distance of 200 km. The ostrich eggshell beads from Sehonghong were also probably imported (from further inland) given the local absence of ostriches (Mitchell, 1995). These data suggest an emphasis on ornamentation and the existence of inter-group interaction across broad and environmentally-variable areas in MIS 2.

Conclusions

The objective of this paper was to examine causality in technological change across southernmost Africa through the late Pleistocene. We posed three questions pertaining to the influence of environments, the role of information transmission, and the extent of variability in population interaction. By separating out different aspects of technology and technological organisation, we have been able to explore these questions with a reasonable degree of success. Both environments and information transmission between groups were clearly important factors in generating previously identified patterns, but the extent of their influence varied through time. Technological and occupational systems were not always in agreement across southernmost Africa and the efficacy of universalising industrial schemes, particularly where attention is not given to underlying causes, is questionable (Mitchell, 2002).

Our analysis of the lithic and occupational data from 46 sites across southernmost Africa reveals apparently widespread population interaction at various times, and most especially in the Still Bay, classic Howiesons Poort and Robberg. During these periods we identified between-region similarities in flaking systems and implement types, and also material selection within the constraints of local/regional geology. At the same time, similarity in modes of technological delivery (provisioning systems) suggests similarities in the predictability of movement and subsistence conditions, and thus underlying environmental conditions. We suggest that these similarities may result from the expansion of westerly influence during cooler conditions as argued by Chase (2010).

These periods of inter-regional population interaction also correlate with periods in which ornaments and symbolic items become common in the archaeological record. This provides a relatively parsimonious and theoretically grounded explanation for their complex temporal distribution, and one which does not rely on forces that are difficult to detect archaeologically.

Outside of MIS 4 and MIS 2 there appears to be strong evidence for fragmentation of populations. There is little coherence in technology and technological organisation, we have been able to explore these questions with a reasonable degree of success. Both environments and information transmission between groups were clearly important factors in generating previously identified patterns, but the extent of their influence varied through time. Technological and occupational systems were not always in agreement across southernmost Africa and the efficacy of universalising industrial schemes, particularly where attention is not given to underlying causes, is questionable (Mitchell, 2002).

Our analysis of the lithic and occupational data from 46 sites across southernmost Africa reveals apparently widespread population interaction at various times, and most especially in the Still Bay, classic Howiesons Poort and Robberg. During these periods we identified between-region similarities in flaking systems and implement types, and also material selection within the constraints of local/regional geology. At the same time, similarity in modes of technological delivery (provisioning systems) suggests similarities in the predictability of movement and subsistence conditions, and thus underlying environmental conditions. We suggest that these similarities may result from the expansion of westerly influence during cooler conditions as argued by Chase (2010).

These periods of inter-regional population interaction also correlate with periods in which ornaments and symbolic items become common in the archaeological record. This provides a relatively parsimonious and theoretically grounded explanation for their complex temporal distribution, and one which does not rely on forces that are difficult to detect archaeologically.

Outside of MIS 4 and MIS 2 there appears to be strong evidence for fragmentation of populations. There is little coherence in flaking systems across climate regions during MIS 5 and material selection often appears highly localised, both of which imply localised spheres of interaction. Simple and readily-transmittable unifacial implements, denticulates, characterise many WRZ-YRZ sites in this period, something which contrasts with the production of bifacial and unifacial points in the SRZ. The production of bifacial points in the SRZ is of particular interest, as there appears to be continuity in pursuit of this technology in the region, albeit perhaps in pulses, for more than 35 kyr. In the WRZ-YRZ, by contrast, bifacial technology invariably appears to have been temporally restricted and centred on 74–70 ka.

A second period of fragmentation in MIS 3 is most clearly marked by the cessation of occupation of most WRZ-YRZ sites, including the major archives at Klases River, Nelson Bay Cave, Pinnacle Point, Blombos and Diepkloof. Even within the SRZ, where evidence for occupation remains strong, technological systems become increasingly localised in this period, with a spatially-constrained early LSA in the northern SRZ, and somewhat enigmatic implement forms and MSA flaking systems in much of the southern SRZ through to the start of MIS 2. While we do not posit an explanation for the subsequent expansion of LSA technologies across southernmost Africa, we note that this expansion occurs in the aftermath of what appears to have been significant occupational perturbation particularly in the WRZ-YRZ, but also reflected in pulses of occupation and localised spheres of interaction in the SRZ.

Beyond these important results, the data we have presented provide directions for future work that will allow our suggestions to be tested. Improved dating is needed to clarify the timing of changes, particularly in MIS 5, MIS 3 and MIS 2. The bulk of the latter two periods are amenable to radiocarbon dating, and a dedicated program (re)dating key sites would be valuable, particularly given that these stages witness the variable onset of the LSA. Improved chronometry in this period might reveal the directionality of movement for the appearance of heavy bipolar reduction and small blade manufacture, or indeed lack thereof if they reflect convergence.

Also critical is more detailed and perhaps more consistent technological analysis. Data are insufficient for many periods to address questions of provisioning, and the tendency to present site sequences in bulk culture historic units makes the assessment of underlying processes extremely difficult. Resolving the extent to which apparent technological similarities are artefacts of classification rather than genuine consistencies in reduction behaviour presently rests on concerted programs of technological analysis being undertaken by a limited number of researchers (Soriano et al., 2007; Villa et al., 2009; Mourre et al., 2010; Villa et al., 2010; Conard et al., 2012; Wurz, 2012; Porraz et al., 2013a). Similar programs could profitably be applied to MIS 5, late MIS 3 and MIS 2.

Additional application of morphometric techniques to cores (Clarkson, 2010) and implement types such as backed artefacts, bifacial points and unifacial points might allow the relative influences of different transmission systems to be better understood (e.g., Bettinger and Eerkens, 1999; Cardillo, 2010). The hypothesis presented here would be supported by greater heterogeneity in bifacial point form in the SRZ in late MIS 5 and early MIS 4 as a consequence of its proposed origin there, and greater homogeneity in the WRZ as a consequence of its later spread. Inter-regional similarities should diminish with distance from origin, and thus from SRZ to YRZ to WRZ. The reverse is expected for backed artefacts from 65 to 60 ka. Inter-regional heterogeneity in implement form and core reduction should be most marked in MIS 5 and MIS 3, with the reappearance of generalised inter-regional similarities in MIS 2.

Finally, beyond the climate region scheme this paper has made limited reference to palaeoenvironmental changes through the late Pleistocene. This reflects the limitations of appropriate data

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presently available from the wider region with which to carry out truly robust comparative analyses (see Deacon and Lancaster, 1988; Chase and Meadows, 2007). Few independent continental records exist for the period considered here, and while the archaeological sites themselves often contain important paleoenvironmental proxies, the aggregate sub-continental dataset has not yet been sufficiently resolved to provide a coherent picture of the nature and mechanisms of past environmental change. Whilst new records are providing fresh opportunities to study the evolution of the region’s climate systems (e.g., Peeters et al., 2004; Caley et al., 2011; Dumport et al., 2011; Châse et al., 2012, 2013; Valsecchi et al., 2013; Ziegler et al., 2013), and their impact on the flora and fauna that are the baseline of subsistence, considerable work remains to be done before specific comparisons can be made.

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