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# What factors govern the procurement and use of silcrete during the Stone Age of South Africa?

Manuel Will [a,b,c,*], Alex Mackay [d,e]

[a] Gonville & Caius College, University of Cambridge, Cambridge, United Kingdom
[b] PAVE Research Group, Department of Archaeology and Anthropology, Division of Biological Anthropology, University of Cambridge, Cambridge, United Kingdom
[c] Department of Early Prehistory and Quaternary Ecology, University of Tübingen, Schloss Hohentübingen, 72070 Tübingen, Germany
[d] Centre for Archaeological Science, School of Earth and Environmental Sciences, University of Wollongong, Australia
[e] Department of Archaeology, University of Cape Town, South Africa

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Fluctuations in the frequency of silcrete in lithic assemblages have been an important focus of Stone Age research in southern Africa. Here, we review temporal and spatial variation in silcrete abundance during the LSA and MSA of southern Africa and discuss mechanisms that might drive the differential acquisition and treatment of this raw material. Previous research has proposed a variety of explanations that include non-behavioural factors (sea level changes, climatic and environmental driving forces) and various behavioural determinants that range from functional constraints and economic considerations to socio-cultural preferences. In order to test these explanations and provide a systematic spatio-temporal overview of silcrete use, we performed a meta-analysis by collecting a database on silcrete abundance from a total of 25 Stone Age sites that encompass >200 assemblages. Quantitative statistical analyses of this database reveal significant variation in silcrete prevalence among and between sites. The main temporal trajectory conforms to a bimodal pattern that features peak frequencies in MIS 4 & 3 as well as MIS 1. The results also demonstrate a significant association between silcrete abundance and technocomplexes with particularly high values for the Howiesons Poort, "post-HP" and Wilton, but not the Still Bay. Silcrete abundance is significantly correlated with the production of tools in general, and the manufacture of microlithic or backed artefacts in particular, suggesting an influence of functional considerations and potentially cultural preferences. In contrast, we found little support for the dependence of silcrete use on purely economic grounds such as procurement costs or a strong impact of non-behavioural factors such as changes in sea level or environmental circumstances. By operating on a large spatio-temporal scale with aggregated data, the results of this study can help to embed the acquisition and treatment of silcrete by Stone Age people in a wider behavioural and evolutionary framework.



## 1. Introduction

The study of raw materials is an essential step in lithic analyses, regardless of the age, provenance and technology of the assemblages under study. Lithic raw material constitutes the physical source on which stone artefact technology is based, with its procurement being the first stage in the *chaîne opératoire* of knapping systems. For Bamforth (1986, p. 40) "[...] *material for tool manufacture is a resource in the same sense as are plant and animals: its nature and distribution fundamentally condition the ways in which it can be exploited*". Bamforth's assertion, however, stimulates the simple question: Why do proportions of raw materials vary in archaeological sites? If we accept that a given site is a spatially stable point, and that the geological sources from which tool stone derives are spatially steady at timescales relevant to human behaviour, what causes the frequency of rocks from different sources to change at sites?

Many factors have been proposed to explain the observed variance. Some of these mechanisms are non-behavioural, such as the effects of advancing and retreating glaciers on the availability of stone sources (Tripcevich, 2007). Behavioural explanations generally encompass more complicated factors, such as changes in patterns of human movement and settlement strategies. For example, altered territorial coverage might bring people into more or less frequent contact with some sources of raw material making them easier or harder to acquire; changes in the scale of inter-group interaction may function in similar ways (Féblot-Augustins, 1997; Marwick, 2003). Linked to changes in patterns of movement are changes in the organization of technology. Higher group mobility has been thought to favour the transport of fewer and/

* Corresponding author at: Department of Early Prehistory and Quaternary Ecology, University of Tübingen, Schloss Hohentübingen, 72070 Tübingen, Germany.
*E-mail address:* manuel.will@uni-tuebingen.de (M. Will).

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or more lightweight tools, increasing the use of opportunistically acquired local material (Binford, 1979; Bousman, 2005; Kelly, 1983; Kuhn, 1992, 1994; Nelson, 1991; Shott, 1986). Conversely, groups who can anticipate extended or repeated occupation of given sites may be able to shift large quantities of preferred raw materials to a given site, changing their prevalence (Kuhn, 1992, 1995; Parry and Kelly, 1987; Riel-Salvatore and Barton, 2004). Elements of technological design may also influence patterns of preference in the selection of tool stones. Tools or cores anticipated to have particularly long use lives may benefit from the preferential acquisition of predictably flaking rock (Bleed, 1986; Nelson, 1991).

Most of these behavioural explanations can be classed as economic, in the sense that they view procurement patterns of raw material in relation to the costs or benefits of acquisition relative to currencies such as time, energy or risk (Bamforth and Bleed, 1997; Torrence, 1983, 1989). A range of non-economic – or perhaps less tangibly economic – sociocultural factors have also been considered. Certain rocks might be acquired preferentially for trade to build links between groups (e.g., McBryde and Watchment, 1976), or simply as a result of historical contingency whereby use of a particular source relates to group or individual identity (e.g., Gould et al., 1971). In addition – and cross-cutting these broad categories – characteristics of the raw materials themselves, such as their size, shape, accessibility, spatio-temporal distribution, abundance and internal qualities, constitute essential factors that structure the use and overall organization of lithic technologies by hunter and gatherer groups. These variables can influence which types of stones are procured, the methods employed for their reduction, the design and maintenance of blanks and tools, and ultimately the composition of lithic assemblages (Andrefsky, 1994, 2005; Bamforth, 1986; Barton and Riel-Salvatore, 2014; Binford, 1980; Braun et al., 2008; Ditchfield, 2016; Féblot-Augustins, 1997; Floss, 1994; Kelly, 1988; Kuhn, 1991; Parry and Kelly, 1987; Roth and Dibble, 1998; Terradillos-Bernal and Rodríguez-Alvarez, 2016, Tomasso and Porraz, 2016).

Necessarily some or multiple of these factors could be at play in any given set of raw material changes, and the effects of different factors may be difficult to isolate. Nevertheless, some mechanisms generate predictive conditions that may allow us to explore their effects in the archaeological record. In this paper we use these factors to explore variation in the proportions of the fine-grained rock silcrete at archaeological sites across the south west of southern Africa through the last six Marine Isotope Stages (MIS). Our analysis is based on a meta-data set comprising >200 assemblages from 25 different sites.

## 2. The role of silcrete in the Stone Age archaeology of southern Africa

Variations in the proportion of silcrete within and between archaeological sites from southern Africa have attracted a large share of scholarly attention for both the Pleistocene and Holocene periods. In part, this focus derives from the fact that silcrete constitutes a raw material of generally high quality and well-known distribution that can also be recognized fairly easily. Silcrete is a sedimentary rock in which large quantities of authigenic silica have either accumulated in or replaced surface and near-surface geologic deposits to form an indurated mass (see for a more detailed discussion: Cochrane et al., this issue; Milnes and Thiry, 1992; Nash and Ullyott, 2007; Summerfield, 1983; Thiry and Milnes, this issue; Watson and Nash, 1997). The rock is common in archaeological assemblages in southern Africa and Australia, and occurs with less frequency in other regions such as South America or Europe (Ballin and Faithfull, this issue; Nami, this issue; Nash and Ullyott, 2007; Wragg Sykes et al., this issue). In southern Africa, silcrete takes a variety of forms due to differences in formation processes and the nature of the host sediments (Roberts, 2003; Summerfield, 1981, 1982, 1983), although it can be generally described as a raw material that fractures in a conchoidal manner, producing fine flakes with sharp and durable edges (Mackay, 2008; Porraz et al., 2013; Will et al., 2013).

Silcrete shows a clear pattern of geographical distribution in South Africa, occurring within the Kalahari of the Northern Cape, but otherwise in a band from the Richtersveld in the northwest to a nearly continuous belt along the Cape Fold Mountains in the southwest all the way through to east of Grahamstown (Nash et al., 2013b; Roberts, 2003; Summerfield, 1981, 1982, 1983; see Fig. 1). In these areas, silcrete occurs in large blocks or smaller nodules in extensive primary outcrops, but also as more or less isolated pebbles in rivers or on beaches. It is a reasonably common rock on the landscape in these areas, but generally much less prevalent than quartzite and quartz which occur across extensive geological provinces (Mackay and Marwick, 2011).

The frequency of silcrete in lithic assemblages from southern African undergoes significant fluctuations during the Middle Stone Age (MSA) and Later Stone Age (LSA). Some technocomplexes, such as the Howiesons Poort (HP) and Wilton are in some regions identified in part through marked increases in silcrete and potentially higher amounts of non-local raw materials, while others are known particularly for their lack of such fine-grained rocks (e.g., Lombard et al., 2012). One of the latter would be the "early MSA" which in our definition encompasses MSA variants in southern Africa during MIS 6 and 5 that predate the Still Bay (see also Kandel et al., 2016; Will et al., 2015; but different from Lombard et al., 2012), including units such as "Klasies River", "Mossel Bay" and "pre-Still Bay" (Lombard et al., 2012; Wurz, 2002) or MSA 1, 2a and 2b (Volman, 1981). The extent of variation in silcrete throughout the Stone Age of southern Africa has prompted a variety of explanations, many of which are examples of the types described above.

With respect to non-behavioural explanations, Deacon (1982), Brown (2011) and Porraz et al. (2013) have discussed the possibility that sea level rise may have periodically inundated silcrete deposits near the coastal sites of Nelson Bay Cave, Pinnacle Point and Diepkloof respectively, influencing their procurement (see also Nash et al., 2013a). Similarly, the possibility of source exhaustion has been raised by Marean (2010), who suggested that secondary cobble sources near the site of Pinnacle Point may have been rapidly depleted with use, though this discussion does not relate specifically to silcrete. Some researchers claim that the variable frequency in silcrete use might be explained by constraints set by heat-treatment such as the changing availability of firewood (Brown and Marean, 2010; Brown et al., 2012) and thus a combination of environmental constraints and behavioural factors. This hypothesis presupposes that heat treatment was indispensable for silcrete knapping (but see Schmidt and Mackay, 2016; Schmidt et al., 2013) and for the production of certain tools such as Still Bay bifacial points by means of pressure flaking, and thus only economic when firewood was abundantly available (Brown and Marean, 2010; Brown et al., 2012; Mourre et al., 2010).

Regarding economic behavioural factors, numerous scholars have suggested that a greater prevalence of silcrete at sites reflects modification of territorial organization, implying increased levels of residential mobility and larger foraging radii during certain periods (Ambrose and Lorenz, 1990; Ambrose, 2002; McCall, 2007; McCall and Thomas, 2012). Complicating this interpretation are difficulties in isolating the sources from which silcrete artefacts derive, particularly where they are available in both primary and secondary contexts (Minichillo, 2006). There are, however, examples where this has been done more effectively, most notably by extensive field surveys on the west coast of South Africa around Diepkloof (see Porraz, 2007; Porraz et al., 2008, 2013), whose coverage also encompasses sites like Hoedjiespunt 1 (Will et al., 2013). At both of these sites, some silcretes were found to be sourced from at least 20 km away, and changes in frequency may well reflect changes in movement range. Two intriguing studies by Nash et al. (2013a, 2016) in Botswana identified habitual transfer of silcretes over >200 km during the MSA, suggesting that economic costs (acquisition and transport) induced minimal constraints on the frequency of the rock at these sites.

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