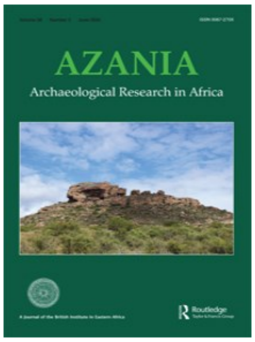


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# Small tool production in the Howiesons Poort: a view from Montagu Cave, South Africa

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ABSTRACT

In southern Africa, the Howiesons Poort is one of the earliest technocomplexes in which small blades and bladelets were systematically produced and retouched into formal tools. While the presence of small lithic artefacts in an assemblage is well-documented, little is known about production pathways. This paper reports on the analysis of the lithic assemblage from Horizon 6/7 of Charles Keller's excavations of Montagu Cave, South Africa, to evaluate how raw material and decision-making affects the size of stone tools in Howiesons Poort assemblages. It addresses the following questions: how were small blades produced? Was it a deliberate choice or a constraint imposed by raw material availability? Results show branching modes of production for large and small blanks beginning with raw material acquisition. The independent production of small blanks is reinforced by the presence of cores on flakes in the assemblage. However, a relatively standardised core reduction process was used consistently, regardless of core size. The main technological and typological features observed in Horizon 6/7 are in line with other known Howiesons Poort assemblages. Considered as a whole, these observations highlight the consistency of Howiesons Poort blade technology and the deliberate production of small blanks and tools.

RÉSUMÉ

En Afrique méridionale, le Howiesons Poort est l'un des premiers complexes technologiques dans lequel de petites lames et lamelles furent systématiquement produites et retouchées pour en faire des outils formels. Bien que la présence de petits objets lithiques dans un assemblage soit bien documentée, on sait peu de choses sur les voies de production. Cet article présente les résultats de l'analyse de l'assemblage lithique de l'Horizon 6/7 des fouilles de Charles Keller dans la grotte de Montagu, en Afrique du Sud, afin d'évaluer comment les matières premières et la prise de décisions affectèrent la grandeur des outils en pierre dans les assemblages Howiesons Poort. L'étude répond à deux questions: comment les petites lames étaient-elles produites? Et leur fabrication était-elle un choix délibéré ou une contrainte imposée par la disponibilité des matières premières? Les résultats

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démontrent des modes de production diversifiés pour les grandes et petites ébauches, en commençant par l'acquisition des matières premières. La production indépendante de petites ébauches est renforcée par la présence de nucléus sur éclats dans l'assemblage. Cependant, un processus de réduction des nucléus relativement standardisés a été systématiquement utilisé, quelle que soit leur taille. Les principales caractéristiques technologiques et typologiques observées dans l'Horizon 6/7 sont conformes à celles d'autres assemblages Howiesons Poort connus. Considérées dans leur ensemble, ces observations mettent en évidence la cohérence dans la technologie des lames Howiesons Poort, et la production délibérée d'ébauches et d'outils de petite taille.

## Introduction

During the late Pleistocene, the emergence and spread of so-called 'microlithic' technologies focused on the intentional production of small stone artefacts from small cores in the broadest definitions are argued to have been part of a global-scale reorganisation of lithic technologies (Elston and Kuhn 2002). Within southern Africa, small lithic blanks and tools become prevalent in the Howiesons Poort technocomplex (~65–58 ka), with the inclusion of backed geometrics that are <4 cm long and of bladelets <12 mm wide (Lombard 2009; Lombard et al. 2012, 2022; Wurz 2013). Although described by some researchers as 'microlithic,' Howiesons Poort segments, small blades and bladelets are typically larger than those seen later in time (H. Deacon 1995; Wurz 1999; Cochrane 2008). Small lithic artefacts, like those observed in Howiesons Poort assemblages, may be present in a lithic assemblage because they were intentionally produced as a by-product of the production of larger blanks or they may be the result of raw material constraints, alternatives that must be resolved before we can consider what variability in the processes used to produce microlithic technologies meant for the conditions experienced by the people producing them.

Here, we analyse Howiesons Poort lithic artefacts from Charles Keller's excavations at Montagu Cave, Western Cape Province, South Africa, emphasising those from Horizon 6/7 within Layer 2 (Keller 1973). First, we describe the assemblage to document variations and patterns in the presence and frequency of core, blades and tool types. Then, we propose a parsimonious reduction model and discuss the implications for understanding variability within and between assemblages. We address the following questions: did people produce small blades because of a deliberate choice or as a result of a constraint imposed by raw material availability? To do this we consider three simplified scenarios: 1) objects were designed to be transported over long distances and/or they were curated; 2) raw material occurred only in small packages; or 3) there was a deliberate interest toward the production of small blanks/tools. Ultimately, the results should contribute to a better understanding of the Howiesons Poort and of variation within it as well as of the context within which small tool technology occurred in southern Africa.

## The Howiesons Poort of southern Africa

The Howiesons Poort is a Middle Stone Age (MSA; ~315–30 ka) technocomplex found in cave and rock shelter sites in multiple different biomes across southern Africa (Jacobs et al. 2008; Lombard 2009; Lombard et al. 2012; 2022; Wurz 2013; Jacobs and Roberts 2017) (Figure 1). It has featured prominently in arguments focused on the behavioural evolution of Homo sapiens (McBrearty and Brooks 2000; Lombard 2009; Brown et al. 2012; Henshilwood 2012; Wadley 2013; Kandel et al. 2016). Similarities in its material culture and retouched tools across sites in southern Africa are cited as evidence that technological innovations spread because of increased connectivity, social coalescence and the formation of long-distance social ties between groups (J. Deacon 1995; McCall 2007; Lombard 2009; McCall and Thomas 2012; Mackay et al. 2014; d'Errico et al. 2017; Way et al. 2022).

Howiesons Poort lithic assemblages are characterised by the production of blades, but their most recognisable components are the backed geometric tools (segments, trapezes and triangles) that serve as fossiles directeurs (Goodwin and Van Riet Lowe 1929; Wurz 2000; 2013; Lombard 2009; Lombard et al. 2012; 2022). Howiesons Poort technology saw changes in raw material preferences: finer-grained, sometimes non-local materials were utilised in greater frequencies than is common in earlier MSA assemblages (Volman 1981; Wurz 2000; Lombard 2009; Lombard et al. 2012; 2022; Wurz 2013; Mackay et al. 2014), and the use of heat-treated silcrete, a terrestrial sedimentary rock, was prevalent during this time period (Brown et al. 2009; Delagnes et al. 2016; Schmidt and Mackay 2016). A core type first described by Wurz (2000) at Klasies River (also known as 'Howiesons Poort cores') is associated with a method to produce blades specific to this technocomplex (Wurz 2000; Villa et al. 2010; Porraz et al. 2013; de la Peña 2015). The Howiesons Poort includes some of the earliest widespread production of bladelets,


Figure 1. Southern Africa showing the location of Howiesons Poort sites with Montagu Cave indicated by the yellow star. Other Howiesons Poort sites: 1 Apollo 11; 2 Varsche Rivier 003; 3 Putslaagte 8; 4 Klein Kliphuis; 5 Klipfonteinrand; 6 Mertenhof Rock Shelter; 7 Diepkloof Rock Shelter; 8 Peers Cave; 9 Montagu Cave; 10 Klipdrift Rock Shelter; 11 Pinnacle Point; 12 Boomplaas; 13 Nelson Bay Cave; 14 Paardeberg; 15 Klasies River; 16 Howiesons Poort Shelter; 17 Rose Cottage Cave; 18 Ntloana Tšoana; 19 Melikane; 20 Umhlatuzana; 21 Sibudu; 22 Border Cave.

which are defined here as blades <12 mm wide for descriptive purposes (Tixier 1963). The mean width of laminar elements in several well-described Howiesons Poort assemblages falls below this size cut-off, however (e.g. Soriano et al. 2007; Villa et al. 2010; Porraz et al. 2013). Blade distributions at multiple sites are described as unimodal (Wurz 2000; Soriano et al. 2007; Mackay 2009; Villa et al. 2010), indicating that the presence of bladelets in Howiesons Poort lithic assemblages may be the end stage of large blade production rather than an intentional goal of production. However, the employment of a technological analysis at Sibudu indicates the use of different core reduction methods for blades and bladelets, suggesting deliberate production geared toward smaller sizes in a Howiesons Poort context (de la Peña and Wadley 2014; de la Peña 2015). A more holistic integration of technological observations is therefore needed to address design and size constrains in other Howiesons Poort assemblages by examining the different steps of the reduction sequence.

## Small tools or 'microliths'?

The systematic production of small stone tools from small cores relative to the overall size of the assemblage, referred to as 'miniaturisation' or 'microlithisation,' can be seen throughout the evolutionary history of stone tool production (Pargeter 2017; Pargeter and Shea 2019). During the late Pleistocene, the widescale adoption of 'microlithic' technologies in contexts throughout Africa and Eurasia has been suggested to have coincided with the spread of projectile armatures and composite tool technology (Bleed 1986; Bar-Yosef and Kuhn 1999; Elston and Kuhn 2002; Yaroshevich et al. 2010, 2013). However, since 'microlithic' stone tool industries were first described, the term has been used within Africa to refer to different artefact classes together that are not necessarily comparable with one another: geometrics, bladelets and small flakes (Pargeter and Shea 2019). Adding to this challenge is the application of different size criteria to differentiate between 'large' and 'small' or 'microlithic' artefacts in different contexts (for a comprehensive discussion, see Leplongeon (2014) and Pargeter (2016)). The definition and re-definition of 'microlith' to include vastly different end-products made using different production systems limits its value as a descriptive term, despite its continued use in Pleistocene and Holocene archaeology (Kolobova et al. 2019; Rose et al. 2019; Soto et al. 2019; Wedage et al. 2019; Sari 2020).

The point of intentionality in lithic artefact production is an important distinction since lithic tools and blanks are not necessarily small by design. The presence of small blanks in an assemblage is an inevitable part of the reduction process as cores near exhaustion and retouched tools can also be significantly altered in shape and size as a result of continued resharpening and edge rejuvenation events for economic reasons (Frison 1968; Jelinek 1976; Dibble 1995a). Similar constraints apply to blank size if knappable raw materials are only available in small packages (Kuhn 1991; Inizan et al. 1999; Andrefsky 2005; Dogandžić and Đuričić 2017). The development of reduction sequences specific to the production of small blanks has been considered as evidence for intentional production, while some variations in core shape and reduction sequences correspond to different blank morphotypes (e.g. Bon 2002; Boëda and Bonilauri 2006; Zwyns et al. 2012; Wojtczak et al. 2014; Roussel et al. 2016; Falcucci and Peresani 2018).

Predefined size cut-offs used to define 'small' blanks and tools are determined by the intellectual traditions of the analysts and are therefore often regionally and/or temporally specific. This means that that size cut-offs based on metric measurements from one region may not accurately reflect what is considered 'small' and 'large' for an assemblage from a different region or period (Kaufman 1986; Kaufman and Rousseeuw 2009; Leplongeon 2014; Pargeter 2016; Pargeter and Redondo 2016). The identification of groups using statistical methods has been applied to lithic assemblages in southern and eastern Africa to better understand changes in tool production systems during the late Pleistocene (Leplongeon 2014; Pargeter 2016; Pargeter and Redondo 2016). However, applications of statistical categorisation typically require that the assemblage represents the full span of size classes present, which can be challenging when used in museum contexts and on older excavations where the smallest materials may not have been curated. To circumnavigate this issue and make use of older collections, in this study we utilise the entire assemblage to construct the reduction sequences present at a site rather than focusing on end-products alone. We thus address the notion of intentionality in 'small' tool production in the Howiesons Poort of Montagu Cave by examining core reduction sequences and by utilising relative size classes to categorise lithic artefacts.

## Montagu Cave

### Site location, excavation history and stratigraphic sequence

Montagu Cave (33°50′S, 20°10′ E) is located in the Western Cape Province of South Africa, approximately 150 km northeast of Cape Town (Figure 1). Situated on the northern side of the Langeberg Range of the Cape Folded Belt Mountains, this northeast-facing cave is located approximately 60 m above a stream that is currently active all year round. This part of the mountains forms the southern boundary of the Little Karoo, a semi-arid region in the rain shadow of the mountains (Keller 1973). Located in southern Africa's Winter Rainfall Zone, it receives most of its precipitation between June and August (Keller 1973; Chase and Meadows 2007). The cave was formed through dissolution of the Table Mountain Sandstone that forms the range (Keller 1973; Volman 1981). It contains two chambers, but only the outer of the two, which is approximately 11 m high and 17 m deep, has preserved archaeological deposits (Goodwin 1929; Keller 1973; Volman 1981). Based on a raw material survey conducted by one of us (Watson) in 2022, lithic materials are abundant in the area around the cave. Quartzite is the most commonly available knappable material and can be found in a broad range of sizes and formats (cobbles and angular blocks). Chalcedony and quartz occur along rills near the cave and in small cobbles/pebbles in a seasonally flowing stream bed in the valley below the cave. The closest silcrete source documented by Roberts (2003) is ~10–15 km from the site. Material from this source is relatively coarse-grained, with a few inclusions, and reddish/orange in colour based on Watson's survey.

Montagu Cave was originally excavated in 1919 by a team from the South African Museum led by S.H. Houghton and K.H. Bernard. Approximately one-third of the deposits were removed over the course of 38 days and the results published ten years later by Goodwin (1929). The lithic assemblages document evidence of Early, Middle and Later Stone Age (ESA, MSA and LSA) occupations, making the site one of the only known stratified sequences to record all three periods (Volman 1981). Goodwin

(1929) identified four artefact-bearing layers separated by sterile sediments, the lowest of which rested on decayed bedrock. The lower three layers were assigned to the ESA, specifically the Acheulean. At the time, the uppermost layer was difficult to categorise. Goodwin first compared it with the LSA Wilton, before noting combinations of attributes from Wilton and the then recently described Howiesons Poort (Volman 1981).

Between 1964 and 1965, C.M. Keller directed excavations on a 20′ x 25′ (≈6.1 × 7.6 m) area of primary deposits left untouched by Houghton and Bernard (Figure 2). A section was excavated in 15.24 cm (6 inch) arbitrary spits to serve as a stratigraphic control for the rest of the excavation where natural stratigraphy was favoured over spits, due to the slope of the sediments (Keller 1973; Volman 1981). Keller (1973) identified seven layers within his excavations (Figure 2). Layers 1, 2 and 5 were artefact-bearing, while Layers 3, 4, 6 and 7 were sterile deposits. Within Layer 2, which contains Howiesons Poort artefacts, there was no visible stratigraphy, but Keller recorded seven concentrations of lithic artefacts excavated as occupational surfaces (or horizons, see below). The sediments were sieved through a 3 mm (1/8 inch) mesh and artefacts were hand-plotted after each surface had been uncovered. Artefact concentrations increased in density toward the back of the cave and in lower stratigraphic units (Keller 1973). Keller's goal was to document attribute variation in the site's Acheulean layers, but during excavations an artefact-rich layer of over 120,000 pieces was uncovered below the LSA and above the ESA (Keller 1973; Volman 1981). After comparisons with materials that had been excavated at Howiesons Poort Rock Shelter not long before work at Montagu Cave began, Keller (1973) assigned the assemblage to the Howiesons Poort.

Howiesons Poort materials derive from Keller's Layer 2, which varies in depth from 23 cm in the northwest section to 150 cm in its southeastern portion. No visible stratigraphic sub-division was recorded within this layer, but Keller (1973) noted the presence

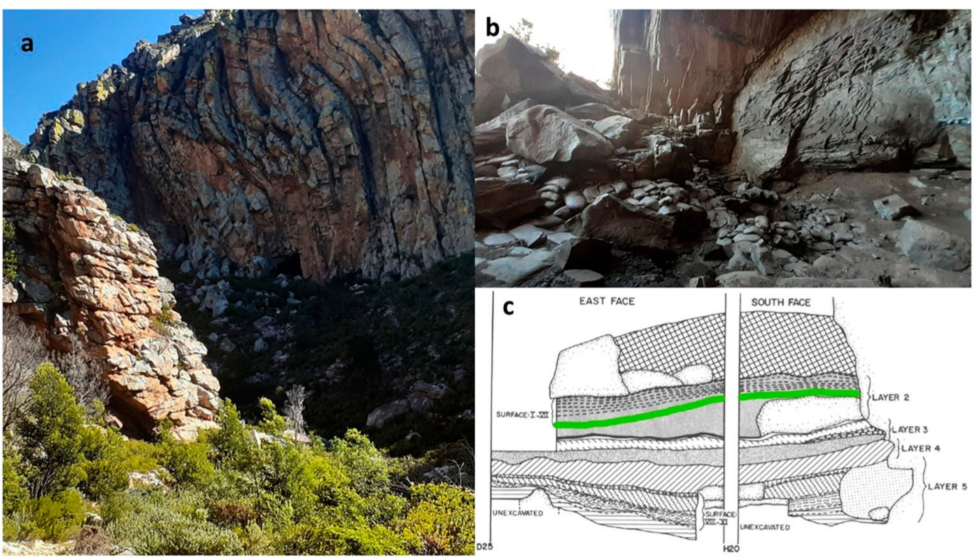


Figure 2. Photographs of Montagu Cave: a) exterior of site from stream bed; b) site interior and excavated area from the back of the cave (both photographs Sara Watson); c) Keller's 1964 excavation stratigraphy. Horizon 6/7 is denoted in green (modified from Keller 1973).

of discrete clusters of artefacts with horizontal associations. Artefacts were categorised as either 'surfaces,' when their densities were high, or as 'horizons,' when they were lower. Charcoal was documented throughout Layer 2, as well as five 'hearths' that were excavated as individual features. Artefact density within Layer 2 increased with depth from approximately 300 pieces in Surface 1 to over 2200 artefacts in Surface 7 (Keller 1973; Volman 1981). The lithic assemblages from Layer 2 have documented changes in artefact form and raw material within the sequence relative to over- and under-lying layers. Keller (1973) noted the remarkable diversity in artefact size, form and raw material use and described concurrent tool production systems. One focused on large 'Levallois-like' cores and backed blades while the other included single platform cores and 'crescents' typical of the Howiesons Poort (mostly at the base of the layer). Quartzite was the most prevalent raw material in the layer, but the use of finer-grained materials was more frequent in lower surfaces.

While Keller ascribed all the materials from Layer 2 to the Howiesons Poort, a later analysis conducted by Volman argued for the presence of a 'late MSA' technology in Surfaces 1–6 (Volman 1981). He divided the sequence into six separate cultural units based on technological and typological changes within the layer: Howiesons Poort-3 (gravel horizon under surface 7), Howiesons Poort-2 (Horizon 7), Howiesons Poort-1 (Surface 7), HP-0 (Horizon 6/7) and late MSA-2 (Horizon 4/5 through Surface 6), and late MSA-1 (Surfaces 1–4). In addition to the changes in raw material and typology noted by Keller, Volman (1981) documented changes in blank size, treatment of percussion bulbs and core shape. Blank length decreased through time from the Howiesons Poort to the late MSA, while blank width increased, with the longest, thinnest blanks present in the Howiesons Poort-3. Artefacts with the bulb of percussion removed or modified in some way occurred in the Howiesons Poort assemblages but were absent in the late MSA. Core shape changes gradually through time from primarily Levallois-like in Howiesons Poort surfaces to more unidirectional ridge cores in the late MSA.

## Horizon 6/7

Volman (1981) did not include Horizon 6/7 in his detailed analysis because at the time the artefacts could not be assigned to a particular square. However, he classified the artefacts from Horizon 6/7 as Howiesons Poort-0 and made general observations about Horizon 6/7 that are relevant to this material. First, he noted that the lack of evidence for an occupational hiatus at the base of Surface 6 does not necessarily mean that there is a chronological continuity between what he called late Howiesons Poort and late MSA-2. Second, he noted that within the Howiesons Poort and again within the late MSA there is an increase in use of quartzite through time relative to other raw materials. He noted a similar pattern for the Howiesons Poort from Nelson Bay Cave, though use of non-quartzite materials was greater at Montagu (Volman 1981). Third, there is an increase in the frequency of unidirectional cores in the late MSA relative to the Howiesons Poort. This is contrary to patterns noted at other MSA sites in the southern Cape, where unidirectional cores increased in frequency from the Early MSA to the Howiesons poort and then decreased through the late MSA (Volman 1981). Finally, Volman (1981) noted that quartzite flakes larger than 30 mm increased in length and decreased in width from the oldest to youngest material within the Howiesons

Poort and again in the late MSA layers. He recorded little difference in tool typology throughout the Montagu Cave MSA sequence, except that artefacts with modified platforms or removed bulb of percussion were only recorded in the Howiesons Poort. Finally, he suspected that the late MSA artefacts were not much younger than those of the Howiesons Poort based on impressions of continuity in the lithic artefact sequence and the absence of a depositional hiatus at the base of Surface 6.

## Materials and methods

This technological analysis was conducted at the University of California, Berkeley, on the assemblage from Horizon 6/7 of the Keller collection, totalling 370 artefacts. Most of the assemblage is curated at the Phoebe A. Hurst Museum of Anthropology, but a portion of the assemblage is housed at the University of California, Berkeley, Human Origins Research Center (HERC). We were able to locate provenience information in Keller's field notebook and accession documents for the collection archived in records stored at the Phoebe A. Hurst Museum of Anthropology. Artefacts were concentrated in units 258, 291–296, 326–330 and 333, which correspond primarily with squares 30F and 30G of the excavation grid. We accounted for all the plotted lithic artefacts. However, there are additional quantities of quartzite, quartz and chert pieces classified by Keller as 'chips, chunks, and fragments' that are not present with the assemblage. These are listed in pounds/lbs rather than frequencies and typically recorded as '####' or 'lbs' without more specific information. A summary of the Horizon 6/7 assemblage composition is found in Table 1. The studied assemblage comprises 370 pieces in total. Unretouched blanks are most common (N = 161, 44%), followed by retouched tools (N = 119, 32%) and cores (N = 80, 22%). A small number of undiagnostic shatter (N = 5, 1%) and nonflaked lithic artefacts (N = 5, 1%) are also present, which include four rounded quartzite cobbles and one quartzite block. Two of the rounded cobbles preserve evidence of crushing on at least one side, suggesting that they were used as hammerstones. Additionally, one quartz crystal (maximum length 1.93 cm) with regular, well-formed facets was present with the assemblage.

The artefacts are described according to standard attributes and terminology (Tixier et al. 1980; Pigeot 1987; Pelegrin 1995; Inizan et al. 1999; Soriano et al. 2007; Villa et al. 2010; Zwyns 2012). Technological attributes and measurements were recorded for all artefacts using an E4-MSAccess database, digital calipers and USB connections (for more details on attributes, see Soriano et al. 2007; Zwyns

Table 1. Montagu Cave: assemblage composition by lithic artifact class and raw material, regardless of completeness.

| | Total | | Quartzite | | Silcrete | | Quartz | | Other | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % |
| Cores | 80 | 22 | 39 | 11 | 26 | 7 | 9 | 2 | 6 | 2 |
| Blanks | 161 | 44 | 147 | 40 | 8 | 2 | 3 | 1 | 3 | 1 |
| Tools | 119 | 32 | 67 | 18 | 41 | 11 | 6 | 2 | 5 | 1 |
| Non-flaked lithic artefacts | 5 | 1 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shatter | 5 | 1 | 4 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| Total | 370 | 100 | 262 | 71 | 76 | 21 | 18 | 5 | 14 | 4 |

2012; Zwyns and Lbova 2019). Lithic material category, cortex percentage, maximum dimension, weight, retouch extent and nature and evidence of post depositional modification were recorded for all artefacts, regardless of degree of fragmentation. Cortex coverage was estimated based on its extent on the dorsal face. Length, width and thickness of complete and fragmentary pieces were recorded as the maximum dimension for the plane. Additional attributes were recorded for complete specimens. When possible, we considered the minimum number of blanks (MNB) in the assemblage, represented by blanks which retain platforms (complete blanks and proximal blade fragments) (Hiscock 2002). Here, we utilise the minimum number of blanks to focus on blade fragmentation and their effect on dorsal pattern frequencies and artefact size estimates on the level of the sample (Zwyns 2012; Zwyns and Lbova 2019).

All silcrete artefacts were examined for heat treatment proxies according to the method described by Schmidt et al. (2015). This uses contrasts in surface roughness on flaking surfaces within a given source/class of silcrete, while artefacts preserving visually identifiable surfaces flaked before and after heat exposure ('roughness contrast') constitute the basis of a macroscopic referential. These referential artefacts with roughness contrast were used as diagnostic pieces to evaluate the presence of heat treatment proxies on the remaining silcrete pieces using the 'internal calibration' method (Schmidt and Mackay 2016; Schmidt 2017).

Reduction models were generated using the principles of the chaîne opératoire (Leroi-Gourhan 1964; Lemonnier 1976; Karlin et al. 1986; Schlanger 1996) with a distinction between methods (organised pathways involving several steps to achieve a production goal processes at work during lithic reduction) and techniques (the tools, gestures and movements used to knap stone) (Tixier 1963). Methods were described as series of steps in artefact manufacture, from material selection and procurement to artefact discard (Tixier et al. 1980; Geneste 1985; Perlès 1987; Pigeot 1987; Boëda 1988b, 1990, 1994; Boëda et al. 1990; Pelegrin 1995, 2005; Schlanger 1996). The chaîne opératoire approach traditionally identifies the goal of production on a qualitative basis (Sellet 1993). Instead of taking intentionality for granted, we propose reconstructions of reduction sequences as a parsimonious model to explain the quantitative and qualitative data (a reduction sequence approach).

We used non-parametric tests to compare frequencies ($x^2$ test) and linear measurements (Mann-Whitney U test) with a significance threshold set first to 0.05 and then to 0.01 after Bonferroni correction. Mann-Whitney U tests and $x^2$ tests were conducted using the PAST software (Hammer et al. 2009), an interactive calculation tool for chi-square tests of goodness of fit and independence (Preacher 2001). We used the MASS package in the programming language R for summary statistics (Venables and Ripley 2002; R Core Team 2023). To evaluate the presence of statistically identifiable populations of separate 'large' and 'small' laminar blanks, we performed a 2D kernel density analysis and fitted a mixture model using the mclust package (Scrucca et al. 2016; R Core Team 2023). The kernel density analysis and mixture model were bivariate and considered laminar blank width and thickness of all complete and proximal blanks (MNB). Because analyses were bivariate using a small sample, metric measurements were converted to the log scale. The mixture model considered 1-, 2- and 3-component groupings for the assemblage.

## Results

### Raw materials

Quartzite is the primary material used in lithic production (N = 262, 71%), and it is locally available near the site. It is followed by silcrete (N = 76, 21%), quartz (N = 18, 5%) and other raw materials (N = 14, 4%). Roberts (2003) identified the nearest silcrete source as being ∼10–15 km from the cave. It is the likely source for part of the red silcrete found in Horizon 6/7. At least one additional and unidentified silcrete source contributed to the assemblage with a finer-grained material, quartz inclusions and tan colour. Horizon 6/7 has a low rate of cortex preservation across lithic artefact classes (Table 2).

When considering the MNB, 50% of cores (N = 40), 78% of unretouched blades MNB (N = 95), 74% of unretouched flakes MNB (N = 29) and 87% of retouched tools MNB (N = 104) are completely void of cortex. Early stage blades with >60% cortex are rare and only present in quartzite (four blades plus five flakes), with the addition of one chalcedony blade with 91–99% cortex. Tools with >60% cortex are also only found in quartzite (N = 2). Early stage cores with >60% cortex are present in low frequencies in quartzite (N = 4) and silcrete (N = 1).

### Heat treatment

All silcrete artefacts (N = 76), regardless of completeness, were macroscopically assessed for evidence of heat treatment (Table 3). Artefacts from Horizon 6/7 likely represent at least two separate sources. A total of four silcrete artefacts (including one core and three retouched tools) preserved roughness contrast and were used as a reference collection to assess the likelihood of heat treatment on artefacts without roughness contrast. Most silcrete artefacts from Horizon 6/7 appear to be heat-treated (N = 48, 63%), while one retouched tool fragment was determined to be unheated; the assemblage contains a high number of artefacts classified as indeterminate (N = 27, 36%) because of a lack of comparative samples.

### Cores

The sample studied here includes 80 cores (Figures 3 and 4). Most are blade cores (N = 62, 78%), or cores that have produced one or more blades, with a minority producing flakes at the point of discard (N = 18, 23%) (Table 4). Regardless of raw material, cores are mostly modified small cobbles/pebbles. However, quartzite core reduction may also start with larger blocks/nodules that are rare, if present at all, in other raw material classes. Additionally, some quartzite flakes were turned into cores (N = 13, 15%). Here, we divide the core assemblage into six core types based on morphology, flaking surface size and flaking surface position (Figures 5):

- flat-faced (N = 10, 13%): cores with two opposed surfaces separated by a mid-line (Figure 4.1). The functions of these surfaces are different, with a flaking surface opposed to a lower face with negative of peripheral removals and sometimes cortex. As noted by Villa and colleagues (2010), the mid-line does not always draw a plane, although the core could fit in the loosely defined Levallois blade core variations

Table 2. Montagu Cave: cortex coverage for all complete cores and minimum number of blanks (complete blanks and proximal fragments) for unretouched blades, unretouched flakes and retouched tools by raw material.

| | | | 0% | | 1–10% | | 11–40% | | 41–60% | | 61–90% | | 91–99% | | 100% | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Raw Material | Total N | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Cores | Quartzite | 39 | 23 | 57.5 | 1 | 20.0 | 6 | 46.2 | 5 | 29.4 | 0 | 0.0 | 4 | 100.0 | 0 | 0.0 |
| | Silcrete | 26 | 11 | 27.5 | 2 | 40.0 | 5 | 38.5 | 7 | 41.2 | 1 | 100.0 | 0 | 0.0 | 0 | 0.0 |
| | Quartz | 9 | 6 | 15.0 | 1 | 20.0 | 2 | 15.4 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| | Other | 6 | 0 | 0.0 | 1 | 20.0 | 0 | 0.0 | 5 | 29.4 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| | Total | 80 | 40 | 50.0 | 5 | 6.3 | 13 | 16.3 | 17 | 21.3 | 1 | 1.0 | 4 | 5.0 | 0 | 0.0 |
| Unretouched blades | Quartzite | 110 | 84 | 88.4 | 6 | 100.0 | 10 | 100.0 | 5 | 100.0 | 3 | 100.0 | 1 | 50.0 | 1 | 100.0 |
| | Silcrete | 6 | 6 | 6.3 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| | Quartz | 3 | 3 | 3.2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| | Other | 3 | 2 | 2.1 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 50.0 | 0 | 0.0 |
| | Total | 122 | 95 | 77.9 | 6 | 4.9 | 10 | 8.2 | 5 | 4.1 | 3 | 2.5 | 2 | 1.6 | 1 | 0.8 |
| Unretouched flakes | Quartzite | 37 | 27 | 93.1 | 3 | 100.0 | 0 | 0.0 | 2 | 100.0 | 5 | 100.0 | 0 | 0.0 | 0 | 0.0 |
| | Silcrete | 2 | 2 | 6.9 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| | Quartz | 0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| | Other | 0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| | Total | 39 | 29 | 74.4 | 3 | 7.7 | 0 | 0.0 | 2 | 5.1 | 5 | 12.8 | 0 | 0.0 | 0 | 0.0 |
| Retouched tools | Quartzite | 67 | 56 | 53.8 | 4 | 66.7 | 3 | 60.0 | 0 | 0.0 | 4 | 100.0 | 0 | 0.0 | 0 | 0.0 |
| | Silcrete | 41 | 39 | 37.5 | 0 | 0.0 | 2 | 40.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| | Quartz | 6 | 5 | 4.8 | 1 | 16.7 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| | Other | 5 | 4 | 3.8 | 1 | 16.7 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| | Total | 119 | 104 | 87.4 | 6 | 5.0 | 5 | 4.2 | 0 | 0.0 | 4 | 3.4 | 0 | 0.0 | 0 | 0.0 |

Table 3. Montagu Cave: assessment of heat treatment in silcrete artifacts. Roughness contrast pieces preserve both pre- and post-heating surfaces and are included in heat treated counts.

| Artefact class | Total (N) | Roughness contrast N | Heat-treated N | Heat-treated % | Indeterminate N | Indeterminate % | Unheated N | Unheated % |
|---|---|---|---|---|---|---|---|---|
| Cores | 26 | 1 | 16 | 61.5 | 10 | 38.5 | 0 | 0.0 |
| Blanks | 9 | 0 | 5 | 55.6 | 4 | 44.4 | 0 | 0.0 |
| Tools | 41 | 3 | 27 | 65.9 | 13 | 31.7 | 1 | 2.4 |
| Total | 76 | 4 | 48 | 63.2 | 27 | 35.5 | 1 | 1.3 |


Figure 3. Selection of cores from Horizon 6/7 of Montagu Cave. Scale bar = 1 mm: 1–4) Klasies River Type 2b (quartzite); 5) Klasies River Type 2a (quartz); 6) Klasies River Type 2a (silcrete); 8)11) centripetal (quartzite); 12) centripetal (silcrete); 13, Klasies River Type 2b (quartzite); 14 and 16, Klasies River Type 2b (silcrete); 15 and 18) Klasies River Type 2b (quartz); 17) Klasies River Type 2b (CCS). Note the simi-larities between small and large cores and across raw material types (photograph Sara Watson).

(Boëda 1994). The flaking surface appears to exploit a broad face, with unidirectional or bidirectional laminar removals;

- Klasies River cores (N = 37, 46%): the core morphology is very similar to the that of the flat-faced cores and mainly differs by the occurrence of peripheral negatives along/around extending from the lower face to the flaking surface (Figure 4.2a, 2b). First recognised in the Klasies River Howiesons Poort assemblage by Wurz (2002, 2005), these cores were then described by Soriano et al. (2007) as a 'second configuration' at Rose Cottage Cave, by Porraz et al. (2013) in layer 'Jeff' (assigned to the Intermediate Howiesons Poort) at Diepkloof, again at Klasies River as a specific reduction method by Villa et al. (2010) and finally as 'Howiesons Poort cores' at Sibudu (de la Peña 2015);

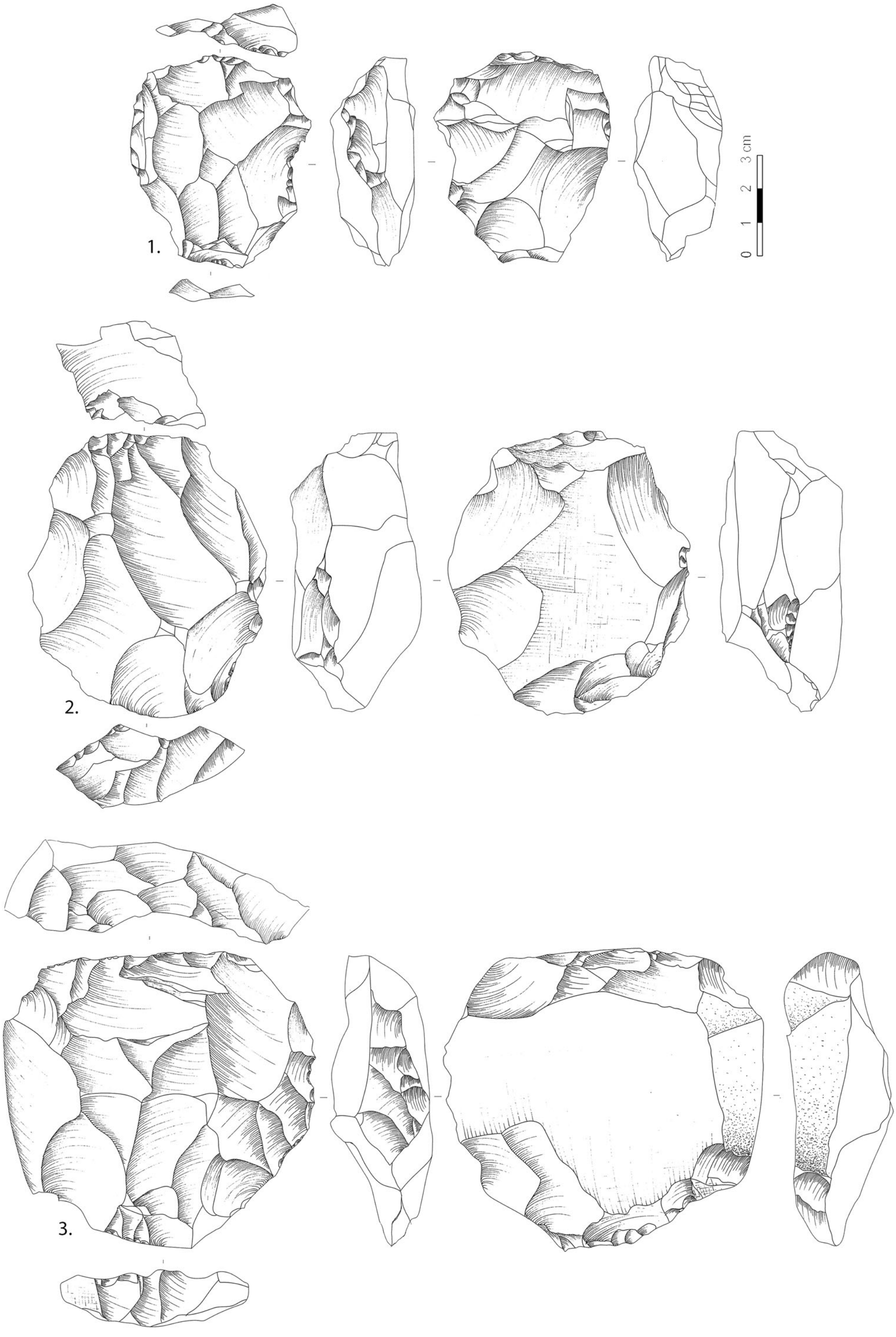


Figure 4. Montagu Cave: variants in the Klasies River Core category from Horizon 6/7: 1 and 2) cores with bilateral and distal management (Type 2b); 3) (also in Figure 5.5) core with orthogonal removals along one side (the other side is thick and abrupt) and on the distal end of the flaking surface. The back of the cores was often used as striking platform for such core management operation. Note the opposed bidirectional removals on flaking surfaces (illustration Nicolas Zywns).

Table 4. Montagu Cave: attributes of cores by raw material.

| Attribute | Total | | Quartzite | | Silcrete | | Quartz | | Other | |
|---|---|---|---|---|---|---|---|---|---|---|
| Core blank | N | % | N | % | N | % | N | % | N | % |
| Block | 23 | 28.8 | 20 | 51.3 | 2 | 7.7 | 0 | 0.0 | 1 | 16.7 |
| Pebble | 33 | 41.2 | 5 | 12.8 | 18 | 69.2 | 5 | 55.6 | 5 | 83.3 |
| Flake | 20 | 25.0 | 13 | 33.3 | 4 | 15.4 | 3 | 33.3 | 0 | 0.0 |
| Indeterminate | 4 | 5.0 | 1 | 2.6 | 2 | 7.7 | 1 | 11.1 | 0 | 0.0 |
| Primary product | | | | | | | | | | |
| Blades | 62 | 77.5 | 26 | 66.7 | 22 | 84.6 | 8 | 88.9 | 6 | 100.0 |
| Flakes | 18 | 22.5 | 13 | 33.3 | 4 | 15.4 | 1 | 11.1 | 0 | 0.0 |
| Core morphology | | | | | | | | | | |
| Flat-faced | 10 | 12.5 | 7 | 17.9 | 3 | 11.5 | 0 | 0.0 | 0 | 0.0 |
| Klasies River core | 37 | 46.3 | 17 | 43.6 | 13 | 50.0 | 4 | 44.4 | 3 | 50.0 |
| Asymmetrical | 8 | 10.0 | 4 | 10.3 | 2 | 7.7 | 1 | 11.1 | 1 | 16.7 |
| Prismatic | 8 | 10.0 | 2 | 5.1 | 2 | 7.7 | 2 | 22.2 | 2 | 33.3 |
| Centripetal | 6 | 7.5 | 2 | 5.1 | 3 | 11.5 | 1 | 11.1 | 0 | 0.0 |
| Multiplatform | 5 | 6.2 | 3 | 7.7 | 1 | 3.8 | 1 | 11.1 | 0 | 0.0 |
| Other | 6 | 7.5 | 4 | 10.3 | 2 | 7.7 | 0 | 0.0 | 0 | 0.0 |

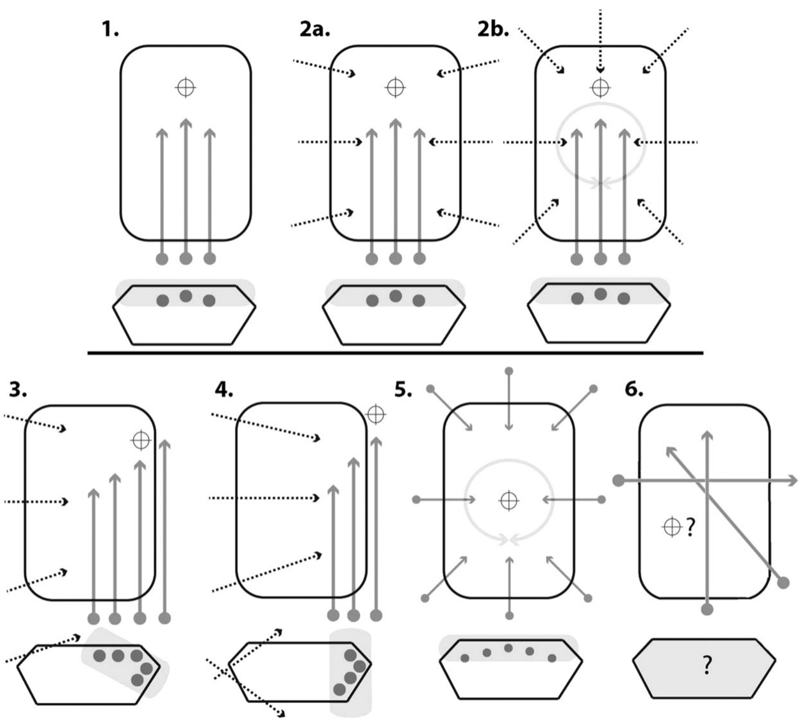


Figure 5. Montagu Cave: core types as described in the text. 1) flat-faced core; 2) variations of Klasies River core (2a, with lateral; 2b, radial flaking-surface preparation); 3) asymmetrical core; 4) prismatic core (with frontal progression); 5) centripetal core (illustration Nicolas Zywns).

- asymmetrical (N = 8, 10%): intermediate between the two types described above, asymmetrical cores show orthogonal removals along one edge of the flaking surface, opposed to an extension of the broad flaking surface towards the narrow sides

(Figure 4.3). This core type has been first described in other chrono-cultural contexts (e.g. Roussel 2011; Zwyns 2012, 2021; Roussel et al. 2016) and was first recognised by Boëda (1990) as evidence for a specific method of reduction on the Châtelperronian material from Roc-de-Combe Layer 8, France;

- prismatic (N = 8, 10%): with a polygonal cross-section and with one/two striking platforms (de Sonneville-Bordes 1960; Brézillon 1968), the core prismatic shape reflects numerous blade removals (De Braucourt 1962) with a semi-turning pattern of core reduction (Figure 4.4). We lumped in this morphological category the rare cores for which the flaking surface is restricted to a narrow side with a frontal progression;
- centripetal (N = 6, 8%): cores that show a sub-radial or radial series of flake negatives around the main flaking surface with negatives oriented toward the central part of the surface (Figure 4.5). Originally, this term refers to a type of preparation for Levallois flake production (Bordes 1980; Tixier et al. 1980; Copeland 1983) and it is further described as 'predetermining flakes' (enlèvement prédéterminant) by Boëda (1994). As mentioned above, the use of this type here is not restricted to cores separated by a mid-plane;
- multiplatform (N = 5, 6%): this includes miscellaneous cores that show two or more platform changes during reduction, usually with a change of orientation of the removals. This category includes both flake and blade cores;
- others (N = 6, 7.5%): all cores that do not fit in the above categories. They are usually preforms or amorphous.

Klasies River cores are the most common across all raw materials and represent 46% of cores, while prismatic cores (10%), which are less common, are also present across all raw material classes. Flat-faced cores (13%) are only made of quartzite and silcrete. Multidirectional cores and other core morphologies show evidence of both blade and flake production. They make small contributions to the assemblage and are found primarily in quartzite and silcrete. Size variation in the core assemblage depends primarily on raw material categories (Table 5). There are clear differences in length, width and thickness between quartzite cores and those in all other raw materials (Figure 6). Looking at the core longest axis of quartzite cores, we can observe that the distribution is bimodal (Figure 7). Cores smaller than 10 cm in maximum dimension are the most numerous, but a few much larger quartzite cores are also included.

## Blank production

### Blades and bladelets

Blade/bladelet production was the focus of core reduction in Horizon 6/7 (Figure 8). Of the 161 unretouched blanks in the assemblage, 122 (76%) are blades (Table 2). Blades are primarily made from quartzite (N = 110, 90%), with small representations of silcrete (N = 6, 5%), quartz (nN = 3, 3%) and other raw materials (N = 3, 3%). Complete blanks comprise about one-quarter of the assemblage (N = 41) while the rest occur as fragments. Blade fragments were identified by their parallel or subparallel lateral edges and triangular or trapezoidal sections. Metric measurements (mass, length, width and thickness) are summarised in Table 5.

Table 5. Montague Cave: mean and standard deviation (SD) for metric measurements of all cores, complete unretouched blades and complete retouched blades by raw material.

| | | | | Mass | | Length | | Width | | Thickness | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Class | Material | N | % | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Cores | Quartzite | 39 | 48.8 | 14.13 | 9.58 | 63.88 | 30.15 | 57.13 | 22.92 | 31.42 | 15.73 |
| | Silcrete | 26 | 32.5 | 10.54 | 5.64 | 30.12 | 7.6 | 22.94 | 6.6 | 12.12 | 3.5 |
| | Quartz | 9 | 11.3 | 4.89 | 2.57 | 26.74 | 12.43 | 24.66 | 7.35 | 15.09 | 5.49 |
| | Other | 6 | 7.5 | 3.33 | 1.63 | 23.37 | 1.42 | 20.64 | 5.5 | 14.93 | 2.22 |
| Unretouched blades | Quartzite | 38 | 92.7 | 51.61 | 52.52 | 85.71 | 22.8 | 35.95 | 12.07 | 15.93 | 5.73 |
| | Silcrete | 2 | 4.9 | 3.24 | 0.76 | 43.91 | 8.2 | 17.1 | 2.03 | 5.54 | 1.46 |
| | Other | 1 | 2.4 | 1.99 | n/a | 50.58 | n/a | 15.36 | n/a | 7.58 | n/a |
| Retouched blades | Quartzite | 25 | 55.6 | 63.08 | 54.31 | 84.48 | 24.77 | 43.88 | 16.46 | 16.75 | 6.32 |
| | Silcrete | 15 | 33.3 | 4.15 | 2.87 | 32.73 | 5.78 | 18.72 | 5.81 | 6 | 2.24 |
| | Quartz | 3 | 6.7 | 2.19 | 1.05 | 36.37 | 9.29 | 15.33 | 1.92 | 3.43 | 0.7 |
| | Other | 2 | 4.4 | 1.96 | 1.46 | 28.06 | 9.65 | 13 | 2.64 | 4.06 | 0.02 |

When considering the histograms, we observe that the width distribution of the laminar blanks is multimodal (Figure 9). To better understand whether the distribution of laminar blanks represents a single group or statistically identifiable separate populations of large and small blades, we performed a kernel density analysis. We examined the bivariate density for width and thickness of laminar elements in the assemblage. The kernel density analysis suggests two modes (Figure 10). To further define these potential groups, we performed a 2D mixture analysis examining the possibility of groups with 1, 2 and 3 components. Based on comparisons of the BIC (Bayesian Information Criteria) value for the 1-, 2- and 3-component mixture models, two mixture components have the best support relative to either one or three components (Table 6). Group centroids cluster at widths of 49.2 ± 14.4 mm for the larger component and 24.6 ± 9.8 mm for the smaller component.

Attributes for the assemblage MNB are summarised in Table 7. Terminations consider complete blanks and distal fragments. Most of the unretouched blades have a straight (N

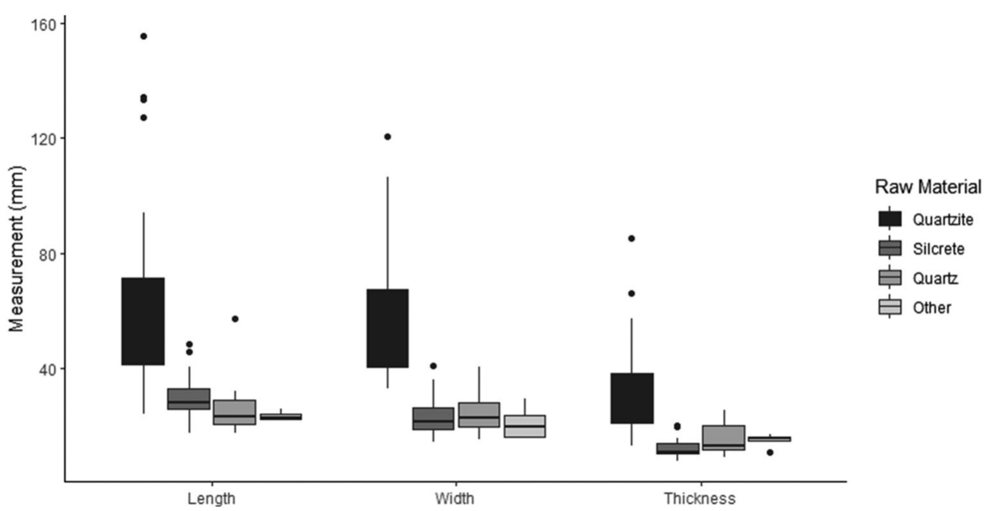


Figure 6. Montagu Cave: boxplots of core metric measurements (length, width, thickness) by raw material.

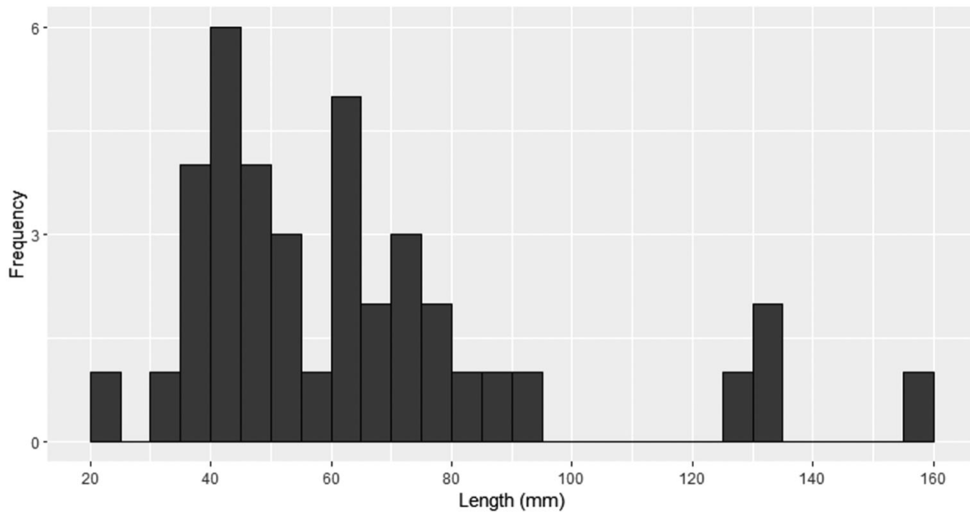


Figure 7. Montagu Cave: histogram showing length in millimetres of maximum dimension for quartzite cores.

= 61, 69%) or curved (N = 20, 23%) profile and triangular or trapezoidal section with unidirectional (N = 48, 54%) or bidirectional (N = 29, 33%) dorsal scars. While the frequency of bidirectional removals is higher on blanks than cores, it does not exceed a third of the assemblage. Two crested blades of second generation (neo-crêtes) show evidence of lateral core convexity management. Most laminar blanks are axial removals (N = 91, 70%), but off-axis blanks are relatively common (N = 33, 25%). Similarly, most laminar blanks are symmetrical in section (N = 55, 56%), one blade out of three (including débordant blanks and naturally backed blades) is asymmetric (N = 21, 33%). Half of the blades have a feathered termination, and the frequency of overshot terminations is notable (N = 17, 22%).

When considering blades with preserved platforms (N = 89), platform preparation (Table 8) is primarily plain (N = 44, 49%) or facetted (N = 30, 34%) with a visible point of percussion on the platform (N = 65, 73%) and no lip (N = 58, 65%). External platform edges are mostly prepared (N = 63, 71%), with abrasion (N = 38, 43%) being the most common form of core edge preparation. Mean platform thickness is multimodal and varies by raw material (Table 9). Quartzite blades have the thickest platforms, with a mean thickness of 12.07 ± 5.48 mm. Silcrete platforms are thinner but with a large standard deviation driven by a few outliers (mean thickness 6.6 ± 5.18 mm). The single chalcedony blade with a platform is similar in thickness to the silcrete blades in the assemblage (5.61 mm) while the single quartz blade preserving a platform is much thinner (2.72 mm). Overall, thick platforms, the presence of a visible point of percussion and a lack of lipping suggest the extensive use of mineral hammers.

In terms of qualitative technological markers, three main categories stand out:

1. blades from the centre of the flaking surface: the most common in the assemblage, they have flat, slightly curved or curved profiles, symmetrical triangular or trapezoidal

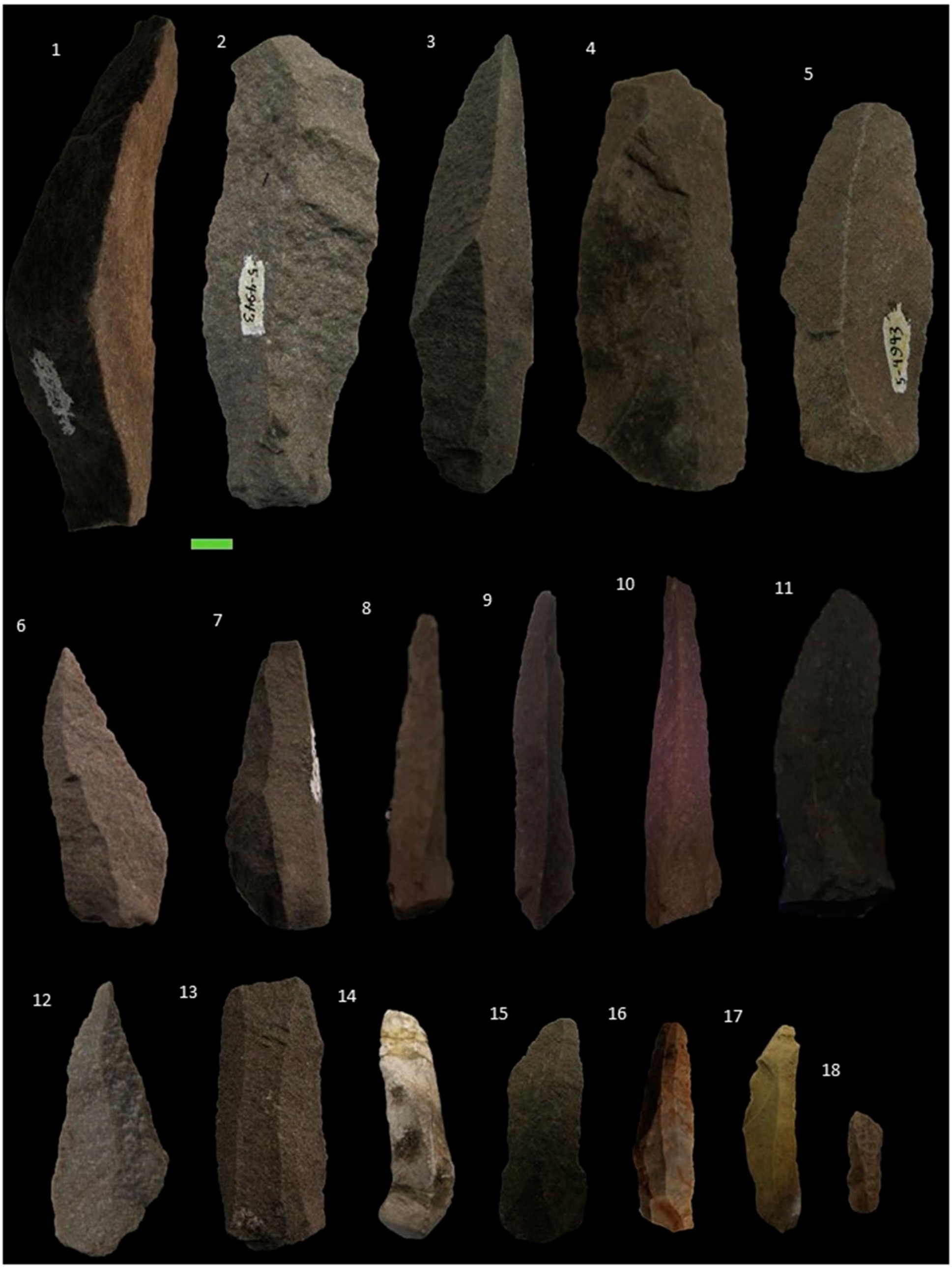


Figure 8. Montagu Cave: selection of unretouched laminar blanks from Horizon 6/7. Scale bar = 1 mm: 1–13 and 15) quartzite; 14 and 17–18) silcrete; 16) CCS (photograph Sara Watson).

sections and unidirectional or bidirectional dorsal scars. These blanks are consistent with the main phase of production on both the Klasies River and prismatic blade cores present in the Horizon 6/7 assemblage;

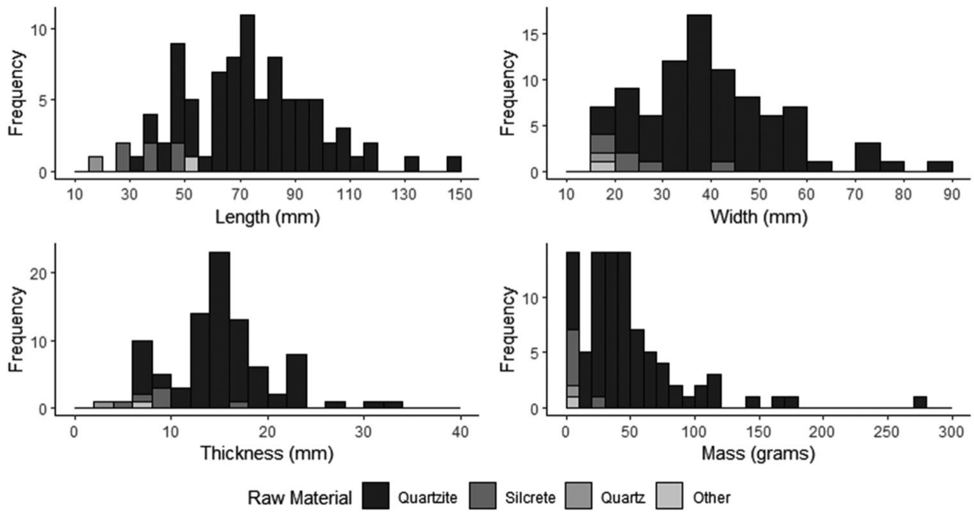


Figure 9. Montagu Cave: histograms showing metric measurements (length, width, thickness, mass) of unretouched laminar blanks with proportions of raw material indicated.

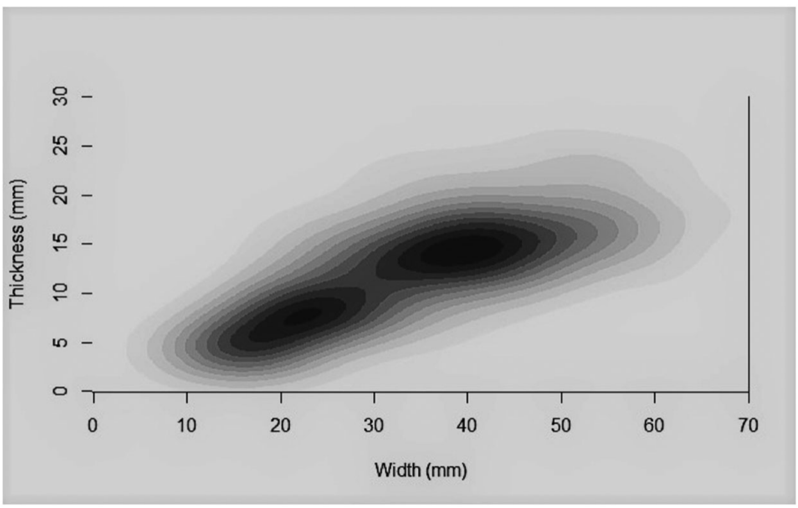


Figure 10. Montagu Cave: results of 2-component mixture analysis of blade width/thickness for complete and proximal unretouched laminar blanks.

Table 6. Montagu Cave: results of mixture analysis of blade width for complete and proximal unretouched laminar blanks considering groups with 1, 2 and 3 components.

| Number of groups | BIC value |
|---|---|
| 1 | -555.9418 |
| 2 | -524.7588 |
| 3 | -539.7245 |

Table 7. Montagu Cave: attributes of minimum number of blanks (complete blanks and proximal fragments) for unretouched blades and retouched blades by raw material.

| | Unretouched blades | | | | | | | | | | Retouched blades | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | | Quartzite | | Silcrete | | Quartz | | Other | | Total | | Quartzite | | Silcrete | | Quartz | | Other | |
| Completeness | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Complete | 41 | 33.6 | 38 | 34.5 | 2 | 33.3 | 0 | 0.0 | 1 | 33.3 | 24 | 30.0 | 13 | 26.5 | 6 | 28.6 | 3 | 60.0 | 2 | 40.0 |
| Proximal | 48 | 39.3 | 43 | 39.1 | 4 | 66.7 | 1 | 33.3 | 0 | 0.0 | 34 | 42.5 | 21 | 42.9 | 9 | 42.9 | 1 | 20.0 | 3 | 60.0 |
| Mesial | 15 | 12.3 | 14 | 12.7 | 0 | 0.0 | 1 | 33.3 | 0 | 0.0 | 8 | 10.0 | 5 | 10.2 | 2 | 9.5 | 1 | 20.0 | 0 | 0.0 |
| Distal | 18 | 14.8 | 15 | 13.6 | 0 | 0.0 | 1 | 33.3 | 2 | 66.7 | 14 | 17.5 | 10 | 20.4 | 4 | 19.0 | 0 | 0.0 | 0 | 0.0 |
| Profile | | | | | | | | | | | | | | | | | | | | |
| Straight | 61 | 68.5 | 58 | 71.6 | 2 | 33.3 | 1 | 100.0 | 0 | 0.0 | 29 | 50.0 | 19 | 55.9 | 8 | 53.3 | 1 | 25.0 | 1 | 20.0 |
| Curved | 20 | 22.5 | 18 | 22.2 | 1 | 16.7 | 0 | 0.0 | 1 | 100.0 | 23 | 39.6 | 11 | 32.4 | 7 | 46.7 | 2 | 50.0 | 3 | 60.0 |
| Twisted | 4 | 4.5 | 3 | 3.7 | 1 | 16.7 | 0 | 0.0 | 0 | 0.0 | 2 | 3.4 | 0 | 0.0 | 0 | 0.0 | 1 | 25.0 | 1 | 20.0 |
| Irregular/Indeterminate | 4 | 4.5 | 2 | 2.5 | 2 | 33.3 | 0 | 0.0 | 0 | 0.0 | 4 | 7.0 | 4 | 11.8 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Section | | | | | | | | | | | | | | | | | | | | |
| Triangular | 46 | 51.7 | 41 | 50.6 | 4 | 66.7 | 1 | 100.0 | 0 | 0.0 | 42 | 72.4 | 28 | 82.4 | 7 | 46.7 | 4 | 100.0 | 3 | 60.0 |
| Trapezoidal | 29 | 32.6 | 26 | 32.1 | 2 | 33.3 | 0 | 0.0 | 1 | 100.0 | 8 | 13.8 | 5 | 14.7 | 3 | 20.0 | 0 | 0.0 | 0 | 0.0 |
| Flat | 8 | 9.0 | 8 | 9.9 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 5 | 8.6 | 0 | 0.0 | 4 | 26.7 | 0 | 0.0 | 1 | 20.0 |
| Other | 6 | 6.7 | 6 | 7.4 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 3 | 5.2 | 1 | 2.9 | 1 | 6.7 | 0 | 0.0 | 1 | 20.0 |
| Dorsal Scars | | | | | | | | | | | | | | | | | | | | |
| Unidirectional | 48 | 53.9 | 47 | 58.0 | 0 | 0.0 | 1 | 100.0 | 0 | 0.0 | 29 | 50.0 | 15 | 44.1 | 9 | 60.0 | 2 | 50.0 | 3 | 60.0 |
| Bidirectional | 29 | 32.6 | 24 | 29.6 | 5 | 83.3 | 0 | 0.0 | 0 | 0.0 | 24 | 41.4 | 15 | 44.1 | 5 | 33.3 | 2 | 50.0 | 2 | 40.0 |
| Transverse | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 3 | 5.2 | 3 | 8.8 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Second crest | 4 | 4.5 | 3 | 3.7 | 1 | 16.7 | 0 | 0.0 | 0 | 0.0 | 1 | 1.7 | 0 | 0.0 | 1 | 6.7 | 0 | 0.0 | 0 | 0.0 |
| Neocrest | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 1.7 | 1 | 2.9 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Indeterminate | 8 | 9.0 | 7 | 8.6 | 0 | 0.0 | 0 | 0.0 | 1 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Asymmetry | | | | | | | | | | | | | | | | | | | | |
| None | 55 | 61.8 | 50 | 61.7 | 3 | 50.0 | 1 | 100.0 | 1 | 100.0 | 36 | 62.1 | 20 | 58.8 | 10 | 66.7 | 4 | 100.0 | 2 | 40.0 |
| Left | 18 | 20.2 | 18 | 22.2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 10 | 17.2 | 6 | 17.6 | 2 | 13.3 | 0 | 0.0 | 2 | 40.0 |
| Right | 13 | 14.6 | 11 | 13.6 | 2 | 33.3 | 0 | 0.0 | 0 | 0.0 | 10 | 17.2 | 7 | 20.6 | 2 | 13.3 | 0 | 0.0 | 1 | 20.0 |
| Indeterminate | 3 | 3.4 | 2 | 2.5 | 1 | 16.7 | 0 | 0.0 | 0 | 0.0 | 2 | 3.4 | 1 | 2.9 | 1 | 6.7 | 0 | 0.0 | 0 | 0.0 |
| Termination | | | | | | | | | | | | | | | | | | | | |
| Feather | 31 | 52.5 | 30 | 56.6 | 0 | 0.0 | 1 | 100.0 | 0 | 0.0 | 10 | 34.5 | 5 | 31.3 | 4 | 50.0 | 1 | 33.3 | 0 | 0.0 |
| Hinge or Step | 5 | 8.5 | 5 | 9.4 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 5 | 17.2 | 4 | 25.0 | 0 | 0.0 | 1 | 33.3 | 0 | 0.0 |
| Overshot | 17 | 28.8 | 13 | 24.6 | 2 | 100.0 | 0 | 0.0 | 2 | 66.7 | 10 | 34.5 | 3 | 18.7 | 4 | 50.0 | 1 | 33.3 | 2 | 100.0 |
| Indeterminate | 6 | 10.2 | 5 | 9.4 | 0 | 0.0 | 0 | 0.0 | 1 | 33.3 | 4 | 13.8 | 4 | 25.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |

Table 8. Montagu Cave: attributes of unretouched blade platforms by raw material.

| Attribute | Total | | Quartzite | | Silcrete | | Quartz | | Other | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | f | N | f | N | f | N | f | N | f |
| Dorsal preparation | | | | | | | | | | |
| None | 22 | 24.7 | 22 | 24.7 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Abrasion | 38 | 42.7 | 36 | 40.5 | 2 | 2.2 | 0 | 0.0 | 0 | 0.0 |
| Marginal faceting | 18 | 20.2 | 14 | 15.7 | 4 | 4.5 | 0 | 0.0 | 0 | 0.0 |
| Trimming | 7 | 7.0 | 6 | 6.0 | 0 | 0.0 | 1 | 1.0 | 0 | 0.0 |
| Indeterminate | 4 | 4.0 | 3 | 3.0 | 0 | 0.0 | 0 | 0.0 | 1 | 1.0 |
| EPA | | | | | | | | | | |
| < 45 | 1 | 1.1 | 1 | 1.1 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| 45-60 | 5 | 5.6 | 5 | 5.6 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 60-75 | 21 | 23.6 | 19 | 21.3 | 2 | 2.2 | 0 | 0.0 | 0 | 0.0 |
| 75-90 | 55 | 61.8 | 50 | 56.2 | 3 | 3.4 | 1 | 1.1 | 1 | 1.1 |
| Indet | 7 | 7.5 | 6 | 6.4 | 1 | 1.1 | 0 | 0.0 | 0 | 0.0 |
| Lipping | | | | | | | | | | |
| Yes | 31 | 34.8 | 30 | 33.7 | 1 | 1.1 | 0 | 0.0 | 0 | 0.0 |
| No | 58 | 65.2 | 51 | 57.3 | 5 | 5.6 | 1 | 1.1 | 1 | 1.1 |
| Percussion point | | | | | | | | | | |
| Yes | 65 | 73.0 | 60 | 67.4 | 4 | 4.5 | 1 | 1.1 | 0 | 0.0 |
| No | 24 | 27.0 | 21 | 23.6 | 2 | 2.2 | 0 | 0.0 | 1 | 1.1 |
| Platform morphology | | | | | | | | | | |
| Plain | 44 | 49.4 | 41 | 46.1 | 1 | 1.1 | 1 | 1.1 | 1 | 1.1 |
| Faceted | 30 | 33.7 | 28 | 31.5 | 2 | 2.2 | 0 | 0.0 | 0 | 0.0 |
| Dihedral | 9 | 10.1 | 7 | 7.9 | 2 | 2.2 | 0 | 0.0 | 0 | 0.0 |
| Punctiform | 2 | 2.2 | 2 | 2.2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Other | 4 | 4.5 | 3 | 3.4 | 1 | 1.1 | 0 | 0.0 | 0 | 0.0 |

Table 9. Montagu Cave: mean, standard deviation (SD) and median for unretouched blade platform maximum width and maximum thickness by raw material.

| | | Width | | | Thickness | | |
|---|---|---|---|---|---|---|---|
| Material | N | Mean | SD | Median | Mean | SD | Median |
| Quartzite | 81 | 26.08 | 12.41 | 26.56 | 12.07 | 5.48 | 12.15 |
| Silcrete | 6 | 15.64 | 7.84 | 15.2 | 6.76 | 5.18 | 6.14 |
| Quartz | 1 | 6.66 | n/a | 6.66 | 2.72 | n/a | 2.72 |
| Other | 1 | 13.61 | n/a | 13.61 | 5.61 | n/a | 5.61 |

2. blades from the side of the flaking surface: most frequently curved or twisted profile, with asymmetric triangular or trapezoidal sections. Asymmetry is visible along the left or right edge and some can be described as débordant blanks, preserving part of the core flank or naturally backed blades. In rare cases, crested blades of the second degree (neo-crêtes) show evidence of other solutions for lateral core convexity management;
3. overshot blades: most frequently from the centre of the knapping surface, with varying degrees of overshot terminations (outrepassé, outrepassant and pyramidion; Tixier et al. 1980), some of which preserve part of the flaking surface at their distal end. They are mostly curved and may have bidirectional dorsal scars. As noted in other Howiesons Poort assemblages, overshot blades are involved in the management of the flaking surface distal convexities (Soriano et al. 2007; Villa et al. 2010).

## Flakes

The unretouched flake assemblage is small and almost exclusively made from quartzite (N = 34), with the addition of a single complete silcrete flake. Quartzite flakes are mostly complete (N = 29, 83%) or proximal fragments (N = 5, 14%). Dorsal scars are primarily unidirectional (N = 15, 43%) or bidirectional (N = 11, 31%). The presence of flakes with dorsal scars perpendicular to the axis of flaking (N = 6, 17%) is consistent with observations of lateral convexity management of Klasies River cores. Terminations are primarily feather (N = 19, 59%) with regular occurrences of step (N = 5, 16%) and overshot (N = 6, 19%) terminations. Quartzite unretouched flakes overlap in size with cores and retouched tools.

## Retouched tools

Among the 119 retouched tools identified (Figures 11 and 12), 80 (67%) were produced on blades and 39 (33%) were produced on flakes. Raw material representation within the tools assemblage of Horizon 6/7 resembles what is observed in the core assemblage. Quartzite (N = 67, 56%) is the most common raw material, followed by silcrete (N = 41, 35%), quartz (N = 6, 5%) and other raw materials (N = 5, 4%). Blade tool blanks are mostly proximal sections (N = 34, 43%) and complete blanks (N = 25, 31%) with notable frequencies of distal sections (N = 14, 18%). Secondary treatment consists primarily of short, continuous retouch applied to one lateral edge. Notches (N = 26, 33%) are the most common tool type identified in the assemblage (Table 10). Six segments were identified in the assemblage: four in silcrete, one in quartz and one in chalcedony. One silcrete segment is a proximal fragment and the rest are complete. Two of the segments are naturally backed/débordant blanks with marginal retouch along the non-backed edge. The chalcedony segment also has a slightly overshot termination (outrepassant; Tixier et al. 1980), which serves as a continuation of the natural backing from the débordant edge. All six segments are made from blade blanks with curved profiles.

When comparing the MNB of unretouched (N = 89) and retouched (N = 59) blades, we observed that retouched blades are narrower and thinner than unretouched blades. The width distributions between the whole set of unretouched and retouched blades are also different (Figure 13) (N = 220, U = 3071, $p \le 0.05$), with a mean of 40.5 ± 14.4 mm for unretouched blades and a mean of 28.5 ± 13.4 mm for retouched blades.

While the width of a retouch blade may or may not be affected by the retouch, depending on the location and the distribution of the retouch (e.g. proximal or distal retouch does not necessarily affect the maximum width), we observe a corresponding difference in thickness too (N = 220, U = 3011, $p \le 0.05$). This is notable given that the frequencies of asymmetrical blades, usually thicker, does not differ significantly between retouched (N = 29, 32%) and unretouched blanks (N = 48, 37%) ($x^2(1)$, 0.517, p =0.47). We note an increase in the frequency of convergent blades among retouched tools, concomitant to a decrease in the frequency of tools with parallel edges.

Of the 39 flake tools, over half (N = 20) are complete flakes while the rest are fragments. Retouched flakes are found almost exclusively in quartzite (N = 19) and silcrete (N = 19), with the addition of one quartz distal fragment. Secondary treatment of flake tools consists primarily of short, continuous retouch applied to any edge. The range of tool types (Table 10) among retouched flakes is more restricted than retouched blades and consists of regular retouch (N = 23, 59%), notched (N = 8, 21%), irregular retouch (N = 7, 18%) and convex retouch (N = 1, 3%). When comparing unretouched (N = 30) and retouched (N = 20) flakes, we observe that the width is similar between the groups, with retouched flakes being slightly narrower.

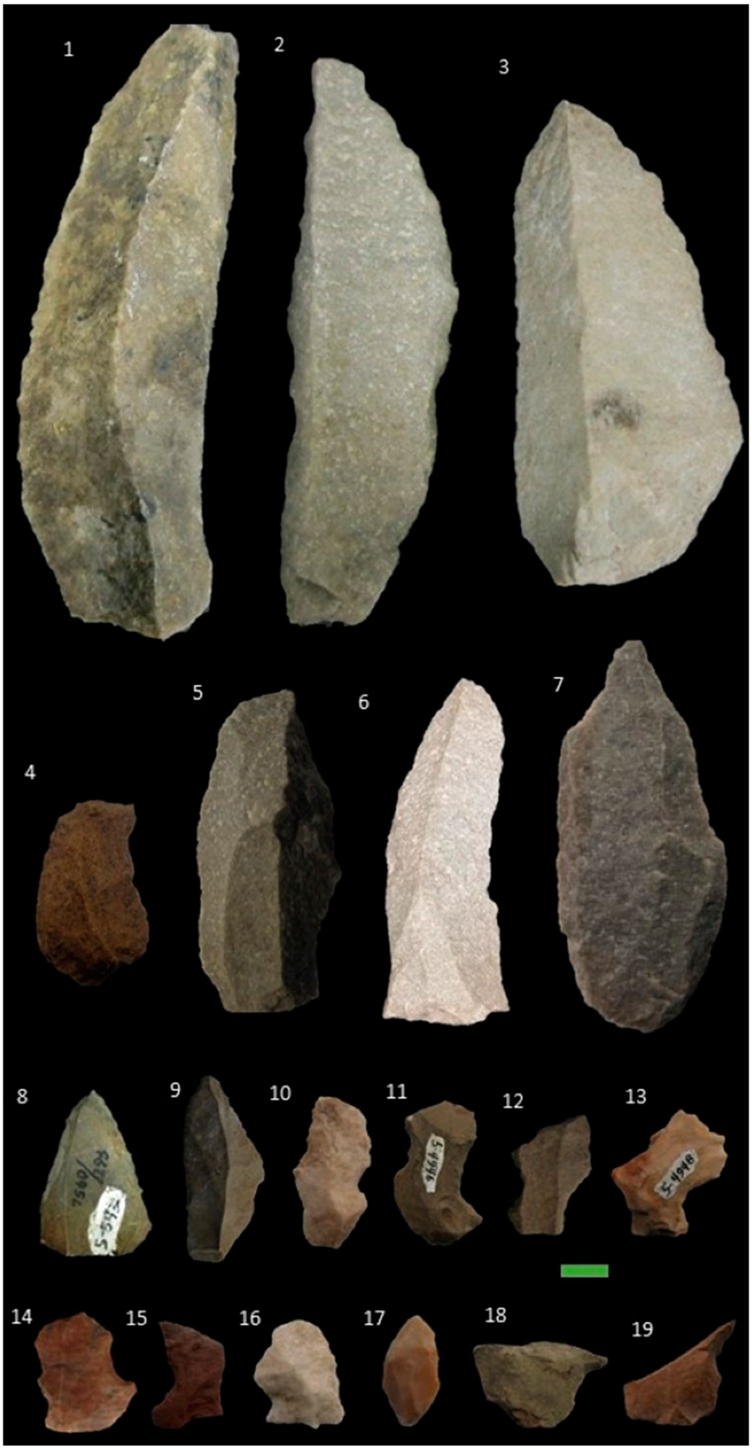


Figure 11. Montagu Cave: selection of retouched tools from Horizon 6/7. Scale bar = 1 mm: 1–3, 6, 8 and 16) rectilinear; 6) irregular; 7) burin; 9–15 and 18–19) notches; 4 and 17) segments (photograph Sara Watson).

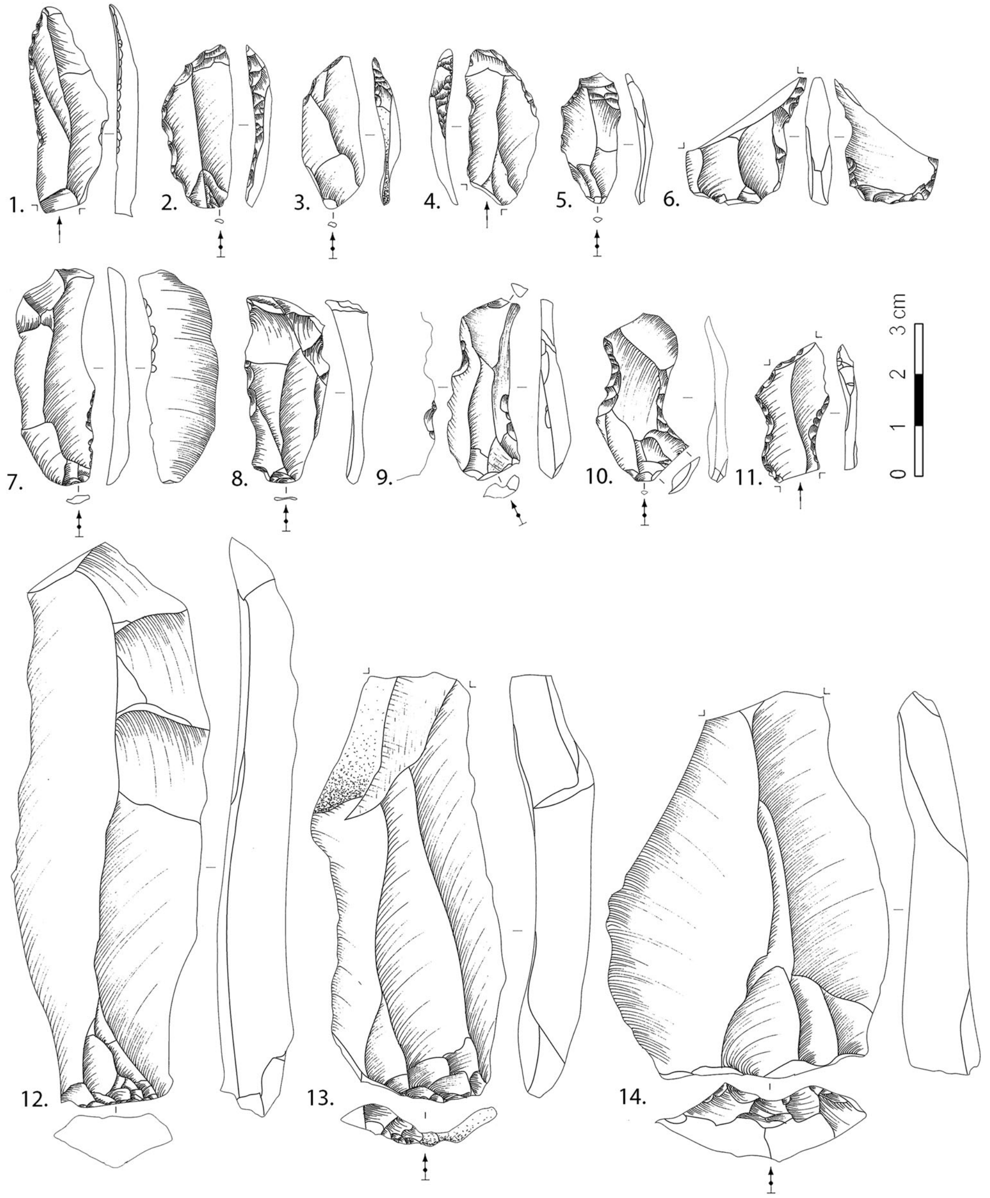


Figure 12. Montagu Cave: blanks and tools from Horizon 6/7: 1) blade with marginal, mesio-distal thin retouch along the left edge; 2) segment with continuous semi-abrupt retouch and a distal oblique truncation along the left edge (note the curved profile); 3) segment on a cortical overshot blank with a distal oblique truncation on the left edge; 4) segment on a blank with distal oblique truncation on the right edge; 5) small overshot blank with possible distal retouch; 6) distal fragment with inverse esquillées/retouch and irregular retouch along the right edge; 7–9) potential blanks for segments, including overshot (8), showing dorsal scars consistent with a Klasies River Howiesons Poort core management; 10–11) blanks with two opposed notches; 12–14) examples of parallel (12), sub-parallel (13) and convergent quartzite blanks (14). Note the distal orthogonal removals (12) (illustration Nicolas Zywns).

Table 10. Montagu Cave: retouched tool typology for blade tools and flake tools by raw material.

| | Blade tools | | | | | | | | | | Flake tools | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | | Quartzite | | Silcrete | | Quartz | | Other | | Total | | Quartzite | | Silcrete | | Quartz | | Other | |
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Burin | 9 | 11.3 | 8 | 16.7 | 1 | 4.5 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Concave | 3 | 3.8 | 2 | 4.2 | 0 | 0.0 | 0 | 0.0 | 1 | 20.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Convex | 3 | 3.8 | 2 | 4.2 | 1 | 4.5 | 0 | 0.0 | 0 | 0.0 | 1 | 2.6 | 0 | 0.0 | 1 | 5.3 | 0 | 0.0 | 0 | 0.0 |
| Denticulate | 3 | 3.8 | 2 | 4.2 | 0 | 0.0 | 1 | 20.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Notch | 26 | 32.5 | 11 | 22.9 | 10 | 45.5 | 2 | 40.0 | 3 | 60.0 | 8 | 20.5 | 4 | 21.1 | 4 | 21.1 | 0 | 0.0 | 0 | 0.0 |
| Regular | 20 | 25.0 | 16 | 33.3 | 3 | 13.6 | 1 | 20.0 | 0 | 0.0 | 23 | 59.0 | 9 | 47.4 | 13 | 68.4 | 1 | 100.0 | 0 | 0.0 |
| Truncation | 3 | 3.8 | 3 | 6.3 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Segment | 6 | 7.5 | 0 | 0.0 | 4 | 18.2 | 1 | 20.0 | 1 | 20.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Irregular | 7 | 8.8 | 4 | 8.3 | 3 | 13.6 | 0 | 0.0 | 0 | 0.0 | 7 | 17.9 | 6 | 31.6 | 1 | 5.3 | 0 | 0.0 | 0 | 0.0 |
| Total | 80 | 100.0 | 48 | 60.0 | 22 | 27.5 | 5 | 6.3 | 5 | 6.3 | 39 | 100 | 19 | 48.7 | 19 | 48.7 | 1 | 2.6 | 0 | 0.0 |

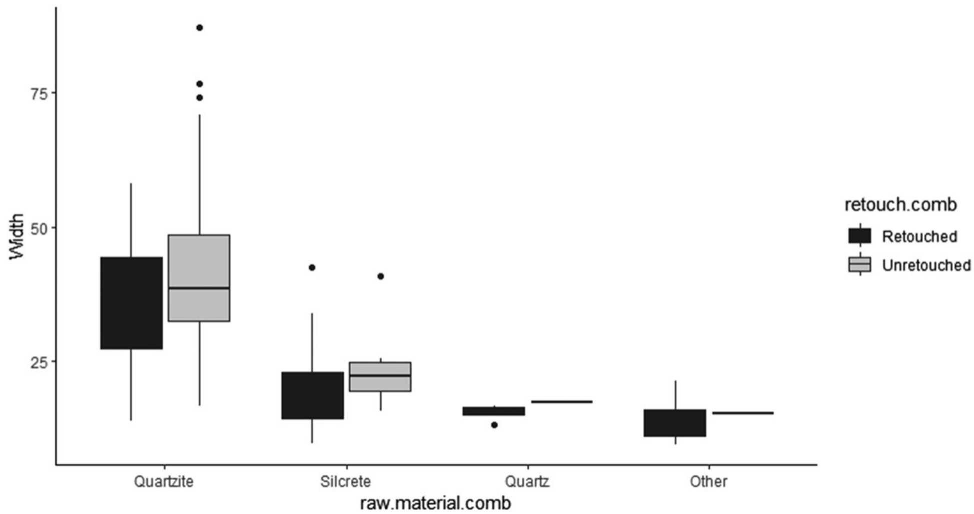


Figure 13. Montagu Cave: boxplots showing width in millimetres of unretouched laminar blanks and retouched laminar tools by raw material.

## Discussion

### The Horizon 6/7 assemblage

The main technological and typological features from Montagu Cave Horizon 6/7 are in line with other known Howiesons Poort assemblages. However, there are some fundamental differences that must also be addressed. The frequency of cores, laminar blanks and retouched tools in Horizon 6/7 is much higher than that recorded for other Howiesons Poort assemblages. There is also a notable absence of bipolar reduction. These differences might be the result of differences in definitions and of this being an old or an incomplete collection.

Volman (1981) did not provide descriptions for most of the Horizon 6/7 assemblage because he did not have access to the provenience documents for it. He did, however, provide a table of artefact frequencies by raw material for cores and retouched tool types, but we feel it is inappropriate to attempt direct comparisons of the data presented in this analysis with Volman's tables. Results from the Comparative analysis of Middle Stone Age Artefacts in Africa (CoMSAfrica) project show that differences in definitions, data collection methods, research traditions and theoretical schools (i.e. attribute analysis versus chaîne opératoire) between researchers provide obstacles in integrating data between individual researchers who have few shared basic definitions (Will et al. 2019). Additionally, since we do not know the size of the overall assemblage examined by Volman (1981), we cannot determine whether both analyses examined the same number of artefacts.

We do note that we record fewer cores than Volman did (80 in this study versus 99 in Volman's study). We also recorded fewer retouched tools than Volman (119 in this study versus 223 in Volman's study). However, over 50% of the retouched artefacts recorded by Volman (1981) were described as "minimal retouch and/or utilization" (N = 115). Because artefacts were curated such that multiple pieces were placed together in a single plastic bag, we did not record possible utilisation on the artefacts due to the likelihood of more recent damage that might be mistaken for it. When these artefacts are removed from the frequencies recorded by Volman, the frequencies of retouched tools recorded in this study and his are more similar (119 in this study versus 108 in Volman's).

During his analysis, Volman (1981) acknowledged the Horizon 6/7 assemblage curated at the University of California Berkeley as nearly complete. Provenance documents acquired from the Phoebe A. Hurst Museum of Anthropology during this analysis indicate that we have accounted for all plotted lithic artefacts from Keller's (1973) excavations. However, quantities of quartzite, quartz and chert artefacts classified as 'chips, chunks, and fragments' and recorded by weight were not present with the plotted artefacts, indicating that these pieces may not have been curated after excavation. This may have resulted in an over-representation of retouched pieces, large and/or complete artefacts and cores, a pattern which was documented at the site of La Ferrassie in France when assemblage composition was compared between excavations from the late nineteenth and early twenty-first centuries (Dibble et al. 2018).

Because the Horizon 6/7 assemblage was excavated in the 1960s, we focus on the reduction systems employed in assemblage formation rather than emphasising frequency-based models of analysis, which may be affected by processes such as incomplete/selective curation or the structured use of space. Implementing traditional size-based definitions of microliths can present challenges for older assemblages where small debris is under-represented. Evaluating the development of reduction sequences that are specific to the production of small blanks and independent of the production of large blanks utilises the whole assemblage rather than only end-products and so can still provide insight into the relative importance of small blanks in instances when the smallest materials are not available for analysis. However, the lack of the smallest materials likely contributes to an underestimation of the rate at which bipolar reduction is utilised in an assemblage and a paucity in cores from the very end stages of reduction. This is a likely cause for the under-representation of bipolar reduction in the Horizon 6/7 assemblage and so we consider the counts and frequencies presented in this study to represent a minimum number of such pieces.

## Reduction sequence reconstruction

The lithic assemblage from Horizon 6/7 of Montagu Cave is characterised by the production of blades. Below, we lay out a provisional model of reduction sequence consistent with the data presented above. We also introduce elements of comparisons with other Howiesons Poort assemblages for which the lithic technology is described in detail. The core reduction sequence is modelled as follows:

- early stages: the early stages of reduction are poorly documented in the assemblage. Neither cores nor blades preserve large proportions of cortex, indicating that nodules were likely decortified before being brought to the site. Hence, it is unclear how reduction started. At Rose Cottage Cave, Soriano and colleagues (2007) suggested that the first blades were detached from the intersection between a broad and a narrow face, based on the prevalence of cortex on the dorsal face of asymmetrical blades. With a greater number of asymmetrical blades preserving cortex (n = 18; 38%) than for plein débitage (N = 13, 16%) ($x^2(1)$, 6.952, $p \leq 0.05$), our data are consistent with this suggestion. Blades with 60–100% of cortex on the dorsal face are also more common for the former (N = 8, 10%) than for the latter (N = 5, 6%). Another option was the shaping of an initial crest, but such blades are absent from our sample. We do not recognise clear examples of 'first configuration' cores as identified at Rose Cottage Cave (Soriano et al. 2007). As suggested by Villa et al. (2010), it is difficult to rule out the importion of prepared cores when there are no signs of elaborate preparation of the core at the site.

- core reduction: as at Klasies River, the flaking surface of the cores at Montagu Cave are often prominent and convex (Wurz 2000; Villa et al. 2010). The main striking platform was prepared at one end of the long axis. The distal end of the flaking surface was bevelled by the removal of small flakes, thereby increasing the expected frequency of feather terminations. The core was then reduced by series of (mostly) unidirectional removals, by direct percussion, probably using a stone hammer. Pending knapping accidents, convexity issues (e.g. overshot) or flaking surface management, cores will look like our flat-faced type ('second configuration' in Soriano et al. 2007). We note that the contour of the core flaking surfaces may be sub-triangular or triangular and that a series of two to three off-axis removals may lead to the production of convergent blanks.
- core management: postero-lateral removals (using the lower face of the core as striking platforms) along the margins of the flaking surface maintained the lateral convexities. The Klasies River or centripetal core types may capture such reshaping of the flaking surface. Occasionally, the detachment of crested blades of the second degree (N = 2) may lead to an asymmetrical core morphology. Hence, the latter type may document additional variations in the process.
- platform preparation: although half of the blank platforms are plain, about one blade out of three shows a faceting of the platform. Such frequencies are roughly equal between unretouched and retouched blanks. No evidence for core tablets was identified in the flake assemblage.

To summarise, blade production rests on the application of a specific method, different from the classic Levallois or volumetric blade cores (Boëda 1994; Villa et al. 2010). The core configuration was maintained by using débordant flake/blades and shaping and there is no evidence for the systematic use of crests. The main reduction was mostly unidirectional, and the technique was one of direct percussion with stone hammers. The system produces flat but also thick, asymmetrical blades. All blade types were retouched at the same frequency as they occur in the unretouched sample.

An additional step is present in the chaîne opératoire of silcrete artefacts. A majority (N = 48, 63%) of silcrete pieces across all artefact classes were determined to be heat-treated (Table 3). We cannot determine whether heat treatment occurred on site or elsewhere due to the lack of small chips, chunks and fragments from the assemblage. The presence of post-heating surfaces on Horizon 6/7 cores nevertheless suggests that it occurred early in the production sequence. Just over one-third of the silcrete artefacts were classified as 'indeterminate' (N = 27, 36%), primarily due to the lack of referential pieces preserving roughness contrast. Raw material survey is required to determine if these artefacts represent a separate raw material source or if variation in their appearance can be explained by heterogeneity within the sources identified in the assemblage.

## Core shape variations

We consider that the variations of core types reflect the different steps described above. What are referred to as Klasies River cores here are now considered as typical of the Howiesons Poort technocomplex (de la Peña 2015). Wurz (2002, 2005) first recognised the type at Klasies River, while similar forms were described in the pre-Howiesons Poort and Howiesons Poort levels at Diepkloof (Porraz et al. 2008, 2013). Since then, they have been identified in several other Howiesons Poort assemblages (Soriano et al. 2007; Villa et al. 2010; Hallinan and Parkington 2017; Shaw et al. 2019). At Montagu, they represent a little less than half of the core assemblage (N = 37, 44%) (Table 4). The model of reduction presented above revolves around the occurrence of the flat-faced cores and the Klasies River core types in a relatively systematic fashion. Core geometry in the Horizon 6/7 assemblage does not appear to be solely conditioned by raw material properties, raw material availability (based on survey) or specific blank sizes. Wurz (2002, 2005) and Villa et al. (2010) describe a similar situation at Klasies River, where nearly 70% of cores were reduced using methods associated with Klasies River core morphology on both quartzite and silcrete. At Sibudu, however, Klasies River cores are present but contribute to only ∼20% of cores; other blade production methods were favoured (de la Peña 2015; de la Peña and Wadley 2017).

We consider here that core types (used here for analytical purposes) take part in a reduction dynamic (e.g. Dibble 1995b), as opposed to documenting independent methods of reduction (e.g. Boëda 1988b). When comparing the longest flaking axis across core types, flat-faced cores show the broadest size distribution followed by Klasies River and asymmetrical cores and then centripetal types (Figure 5). Prismatic cores are smaller. Hence in Montagu, flat-faced cores may not document an exhausted stage of the Klasies River cores (Villa et al. 2010). In addition, asymmetrical and centripetal types may represent examples of cores abandoned during flaking surface management operations.

To summarise, our results are consistent with previous observations suggesting that Klasies River cores are among the clearest evidence for a blade production method specific to the Howiesons Poort technocomplex. We further suggest that flat-faced, Klasies River and asymmetrical cores document different phases of a reduction process, as proposed by Soriano and colleagues (2007). Geared toward the production of blades and bladelets, it includes management steps that account for variations in core shape in the framework of a dynamic of process. Hence, core types do not necessarily illustrate independent reduction sequences.

## Raw material shortage or deliberately small?

Small blades/bladelets (<24.6 ± 9.8 mm) occur alongside larger blades in the Horizon 6/7. However, the occurrence of small lithic artefacts is inherent to all reduction processes. It could be a stochastic effect of core reduction, reflecting the exhaustion of larger cores, as opposed to an effort to produce 'small' materials. Here, we consider three simplified scenarios to explain the occurrence of small cores, blanks or tools: 1) objects were transported over long distances and they are heavily curated; 2) raw material occurred only in small packages; or 3) there was a deliberate interest toward the production of small blanks/tools. The first two explanations imply a raw material shortage or constraints and, given the differences in size observed between raw material classes, the scenarios proposed above are not mutually exclusive.

## Raw material shortage

At Montagu, aspects of raw material economy are expressed by the differences in artefact size between raw material classes (Figures 6, 9 and 13). Available in front of the cave, quartzite is the dominant raw material and the only one documenting a broad range of formats. Chalcedony and quartz occur along rills near the cave, while the closest silcrete sources are approximately 10–15 km away. Artefacts made of these raw materials are mostly small, including rare prismatic blade cores. Hence, size data are consistent with an extensive use of local, relatively coarse-grained raw material. A more limited importation of other material (not always of finer grain texture) illustrates a more complex history of transport and reduction. Given its proximity and abundance, quartzite shows that distance and shortage of raw material are not always a reliable predictor for the occurrence of small blanks. Not only do core types occur in all sizes, but some of them are made of quartzite flakes (and therefore started small).

In the absence of long refitted technological sequences, we looked at the distribution of core and blank sizes as a proxy for possible continuous reduction from large to small blades. When considering the longest axis of quartzite cores, we can observe that the distribution is not unimodal and therefore inconsistent with a gradual reduction process (Figure 7). Small sizes are the most numerous, but a few much larger cores are also included in the assemblage. In this context, the presence of some cores on flakes further indicates that (at least sometimes) a branching of the reduction sequence (or recycling) took place, leading straight to the production of small blanks (Figure 14). Recycling or not, this shows that small blanks were the only possible outcome of such reduction processes. We note that, apart from being on flakes, these cores followed the same method of flaking as for the production of larger blades.

As opposed to other raw materials, silcrete is not available in the direct vicinity of the site. The nearest known source is at the edge of a daily foraging range for a unidirectional walk (Kelly 2007). Considered together with the lack of cortex, long distance transport may explain the small size of silcrete artefacts in the assemblage. Silcrete stands out for its smaller grain size relative to other materials. We note that in our sample segments were exclusively produced using such higher quality material that may be curated differently than quartzite. Although transporting large cores beyond a certain distance might not be the most efficient way to optimise blank production (Kuhn 1993), the trade-off is different when transporting smaller nodules of higher raw material quality. Bon (2002, 2005) observes that bladelet production during the European Aurignacian (and beyond) may partly owe its success to the advantages that it brought not only in terms of mobility, but also of raw material quality. In a situation in which the need for small blanks is anticipated, small nodules/cores may be selected for transport because they are easy to carry and because they are less likely to have internal flaws. In that case,

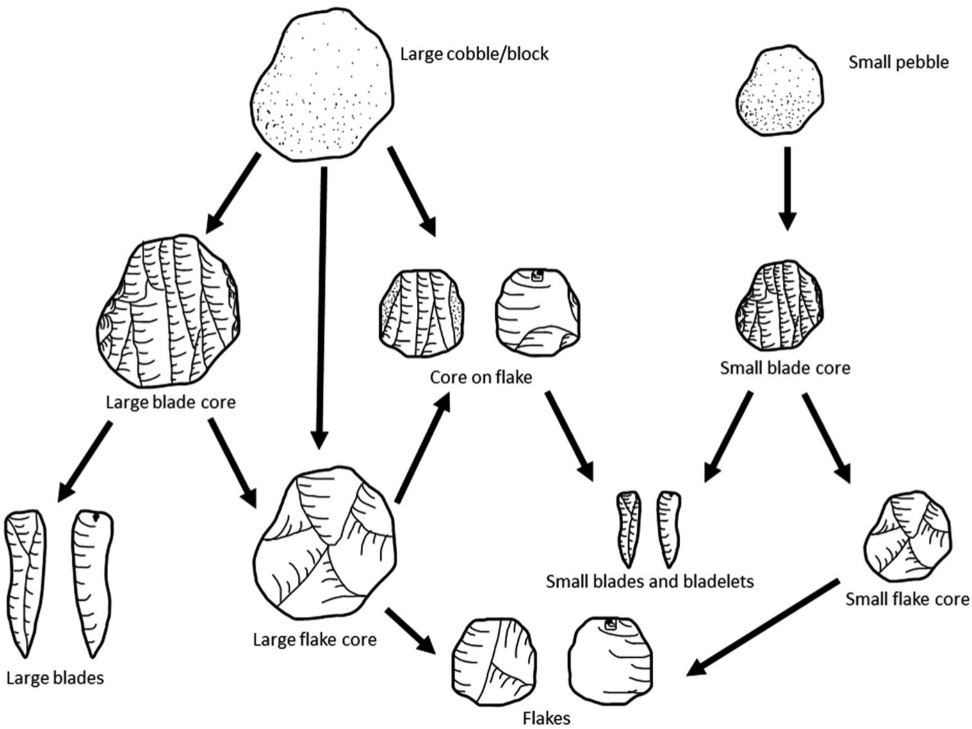


Figure 14. Montagu Cave: illustration of branching reduction sequences observed in Horizon 6/7.

selection criteria are geared toward grain size and overall qualities of the material, not toward the size of the nodules. In other words, the size of the nodule is not necessarily a constraint on the blank size. Alternatively, small cores may be favoured because trans-port of cores is anticipated (enabling continued, on-site production of blanks and implements away from source) and small blanks would be the inevitable result. While these scenarios are not mutually exclusive, assemblage data from Horizon 6/7 indicate selection for and intentional production of small blanks rather than scenarios of raw material constraints.

## Deliberately small

Overall, it seems parsimonious to consider that at least some of the small laminar elements from Horizon 6/7 (<24.6 ± 9.8 mm) are small on purpose and do not owe their size only because of raw material shortage. Montagu Cave is not an isolated case in this. For example, we note similarities with the Sibudu Howiesons Poort assemblage (de la Peña and Wadley 2014; de la Peña 2015), where smaller Klasies River cores on flakes also occur, along with bimodal size distributions for cores and blades (de la Peña 2015). These examples suggest that producing 'small' was an integrated part of the larger Howiesons Poort technological repertoire, as opposed to an immediate response to exceptional constraints. However, at Sibudu large blade blanks were produced primarily using volumetric reduction. Cores on flakes were the primary source for small blades and bladelets (de la Peña 2015).

In the sample considered here, Klasies River core reduction was used to produce large blades as well as smaller blades and bladelets, while volumetric cores are only small and rare. Variations therefore remain and what drives these differences is still unclear. We also note that the average blank size in the Horizon 6/7 assemblage from Montagu Cave is larger than what is documented at sites like Sibudu (de la Peña and Wadley 2014; de la Peña 2015), Klasies River (Villa et al. 2010) or Rose Cottage Cave (Soriano et al. 2007). 'Microlithic' strategies included production of small blades and bladelets, as well as geometric segments, but the average small blanks' width from Horizon 6/7 (20.31 mm) is almost twice as large as Tixier's (1963) cut-off used to identify bladelets (<12 mm wide). While Tixier's (1963) bladelet definition includes length cut-offs of <50 mm long, length is not retained as a comparative criterion in this study because bladelets are often fragmented. We did not identify multiple groups in our mixture analysis of width and thickness, but attribute this to the small size of the analysed sample.

The production strategies observed in Horizon 6/7 are microlithic in the sense that small artefacts are being intentionally produced from small cores (Petraglia et al. 2009; Pargeter 2016; Pargeter and Shea 2019), but not according to most imposed size cut-offs (Deacon 1984; Clark 1985; Mitchell 1988; Elston and Kuhn 2002; Brown et al. 2012). This reinforces the need to describe the development of reduction sequences specific to the production of small blanks and independent of the production of large blanks rather than rely on contextual definitions of the term 'microlith' to understand the context of small blank production.

## Implications for tool manufacture

Backed tools and segment production are considered characteristic of Howiesons Poort technology, even though their frequencies show temporal variation in long cultural sequences such as Diepkloof (Porraz et al. 2013), Rose Cottage Cave (Soriano et al. 2007), Klipdrift Shelter (Douze et al. 2018) and Klasies River (Villa et al. 2010). At Klasies River, backed artefacts decrease in frequency through time while the production of asymmetrical blades increases in the youngest Howiesons Poort assemblages of the Howiesons Poort Upper component. The authors argue that this reflects a shift in the percussion technique. Tangential percussion in earlier Howiesons Poort components would have led to the production of thinner blanks than less marginal percussions in Howiesons Poort Upper would have done (Villa et al. 2010). Negative correlations between frequencies of backed retouch tools and asymmetrical blades are also observed as a time transgressive trend in the late Howiesons Poort assemblage at Rose Cottage Cave (Soriano et al. 2007). At Rose Cottage Cave, naturally backed flakes and blades show the same distribution of hafting residues as backed artefacts, suggesting similar functions between naturally backed pieces and those formally backed through retouch (Gibson et al. 2004; Soriano et al. 2007).

At Montagu, asymmetrical blades represent a third of unretouched (N = 48, 37%) and retouched (N = 29, 32%) blades. Because of their technological function in a core reduction process, they are expected (by)-products with a predictable shape. By comparison, finished segments and artefacts formally backed through retouch are not so common in the Horizon 6/7 assemblage. We note that the six segments are all produced on fine-grained raw materials, on curved blanks, and at least three take advantage of naturally backed blade blanks and are overshot, showing a relative degree of awareness toward the morphological attributes of the débitage. Boëda (1994) notes that the distinction between predetermined and predetermining flakes is rather arbitrary, given that the latter have stereotyped shapes and their production is anticipated. Hence, it is not surprising that 'by-products' from large blade production was sometimes integrated in the toolkit (Roussel 2011) or re-used as cores to produce small blades/bladelets (Zwyns et al. 2012). How they are selected is unclear, but our data suggest that retouched blanks are narrower and thinner than the average blank. Given that other morphological criteria assessed during the analysis are similarly represented among both blanks and tools (Table 7), we interpret this difference in size as reflecting an interest in smaller blanks rather than selection of specific blade morphologies for retouch into formal tools.

## Conclusion

In the Howiesons Poort, technology that would typically be considered 'microlithic' includes the production of small blades and bladelets as well as geometric segments (Leplongeon 2014; Pargeter 2016). As shown in this study, the small size of the blades and bladelets was an intentional decision and not the result of raw material constraints or a reduction continuum. Selection for small blanks began at raw material acquisition and core blank preparation, with toolmakers utilising small nodules of fine-grained raw materials and producing quartzite cores on flakes to quickly reduce the size of large raw material nodules for dedicated small blade and bladelet production. Quartzite cores on flakes show dedicated production systems for small blanks. Additionally, we also see a selection for small starting nodules of finer-grained raw materials for systems of small blade and bladelet production that started off small. Because almost all raw material categories have yielded small blades/bladelets, it is parsimonious to consider that part of the blanks were produced small deliberately.

Methods of reduction do not differ significantly across raw material classes, but core and blank sizes do. Only quartzite, available in a range of sizes near the cave, shows a broad distribution of artefact sizes, while other materials, such as quartz and chalcedony, may only occur in small nodules near the site. Cores made of silcrete seems to have been imported from another location, with the closest raw material source identified at ∼10– 15 km distant. A core reduction method described elsewhere as being consistently associ-ated with the Howiesons Poort is represented here and accounts for the greater part of core shape variation. We note, however, that the Klasies River core reduction method is used regardless of the size. In terms of the geometrics, blank selection varies by site. In Horizon 6/7, toolmakers selected small blades from fine-grained raw materials for backed geometric production. They utilised asymmetrical blades, débordant blanks from the edge of the core and overshot terminations as extensions or replacements for backing retouch. We see an intentional production of small blades at both sites, but not all of them are small enough to be included in the 'microlith' category of bladelets (<12 mm wide). There is a bimodal distribution, so we observe distinct size ranges for large (49.2 ± 14.4 mm) and small blades (<24.6 ± 9.8 mm). Therefore, focus on intentionality in small tool production using the entire assemblage and relative size classes may be more useful for understanding early manifestations of so-called 'microlithic' technologies and is more productive for making use of abundant museum collections from previous excavations that may not preserve the smallest materials.

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