The MIS 5 Lithic Assemblages of Klasies River

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in fulfilment of the requirements for the degree of
Doctor of Philosophy

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DECLARATION

I declare that this thesis is my own, unaided work. It is submitted for the degree of Doctor of Philosophy at the University of the Witwatersrand by published and submitted papers. It has not been submitted before for any degree or examination at any other University.

Signature: ____

Mareike Juliane Brenner

the 19th day of December 2019 in Großbettlingen

ABSTRACT

Klasies River is a well-known site with an exceptionally long Middle Stone Age sequence. A new analysis of the early Marine Isotope Stage 5 layers from the Witness Baulk in Cave 1 at Klasies River main site, SMONE - SLBS, is conducted here. This study presents a detailed technological analysis, which identified more complicated *chaînes opératoires* than currently known. In agreement with earlier technological analyses, the end products are points and blades of varying morphologies. The cores belong to one main *chaîne opératoire* although their morphologies differ depending on the reduction phase. A predominately unidirectional reduction method is found throughout the sequence of the analysed layers. The lithic characteristics point to a place provisioning system of a residential site. There is however slight variation, especially in the lowest layer SBLS, where more features of individual provisioning and mobility are found. When combining shellfish and lithic data, it was further found that the intensive lithic knapping activity coincides with a high degree of shellfish collection. Therefore, Klasies River is one of the earliest sites where coastal adaptation is evident. The lithic behaviour at Klasies River was compared with that from the broadly contemporaneous open-air Florisbad site situated within the interior. The MSA horizon at Florisbad exhibits very similar technologies in core reduction method, end product morphology and tool types. Additional reduction methods found at Florisbad, including burin-cores, are probably due to highly opportunistic behaviour and a specialised site function. Nevertheless, similarities between assemblages from sites far apart, with different settings, function and environment, might indicate past routes of mobility and knowledge transmission of much further extent than thus far estimated.

“THOUGH YOU CAN LOVE WHAT YOU DO NOT MASTER, YOU CANNOT MASTER WHAT YOU DO NOT LOVE.”

— Mokokoma Mokhonoana

ACKNOWLEDGEMENTS

I cannot say how much I appreciate the support and dedication of my supervisor Professor Sarah Wurz. She has welcomed me at the University of the Witwatersrand with an open heart and helped me to settle in a foreign country. Her experience in South African prehistory and stone tools has taught me humbleness and shaped me as a lithic analyst and archaeologist. I also want to thank the archaeology department staff members and students, who engaged in inspiring discussions and never failed to support me in my research and motivation. I am thankful to all the people who furthered my passion in lithic technology, who are Sarah Wurz, Guillaume Porraz and Paloma de la Pena from the University of the Witwatersrand, Nicholas Conard, Manuel Will, Gregor Bader and Viola Schmid from the University of Tübingen and Curtis Marean from the University of Arizona.

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CHAPTER 1: INTRODUCTION

1.1. BACKGROUND AND RESEARCH HISTORY OF KLASIES RIVER

The Klasies River landscape is a declared national monument or Grade 1 site. Its location is on the coast of Tsitsikamma in the Eastern Cape. Klasies River main site (KRM) comprises five tightly grouped caves and rock shelters. The profile spans more than 21 m of deposit and comprises layers from the early Middle Stone Age (MSA) up to the Later Stone Age. John Wymer and Ronald Singer (1982) first excavated the site between 1967 and 1968. They left a Witness Baulk in the middle of Cave 1, stretching from the entrance to the back of the cave (see Figure 1). Hilary Deacon (Deacon and Geleijnse 1988) thereafter opened various excavation areas at Klasies River main site from 1984 to 1995. In 2015 Sarah Wurz (Wurz et al. 2018) re-opened the excavations with a focus on the Witness Baulk and this project is ongoing.

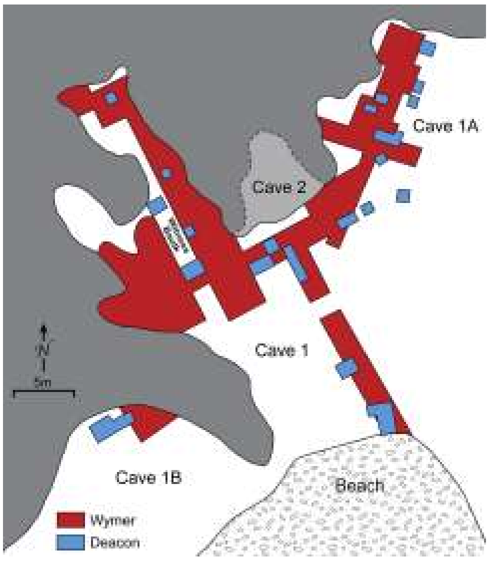


FIGURE 1: KLASIES RIVER MAIN SITE PLAN (AFTER GRINE *ET AL.* 2017: 56, FIG.3)

Generations of researchers have analysed the pre-Howiesons Poort Middle Stone Age tools from Klasies River, including Singer and Wymer (1982), Volman (1981), Thackeray (1989) and Wurz (2000, 2002; Wurz et al. 2003). This led to an accumulation of different names for the early MSA techno-complexes at Klasies River; Singer and Wymer (1982) first termed them MSA I and II and Volman MSA

2a and 2b. Wurz (2000, 2002), in her more recent study, relates these terms to the Klasies River and Mossel Bay techno-complex. The deposits with MSA II//MSA 2b/Mossel Bay material are dated to ca. 100 000 years ago (ka), which falls into Marine Isotope Stage (MIS) 5c-d sub-stages (Grün et al. 1990; Vogel 2001; Feathers 2002; Eggins et al. 2005; Millard 2008; Wurz et al. 2018: 108; Brenner & Wurz 2019). From now on, Singer and Wymer's designation MSA I and II are used to avoid confusion.

1.2. Rationale and research problem

The MSA is an important period, as modern humans evolved in Africa and complex behaviour developed during this time (see, e.g. McBrearty & Brooks 2000; d'Errico et al. 2003; Willoughby 2006; Conard 2008; Wadley 2013, 2016; Soriano et al. 2015; Kandel et al. 2016). Advanced cognition can already be seen with the introduction of Levallois technology (e.g. Muller 2017: 115) and most researchers agree that behavioural and technological innovations are strong signs of complexity in behaviour (e.g. Henshilwood and d'Errico 2005; Wadley 2010; Lombard and Haidle 2012). Multiple examples of such innovations appear during the Still Bay and Howiesons Poort in South Africa. It is proposed that these innovations, like refined tools, heat treatment, symbolic engravings, medical plant use, etc., flourished during MIS 4 but disappear afterwards (Jacobs et al. 2008; Jacobs & Roberts 2009; Henshilwood & Dubreuil 2011; Ziegler et al. 2013; Sealy 2016; Wurz 2019). The roots of these behavioural advances might already be found in MIS 5.

Stone tools are a key element that preserves well and can therefore, be used to address cultural and behavioural questions. Higher-resolution technological analyses have the potential to provide data to address the origins of MIS 4 lithic innovations in the MSA, like Still Bay points and segments from the Howieson's Poort. The MIS 5 lithic materials from Klasies River are abundant and lend themselves to technological analyses to investigate this issue. Variability within MIS 5 assemblages is still an under-researched topic (exceptions are e.g. Porraz et al. 2013, 2018) and in most cases, lithic artefacts from multiple layers are lumped together for a technological analysis (e.g. Wurz 2000, 2002; Thompson et al. 2010; Douze et al. 2015). The material from the new excavations at Klasies

River provides the opportunity to observe changes throughout the sequence in high resolution.

In the context of evolutionary advances, coastal adaptation has been argued to be a key factor in South Africa(Parkington 2010; Will et al. 2013, 2016, 2019; Marean 2016). It is debated that high nutritional values from marine food resources, such as proteins, fatty acids and omega-3, which are available year-round, could have accelerated the cognitive development of modern humans (Parkington 2010; Marean 2016. Coastal adaptation with systematic use of coastal resources is seen as an advancement in behavioural flexibility, expressed by successfully adapting to a niche habitat (Will et al. 2013, 2016, 2019; Marean 2016).

The coastal site Klasies River has good preservation of shellfish (Singer and Wymer 1982; Langejans et al. 2012; Dusseldorp and Langejans 2013; Wurz 2018) and is thus an appropriatecandidate to address possible coastal adaptation as early as MIS 5. The degree of "systemic" use of coastal resources is still a matter for discussion (Will et al. 2016; Marean 2016). With a high-resolution approach at Klasies River and southern Cape sites, slight changes can be identified throughout the MIS 5c-d sequence and the degree of coastal adaptation can be determined.

Inter-assemblage comparisons are rare for this period (Porraz et al. 2013, 2018; Mackay 2014, 2016; Douze et al. 2015). An extensive analysis including all MIS 5 assemblages described in the last 20 years could be the basis of reconstructing the South African behavioural networks during this time. Together with a high chronological resolution, this enables assemblage comparisons to the level of detail of MIS 5 sub-stages. With this approach, spatial and temporal variation in lithic technology within MIS 5 can be identified.

Apart from the multitude of coastal cave sites, few open-air sites in the interior of the country show preservation of occupational horizons (see, e.g. Caruana and Stratford 2019 for sites at the Cradle of Humankind World Heritage Site). The spring site Florisbad has an MSA horizon with a confirmed age in MIS 5e (Kuman et al. 1999; Henderson 2001), this gives a rare opportunity to increase our understanding of the role of interior open-air sites in the South African landscape. Florisbad with its unique setting is chosen for a detailed comparison, as it could possibly reveal similarities between sites from very different regions, environments and settings.

1.3. Aims and research questions

The main research question investigated is the nature of lithic variability during early MIS 5 at Klasies River and how it relates to coastal adaptation during this time. It is further explored how these Klasies River MIS 5 assemblages compare to other MIS 5 assemblages on the southern Cape like Pinnacle Point, Blombos and Cape Saint Blaize. Additionally, Klasies River is compared with Florisbad from a very different environmental and ecological setting. This allows investigation on whether these aspects might have played a role in technological patterning from two very different contexts within a detailed comparative framework involving most known MIS 5 sites in South Africa.

The following aims are set:

1. Provide a detailed description of the Klasies River lithic technology of the MIS 5 layers SMONE-SBLS.
2. Investigate how the lithic material from Klasies River fits into the southern Cape landscape during MIS 5c-d.
3. Integrate the lithic technology at Klasies River with shellfish utilisation to provide a perspective on coastal adaptation at the site.
4. Present a comparison of the lithic technology and shellfish exploitation with other broadly contemporaneous sites, Blombos Cave and Pinnacle Point 13B in the southern Cape.
5. Provide a detailed view of the lithic technology at Florisbad from the MIS 5e layer.
6. Offer a South African landscape perspective on lithic technology within MIS 5.

1.4. List of published and submitted papers

published paper #1:

Wurz, S., Bentsen, S. E., Reynard, J., Van Pletzen-Vos, L., Brenner, M., Mentzer, S., Pickering, R. and Green, H. 2018. Connections, culture and environments around 100 000 years ago at Klasies River main site. **Quaternary International** 495: 102-115. Impact factor: 1.95

Brenner: 15% (conducted the research and wrote drafts of the lithics section of the manuscript and integrated it in the discussion)

published paper #2:

Brenner, M. J. and Wurz, S. 2019. A high-resolution perspective on MIS 5c-d lithic assemblages from Klasies River main site Cave 1. **Journal of Archaeological Science: Reports** 26: 101891. Impact factor: 1.75

Brenner: 70% (conducted the research, wrote the manuscript)

submitted paper #3:

Brenner, M.J., Ryano, K. and Wurz, S. 2019. Coastal Adaptation at Klasies River main site during MIS 5c-d (93 - 110 000 years ago) from a southern Caper Perspective. **Journal of Coastal and Island Archaeology**. Impact factor: 2.00

Brenner: 50% (conducted the research on the lithics, wrote the relevant parts of the manuscript)

submitted paper #4:

Brenner, M. J. Interglacial perspective on the lithic technology from the MSA horizon at Florisbad. **PLOS One**. Impact factor: 2.78

Brenner: 100%. (conducted the research, wrote the manuscript)

Chapter 2: Middle Stone Age in South Africa from a lithic perspective?

2.1. Research history

John Goodwin and Clarence van Riet Lowe (1929; van Riet Lowe 1927; Goodwin 1929) were the first to define "The Stone Age cultures of South Africa" as three main periods, namely the Earlier, Middle and Later Stone Age. They (Goodwin and van Riet Lowe 1929) identified two main characteristics of the MSA, which were convergent flakes and facetted platforms. Additionally to this very broad description, distinct tool types were seen in MSA variations, such as the Still Bay and Howiesons Poort. A large part of the MSA however, does not have a prolific tool component. Hence, the typological approach was not very fruitful in describing most MSA assemblages. This led to a perception of the MSA as a stagnant period with little variation (*ibid.*).

A significant advance was made, when Singer and Wymer (1982) described the MSA sequence from Klasies River in the 1980s. In the exceptionally thick MSA deposits, they found distinct differences throughout the sequence. Apart from the already known Howiesons Poort industry, they described four more MSA stages, namely MSA I-IV. Although they only related the MSA I-IV to the stratigraphy at Klasies River, which showed that the MSA was definitely not a stagnant phase. By stratigraphic comparison, the chronological sequence of the MSA industries could be identified to some degree. With the introduction of appropriate dating techniques, assemblages could be reliably dated.

The MSA starts ca. 300 ka and lasts until about 25 ka (Wadley 2015: 159). During this time anatomically modern humans, *Homo sapiens,* first appeared in Africa (Bräuer 1984; White et al. 2003; Scerri et al. 2018). The origins of modern humans furthered research interest in the MSA in the 1990's. The research focus, however, was on the Still Bay and Howiesons Poort periods, as these phases comprised a sudden increase of complex behaviours and innovations, not only in the form of sophisticated stone tools (e.g., Wurz 2008; Högberg and Larsson 2011) but also with marine shell beads (e.g., d'Errico et al. 2005; Vanhaeren et al. 2019), bone tools (e.g., Henshilwood et al. 2001; Backwell et al. 2008; Backwell and d'Errico 2016), engravings on ochre, bone and ostrich eggshell (e.g., Henshilwood and Dubreuil 2011: 361), heat-treatment of silcrete (e.g., Schmidt et al. 2013; Delagnes et al. 2016; Schmidt and Mackay 2016) and bedding constructions (Wadley et al. 2011).

Only in the last ten years, a shift in research is seen. Now the focus is on earlier MSA lithic technologies. A growing body of literature about MIS 5 technology is developing, including recent studies of Blombos Cave (Douze et al. 2015), Bushman Rockshelter (Porraz et al. 2015; 2018), Diepkloof Rockshelter (Porraz et al. 2013a; 2013b), Hoedjiespunt (Will et al. 2013), Pinnacle Point 13B (Thompson et al. 2010), Putslaagte 8 (Mackay et al. 2015) and Sibudu Cave (Schmid et al. 2019). An orientation towards lithic technology versus typology is one of the main characteristics in recent studies of MSA assemblages. This includes the concepts of core reduction sequences and *chaînes opératoires.* With the technological approach, the problematic situation of scarce formal tools in most early MSA materials is circumvented.

2.2. Methods used in this study

2.2.1. The *chaîne opératoire* approach

The *chaîne opératoire* approach in lithic analysis was first used by Jean-Michel Geneste (1985) to describe Middle Paleolithic technology. The concept has since been used and further developed by several influential French archaeologists (e.g. Perlès 1987; Pelegrin et al. 1988; Boëda et al. 1990; Sellet 1993) and also in more recent literature (e.g. Shott 2003; Delagnes et al. 2007; Tostevin 2011). Although the concept was well established by the late 1990s in most parts of Europe, it only became more regularly used for the South African MSA since the early 2000s (e.g. Wurz 2000; Soriano et al. 2007). The *chaîne opératoire* is a technological approach to describe all stages of an artefact from the raw material procurement to the discard of the stone tool (Sellet 1993: 106). It is a "chronological segmentation" (ibid: 106) of the mental processes and technical gestures involved in the manufacture and maintenance of an artefact. The organisation of a technological system from a prehistoric context can be reconstructed with this approach.

2.2.2. Attribute Analysis

The basis of any interpretation in *chaînes opératoires* theory is the quantitative data that supports it. The analysis of quantitative and qualitative attributes is essential in lithic analysis, as good science is based on reproducibility. Therefore, all attributes need to be defined; a list of the attributes used in this study can be found in the Appendix (Table A1). All lithic artefacts were attributed with a find ID number given in the field, as well as a layer and square affiliation. Raw material type, texture and amount of cortex and patina were determined for all artefacts. Measurements followed the recommendations defined by Andrefsky (2005). Digital scales and callipers and an analogue goniometer were used for all measurements. All lithic materials were weighed and measured for its maximum dimension. For blanks (flakes, blades and points) and cores also the technological length, width and thickness were measured. On blanks, the external platform angle was recorded.

Other quantitative and qualitative attributes were described following Cotterell and Kamminga (1987), Inizan et al. (1999) and Andrefsky, Jr. (2005). Blanks were analysed for percussion indicators, such as the presence of a bulb, a circular crack on the impact point and the presence of a lip. Figure 2 shows the different platform types of blanks according to Inizan et al (1999: 136). Figure 3 illustrates flake terminations following Andrefsky (2005: 21).

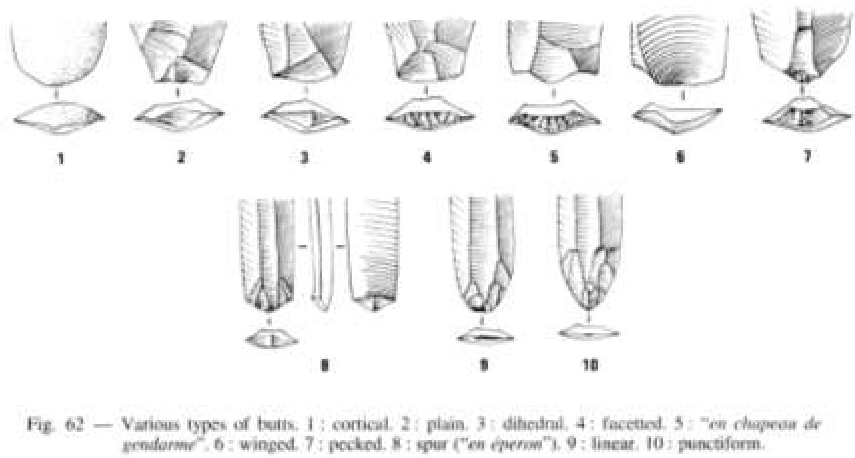


Figure 2:Different platform types by Inizan et al. (1999: 136 Figure 62).

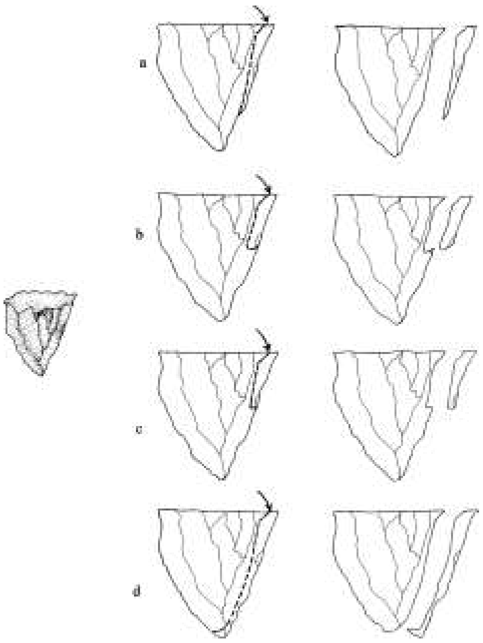


FIGURE 3: FLAKE TERMINATION BY ANDREFSKY , JR. (2005: 21 FIGURE 2.8)

Other attributes recorded are blade curvature (after Högberg 2016) and regularity (after Damlien 2015). Technological categories are determined following the MSA study by Douze et al. (2015). Tool types are described following recent studies of South African MSA material (e.g. Wurz 2002; Porraz et al. 2013a; Douze et al. 2015). The presence of edge damage is recorded as well, as recently a spotlight has been on the identification of edge damage, especially on MSA points (e.g. Schoeville et al. 2016; Werner and Willoughby 2018). Percussive marks typical for hammerstones were determined by visual inspection (see, e.g. Caruana et al. 2014).

The core nomenclature is described in more detail below in section 2.2.3 and chapters 3 and 4, as this is one of the main ways to describe technology. The attributes on cores include for example position of striking platforms, platform preparation, amount of negative scars, the direction of removals and how exhausted the core is (see also Table A1 in the Appendix).

2.2.3. Core Nomenclature

2.2.3.1. MSA Core Definitions

Since the early description of MSA assemblages in the 1980s, the definition of different core types evolved drastically. Especially with the introduction of the volumetric conception (Boëda 1995: 53), it became easier to relate core types to a technological sequence of reduction.

However, the work of earlier researchers, e.g. Volman (1981, 1984) who followed the typological approach then conventional, is still used to describe MSA cores (e.g. Wilkins et al. 2017). For example, Volman (1981: 21) describes the general category of parallel cores as: "Cores for the production of flakes with parallel, sub-parallel or convergent scars (uni-directional ridge core), on which flake scars from a platform tend to run in a single direction." He further subdivides this category into six types, which are defined by the number and orientation of striking platforms, as well as the number and position of removal surfaces (e.g. single platform cores, opposed platform cores or cylinder cores) (*ibid*: 21). However, there are multiple ways how platforms and removal surfaces can be organised on a core, and it seems needlessly complicated to create a type name for every possible composition. Therefore the number of platforms, platform orientation and the number of removal surfaces are treated as separate attributes here, rather than attempting to combine them in one classificatory system as Volman did. The differentiation of cores in terms of shape here, does therefore not include any information about the number of striking platforms. By separating this information, a more objective description of the cores can be reached. In this aspect, this study differs from Volman's (1981) approach to characterise cores (see also Table A2 in the Appendix).

Volman (1981: 21) uses the term "intersecting ridge core", which includes radial and adjacent platform cores. Radial cores are described having "flake removals directed from the circumference towards the centre of one surface or towards the centres of two opposed surfaces" (Volman 1981: 21). Adjacent platform cores are flaked to two opposed surfaces from only a portion of the circumference (Volman 1981: 21). Radial and adjacent platform cores thus correspond to inclined cores in this study.

Other recent studies (Thompson et al. 2010) used the final scar visible on a core s a defining attribute. Thompson and colleagues (2010: 365) describe blade and point cores at Pinnacle Point 13B.

However, this study does not assume a relationship between end products and core categories . It seems that the final removal or principle scar does not necessarily reflect the main types of products which have been produced (Marks and Volkman 1983; Wurz 2002: 1005).

2.2.3.2. Core definitions in this study

For the analysis of the Klasies River MSA I and II cores, the definitions of Conard and colleagues (2004) are used as a basis, as they are unifying many ideas and make them universally applicable. This is a general classificatory system for a volumetric and technological characterisation. There are three main core systems: Platform, inclined and parallel cores.

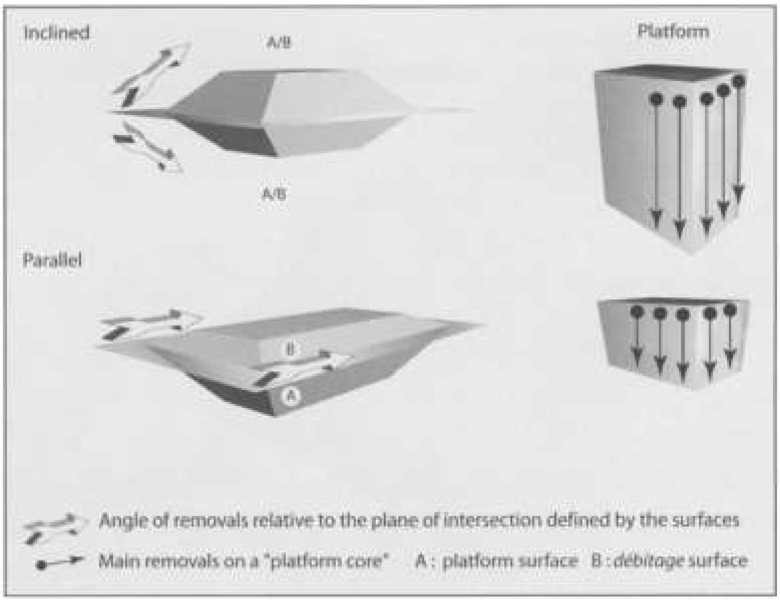


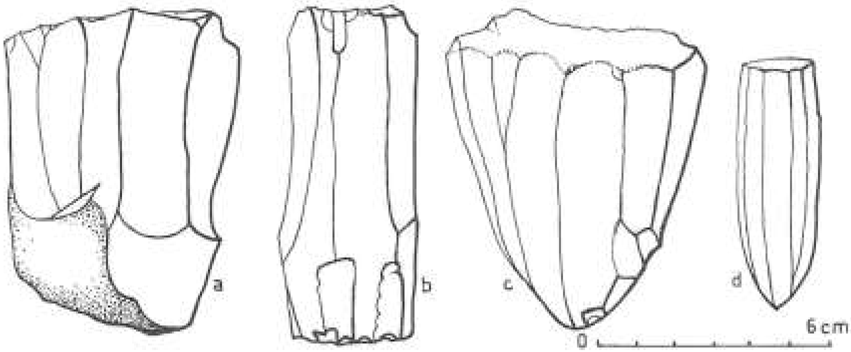
Figure 4: Unified core taxonomy by Conard et al. (2004: 12).

2.2.3.2.1. Platform

More than two faces define the volume of platform cores, which include at least one striking platform and two or more removal surfaces. The main removals are struck from well defined striking platforms, which can be cortical, plain or prepared (Conard et al. 2004: 16). The removals are oriented parallel on a typically narrow removal surface (*ibid:* 14). The angle is often 90°, but always greater than 45° (*ibid*: 16).

Platform cores are further subdivided in this study into categories of overall shape and morphology of removal surfaces. The shape of platform cores can be pyramidal or prismatic. The first definitions of pyramidal and prismatic cores originate from de Sonneville-Borde (1960: 808), de Heinzlin de Braucourt (1962: 463, 527) and Brézillon (1968: 92-93). They describe prismatic cores as laminar cores with a prismatic frontal view; the scars are parallel along the removal surface (*ibid*: 93). Prismatic cores can have one or two striking platforms. Pyramidal cores are rotational (*tournant*) laminar cores with a curved removal surface so that the removals are slightly retrogradingly inclined and convergent (*ibid*: 93). According to Sonnevill-Borde (1960), de Heinzlin de Braucourt (1962) and Brézillon (1968) pyramidal cores have only one striking platform.

The terms "conical" (Wurz 2000: 61), "pyramidal" (Wurz 2002: 1004) and "semi-rotational" cores have been used for Klasies River MSA cores. These cores would fit within the pyramidal and prismatic core categories used here. In this study, the term pyramidal is used for platform cores, that show a clear change in width and thickness from proximal to distal and converging lateral edges. Parallel cores are always semi-rotational or rotational, which means the cores show removals around at least one edge of a striking platform (Wurz et al. 2005: 6). The early French definition for pyramidal cores stipulates only one striking platform; however, this is too specific for this study. Prismatic cores, on the other hand, have about the same width throughout the core, so that the lateral edges are parallel. The removal surface of prismatic cores can be semi-rotational or flat. No differentiation between pyramidal and conical or prismatic and cylindrical shapes are made, as in studies of Inizian et al. (1999: 76), Wurz (2000: 61) or Clarkson (2013: 4350).



13. Types de nucléus à lames, d'après G. et A. de Mortillet : a — prismatique à un plan de frappe, b — prismatique à deux plans de frappe opposés, b-c — nucléus conique ou pyramidal.

FIGURE 5: LAMINAR CORE TYPES AFTER G. AND A. DE MORTILLET. A-B – PRISMATIC CORE, C-D – PYRAMIDAL CORE. (BRÉZILLON 1968: 93).

2.2.3.2.2. INCLINED

Two faces, upper and lower, define the volume of inclined cores. From the intersection plane of the surfaces, removals are struck on both faces with an angle of roughly 45° (Conard et al. 2004: 15). The orientation of the main removals is towards the centre of the removal surface (*ibid*: 15). Inclined cores are usually employed to produce flakes. The term inclined was introduced by Conard and colleagues (2004: 15) and is since then used by researchers like Douze (et al. 2015: 14) and Will & Conard (2015: 6;). Other researchers use the term discoidal (Volman 1981: 316; Singer & Wymer 1982: 47) for the same type of core.

2.2.3.2.3. PARALLEL

Parallel cores have two volumes, separated by a plane of intersection, and one main reduction surface. The removals are parallel to the intersection plane between the two surfaces. The underside of the core can be worked or fully cortical (Conard et al. 2004: 16).

Volman (198: 20) describes cores "prepared for one major removal", which refers to a preferential Levallois system. He explicitly includes cores, which are "commonly called Levallois flake or blade cores by other researchers" (Volman 1982: 20). Singer and Wymer (1982: 47) describe them as tortoise cores, which are of "Levalloisian industry". Thompson et al. (2010) use the term prepared core, for cores that *"are not unambiguously identifiable as point or blade cores - this category also includes cores that would be classified as "Levallois" cores in other typologies. These cores exhibit radial or centripetal flaking*." (Thompson et al. 2010: 366). Point or blade cores described by Thompson and colleagues (2010: 366) are solely defined by their principle scar. In this study, the term parallel core is preferred over the term prepared core, as it describes the shape and type of removal. Flake of blade cores worked with the Levallois method belong to this category. The term Levallois has a contentious nature, as it is used for many kinds of "prepared cores". This makes it difficult to distinguish the Levallois system from other reduction systems, as a preparation of the core is part of almost all reduction systems. Discoid cores resemble Levallois cores in shape and some end products, the so-called pseudo-Levallois points, are only distinguishable by the position of the striking platform. Some French researchers argue that discoid cores represent the final stage of a Levallois reduction (Chazan 1997: 732).

2.2.3.2.4. Multidirectional

Multidirectional cores have three or more removal surfaces and striking platforms oriented on different planes. The shape can be polyhedral or any other morphology. Volman's (1981: 21) change of orientation cores would fall into this category: "Three or more striking platforms oriented on different planes with respect to one another, with intersecting removals on one or more planes."

2.2.3.2.5. Bipolar

Bipolar cores are worked using hammer and anvil (e.g. Conard et al. 2004: 16; Douze et al. 2015: 10). The core is placed on an anvil and held with one hand when the stone is struck two removals occur, one is on the top, and one removal or edge damage occurs on the bottom (de la Peña & Wadley 2014: 30). De la Peña (2015) created a list of different characteristics for bipolar knapping in quartz and flint raw material. Bipolar cores usually have two opposing striking platforms with much evidence for blunting and fissuring bottom (de la Peña and Wadley 2014: 30).

2.2.3.2.6. Initial

Initial cores show only the beginning of a preparation (Conard et al. 2004: 15). Sometimes they are called tested cores or preforms (Wurz 2000: 174). Singer and Wymer (1982: 45) termed them undeveloped cores. Those pieces show clear negatives from removals but are not further differentiable into one of the other categories.

2.2.3.2.7. Core Fragment

Core fragments are broken and indeterminate of their original category (Wurz 2000: 62, 174; Conard et al. 2004: 16).

2.2.3.2.8. Irregular

The term irregular core is used to describe any type of core that does not fit in any of the above-described core categories (Conard et al. 2004: 16). In the system used here, Volman's (1981: 20) minimal cores with "only a few irregularly oriented flake removals" would be described as irregular cores.

CHAPTER 3: PUBLISHED PAPER #1

Published in 2018

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Connections, culture and environments around 100 000 years ago at Klasies River main site

CONTENT

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Connections, culture and environments around 100 000 years ago at Klasies River main site

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Middle Stone Age technology

ABSTRACT

In this paper the new excavations at Klasies River main site are introduced and the first results presented and linked with previous work, establishing a baseline for future reporting. Data from the earliest phase of the SAS member, comprising the basal SASU and SASL sub-members from caves 1 and 1A are discussed. A new U-Th date of 126.0 ± 1.5 ka on flowstone associated with fallen tufa material within the base of the SASU sub-member provides a maximum age for this part of the sequence. The lowermost SASU sub-member formed most likely around 100 000 years ago during a period associated with increased precipitation whereas the age of the underlying SASL sub-member is uncertain. The SASU sub-member contains *in situ* deposits that include hearths, in contrast to the underlying SASL sub-member that was subject to post depositional disturbance. Despite the different site formation processes the lithic industry of both sub-members is similar although quartz utilization is somewhat more prominent in the SASL sub-member. The main reduction strategy involves a parallel uni-directional convergent method to produce quartzite blade and point blanks with rare retouch. Relatively more browsing fauna and riparian species, indicating more closed environments, occur in the SASU layers. The older SASL sub-member, not previously described as an independent unit, contains relatively more grazers suggesting drier and more open habitats. It is vital to link evidence from coastal sites such as Klasies River to data from the interior to promote insight into modern human origins from a wider landscape perspective. The work of James Brink, to whom this paper is dedicated, is invaluable in developing this connection.

1. Introduction

James Brink's association with Klasies River has been long and fruitful. Two of the authors of this paper (Wurz and Van Pletzen-Vos) shared a supervisor with James Brink, the late Professor Hilary Deacon. Even though we both studied Klasies River material for our post graduate degrees, our discussions with Hilary invariably included emphasis on the data from Florisbad as this is where James was based. We also benefitted directly from our interaction with James. He taught Liezl van Pletzen-Vos how to analyse faunal material at the Florisbad Quaternary research centre. His discussions with Sarah Wurz on the link of Klasies River to interior sites like Florisbad and Erfkroon, and advice on research strategies are highly appreciated. This connection with James inspired holistic thinking on modern human origins at Klasies River, outside of the southern Cape box.

Between 120 000 and 55 000 (abbreviated to ka) years ago modern human populations inhabited numerous cave sites along the coastal and near-coastal region of the contemporary continental edge of southern Africa. Klasies River main site (Fig. 1, Singer and Wymer, 1982; Deacon, 1995; Deacon and Wurz, 2005), the subject of this paper, is one of the most intensively occupied sites within this area and is associated with abundant cultural and subsistence remains of Middle Stone Age (MSA) hunter-gatherer-fishers. Investigations at Klasies River main site have led to many significant discoveries. For example, analyses of the recovered human remains have contributed to our understanding of the evolution of modern human anatomy (e.g., Rightmire and Deacon,

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Fig. 1. Sites and places mentioned in the text. Abbreviations used: BC = Border Cave; SC = Sibudu Cave; FRS = Florisbad Research Station; KRM = Klasies River main site; PP = Pinnacle Point cave complex; BBC = Blombos Cave; KDS = Klipdrift Shelter; DK1 = Die Kelders Cave 1; and DRS = Diepkloof Rock Shelter.

1991; Churchill et al., 1996; Grine et al., 1998; Rightmire and Deacon, 2001; Grine et al., 2017). The shellfish and fish remains from the site provided notable information on early exploitation of coastal resources (Thackeray, 1988; Von den Driesch, 2004; Van Niekerk, 2011; Langejans et al., 2012, 2017), and lithic analyses contributed towards understanding of MSA technological strategies (Thackeray, 1989; Wurz, 1999, 2002; 2012, 2013; Wurz et al., 2003; Villa et al., 2010). The faunal data have been discussed in the context of subsistence behavior (Klein, 1976, 1989; Milo, 1998) and palaeoenvironmental reconstructions (e.g. Klein, 1976; Avery, 1987; Van Pletzen, 2000; Hillestad-Nel et al. 2018).

During the Middle Stone Age the Cape coastal area was characterized by unique endemic mammal fauna (e.g. Klein, 1983, 1984; Klein et al., 2007; Faith, 2013) adapted to vegetation types from the Cape Fynbos and Albany thicket biomes (Mucina and Rutherford, 2006). In contrast some areas of the interior of South Africa, for example the region around Florisbad, were associated with savanna and grasslands (Mucina and Rutherford, 2006). Such grasslands were fully established during the Florisian Land Mammal Age (FMLA) that lasted from 600 to 10 ka (Brink, 2016). During this time fluctuating perennial lakes, leaving their traces in today's pans (Brink, 1987, 2005), occurred in this area. The "Old Collection" from the Florisbad Spring reflects the faunal composition of the FLMA. It is also at Florisbad that evidence for the earliest Middle Stone Age assemblage in South Africa, dating to ca. 279 ka (Grün et al., 1996; Kuman et al., 1999), and a *Homo sapiens* root species, *Homo helmei*, occurs. The Florisbad skull, dating to ca. 259 ka has obtained new significance for understanding modern human origins as recent genetic analyses estimated modern human divergence to between 350 ka and 260 ka (Schlebusch et al., 2017). The aim of this paper is to present the first results from new excavations at Klasies River and to link this to the existing data generated by the Singer and Wymer and Deacon excavations. The lowermost part of the 10 m Shell and Sand (SAS) member, the basal SASU and SASL sub-members from Klasies River main site from caves 1 and cave 1A are discussed. The new findings are presented and thereafter integrated with the existing body of knowledge generated by the previous research. The wider implications of the Klasies River data from the basal SASU and SASL sub-members are further discussed from a broader landscape perspective by exploring connections to contemporaneous coastal assemblages on the Palaeo-Agulhas plain and the interior.

2. Klasies River main site and the basal SASU and SASL deposits

Klasies River main site is part of a cultural landscape that has been declared a National Heritage Site. The heritage landscape is situated in the Eastern Cape region of South Africa, and encompasses a ca. 2 km stretch along the beach between the Klasies River in the west and Druipkelder point towards the east. Klasies River main site consists of two caves (caves 1 and 2) and associated overhangs (named caves 1A and 1B). The caves face the Indian Ocean and are cut into cliffs that form the seaward edge of a 13 km coastal platform running along the Tsitsikamma mountain range. Caves 1 and 1A, discussed in this article, are currently 6 m above sea level, but prehistoric fluctuations in sea levels would have led to new areas opening as the sea retreated or areas becoming submerged as the sea rose (e.g., Bateman et al., 2004; Fisher et al., 2010; Bateman et al., 2011; Compton, 2011; Cawthra et al., 2014; Carr et al., 2016). Klasies River is situated at the easternmost extent of the Palaeo-Agulhas plain (Van Andel, 1989; Marean et al., 2014). The coastal plain is less extensive in this area than at Blombos Cave and Pinnacle Point further to the west on the southern Cape coast. During MIS 5c (ca.106 - 93 ka, Lisiecki and Raymo, 2005), the time period discussed here, Klasies River would have been within 2 km from the coast (Langejans et al., 2012). Table Mountain Group sandstone and quartzite with slate and shale and Bokkeveld metashales form part of the landscape around the Klasies River main site (e.g., Butzer, 1978; Marker and Holmes, 2010). The site is located within the broad Fynbos Biome, but the vegetation is in fact a complex mosaic of thicket, forest, and coastal vegetation. This densely interdigitated vegetation provides a wide variety of useful resources (Van Wijk et al., 2017).

Klasies River main site is the largest archaeological feature in the heritage landscape and comprises 21 m of archaeologically significant deposits. The site was first excavated by Singer and Wymer in 1967–68 (Singer and Wymer, 1982, Fig. 2). "Singer and Wymer" is hereafter abbreviated as S-W when referring to the stratigraphy. The excavation

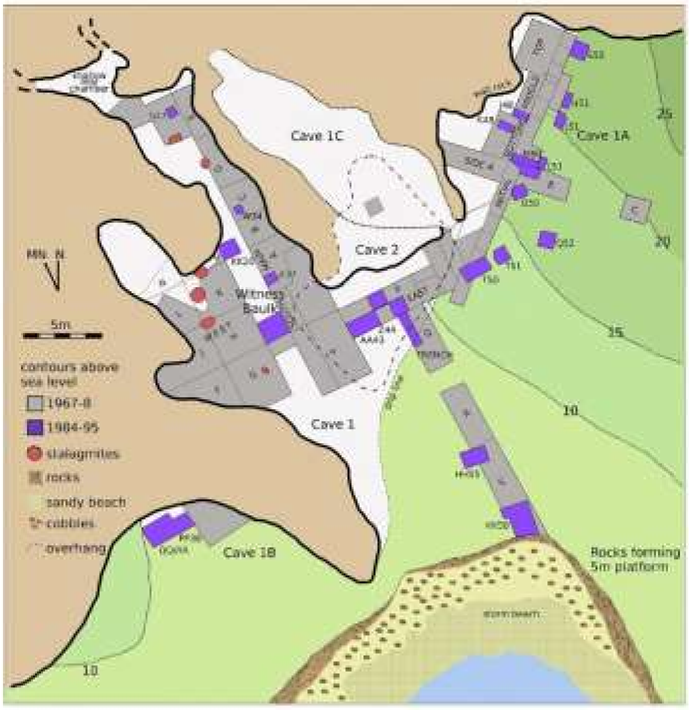

Fig. 2. Plan of main site, Klasies River.

was extensive and removed most of the deposits from caves 1 and 1A (Fig. 2, light grey/purple areas). Hilary Deacon (e.g. Deacon and Geleijnse, 1988; Deacon, 1995) subsequently excavated Klasies River main site, including caves 1, 2, 1A and 1B, from 1984 to 1995 (Fig. 2, dark grey/purple areas). He excavated the Witness Baulk in cave 1 between 1991 and 1995, but did not reach bedrock. The Witness Baulk is a ca. 12 m baulk of sediment occupying the central area of cave 1 that was left behind following the Singer and Wymer excavations. The current excavation phase at Klasies River main site is led by Sarah Wurz and started in 2015 by continuing the Deacon excavation of the Witness Baulk (Fig. 3). The other area from which results are discussed is from the intersection of cave 1/1A where Deacon excavated Squares AA43/Z44 in the late 1980's. The Singer and Wymer excavations removed the connection between the Witness Baulk and Squares AA43/Z44, but the top layers from this area are stratigraphically equivalent to the new layers excavated by Wurz in the Witness Baulk (see discussion below). The current excavation follows the same protocols as those established by Deacon. In general, sediments are carefully removed around the archaeological remains with wooden implements. Objects > 2 cm are given unique ID numbers and their coordinates are captured with a Nikon Nivo total station before each object is removed and bagged separately. Sediments are sieved in stacks of sieves with mesh sizes of 3 and 2 mm. Soil samples are routinely collected from each layer and other samples, such as wood ash samples, are collected when needed. The excavation surfaces are regularly photographed for digital reconstruction.

Deacon classified the MSA deposits in the main site into different lithological members, a system continued by Wurz. These include the lowest member, Light Brown Sand (LBS), followed by the Rubble Brown Sand (RBS), Shell and Sand (SAS), Rock Fall (RF), Upper as well as the White Sand (WS) members (Fig. 4). The uppermost part of the sequence, represented by the RF and Upper members, occurs only in caves 1A and 2. The underlying SAS member is the thickest unit and comprises ca. 10 m in cave 1A, 3 m in cave 1 and 1.5 m in cave 1B (Deacon and Geleijnse, 1988, Fig. 6). The SAS sub-member, the focus of this paper, is divided into sub-members, from top to bottom, the SAS Rubble (SASR), SAS Wedge (SAS-W) that is only present in cave 1 and the SAS Upper (SASU) and SAS Lower (SASL) sub-members that are present in caves 1, 1A and 1B. The areas under discussion in this paper are the Witness Baulk in cave 1 that preserves the SAS to LBS members, and the easternmost section where cave 1 and 1A intersect where only the SASL sub-member to the LBS member remains.

The lowermost layers (OHO−HHH) in the Witness Baulk excavated by Deacon in the 1990's represent the base of the SASU sub-member and form part of Singer and Wymer's layer 16. The immediately underlying SASL sub-member in the Witness Baulk of cave 1 was not excavated by Deacon and this is where the new Wurz excavations started (layers HHH Base and SMONE). The uppermost layers from Squares AA43/Z44 that were excavated by Deacon in the late 1980's correspond to the SASL sub-member in the Witness Baulk excavated by Wurz. The SASL sub-member discussed here forms part of Singer and Wymer's layer 17a. In the following section the stratigraphy of the Deacon material from the base of SASU in the Witness Baulk and SASL in AA43/Z44 is discussed, followed by the description of layer SMONE excavated by Wurz. In both these sections the stratigraphy is integrated with information from Singer and Wymer (1982). In Table 1 the stratigraphy of all three generations of excavations are presented in addition to the volume of deposit for the Deacon and Wurz excavations.

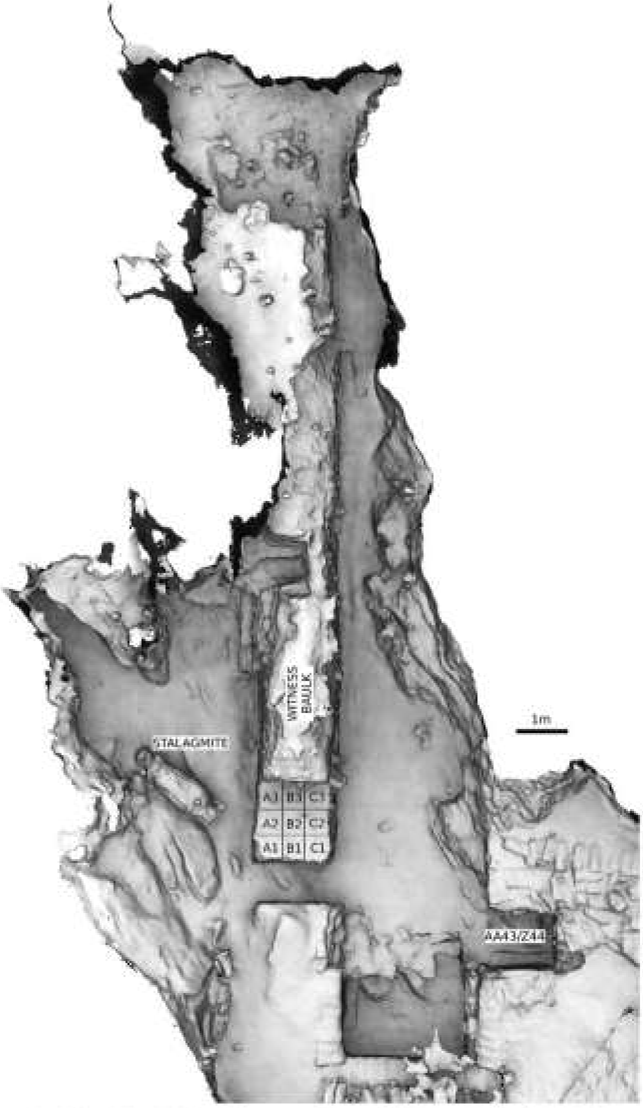

Fig. 3. Plan of cave 1 indicating the excavated areas of the Witness Baulk and AA43/Z44.

2.1. The SASU sub-member in Squares A1-C3 from the Witness Baulk in cave 1 (S-W layer 16), Deacon Excavation

The SASU-sub-member in the Witness Baulk of cave 1 contains several layers (HHH-D2, Fig. 5), but only the basal part consisting of layers OHO (Over Hearth Over) and HHH (Hearth Hearth Hearth) (Fig. 5 a and b) are discussed in this paper. The deposits from these layers comprise rubble with pebbles, angular rock fragments, large lumps of soft and hard calcite as well as broken stalagmites in association with well-preserved fauna and stone artefacts (Deacon site notes and photographs; Deacon and Geleijnse, 1988). This content is similar to that noted by Singer and Wymer (1982, pp. 14) for layer 16, the equivalent of SASU. Layers HHH and OHO, like the rest of SASU, contain remnants of multiple fires in the form of black sediments with carbonised material (possibly plant material) and ash. These combustion features are superimposed and interleaved (Deacon and Geleijnse, 1988), bearing witness to intensive occupations. Combustion features in similarly aged levels in cave 1B were described by Henderson (1990, 1992) as ash patches less than 0.5 m in diameter, and interpreted by Deacon (1995) as small domestic hearths used by family units for the

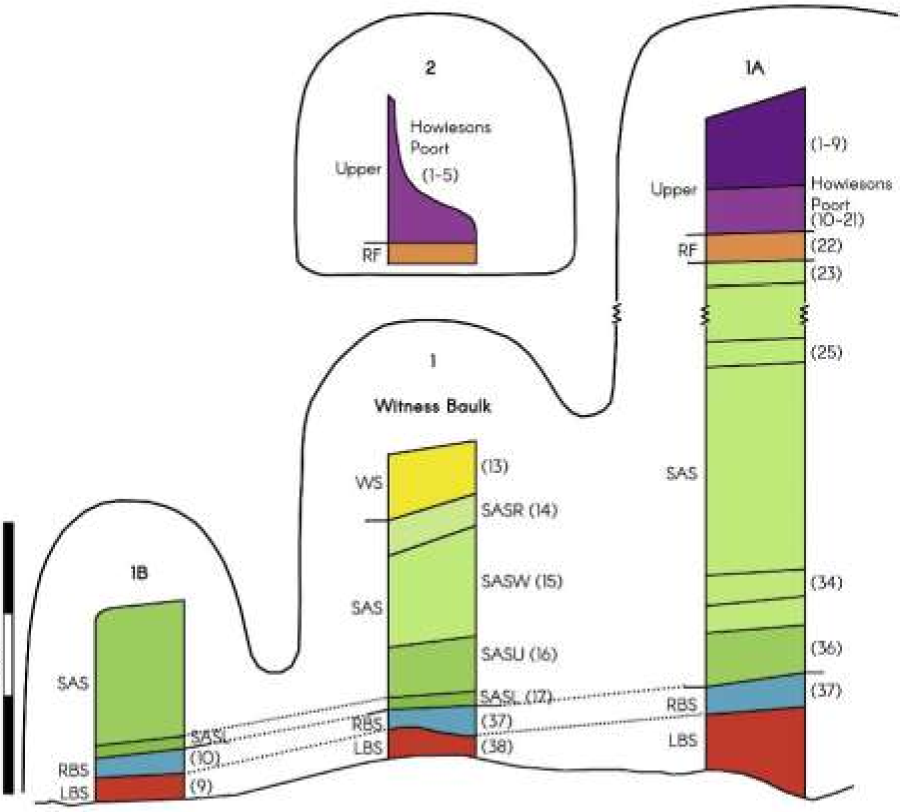

Fig. 4. Generalized stratigraphy of main site (updating Fig. 4 from Grine et al., 2017 and Fig. 2 of Hillestad-Nel et al., 2018).

Table 1
Stratigraphy and volume of deposit excavated of the SASU and SASL sub-members for the Deacon and Wurz excavations.

Sub-Member	S-W Layer Designations	Cave 1 Witness Baulk	Volume of deposit excavated (m^3)*	Cave 1/1A AA43/Z44	Volume of deposit excavated (m^3)
SASU	Layer 16	OHO	0.2690		
		HHH	0.2345		
		HHH Base	0.007		
SASL	Layer 17a	SMONE	0.05315		
				SM1 – BS2	0.0532

*The volume of deposit excavated comprises nine 50 × 50 cm squares, numbered A1-C3.

processing of shellfish and possibly other foods. The combustion features as well as the trampled microfauna from layers OHO and HHH (Hillestad Nel et al., 2018) indicate that these layers represent primary occupation debris. The shell from the Deacon excavation is in the process of being analysed by Richard Klein, but the site notes and raw data indicate the abundance of brown mussel (*Perna perna*).

2.2. The SASL sub-member in squares AA43/Z44 from cave 1/1A (S-W layer 17a), Deacon excavation

The SASL sub-member excavated by Deacon occurs in squares AA43/Z44, to the east of the Witness Baulk (Deacon and Geleijnse, 1988, Fig. 8). The SASL sub-member comprises layers SM1 (Shell Midden 1) to BS2 (Brown Sand 2) (Table 1, Fig. 6a). This group of layers is equivalent to layer 17a of Singer and Wymer (1982). Our hypothesis is that one or more of these layers link to layer SMONE (Shell Midden ONE) in the Witness Baulk (see below), but relating the individual layers of AA43/Z44 to the Witness Baulk is not straightforward as Singer and Wymer's cuttings a and A (see Fig. 2) removed the connection between these areas. Our observations of the remaining AA43/Z44 profiles indicate that there are lateral changes in the defining characteristics of the layers, including the abundance of coarse rubble. Furthermore, it is highly likely that anthropogenic features related to primary activities, such as ash lenses, are not evenly distributed throughout the cave and these therefore cannot be used to link the profiles. We acknowledge the possibility that further analyses (e.g. micromorphology, radiometric dating) of the AA43/Z44 deposits may prompt redefinition of layer groupings. Layers SM1-BS2 consist of soil and rubble with artefacts and other finds lying at all angles (Deacon site notes), thus they do not represent *in situ* deposits. Brown mussel is also the most abundant shell fish species in these layers (Deacon site

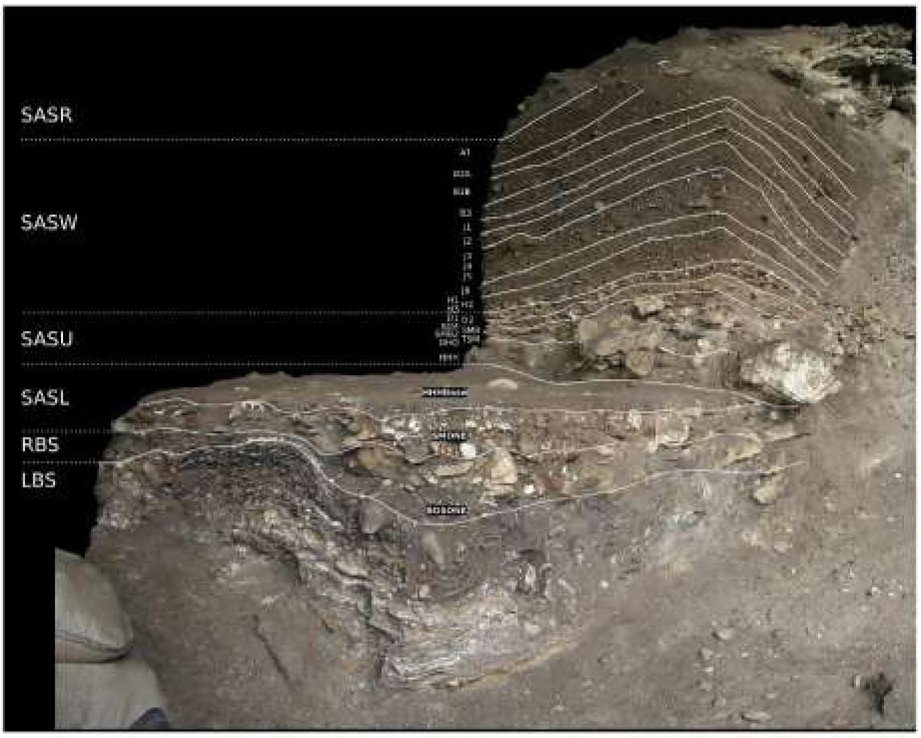

Fig. 5. Stratigraphy of the Witness Baulk indicating the origin of the U-Th dating sample.

records; see also Thackeray, 1988).

2.3. The SASL sub-member in squares A1-C3 from the Witness Baulk in cave 1 (S-W layer 17a), Wurz excavation

The new excavations targeted the Witness Baulk where the very base of the SASU sub-member was left unexcavated by Deacon in 1995. A thin layer designated as HHH Base was removed in 2015. The SASL sub-member comprises the SMONE unit, equivalent to Singer and Wymer's layer 17a (1982, Fig. 3). This unit could not be excavated in individual layers as the artefacts and other finds from this soil and rubble matrix occurred at all angles with overprinting evident. The SMONE unit varied from 5 mm thick in the west to 15 cm thick in the eastern part of the Witness Baulk. The matrix included many disintegrated tufa blocks, leached ash, and small charcoal pieces. No *in situ* combustion features were observed, but 82 quartzite rocks, including lithics, displayed color changes, fractures and other signs of being exposed to fire. Fish scales occurred, and while some of the shell fish remains were well preserved, many shells were dissolved. Land snail (*Achatina* sp.) from this layer was plentiful and well preserved and ostrich egg shell has been recovered. These remains are under analysis.

2.4. Summary

This article reports on three stratigraphic units that occur at the interface of the Deacon and the Wurz excavations in caves 1 and 1A. From Squares A1- C3 in the Witness Baulk, the basal SASU sub-member excavated by Deacon and the SASL sub-member excavated by Wurz are discussed. The SASL sub-member excavated by Deacon from squares AA43/Z44 east of the Witness Baulk is discussed as well. The data from Deacon and the new excavations by Wurz are integrated by comparing and discussing this nexus of layers.

2.5. Dating

The ages of the SASU and SASL sub-members are established from past and new dating. U-Th ages of 85.2 ± 2.1 and 94.6 ± 3.2 ka for the base and top of a 30 cm long stalagmite from Singer and Wymer's layer 14, higher in the sequence than the S-W layers 16 and 17, in Square D (Fig. 2) were obtained by Vogel (2001). The exact position of the stalagmite from square D is not known as it was removed for dating (Stefan Woodborne, Wits, pers comm to Wurz, September 2017). The deposits of the Witness Baulk thin out significantly towards Squares D and E at the back of the cave and this obscures the link with deposits towards Singer and Wymer's area A (Fig. 2). The Deacon and the current excavation of the Witness Baulk are in the region of area A. A stalagmite from square M from the western side of the Witness Baulk (Fig. 2), perhaps in similar stratigraphic context to the S-W layer 14 stalagmite, provided a U-Th age of 100.8 ± 7.5 ka (Vogel, 2001, pp. 266). There is also no direct link between this stalagmite and the Witness Baulk deposits. The lack of connection between the stalagmites and the Witness Baulk complicates interpreting these ages in relation to the deposits reported in this article. As these dates relate to layer 14 or Deacon's SASR sub-member stratigraphically above the deposits discussed here, the Vogel dates provide minimum estimates for the SASU and SASL sub-members. Another age estimate from the base of layer 17

Fig. 6. Stratigraphy of squares AA43 and Z44.

of the Singer and Wymer excavation, presumably of area A, is more directly relevant. A bovid upper molar fragment from the base of layer 17 was initially dated using ESR, to between ca. 93 and 88 ka (linear uptake model (LU)), or ca 67-63 ka (early uptake model (EU)) (Grün et al., 1990). Millard (2008) revised these ESR ages to ca 102-63 (EU) and 104-64 (LU) ka. Laser ablation MC-ICPMS applied to this same bovid tooth (Eggins et al., 2005) provided an U-series/ESR estimate of 101 ± 12 ka.

New dating for the base of the SASU sub-member in the Witness Baulk of cave 1 is reported here. Robyn Pickering and Helen Green used U-Th dating on flowstone associated with tufa material that fell into layer HHH, and obtained an age of 126.0 ± 1.5 ka (see Fig. 5 and Supplemental Materials). The flowstone formed on the surface of the tufa before it fell from either the cave 1 ceiling or the cliff face above cave 1A. Speleothems from cave 1C, a closed off cave situated below cave 1A (Fig. 2) with no archaeological deposit have been dated as part of a larger palaeoenvironmental project by Kerstin Braun (2014). U-Th ages of these speleothems indicate several phases of formation, at for example 122 ± 1.2 ka, between 105 and 101 ka, and a younger phase dating to around 95 ka. This data still need to be integrated with the tufa formations from cave 1. The range of ages discussed here provides a general estimate for the base of the SASU sub-member of ca. 100 ka, MIS 5c. A hiatus occurred between the SASL sub-member and the base of the SASU sub-member, indicating that SASL formed prior to or in early MIS 5c.

3. Lithic industry

The lithics from the SASU and SASL sub-members have been placed in the MSA II lower phase and are part of the Mossel Bay techno-complex (Wurz, 2002) or the MSA 2b (Volman, 1981). The material discussed here have been analysed by three generations of researchers - Anne Thackeray (Thackeray, 1989; Thackeray and Kelly, 1988), Sarah Wurz (Wurz, 2000, 2002)) and currently Mareike Brenner for her PhD thesis (Brenner and Wurz, in prep.) The assemblage composition data for AA43 are from Anne Thackeray's records (no data for Z44 could be found), for Layers OHO-HHH from Wurz (2000, 2002) and for HHH Base and SMONE from Brenner. South African MSA analytical paradigms and reporting protocols have changed significantly from the 1980's to 2017, the time span covered by this analysis, leading to some differences in the lithic classes reported (Table 2).

The technological analysis of the assemblages was undertaken using a *chaîne opératoire* approach combined with attribute analysis. Wurz analysed the SASU material from the Deacon excavations of the Witness Baulk, and SASL artefacts from cave 1/1A while Brenner studied the Witness Baulk layers HHHBase and SMONE from the Wurz excavations. Slightly different analytical procedures have been followed in the analyses of the Deacon and Wurz artefact samples. For the Deacon sample only 'end products' or regular artefacts were subjected to a detailed analysis, while the details of all products have been noted for the Wurz assemblage. The primary raw material utilized in the SASU and SASL sub-members is quartzite obtained from water rounded cobbles (Table 2). When the total number of artefacts is considered, quartzite comprises more than 99% in SASU (OHO-HHH) and 93% in SASL (SMONE) (discounting HHH Base and the AA43 layers due to small sample size). Hornfels and silcrete occur in negligible amounts in both the SASU and SASL sub-members (Table 2). In OHO 0.2% and HHH 0.4% of the artefacts are in quartz, with higher numbers occurring in HHH Base (10%), and SMONE (6%). Although most of the quartz pieces (n = 131) are smaller than 20 mm, its presence may indicate an increased interest for this raw material in layers HHH Base and in SMONE.

Table 2
Assemblage composition (numbers of artefacts) of layers from the SASU and SASL sub-members (Data for OHO, HHH, and AA43 SM1-BS2 from the Deacon excavation; data for HHH Base and SMONE from the Wurz excavation).

	OHO	HHH	HHH Base	SMONE	AA43 SM1-BS2
Quartzite					
Hammerstone	0	0	1	3	
Core	16	2	1	14	2
Core rejuvenation	2	0			
Points	14	6	7	35	12
Blades	15	3		19	10
Point and blade fragments	28	16	20	67	39
Flakes			22	139	
Flake fragments			14	170	
Fragments > 10 mm incl chunks and "irregular flakes"	995	568			213
Edge damaged	82	26		94	8
Tools	60	24	5	9	6
Cobble frag	1		1	12	
Pebble frag	6		4	83	
Chunks			12*	168*	
Pieces < 20 mm			114	1325	
Chips (pieces < 10 mm)	377	277			
TOTAL for Quartzite	**1596**	**922**	**201**	**2034**	**290**
Non -quartzite (pieces < 20 mm)					
Quartz	3	4	23	131	2
Hornfels	2	2	1		
Silcrete				5	1
TOTAL for non quartzite	**5**	**6**	**24**	**136**	**3**
GRAND TOTAL	**1601**	**928**	**225**	**2170**	**293**

*2 in quartz.

A uniform reduction strategy was used in the SASU and SASL sub-members (Fig. 7). The cores for both sub-members are in an advanced reduction stage and many had point scars as last removal. In the SASU sub-member some of the core blanks consist of split quartzite cobbles, a phenomenon also observed for layer SMONE. These cores show clear crushing at the impact point and prominent striations radiating from this area. It is likely that a bipolar on anvil technique (see e.g. Shott and Tostevin, 2015) has been used, and two anvils found in SMONE support this inference.

In both the SASU and SASL sub-members the dominant technique used was free-hand hard hammer percussion as indicated by the prominent bulbs of percussion. For SMONE 62% of the flaked products (n = 191/310) had prominent bulbs of percussion accompanied by ring cracks at the point of impact (65%, n = 201/310). In SASU the cores conform to criteria typical of a unipolar convergent Levallois reduction method (Wurz, 2002, pp.1008) and the same features are apparent in the SASL cores. The striking platform, or passive under surfaces of the cores, almost always carry cobble cortex, with the production surfaces' scars more organized. The production surface has been domed by the removal of elongated "debordantes", frequently retaining cortex on the back. There is little evidence for preparation of the distal part of the reduction surface with knappers taking advantage of the flatness of the split cobble face to create the appropriate angle for end product removal. Other more informal types of cores also occur, some of these resembling platform cores with one or two opposed platforms and multiple reduction surfaces (Conard et al., 2004).

The production surfaces have been exploited in a recurrent manner creating points and blades (also referred to as blanks here) with thick platforms and straight profiles. For SASU the average thickness of the platforms are 10 mm (n = 1338) and for SMONE it is 9.6 mm (n = 71). As also remarked for the SASU assemblage (Wurz, 2002), the blade forms for SASL have not been produced within a laminar production system as most have a sturdy appearance and are irregular with steeply angled lateral sides. The high incidence of points with a regular morphology suggests that they were the main intended debitage products in SASU and SASL.

The points from SASU and SASL occur in various shapes and vary from symmetrical to skewly convergent (e.g. Fig. 7b,e,f,g). They also vary in their degrees of elongatedness. The range of point shapes is similar to those produced from the parallel unidirectional convergent method in the M3 phase at Blombos cave (Douze et al., 2015, pp. 14).

In both SASU and SASL artefacts have clearly observable lateral edge damage. This type of modification is more numerous than the formal tools that consist of notched and denticulated artefacts (Table 3). This modification may relate to utilization and artefacts with this type of edge damage may have been "informal" tools (Douze et al., 2015). The notched artefacts exceed the denticulated pieces by far and represent 25.6% (51), 30.7% (1) and 1.4% (6) of the respective assemblages (Table 3). The notches are frequently restricted to one lateral edge on the dorsal side, but sometimes also occur on both the ventral and dorsal surfaces. This degree of formal retouch (notches and denticulates) is comparable to other MIS 5 assemblages from the Cape, e.g. Blombos (4.5%) and Diepkloof (2.3%) (Douze et al., 2015, pp.10, 22).

4. The large mammals from the SASL and SASU SUB-MEMBERS

The large mammal data for the basal SASU sub-member presented here are derived from layers OHO-HHH of the Deacon excavations of the Witness Baulk in cave 1. The data for the SASL sub-member originate from the Deacon excavation of AA43/Z44, layers SM1-BS2 in cave 1/1A and the 2015 Wurz excavation of layer SMONE of the Witness Baulk. The Deacon sample has been analysed by Van Pletzen Vos (Van Pletzen, 2000), and the Wurz sample by Reynard (this paper). The SASU deposits are five times larger than that from SASL and we are cognizant of this when comparing these sub-members. HHH Base yielded a very small volume of deposit and sample, and only one identifiable specimen, a Cape fur seal (*Arctocephalus pusillus*) tooth, was found. No taphonomic analysis has been undertaken, but this study is in progress. We do, however, note that – as with other MSA faunal remains from sites such as Sibudu Cave (Clark, 2017), Diepkloof Rockshelter (Steele and Klein, 2013) and Klipdrift Shelter (Reynard et al., 2016) – the assemblage is fragmented. Teeth were generally used to assign faunal material to Class, Order or Family. The cranial and post-cranial remains of bovids that could not be assigned to Family were placed in size classes based on Brain (1974). We use the number of identified specimens (NISP) instead of the minimum number of individuals (MNI) because NISP is a primary quantitative unit. Our samples are small and fragmented which is challenging to measure using MNI (Marshall and Pilgram, 1993). NISP is also not subject to aggregation effects (Grayson and Frey, 2004) and generally less contentious than MNI (e.g., Grayson, 1978; Turner, 1980; Plug and Plug, 1990).

The taxonomic composition (Table 4) shows that the most abundant taxa in the SASU and SASL sub-members are rock hyrax (*Procavia capensis*). This is not surprising, as rock hyrax is adapted to a wide variety of environments but is especially associated with rocky crevices (Maswanganye et al., 2017) that characterize the Klasies River environment. The second most abundant taxon is represented by Cape fur seals. Given that SASU and perhaps SASL are associated with the high sea level period of MIS 5c (Van Andel, 1989; Carr et al., 2016), this might correspond to a shoreline positioned relatively close to the site. Four taxa occur only in the SASU sub-member – brown hyena (*Parahyaena brunnea*), Cape dune mole rat (*Bathyergus suillus*), hippopotamus (*Hippopotamus amphibius*) and alcelaphines. Although hyena is not present in the identified species list of SMONE, there is some evidence of extreme acid-etched bone in this layer which may point to the presence of this taxon.

The presence or absence of specific ungulate taxa can be used to track changing palaeoenvironmental trends at Klasies River. Our assessments of extant ungulate diets (Fig. 8) and habitat preference are based on modern data from Skinner and Chimimba (2005). Not all groups are sensitive habitat indicators. Eland (*Tragelaphus oryx*), for

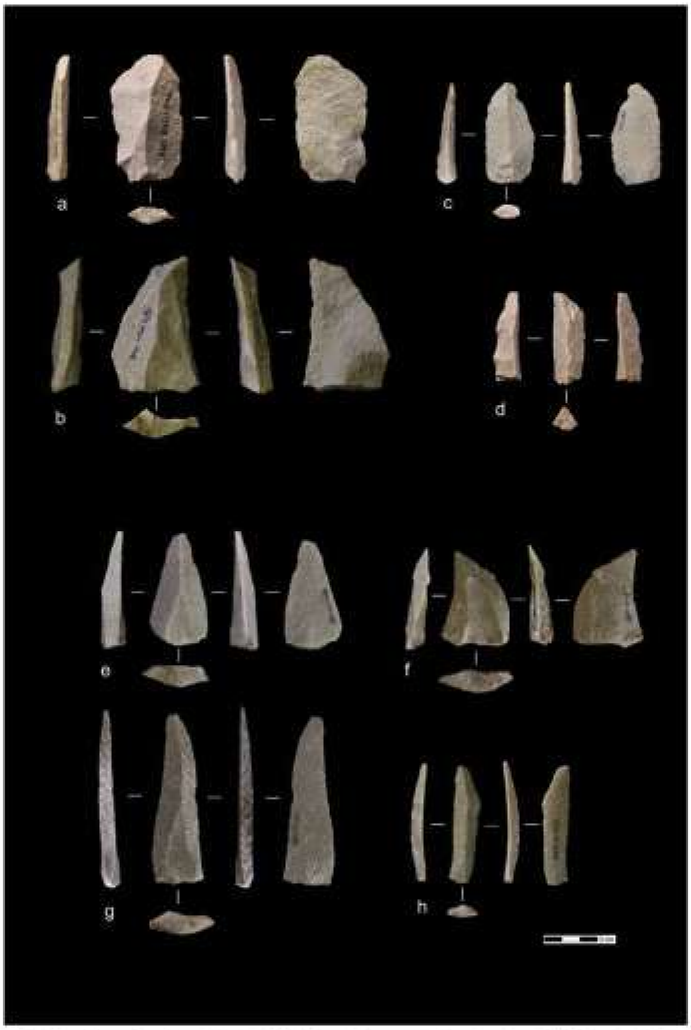

Fig. 7. Blanks from the SASU and SASL sub-members: Layer SASU: a) blade, b) point, layer HHH Base: c) point d) blade; layer SMONE: e)-g) points, h) pointed blade.

example, has been described by Thouless (2013) as a highly adaptable ruminant that once ranged over most of sub-Saharan Africa. Cape grysbok (*Raphicerus melanotis*) is primarily a browsing antelope often replaced by steenbok (*R. campestris*) when browse is less common (Skinner and Chimimba, 2005). Grysbok, however, is also able to shift its dietary habits as the dominant vegetation changes (Faith, 2011a). Research on the fossil populations at Klasies River suggests that these small bovids could successfully switch between browsing and mixed feeding (Faith, 2013). Grysbok grazing preference would likely be fresh, newly grown grass shoots since *Raphicerus* require high quality food (Skinner and Chimimba, 2005). With the exception of *Raphicerus*, diet and habitat preference are usually closely correlated. Following meso-wear analysis, the blue antelope (*Hippotragus leucopheas*), found in both SASU and the SASL sub-members, has been classified as a grazer (Faith and Thompson, 2013). Other grazers from the analysed assemblage include equids, the African buffalo (*Syncerus caffer*) and the extinct long-horn buffalo (*Syncerus antiquus*). The common duiker (*Sylvicapra grimmia*), greater kudu (*Tragelaphus strepsiceros*) and bushbuck (*T. scriptus*) are the browsers identified from SASU and SASL sub-members.

Richard Klein (1976) undertook a seminal study on all the fauna excavated by Singer and Wymer (1982). The very large sample size for S-W layers 16 and 17 relevant here allowed the use of the minimum number of individuals (MNI's) to infer palaeoenvironmental changes. Although Klein (1976) analysis of the Singer and Wymer fauna used MNI and the Deacon and Wurz studies rely on NISP, Klein's raw data (R. Klein, pers. comm., 7 May 2014) show that MNI is significantly correlated to NISP for both the MSA II ($r_s = 0.94459$; $p < 0.0001$) and MSA I ($r_s = 0.93507$; $p < 0.0001$) indicating that it is reasonable to

Table 3
Modification of blanks.

	lateral		notched		denticulate		no damage		Total	
	n =	%	n =	%	n =	%	n =	%	n =	%
OHD										
Fragment	43	21.6	23	11.6	4	2.0	28	14.1	98	49.2
Blade	8	4.0	11	5.5	3	1.5	15	7.5	37	18.6
Point	30	15.1	13	6.5	1	0.5	14	7.0	58	29.1
Flake	1	0.5	4	2.0	1	0.5	0	0.0	6	3.0
Total	82	41.2	51	25.6	9	4.5	57	28.6	199	100.0
HHH										
Fragment	12	16.0	8	10.7	0	0.0	16	21.3	36	48.0
Blade3	1	1.3	2	2.7	1	1.3	3	4.0	7	9.3
Point	8	10.7	12	16.0	0	0.0	6	8.0	26	34.7
Flake	5	6.7	1	1.3	0	0.0	0	0.0	6	8.0
Total	26	34.7	23	30.7	1	1.3	25	33.3	75	100.0
SMONE										
Fragment	50	11.6	4	1.0	0	0.0	183	42.6	237	55.1
Blade	5	1.2	1	0.2	0	0.0	13	3.0	19	4.4
Point	19	4.4	0	0.0	1	0.2	15	3.5	35	8.1
Flake	22	5.1	1	0.2	0	0.0	116	27.0	139	32.3
TOTAL	94	21.9	6	1.4	1	0.2	327	76.0	430	100.0

compare these datasets. In the Deacon and Wurz samples, equids and *Hippotragini* – obligate grazers – are especially common in the SASL sub-member. Klein (1976) analysis shows a similar trend with grazing taxa more common in layer 17 (SASL) and browsers more prevalent in layer 16 (SASU). The environment around Klasies River during the phases discussed here appears to have been a patchwork of woodland thicket interspersed with grasslands in the SASL sub-member, becoming bushier in the SASU sub-member. Given the small size of the faunal sample, in the following section we focus our discussion of palaeoenvironmental trends on the more robust data set of Klein (1976).

5. Discussion: wider connections

This paper discussed the last layers excavated by Deacon in 1995 and the first layers excavated by Wurz in 2015 in the Witness Baulk, cave 1. The Wurz data were also related to equivalent layers excavated by Deacon in the late 1980's in squares AA43/Z44, adjacent to but not connected to the Witness Baulk. This linkage between old and new excavations and datasets is vital to provide a new basis for further analysis and discussions of Klasies River. The lithics from layer SMONE from the SASL sub-member are technologically similar to that from the SASU sub-member. These lithic industries have been produced using free-hand hard hammer percussion and a unidirectional convergent core reduction strategy. Quartzite blanks with a variety of point shapes and blades were produced. The formal retouched component is small and consists mainly of notches. There are technological parallels between these Klasies River assemblages and broadly contemporaneous assemblages from Blombos Cave, Pinnacle Point 13B and Diepkloof Rockshelter (Thompson et al., 2010; Douze et al., 2015; Porraz et al., 2013), but the degree of technological convergence still needs to be further investigated, an endeavor hampered by the general absence of high resolution age estimates. MSA lithic production systems, such as these discussed here, indicate considerable planning depth in the process of designing cores to produce preformed blanks of specific shapes (Wurz, 2016). This level of complexity may also be reflected in three regularly notched bones from Singer and Wymer's layer 36 in cave 1A (equivalent to S-W layer 16 and the SASU sub-member) (Wurz, 2000).

Intact hearths have been recorded by Deacon for the SASU sub-member, but such hearths have not been documented in the Wurz excavation of SMONE. Instead the association of fire use and different activities in the form of heat-affected fauna, lithics and shellfish has been uncovered. In addition, 82 potentially heat-affected quartzite rocks were documented in layer SMONE. A detailed analysis of these is still in progress, but an analysis of 323 similar heat-affected rocks from

Table 4
Number of identified specimens (NISP) and ungulate dietary preference.

Order	Taxa	Common Name	Diet	SASU	SASL	SMONE	Total
Rodentia	*Bathyergus suillus*	Cape dune mole rat		1	0	0	1
Carnivora	*Arctocephalus pusillus*	Cape fur seal		11	16	2	29
	Parahyaena brunnea	Brown hyena		2	0	0	2
	Orycteropus afer	Aardvark		1	0	1	2
Hyracoidae	*Procavia capensis*	Rock hyrax		56	11	3	70
Perissodactyla	*Equus* sp.	Zebra/quagga	Grazer	1	6	1	8
Ruminantia	*Raphicerus cf.melanotis*	Grysbok	Mixed	9	0	1	10
	Sylvicapra grimmia	Common duiker	Browser	1	0	2	3
	Tragelaphus oryx	Eland	Mixed	6	1	2	9
	Tragelaphus strepsiceros	Greater kudu	Browser	7	1	0	8
	Tragelaphus scriptus	Bushbuck	Browser	0	0	3	3
	Hippotragus cf.		Grazer	0	4	2	6
	Hippotragus leucophaeus	Blue antelope	Grazer	2	0	1	3
	Syncerus caffer	African buffalo	Grazer	4	0	2	6
	Syncerus antiquus	Long-horned buffalo	Grazer	1	2	0	3
	Hippopotamus amphibius	Hippopotamus	Grazer	1	0	0	1
	Alcelaphinae cf.	Hartebeest Wildebeest Bontebok	Grazer	1	0	0	1

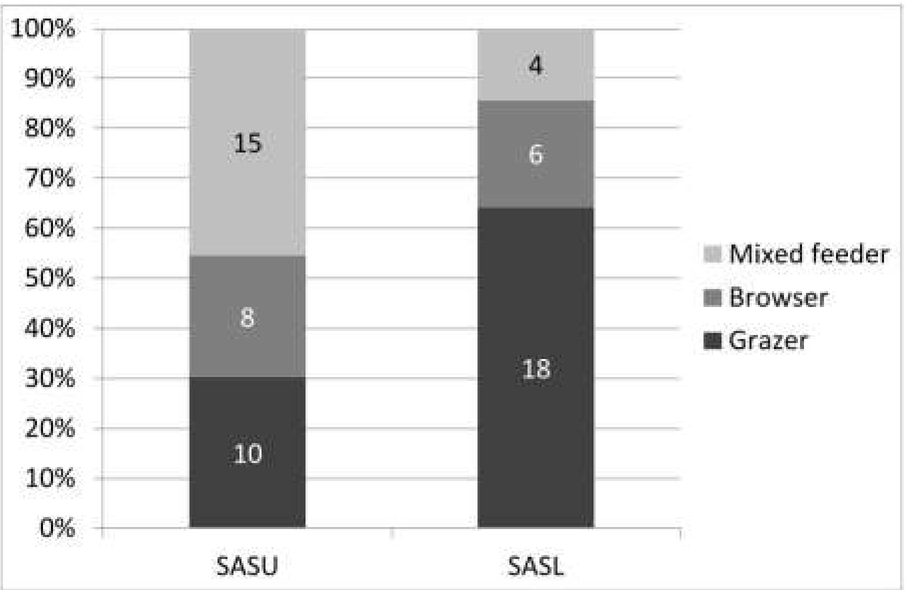

Fig. 8. Dietary preference in SASU and SASL at Klasies River. AA43 layers combined with layer SMONE. NISP in columns.

the underlying layer BOSONE (Black Occupational Soil ONE) has been conducted. A comparison of quartzite from the beach by Klasies River main site and the archaeological samples from BOSONE showed that the archaeological samples displayed fractures and color changes similar to local quartzite that was repeatedly heated in experimental fires (Bentsen and Wurz, 2017). If the rocks were intentionally heated, this could point towards the use of hearthstones or cooking with hot rocks. However, such practices have not been recorded in the MSA before (Bentsen, 2014; Bentsen and Wurz, 2017). Furthermore, intentional and repeated heating of rocks might imply long occupation phases at the site. The current micromorphological and other analyses will provide more data on fire-related behavior at the site, and we are waiting for these results to further interpret the use of fire at Klasies River.

During MIS 5c at Klasies River, the Mean Sea Surface Temperature (SST), calculated from serial $\delta^{18}O$ measurements of *Turbo sarmaticus* opercula varied between 13.2° and 11.1° C, cooler than modern values of between 19.0° and 15.6° C (Loftus et al., 2017). In spite of the relatively cooler SST's, the same range of molluscan faunal species occurred at Klasies River than today (Langejans et al., 2012). The shell fish for the MSA II Lower, of which SASU and SASL sub-members form part, is completely dominated by rocky shore species, especially the brown mussel (*Perna perna*) (Thackeray, 1988; Langejans et al., 2012, 2017). It is possible that there was an estuary close to Klasies River during periods of lower sea level (Von den Driesch, 2004; Van Niekerk, 2011; Langejans et al., 2017). Some of the foraged species and incidentals do indicate sheltered, protected conditions such as tidal pools and crevices (Langejans et al., 2017) during the time period discussed here.

Faunal data also suggest the presence of lakes, estuaries or wetlands near the site. Hippopotamus are present throughout the Klasies River sequence but are somewhat more common during SASU (Table 4; Table 1 in Klein, 1976). Klein (1976) documents other riparian-linked taxa such as water mongoose (*Atilax paludinosus*) and clawless otter (*Aonyx capensis*) at Klasies River throughout the MSA II sequence but particularly in layer 16 and above. Relatively wet conditions and a more browse-dominated environment in the SASU sub-member (S-W layer 16) are implied by an increase in the abundance of greater kudu and bushbuck (Klein, 1976). In contrast, the SASL sub-member (S-W layer 17) reflects a more open environment with grazers such as African buffalo and wildebeest (Klein, 1976) occurring more frequently. The micromammal data (Nel, 2013; Hillestad Nel et al., 2018) also suggest an increase in riparian environments during MIS 5c/d. In Hillestad-Nel's study the SASU and SASL sub-members have been lumped together in MSA II Lower, but more diverse vegetation occurred in the MSA II Lower compared to the MSA II Upper (S-W Layer 15). Evidence of an increase in moisture in MSA II Lower (containing SASU and SASL) in relation to the underlying LBS member is indicated by the presence of the African marsh rat (*Dasymys incomtus*) and vlei rat (*Otomys* sp.). These species are generally associated with wetlands, reed-beds and semi-aquatic grasses (Skinner and Chimimba, 2005). Micromammals that are linked to 'moist' grasses or waterlogged environments are also generally more abundant during the MSA II Lower period, indicating the presence of small lakes, reed-beds and wetlands, separated by herbaceous and grass covered dunes and thicket components during this period (Avery, 1987; Hillestad Nel et al., 2018).

Correlating the palaeoenvironmental conditions at Klasies River with other southern Cape sites is not straightforward, as the temporal association between sites is not clear-cut, and the sites are subject to somewhat different climatic regimes. However, at Blombos Cave in the M3 phase the prevalence of mixed-feeders such as eland and the occurrence of both grazers and browsers dated to MIS 5c, also suggests a relatively mosaic environment of bush and grasslands (Henshilwood et al., 2001; Badenhorst et al., 2016; Roberts et al., 2016). *Raphicerus* dominates the Blombos assemblages and there are also diverse numbers of grassland-linked taxa. While not particularly abundant, grazers at Blombos Cave such as hartebeest, bontebok (*Damaliscus pygargus*) and reedbuck (*Redunca arundinum*) imply a grassy environment. Extinct Florisian herbivores such as the long-horned buffalo and Cape horse

(*Equus capensis*) are also relatively common in the M3 phase at Blombos.

The SASU sub-member is younger than 126 ka (this paper) and older than ca. 94 ka, the age obtained for the base of Singer and Wymer's layer 14 (Vogel, 2001) higher in the sequence of cave 1. We postulate a date of around 100 ka for the OHO-HHH layers as the fauna and microfauna signal of this SASU phase implies relatively wetter conditions. These conditions may be related to the peak in precipitation experienced by the south eastern part of South Africa around 100 ka (Simon et al., 2015, Fig. 2). The increase in precipitation relates to inter-hemispheric see-saw mechanisms that cause a southward shift of the ITCZ and warming of the Agulhas Current during North Atlantic cooling episodes (Ziegler et al., 2013; Braun, 2014; Simon et al., 2015). Higher precipitation around 100ka is indicated in marine core CD154-10-06P, ca.160 km off the KZN coast (Fig. 1 this paper, Simon et al., 2015) and core CD154-17-17K, situated near the mouth of the Great Kei River (Fig. 1 this paper, Ziegler et al., 2013) in the Eastern Cape, some 500 km north east of Klasies River. The tufa record from Klasies River cave 1C dating to between 105 and 103 ka corroborates these wetter conditions as the peaks in the $\delta^{13}C$ values correspond to high values of Fe/K in core CD154-10-06P (Braun, 2014). It is probable that this wetter episode relates to an increase in summer rain and C4 plants (Bar-Matthews et al., 2010). The relatively moist conditions also occurred to the west of Klasies River during this period. Pollen and charcoal from a sediment core from the Vankervelsvlei wetland in the Wilderness area indicate relatively warm and moderate mesic conditions in MIS 5c/d (Quick et al., 2016). The conditions around 100 ka seemed to have been similar also in the interior. Wetter conditions are indicated in the Tswaing Pretoria Saltpan record (Partridge et al., 1997) that mirrors the changes in core CD154-10-06P (Simon et al., 2015). At Florisbad, lacustrine sands related to bodies of standing water also indicate a wetter period around ca. 100 ka (Toffolo et al., 2017, pp. 475).

Palaeoenvironmental links between the interior and the southern Cape are underexplored (Carr et al., 2016) but this connection has been tracked through the evolution of the black wildebeest (*Connochaetes gnou*) (e.g. Brink et al., 1999; Brink, 2005). Tracing the evolution of Alcelaphines, specifically the black wildebeest, is important for understanding faunal migratory patterns in the Pleistocene. Alcelaphine remains are often recovered from late Pleistocene southern Cape sites (e.g. Klein, 1976; Henshilwood et al., 2001; Van Pletzen, 2000), but it has to be noted that it is generally difficult to differentiate wildebeest from other Alcelephinae in MSA collections. Yet wildebeest – specifically black wildebeest – have been identified at Die Kelders from the MIS 4 layers (Klein and Cruz-Uribe, 2000), Klipdrift Shelter at ~ 60 ka (Reynard et al., 2016) and Pinnacle Point in the Lightly Cemented MSA Lower (LC-MSA) horizon dated to between ~ 153 and 174 ka (Rector and Reed, 2010). Klein (1976), (Table 1) further noted the presence of two specimens of wildebeest in layer 16 (SASU sub-member) and four more from layer 17 (SASL sub-member). These specimens indicate that this species was present in the southern Cape from the later Middle Pleistocene. Brink (Brink et al., 1999; Brink, 2005, pp. 181) has shown that before 90 ka wildebeest from the southern Cape were similar in size than those from the interior. Tali from the Klasies River MIS 5c (layers 15 and 16), for example, are of the same size as Middle Pleistocene Florisbad samples. After 90 ka the black wildebeest became isolated in the Cape area and there was a marked reduction in their size compared to contemporary groups in the interior. They also became stockier and more robust. Even though there was a reduction in size, body proportions remained similar to those from inland species, supporting the possibility that late Florisian coastal *C. gnou* populations descended from interior Florisian groups (Brink, 1993). The reduction in size culminated in the late Pleistocene until a regionally distinct population developed in the late Glacial in the southern Cape coastal zone. Research suggests that large herbivore turnover was driven by climate change in the southern Cape (Faith and Behrensmeyer, 2013). The presence of gregarious ungulates at Klasies and other southern Cape sites implies that large herbivore communities from the interior had contact with the southern Cape coastal plain. This movement would have taken place particularly during the glacial periods when grazing habitat for ungulates increased on the coastal plain (Klein, 1983, 1984; Brink, 1993, 2005; 2016; Faith, 2011b).

The migration routes would have involved crossing a major barrier, the Cape Fold Mountains that physiographically separates the interior from the Cape coastal plain (Fig. 1). Connection between the interior and the coastal plain would have been through narrow pathways or "poorts". Poorts are steep-walled openings that cut perpendicularly across a topographic barrier, usually along river courses (Geldenhuys, 1997). Migration of people and animals between the interior and the coastal plain was probably along such natural paths, historically followed by for example elephants in the Attaquas Kloof, Outeniqua mountains (Ross, 1972). It is also a possibility that grazers migrated in an east west transect across the Palaeo-Agulhas coastal plain (Marean, 2010; Marean et al., 2014; Faith and Thompson, 2013). The coastal plain covers the area south of the Cape Fold Mountains between Bot River in the west and Port Elizabeth in the east (Marker and Holmes, 2005). Grazers may have migrated across the Paleo-Agulhas plain between fresh grass that grows in the winter in the west, and summer in the east. Strontium ($^{87}Sr/^{86}Sr$) isotopes from fossil mammal teeth from the Pinnacle Point area have been compared to bioavailable $^{87}Sr/^{86}Sr$ of plants from a wide range of areas including the Cape Fold mountains, Little Karoo and the Coastal plain (Copeland et al., 2016). Fossil ungulate teeth from 12 taxa, including the black wildebeest, dating to between MIS 6 and MIS 5c from the Pinnacle Point 13B and Pinnacle Point 30 sites indicate that the fossil strontium isotope values are in the range of the bioavailable strontium isotope ratios from the coastal plain. It is inferred that Pleistocene ungulates restricted themselves to the Paleo-Agulhas plain during the Pleistocene, and that they avoided habitats that are currently situated more than about 15 km north from the coastline. Indeed, the Palaeo-Agulhas plain could have formed a new habitat-type in the GCFR and may have been a separate ecosystem where the large grazing ungulates were based (Marean et al., 2014). The black wildebeest, though, had unusually high strontium isotope values and the highest variance between individuals of all the genera tested. It would be informative to compare strontium isotopic values of Middle and Late Pleistocene gnou from the interior and the southern Cape.

6. Conclusions

This paper focuses on the SASU and SASL sub-members at Klasies River main site. A new U-Th age of 126.0 ± 1.5 ka on flowstone associated with fallen tufa material from the base of the SASU sub-member is reported. The falling event post-dates the deposition of SMONE and pre-dates the deposition of layers OHO and HHH. The U-Th age thus provides a maximum age for the contact between layer SMONE of the SASL sub-member and layer HHH of the SASU sub-member. The SASU sub-member deposits are in primary context and were formed by multiple visits of hunter-gatherer-fisher groups whose occupation debris include many lithics, well preserved fauna and multiple superimposed hearths. The underlying SASL sub-member is also associated with a prolific lithic industry and fauna, but some post depositional disturbance occurred and no *in situ* hearths were found. There is evidence of extensive fire use in this layer though, and heat-affected fauna, lithics and shellfish associated with rubefied quartzite, potentially intentionally and repeatedly exposed to fire and heat, occur. The lithic reduction strategy used in SASU and SASL was very similar and in both sub-members quartzite cobbles were used as blanks for core reduction. A parallel unidirectional convergent method of reduction was followed to produce blade and especially pointed blanks.

The basal SASU occupation phase coincided with a wet period, most likely around 100 ka, as recorded in several marine and sediment cores, associated with increased summer rain in the Eastern Cape. This sub-member is associated with relatively more browsing fauna and a higher prevalence of seals and other riparian species, perhaps indicating relatively higher sea levels, and more closed environments. In contrast, the faunal composition of the SASL sub-member indicates a shift towards more open habitats that included relatively more grazers.

The Klasies River evidence discussed here originates from the Florisian period when there was most likely contact between the southern Cape coastal plain and the interior. New genetic research indicates deep divergence dates for modern humans, extending back to 300 ka and it thus becomes crucial to expand the modern human origins research into the Middle Pleistocene. It is also vital to consider modern human origins from a sub-continental perspective and to understand how the Klasies River early humans related and connected to populations from the interior. In doing so, it might be discovered that connections between the interior and the coastal areas were much more prevalent in the Pleistocene than hitherto appreciated.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.quaint.2018.03.039.

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Online Supplementary material

Supplementary text

The dating sample was collected during the 2015 excavation season from the east profile of the Witness Baulk. The large fragment of tufa (see main text, Figure 5; Fig. S1) rests on top of Layer SMONE and is surrounded by sediment from layers OHO and HHH. We estimate that the block fall event post-dates the deposition of SMONE and pre-dates the deposition of HHH and OHO. The morphology of the tufa indicates that it likely formed as a bioconstruction hanging from the ceiling of either Cave 1 or the dripline of Cave 1a. At some later date, a clean calcite flowstone formed along one side of the tufa (Fig. S2). The tufa then fell on top of Layer SMONE, with the flowstone oriented on the underside. The flowstone thus provides a maximum age for the contact between SMONE and HHH.

Samples for uranium-thorium (U-Th) dating were extracted (see Fig. S2 for the sample position) based on the purity of the calcite and clarity and continuity of individual growth layers using a hand-held dental drill fitted with a diamond tipped bur. U-Th ion exchange chemistry and isotope analysis were conducted at The University of Melbourne following the procedure of Hellstrom (2003) using a mixed 229Th-233U spike, calibrated against standard HU-1 uranite solution in secular equilibrium. U-Th isotope ratio analysis was performed on a Nu Instruments Plasma multi collector-inductively coupled plasma mass spectrometer (MC-ICP-MS). A correction assuming an initial 230Th/232Th of 1.1±0.5 for the detrital phase (Hellstrom, 2006) was applied to all samples (Table S1).

Table S1. U-Th dating results of flowstone from HHH stalagmite.

Sample location	Sample description	Sample ID	Mass/g	Age cr ka	2se	% err	238 ng/g	2se	230/238A	95% ext.	234/238A	95% ext.	232/238A	2se	230/232i	2sd	230/232A	[4/8]i Corr	2se
Layer HHH, flowstone adhering to fallen stalagmite	Clean, dense, layered calcite	US38	0.015	126	1.542	1.2	439	33	0.932	0.004	1.306	0.005	0.008	6E-05	1.5	1.5	121.2	1.436	0.006

References of Supplementary material

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List of supplementary Figures

Figure S1. View of the Witness Baulk in 2013 with the sampled tufa visible. Two large tufaceaous stalactites are visible hanging from the cave ceiling today just west of the Witness Baulk (arrows). A smaller feature encased in moss is also visible. Similar features are present along the dripline that defines the overhang of Cave 1a to the east.

Figure S2. Incident light scan of the archive half of the dating sample. The contact between the tufa and the flowstone is visible at the base of the image. The youngest layer of flowstone is present at the top of the image. The position of the U-Th dating sample is indicated above the scale bar.

Figure S1

Figure S2

CHAPTER 4: PUBLISHED PAPER #2

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A high-resolution perspective on MIS 5c-d lithic assemblages from Klasies River main site, Cave 1

CONTENT

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A high-resolution perspective on MIS 5c-d lithic assemblages from Klasies River main site Cave 1

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ABSTRACT

Klasies River contains an extensive MIS 5 MSA sequence, mostly from what has been described as the MSA II, MSA 2a or the Mossel Bay techno-complex. The current Witness Baulk excavations undertaken between 2015 and 2016 allows for a renewed and detailed investigation of the variability of the lithic technology from the lowermost part of the MSA II. This assemblage is equivalent to Deacon's SASL sub-member and Layers 17a and b of Singer and Wymer. Two phases are recognized: An MIS 5c phase in layer SMONE (Singer & Wymer layer 17a) and an MIS 5d phase in layers BOS One and BOS Two (Singer & Wymer layer 17 b). The two phases are characterized by commonalities such as a focus on quartzite utilisation, the presence of a main unidirectional reduction system, similar end products which comprise of points, blades and flakes and a low amount of formal tools. However, this high-resolution investigation of the layers reveals temporal variability. In the Shell Midden ONE (SMONE) layer cores and products are relatively lighter and small debitage is more frequent. There are more flake end products and compared to the lower layer, there are fewer tool types. In the Black Occupational Soil (BOS) layer points and blades are more numerous, products are heavier, core types are more variable, and a higher frequency and variety of tool types occur. Such detailed differences within the MIS 5 assemblages from Klasies River, not described before, shows that the MSA II is not a homogeneous entity, and that subtle patterning occurs that may link to different technological strategies. Compared to other MIS 5 sites on the southern Cape, namely Blombos Cave, Pinnacle Point and Cape St. Blaize, a common pattern in place provisioning is seen, although the technology shows differences between the sites. This study indicates the value of more detailed studies of MIS 5 assemblages as a tool to understand variability from a more refined perspective.

1. Introduction

1.1. Research history and background

Klasies River main site (KRM) has been recognized for its archaeological value at least since the 1950's when the site was brought to the attention of the South African Archaeological Society (Singer and Wymer, 1982, p. 7). Since then, the site has been declared a national monument or Grade 1 site (Deacon, 1995; Wurz et al., 2018). KRM is a unit of five closely located caves and shelters including Caves 1, 1A, 1B, 1C and 2. The site took its name from the near-by river Klasies, which disembogues 0.5 km west of main site. Main site is located on the Tsitsikamma coast of the Southern Cape, an area that receives rainfall throughout the year (Compton, 2011, p. 509; Carr et al., 2016, p. 28). The current vegetation at the Klasies River sites and its immediate environment are characterized by a complex mosaic of thicket, forest and coastal vegetation with some fynbos elements (Cowling, 1984; van Wijk et al., 2017). Natural springs occur plenty-full uphill of the caves (Singer and Wymer, 1982, p. 8). The caves and overhangs are situated in a cliff topped by a calcarenite dune that is the source of lime-rich waters that led to the formation of flowstone, stalagmites and stalactites. This environment is also favourable for the preservation of bones, which was one of the reasons Singer chose to investigate the Klasies River Caves. Singer (Singer and Wymer, 1982, p. 8) was in search of an undisturbed Pleistocene site which could yield bone preservation, in order to contribute research to his main interest, the development of human physical and cultural evolution in South Africa. Excavations started at the end of 1966 under the direction of Singer's colleague Wymer, who undertook two field seasons at KRM between 1966 and 1968 (Singer and Wymer, 1982, p. 7). They excavated vast amounts of material from the caves including parts of an extensive sequence of > 20 m of deposit from the Middle Stone Age (MSA). This

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revealed insights into the MSA culture-stratigraphic succession which displays distinctly different phases through time.

Most of Cave 1 was excavated in trenches or cuttings down to the bedrock (Singer and Wymer, 1982, Fig. 2.1). Wymer (Singer and Wymer, 1982, p. 8) left a ca. 3 m high Witness Baulk in the centre stretching for > 12 m from the entrance to the back of the cave (Fig. 2). Various areas of main site, including the Witness Baulk, were investigated over multiple seasons by Deacon (Deacon and Geleijnse, 1988; Deacon, 1995), who undertook excavations from 1984 to 1995 (Fig. 2). The Deacon excavations of the MSA deposits of the Witness Baulk did not reach bedrock and ended within the lower phases of the MSA II, a techno-complex dating to MIS 5. Excavations resumed in 2015 by Wurz targeting the remaining lowermost deposits within the Witness Baulk (Wurz et al., 2018).

KRM plays a significant role in understanding the evolution of anatomically modern humans during Marine Isotope Stage (MIS) 5 (Grine et al., 2017). The presence of anatomically modern humans in South Africa during MIS 5 is reflected in occupational deposits of a number of MSA sites, including Blombos Cave, Cape St Blaize (Goodwin and Malan, 1935; Thompson and Marean, 2008), Die Kelders (Avery et al., 1997), Diepkloof Rock Shelter (Porraz et al., 2013a, 2013b), Hoedjiespunt (Will et al., 2013), Klasies River main site (Singer and Wymer, 1982; Deacon, 1995; Wurz, 2002), Pinnacle Point (Thompson et al., 2010; Brown, 2011) and possibly Blind River (Wang et al., 2008), Elands Bay Cave (Schmid et al., 2016) and Ysterfontein 1 (Avery et al., 2008; Wurz, 2012) on the western and southern coast, as well as sites from the interior such as Border Cave (Backwell et al., 2018), Bushman Rockshelter (Porraz et al., 2018), Florisbad (Kuman et al., 1999), Putslaagte 8 (Mackay et al., 2015) and Sibudu (Rots et al., 2017) (Fig. 1). Despite the significant human footprint during this time period, human fossils dating to MIS 5 are quite rare and occur only at Blind River, Klasies River and Pinnacle Point (Dusseldorp et al., 2013; Grine et al., 2017). At Pinnacle Point two fossils and at KRM > 50 fossils are directly associated with MIS 5 lithic technology. At KRM, five human remains, including three skull fragments, one mandible and one ulna excavated by Wymer are from the SASL member from other parts of the Cave 1/1A (Grine et al., 2017, p. 46). The lithics from the associated SASL member within the Witness Baulk are discussed in this paper (see Figs. 2 and 3).

1.2. MIS 5 lithic technology

MIS 5 lithic technology in South Africa, in general, is characterized by the use of local raw materials, a low amount of formal tools with denticulates, notches and scrapers as the main tool types (Douze et al., 2015; Mackay, 2016). However, there are exceptions in the formal tool component, in that some other tool types occur frequently but only in specific sites, for example end scrapers at Bushman Rock Shelter and serrated pieces at Sibudu (Rots et al., 2017). It is also worth mentioning that some Pre-Still Bay assemblages show a much higher frequency of tools, as is seen at Diepkloof (Porraz et al., 2013b). MIS 5 assemblages thus cannot be adequately described with typology as universal *fossils directeurs* for this time period does not occur. Since the 1990's the necessity to describe MSA assemblages from a technological perspective by identifying reduction sequences was emphasised (Wurz, 2000, Wurz, 2002; Porraz et al., 2013b; Will et al., 2013; Douze et al., 2015; Schmid et al., 2016). Recently, a number of new studies have been published about the MIS 5 lithic technology, for example at Blombos Cave (Douze et al., 2015), Border Cave (Backwell et al., 2018), Bushman Rock Shelter (Porraz et al., 2018), Diepkloof (Porraz et al., 2013b), Elands Bay Cave (Schmid et al., 2016), Hoedjiespunt (Will et al., 2013), the Pinnacle Point sites 13B and 5–6 (Thompson et al., 2010; Brown, 2011), Putslaagte (Mackay et al., 2015) and Sibudu (Rots et al., 2017). What seems clear is that MIS 5 technology varies greatly between different sites especially in terms of reduction sequences. MIS 5 does not only span an extended time period (from about 125–74 ka), but sites are dotted throughout the country. A number of inland sites in the north-eastern provinces (Border Cave, Bushman Rockshelter, Florisbad, Sibudu) coexist with coastal and inland sites in the Western Cape (Die Kelders, Diepkloof, Elands Bay Cave, Hoedjiespunt, Putslaagte, Ysterfontein) and Southern Cape (Blombos, Cape St Blaize, Klasies River, Pinnacle Point). Mackay et al. (2014) did suggest that there are broad

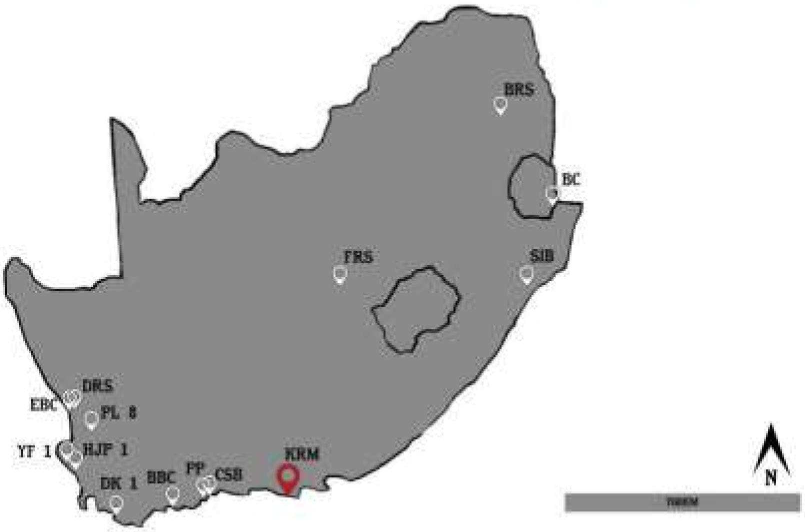

Fig. 1. Map with all the mentioned sites. Blombos Cave (BBC), Border Cave (BC), Bushman Rock Shelter (BRS), Cape St Blaize (CSB), Die Kelders 1 (DK 1), Diepkloof (DRS), Elands Bay Cave (EBC), Florisbad (FRS), Hoedjiespunt 1 (HJP 1), Klasies River (KRM), Pinnacle Point (PP), Putslaagte 8 (PL 8), Sibudu (SIB), Ysterfontein 1 (YF 1).

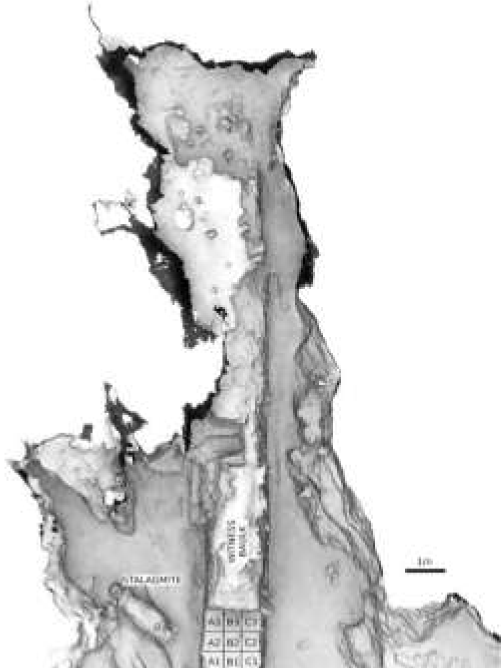

Fig. 2. Klasies River main site Cave 1. 3D model of the site with the Witness Baulk in the centre of the cave. The excavation grid with squares A1 - C3 shows the area where the material discussed in this paper originate from (image courtesy of the Zamani project).

technological similarities between the various sub-regions from South Africa, but as we discuss for MIS 5 sites from the southern Cape in Section 4, at this point it is complex to understand how the sites relate to each other from a technological perspective. In spite of increased focus on lithic technology from MIS 5 assemblages from South African sites, it is not as well understood as the more intensively studied techno complexes from MIS 4, which include the Still Bay and Howiesons Poort. This may be because these phases are characterized by a richer formal tool component in comparison with MIS 5 industries, with tools such as Still Bay points, geometrically backed pieces and distinctive notched artefacts.

MIS 5 lithic material is usually studied concerning units of deposit that reflect extended periods of time. The MIS 5 assemblages from KRM come from > 12 m of deposits. Singer and Wymer (1982) and later also Thackeray (Thackeray and Kelly, 1988; Thackeray, 1989) grouped all of the lithic material of the SAS member into the MSA II, and that of the LBS member into the MSA I. Wurz also divided the MIS 5 lithic material from KRM into two different techno complexes but termed them the Klasies River (MSA I) and the Mossel Bay (MSA II) techno-complexes. These terms are used interchangeably in the literature together with Volman's (1981) MSA 2a for the former and MSA 2b for the latter. In this paper, the terms MSA I and MSA II are used as these were the original labels. The MSA I shows the co-existence of two reduction systems, a laminar production on pyramidal cores and a Levallois production system. The blade and point end products are described as thin and symmetrical with a curved profile (Wurz, 2002, p. 1005). The MSA II is characterized by a unidirectional convergent Levallois method for the production of points. The majority of the blades are thicker and more irregular compared to the MSA I blades (Wurz, 2002, p. 1008). Wurz (2002), recognized differences between an upper and a lower MSA II, especially in the morphology of points. In the upper MSA II, the points are smaller in all dimensions (Thackeray and Kelly, 1988, p. 20; Wurz 2000, p. 79).

Our aim is to explore whether the analysis of fine-grained chronostratigraphic units from the MSA II at KRM results in a deeper understanding of the internal variability of the MSA II and whether this may provide a way to more efficiently link to other MIS 5 assemblages. The results of the technological analysis of two recently excavated layers from the lowermost part of the MSA II at KRM are reported here.

2. Archaeological sample and method

The lithic samples discussed here originate from the Wurz excavations of the Witness Baulk (Fig. 2). The Witness Baulk contains Layers 38, 37, 17-14 of Singer and Wymer (1982, hereafter abbreviated to SW) that were labeled as five members by Deacon (Deacon and Geleijnse, 1988, Fig. 5). The lowermost members include the Layer 38 (SW) or the Light Brown Sand (LBS) member and Layer 37 (SW) or Rubble Brown Sand (RBS) member (see Fig. 3). The RBS member is currently under study from sedimentological and micromorphological perspectives, and this designation within the Witness Baulk may change (Wurz et al. in prep.). The overlying Layers 17-14 (SW) or Shell And Sand (SAS) and White Sand (WS) members are topped by a Later Stone Age shell midden (Fig. 3). The SAS member consists of sub-members SAS Rubble (SASR, SW Layer 14), SAS Wedge (SASW, SW layer 15) SAS Upper (SASU, SW Layer 16) and SAS Lower (SASL, SW Layer 17a and b). Fig. 7 of Deacon and Geleijnse (1988) refers to SASL in the Witness Baulk as SASB, but subsequently, this was changed to SASL (Wurz, 2002; Deacon, 2008). The SAS member in Cave 1A with 10 m of deposit, is much more extensive than in Cave 1. Deposits that accumulated in Cave 1A sloped into Cave 1 and formed the SASW sub-member (SW Layer 14). The artefacts from this unit relate to the MSA II upper (Wurz, 2000). The SASU and SASL sub-members consist of deposits that formed by groups living within Cave 1 and are associated with MSA II lower artefacts (Wurz, 2000). The underlying RBS and LBS members contain MSA I artefacts (Wurz, 2002).

The focus of this paper is on the lithic artefacts from the SASL sub-member of the Witness Baulk, excavated in 2015 and 2016. This excavation continued from where the Deacon excavations ended in 1995. The horizontal extent of the excavation area is 1.7 × 1.7 m (2.89 m^2). Excavation protocols include the piece plotting of all artefacts > 20 mm and frequent photographic recording of small-scale quadrants, as well as the whole excavation surface. At the site all material was dry sieved with 5 and 2 mm meshes, and the resultant coarse and fine fraction further wet-sieved in the laboratory.

The newly excavated SASL sub-member consists of layer SMONE (Shell Midden One), equivalent to Singer & Wymer's Layer 17a (Wurz et al., 2018), and the Black Occupational Soils layer BOS, which is equivalent to Singer and Wymer's Layer 17b (Fig. 4). In Table 1, the layers and volume of deposit for SMONE and BOS are presented. Lithics, shellfish and fauna larger than 2 cm as well as tufa and non-artefactual quartzite that show signs of heat alteration have been piece-plotted and removed prior to measurement of the volume of the excavated sediment.

There are clear differences between SMONE and BOS. Singer &

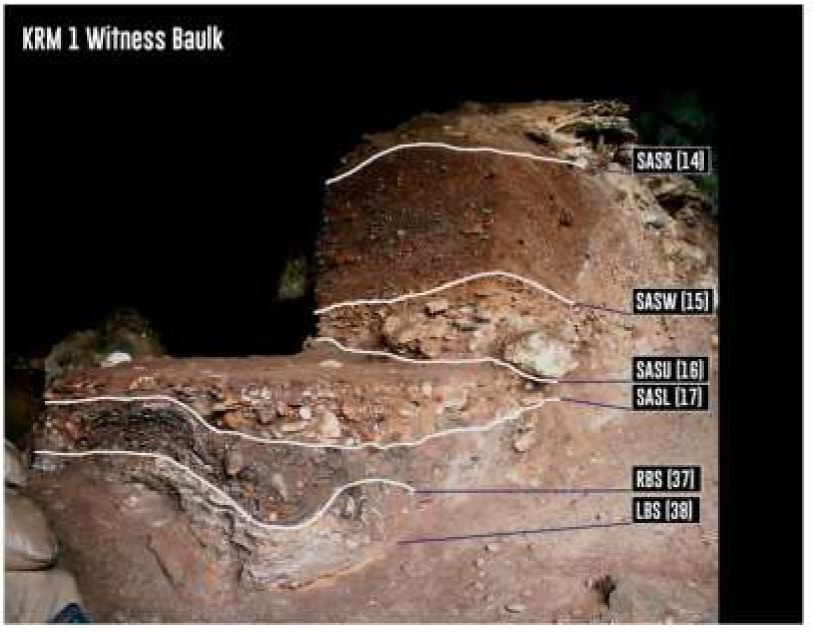

Fig. 3. KRM Cave 1 Witness Baulk. Deacon's designation for the members with Singer and Wymer's layer number in brackets.

Wymer (1982, p. 26) describe layer 17a as a 'tumble layer', and the current excavation confirmed this. The 2015 excavation revealed the SMONE layer in the Witness Baulk to be a wedge of deposit that is up to 15 cm thick in the eastern part and thins out to ca 5 mm in the western part of the Witness Baulk. The deposits consist of a soil and rubble matrix with artefacts and other finds evidencing a palimpsest. The matrix further contains disintegrated tufa blocks, small leached ash patches, and small charcoal pieces with no in situ combustion features. An interesting feature is quartzite rocks, which display colour changes, fractures and other signs of being exposed to fire (Bentsen and Wurz, 2017).

In contrast, BOS are 'occupational soils' (Singer and Wymer, 1982, p. 26). The current excavations confirm this observation, but BOS is also a palimpsest. No in situ combustion features occur here either,

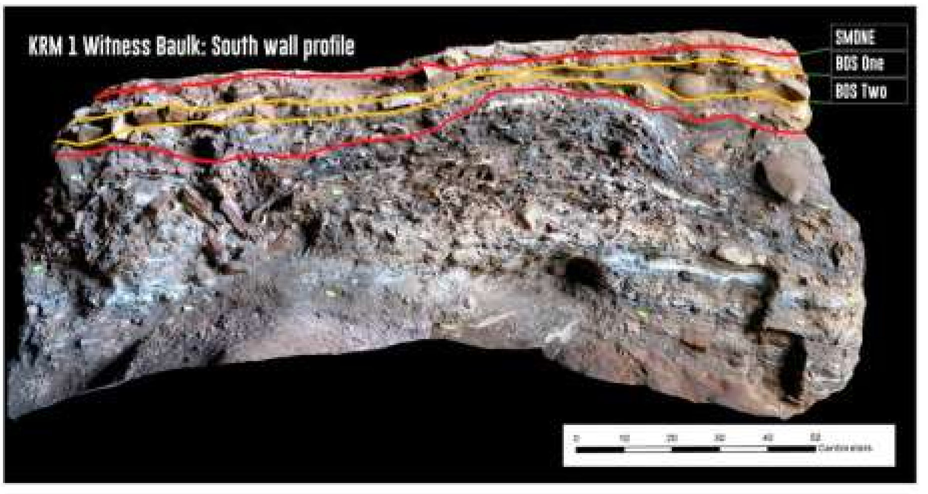

Fig. 4. South profile of the Witness Baulk indicating the layer SMONE and spits one and two of layer BOS excavated between 2015 and 2016, discussed in this paper.

Table 1
Volume of excavated deposit in m^3, total number of lithic artefacts per layer and density in artefact numbers per liter.

Layer	Volume of deposit excavated (m^3)	Lithic artefacts (n)	Density (artefacts per liter)
SMONE	0.054	2671	50
BOS	0.078	4032	52

although large patches of leached ash associated with burnt quartzites (Bentsen and Wurz, 2019) occur. There is also a much more pronounced presence of tufa material, many in the form of large blocks, that cemented some of the archaeological remains associated with BOS. Shell preservation is excellent in pockets and the preservation of bone, many of which are from large mammal fauna, is also very good. Although many of these finds are in situ and preserved in anatomical detail, they show crushing, perhaps from weight of overlying deposit in combination with removal of supporting sediment through leaching. The taphonomic study of the bone in process (Reynard et al. in prep) and the moist, fine clayey nature of the deposits indicate possible water action.

Our excavation of the BOS layer is in progress, and it is divided into arbitrary spits with BOS One about 10 cm thick, and BOS Two around 7 cm, although the presence of large tufa blocks in the deposit precludes an accurate estimation of thickness. The nature of the soils and preservation pattern indicate that BOS One and BOS Two are parts of the same depositional period and therefore these spits are analysed as one layer, BOS, here.

Current dating of the Witness Baulk bracket the deposits between 85 ka and 115 ka. Layer 14 SW (the SASR sub-member of Deacon), 2 m above the SASL sub-member, was dated with U-Th on stalagmites, giving ages of 85.2 ± 2.1, 94.6 ± 3.2 ka and 100.8 ± 7.5 ka (Vogel, 2001). U-Th dating of flowstone that grew on the ceiling of Cave 1 and fell into the base of the SASU sub-member (Deacon's Layer HHH (Wurz, 2000)), was undertaken by Pickering and Green (Wurz et al., 2018). This provides an age of 126.0 ± 1.5 ka and a maximum age for the SASU deposits. A bovid tooth from Singer & Wymer's Layer 17b has an ESR date of 102–63 ka (early uptake model) and 104–64 ka (linear uptake model) (Millard, 2008) and a U-series/ESR estimate of 101 ± 12 ka (Eggins et al., 2005). An age of 100,000 years ago can thus be regarded as a minimum age of the SASL deposits. Other dates available for the lowermost part of the sequence are for the LBS member that, on current evidence, are associated with ages of between 108.6 ± 3.4 ka (Vogel, 2001) and 106.8 ± 12.6 ka (Feathers, 2002). Layer SMONE, thus certainly older than 100 ka, probably dates to within MIS 5c (93–106 ka, MIS boundaries according to Wadley, 2015). Our designation of the BOS layer to MIS 5d (115–106 ka) is based on new uranium-series ages from in situ BOS stalagmitic material dating to within this period (Pickering pers comm; Wurz et al. in prep., Mentzer et al. in prep).

3. Results

3.1. Assemblage composition

The lithics from all of the layers discussed here consist mainly of quartzite, and they have a similar assemblage composition. The total lithic artefacts are 2671 in SMONE, 4032 in BOS (Table 1), whereas the pieces > 20 mm comprise 609 in SMONE and 1244 in BOS (Table 2). The small debitage is somewhat more numerous in the upper layer SMONE with 77.2% of the whole assemblage compared to BOS with 69.2% small debitage.

Flakes constitute the highest percentage of detached debitage in both assemblages, with 24% and 17.3% complete flakes, in addition to 27.9% and 24.5% fragments in SMONE and BOS respectively (Table 2). Blades and points are more numerous in the lower layer (2.1% blades and 5.7% points in SMONE, 3.9% blades and 10.3% points in BOS). The bladelet component shows a decrease from the top with 7.8% in SMONE to 3.3% in BOS. The cores are less numerous in the upper layer SMONE (1.8%) than in the lower layer BOS (4.3%). The hammerstones show the same pattern as the cores, they are least common in SMONE (0.5%) and most abundant in BOS (2%) (Table 2).

3.2. Raw materials

The raw materials from Klasies River were visually inspected based on their macroscopic mineral content; they include quartz, quartzite, altered quartzite, Table Mountain Sandstone, sandstone, silcrete and indeterminable other raw material. Table 2 shows the detailed raw material composition for pieces > 20 mm; the counts of the small debitage < 20 mm indicate only the collective amount of the different quartzite types.

The source or parent rock of Cave 1 is Table Mountain Sandstone, which is a quartzite of the Cape Supergroup. It is coarse-grained, has poor knapping qualities and is present mostly as chunks and flakes making up 1.8–9.2% of the assemblages (Table 2). The raw material used at Klasies River is dominantly quartzite from cobbles and pebbles. It is highly probable that the quartzite was available locally (< 5 km) from beaches and the close vicinity of Klasies River as the shore remained close to the site during MIS 5 (Van Andel, 1989). A medium-grained quartzite is the most frequently occurring raw material (82.2–88.8%). Several quartzite artefacts have been labeled "altered quartzite" (highest amount in BOS, 4.6%) because they have a rough surface appearance (on both the cortex and the flake scars) and reddish, rust-like spots covering the surface (e.g. Fig. 5). It is possible that post-depositional alteration has caused this, but this hypothesis is under investigation. Sandstone is the next most abundant raw material for pieces > 20 mm with frequencies of 2.1–2.3%. Some of the sandstone pieces show cobble cortex, attesting a river or beach source.

Quartz does not occur in notable frequencies in pieces > 20 mm with only 1.3% in SMONE and 1.1% in BOS. Nevertheless, it is more abundant in the small debitage < 20 mm (8.3% in SMONE and 20.4% in BOS), which results in relatively high percentages of quartz in the assemblage composition when the small debitage is included (6.7–14.5%). It seems that the same core reduction strategies were followed as for quartzite. Very few pieces of silcrete are present with 0.2% in SMONE and 0.1% in BOS, including pieces < 20 mm).

3.3. First reduction of cobbles

A relatively large proportion of the lithics > 20 mm show cortex, which is water rounded cobble cortex. Cortex cover occurs more often in BOS (38.7% of artefacts > 20 mm) than in SMONE (28.4%). The cobbles were most probably opened by splitting them with a bipolar on anvil technique (see, e.g. Shott and Tostevin (2015)) as evidenced by crushing marks and radiating striations from the impact point on 13 artefacts in the assemblages (Fig. 6). It could have happened at the beach, or, as the presence of two anvils in the SMONE assemblage attests, in the cave.

The further reduction of unworked split cobbles was conducted in the cave, as shown by the presence of all of the steps of the reduction sequence. The first phase of reduction entailed opening the split cobble core blank by removing debordants or core edge flakes, showing a cortical side and the surface of a split cobble. A few first flakes (*entames*) with cortex on their dorsal side and platform are part of the assemblage as well ($n = 1$ in SMONE, $n = 3$ in BOS).

3.4. Knapping technique

All of the quartzite debitage show clear signs of free-hand percussion with a hard hammer, as prominent bulbs (Table A.1) with a

Table 2
Assemblage compositions by category and raw material of SMONE and BOS.

Raw material/ category	Quartz	Quartzite	Altered quartzite	Table Mountain Sandstone	Cobble sandstone	Silcrete	Other	Total	% of > 20 mm per assemblage
Blade									
SMONE		13						13	2.1%
BOS		49						49	3.9%
Bladelets and bladelet fragments (including < 2cm)									
SMONE	2	47						49	1.5%[a]
BOS	1	40			1			42	0.7%[a]
Point									
SMONE		35						35	5.7%
BOS	1	127						128	10.3%
End product fragment									
SMONE		63	1					64	10.5%
BOS		197	1	1	2			201	16.2%
Flake									
SMONE		131	7		2		1	146	24%
BOS	1	191	5	8	3		2	215	17.3%
Indeterminate fragment									
SMONE	2	154	9	1	3	1		170	27.9%
BOS		281	9	11	3	1		305	24.5%
Core									
SMONE		11						11	1.8%
BOS	2	42	8	2				54	4.3 %
Hammerstone									
SMONE	3							3	0.5%
BOS	19		5	1				25	2.0%
Chunk									
SMONE	5	123	9	10	8		8	163	27.9%
BOS	9	109	29	92	19		3	258	20.7%
Total > 2cm									
SMONE	8	541	26	11	13	1	9	609	100%
BOS	14	1022	57	115	28	1	5	1244	100%
% of total > 2cm									
SMONE	1.3%	88.8%	4.3%	1.8%	2.1%	0.2%	1.5%	100%	
BOS	1.1%	82.2%	4.6%	9.2%	2.3%	0.1	0.4%	100%	
Small debitage < 20 mm									
SMONE	172	1884				5		2062	
BOS	569	2221						2790	
Grand Total									
SMONE	180	2425	26	11	13	6	9	2671	
BOS	583	3243	57	115	28	1	5	4032	
% of total									
SMONE	6.7%	90.8%	1.0%	0.4%	0.5%	0.2%	0.3%	100%	
BOS	14.5%	80.4%	1.4%	2.9%	0.7%	0.1%	0.1%	100%	

[a] Percentage of bladelets including < 20 mm: SMONE 7.8%, BOS 3.3%.

contoured Hertzian cone, as well as well-developed ring cracks at the point of impact (Table A.2) attest. The platforms are rather thick (Table A.3), and the exterior platform angle is very wide, close to 90° (Table A.4). Furthermore, attributes that might have indicated soft hammer percussion, e.g. platform rubbing (Table 12 for blanks) and well-defined lips (after Andrefsky, 2005, p. 18) are rare (Table A.5; 3.7% in SMONE; 1.7% in BOS). These characteristics speak for hard hammer direct percussion.

3.5. Technological analysis of the blanks

The blanks can be divided into preparational pieces and end products (Table 3). The term "end product" is used in the sense of for example Douze et al. (2015), acknowledging the caveats associated with such a premise (Dibble et al., 2017, p. 2) as archaeologists cannot identify the 'emic' connotation and meaning of artefacts (Bar-Yosef and Van Peer, 2009). They are predominantly regular in shape and dorsal scar pattern (following Damlien, 2015, Fig. 8). The end products form between 21.2% in SMONE, 34.6% in BOS of all complete debitage (Table 3) and are discussed in more detail below.

The pointed products of KRM have been described variously in previous studies as "pointed flake-blades" (Singer and Wymer, 1982, p. 56), "convergent flake-blades" (Thackeray, 1989, p. 39) and "points". Here we follow Wurz's terminology, in that all pointed products are called points. This includes convergent blanks (symmetric and asymmetric) and pieces with a pointed tip but otherwise parallel edges (further explanation below). Blades are all products with a length-width ratio of at least 2:1 and parallel or sub-parallel edges (e.g. Crabtree, 1972), excluding pointed pieces and pieces of bladelet dimensions. Bladelets have a similar length-width ratio with parallel edges and, as defined by Tixier (1963) and Deacon (1984, p. 525), have a width of up to 12 mm. Flakes are all detached pieces that have a smaller length to width ratio than 2 and show any shape, except a triangular shape or a pointed tip.

The preparational flakes (details in Table 3) are either for setting up cores, such as *entames* and decortification flakes, or they are adjusting

Fig. 5. Altered quartzite core #2829 from BOS. It shows a rough surface and red-brown staining.

the core convexities. Lateral convexities are set up by the removal of debordants or core edge flakes. Debordants usually show a lateral or central arris with one side fully or partly cortical, although in some cases, no cortex is seen, but negatives from other lateral preparation. Core surface management pieces restore the core surface, e.g. to remove step fractures or to create arrises for the subsequent removal. Platform shaping flakes can be trimming flakes or pieces removing bigger parts or the core platform, in order to adjust the edge angle. Flaking debris are smaller flakes, around 20 mm (n = 66), which are probably waste from knapping, this category also includes indeterminate pieces and flakes which could stem from the opportunistically exploited second generation cores discussed above (see unsystematic core reduction, Fig. 20).

Flakes are the most numerous blank type, and Table 3 clearly shows that they are predominantly related to preparation phases, with the highest amount of core surface management flakes, followed by decortification flakes, debordants and platform shaping flakes. Points are the second most frequent blank type with most of the points interpreted as end products (n = 21/35 in SMONE, n = 94/131 in BOS), although debordants are also common (Table 3). The blades and bladelets occur least frequently. Most of the blades are end products (n = 7/13 in SMONE, n = 21/50 in BOS), although a relatively high amount (5/13 blades in SMONE, 14/50 in BOS) are debordants (Table 3). There are only four complete bladelets longer than 20 mm in SMONE, and they are either categorized as core surface management or debris, due to their thickness and shape. There is, however, a definite bladelet production component in the assemblage as attested by the removal traces on the cores and bladelets/bladelet fragments < 20 mm (Fig. 19: n = 4 cores, Table 2: n = 91 bladelets).

3.5.1. End product morphology

The end products of the SMONE and BOS layer differ in many respects, as discussed below. Student t-tests (t) (for data with normal distributions) and Mann-Whitney U tests (U) (for data that are not normally distributed) were undertaken to compare continuous variables between the layers. Chi-square tests (were undertaken to quantify comparisons between categorical variables.

End products comprise flakes, blades and different types of points (Fig. 7). The points form the most numerous component of the end products, and as other researchers might not group all the morphologies termed here as points into that category, we describe them in more detail in separate point categories to enable comparisons to other sites. All of the KRM points can be categorized into one of the following three morphological types (Fig. 7a–c, Table 4).

Type 1 (Fig. 2, Fig. 7, Table 4) is the most common type and is represented by flake sized triangular flakes with symmetrical or skewly/asymmetrical converging edges (Table 4: 52.4% in SMONE, 69.1% in BOS; Fig. 8a–c). Type 2 points (Table 4: 33.3% in SMONE, 21.3% in BOS) also show converging edges but have blade dimensions (Fig. 8d–e). Type 2 is most common in SMONE. Some of the types 1 and 2 points here, resemble Levallois points (after, e.g. Thompson et al., 2010; Porraz et al., 2013b; Douze et al., 2015). The type 3 points are less frequent (Table 4: 14.3% in SMONE, 9.8% in BOS), and they are characterized by parallel edges and a pointed tip (Fig. 8f and 12e). This type is mostly found on blade sized pieces. Apart from the blade sized points, the blade end products are mostly regular to very regular, which means they have parallel to sub-parallel lateral edges and display mostly parallel dorsal negative scars (following Damlien, 2015). The blades are present in low numbers, with the higher proportion seen in BOS (Fig. 8h-i, Table 3).

The flake end products are rare (Table 3) and SMONE, which has the most flake debitage, also shows the most flake end products (6.3%). The flake shapes are mostly rectangular (Fig. 8g); some are also round/oval, expanding or irregular (Table A.7). Bladelets occur as well (Fig. 10). The complete and fragmentary bladelets form a small component in the assemblages, with the highest number in SMONE (7.8%) and lower frequencies in the BOS assemblage (3.3%; Table 2, Fig. 10). The bladelets interpreted as end products are regularly shaped with parallel edges and a width of between 4 and 10 mm. Of bladelets with preserved proximal ends, plain platforms (n = 9) are as frequent as facetted or informal facetted ones (n = 9), with only one bladelet showing a cortical platform. The same is seen regarding the profiles of the bladelets, nine show a twisted or curved profile, and nine have a straight profile. There is no correlation between profiles and platform preparation. It is, however, highly likely that the bladelets have been produced using a separate reduction sequence, as the distribution of width of blades and bladelets shows a bimodal distribution (Fig. 9). Bladelet cores were identified only in BOS (Fig. 19s).

The weight of the end products varies between the SMONE and the BOS assemblages (Table 5). In SMONE all end product types are lighter than in BOS (average weight for SMONE points 21.7 g, blades 24 g and flakes 17.8 g). In BOS the points and blades have a mean weight of ca.

Fig. 6. Artefacts with a split cobble surface showing crushing and striation marks. The dotted surface represents cortex. All on medium grain quartzite. a) core #3241, BOS; type IV core; b) point #249, SMONE, debordant with one cortical side and one side showing the crush marks from splitting a cobble; c) core #1076, with rusty staining on cortex, SMONE, type III core; d) blade refit #1607 and #2225, BOS, debordant with one cortical side and one side showing the crush marks from splitting a cobble.

30 g (points 29.7 g and blades 30.4 g). The flakes of BOS (37.3 g) are on average heavier than the other blank types. A student's t-test reveals that the points from SMONE and BOS are significantly different in weight ($p < .05$).

Many of the products are much longer than any of the cores (Table A.6 core dimensions), hinting at long reduction sequences and intensive reduction of the cores. The average length of each end product type is very similar in both assemblages (Table 5, Fig. 11a). The length of blades seems to be less variable in SMONE, but this observation is preliminary as the numbers of blades are very low in all assemblages (n between 7 and 21). The point end products are more numerous and have a similar length in both assemblages. It appears that the platform thickness (Fig. 11b) shows a more apparent distinction between the SMONE and the BOS assemblages, with both the blade and point end products, having thicker platforms in BOS, than in SMONE. However, the t-tests attest no statistical significance ($p > .05$). The length/width ratios (Table 11c) of points and blades also show no significant difference between the two layers when a Mann-Whitney U test is used ($U = 791$, $p > .05$).

All of the end products have straight profiles with thick, prepared, mostly trapezoid shaped platforms. The platforms are predominantly prepared (of pieces with preserved platforms: SMONE 82.4%, BOS 87.1%) (Table 6; also see Table A.8 for all blanks). The term 'informal faceting' is used to describe platforms which do not have clear facet negatives, but show little trimming and step flaking on the platform from the dorsal edge. In SMONE informal faceted platforms, with little trimming and step flaking on the platform, is most common, but formal faceting occurs frequently as well. In BOS the formal faceted platforms are most frequent, followed by informal faceted platforms. In all the assemblages, about half of the blanks are without proximal preparation of the dorsal edge. Table 7 shows that step flaking of the proximal edge is quite common (33.3% in SMONE, 39.3% in BOS) and a more invasive preparation with longer removals along the dorsal scar ridges is found on about 10% of the end products in both layers. Rubbing as part of preparation is very scarce and occurs in only 0.2–4.3% of the cases (Table 7). The external platform angle (EPA) for the end products measures close to 90° (see Table A.4 for all detached pieces). In order to detach large pieces at such a wide angle, the platform needs to be thick (Speth, 1981; Pelcin, 1997; Dibble and Rezek, 2009). Variation is seen between SMONE and BOS, with blades and points in SMONE having

Table 3
Technological categories of complete blanks > 20 mm in the two assemblages.

Technological category/ blank	End product		Debordant fully cortical		Debordant partly cortical		Debordant other		Core surface management		Platform shaping		Decortification flake		Entame (first)		Flaking debris		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
SMONE																				
Points	21	11.1%	5	2.6%	4	2.1%	3	1.6%	3	1.6%	–		–		–		1	0.5%	37	19.6%
Blades	7	3.7%	2	1.1%	1	0.5%	2	1.6%	1	0.5%	–		–		–		–		13	6.9%
Bladelets	–		–		–		–		3	1.6%	–		–		–		1	0.5%	4	2.1%
Flakes	12	6.3%	15	7.9%	2	1.1%	1	0.5%	37	19.6%	16	8.5%	18	9.5%	–		34	17.9%	135	71.4%
Total SMONE	40	21.2%	22	11.6%	7	3.7%	6	3.2%	44	23.3%	16	8.5%	18	9.5%	–		36	19.0%	189	100%
BOS																				
Points	94	24.3%	18	4.7%	7	1.8%	1	0.3%	8	2.1%	1	0.3%	1	0.3%	–		1	0.3%	131	33.9%
Blades	21	5.4%	14	3.6%	4	1.0%	1	0.3%	9	2.3%	–		–		–		–		50	12.9%
Flakes	19	4.9%	17	4.4%	5	1.3%	3	0.8%	74	19.1%	19	4.9%	36	9.3%	2	0.5%	31	8.0%	206	53.2%
Total BOS	134	34.6%	49	12.7%	16	4.1%	5	1.3%	91	23.5%	20	5.2%	37	9.6%	2	0.5%	32	8.3%	387	100%
Grand total	174	30.2%	71	12.3%	23	4.0%	11	1.9%	135	23.4%	36	6.3%	55	9.5%	2	0.3%	66	11.4%	576	100%

narrower EPAs, closer to 80° on average than in BOS where EPAs are closer to 90° (Table A.4). The difference between layers is, however, only statistically significant for the blades as attested by a Mann-Whitney U test ($U = 436$, $p < .05$).

Almost none of the end products show remains of cortex, and in the few cases where it is present, it is < 10%. A large percentage of the end products show a unidirectional dorsal scar pattern (Tables 8, 63.9% in SMONE and 54.1% in BOS). This high number confirms the impression from the cores that the main reduction system is unidirectional. The scar shapes indicate convergent (Table 8: $n = 3$ in SMONE, $n = 20$ in BOS) and parallel reduction ($n = 3$ in SMONE, $n = 14$ in BOS). End products with some distal preparation from an opposed platform have a 90% unidirectional scar pattern (with some bidirectional scars on the distal end, $n = 9$ in SMONE, $n = 15$ in BOS). The bidirectional dorsal scar pattern rarely occurs in SMONE ($n = 6$) but is more abundant on blanks in BOS ($n = 31$).

3.5.2. Tools and edge damaged pieces

The formal tool types are denticulates, notched pieces, scrapers and laterally retouched pieces (Fig. 13). Laterally retouched pieces have regular retouch negatives in a restricted area of the lateral edge, which are not sufficiently continuous to be classified as a side-scraper. Formal tools occur in low proportions in both assemblages (in relation to pieces > 20 mm: 0.7% of SMONE, 2.8% of BOS). The main tool types are denticulates and notched pieces (Table 9). SMONE has fewer tools (χ^2 (1) = 8.91, $p < .05$) and shows less variety in tool types. The tools of SMONE are all fragmentary but include three notched pieces and one denticulate on a point. BOS contains seven notched pieces (mostly flakes), eight denticulates, nine pieces with lateral retouch (mostly points) and seven scrapers (Fig. 12, Table 9). Four of the scrapers are on thick core blanks (Fig. 13), the other three are on different blank shapes, including points, blades and flakes. The working edges of the scrapers are mostly convex (Figs. 12b and 13), and only one piece shows a concave working edge.

Three tools from BOS show scraper retouch and notching in combination and all of them are on flake blanks (Table 9). Additionally, heavy-duty scraper damage can be seen on some thick pieces in BOS, which are often core preparation flakes or debordants (Fig. 14f–g). This may speak to some opportunistic utilisation of lithics which are by-products, for example in the early stages of butchering when robust and heavy tools are needed.

A number of pieces have been classified as 'edge damaged' (Table 9). Edge damage does not resemble intentional retouch, as the scars are irregular in their shape and distribution and might have developed through use. Edge damage traces have been identified, macroscopically and microscopically under low magnification (40×). This type of damage has also been referred to as "informal retouch" by Douze et al. (2015). Post-depositional processes may have caused this, but there is no indication of abrasion on the dorsal scar ridges of the lithics. The number of pieces with edge damage exceeds those with formal retouch. In SMONE, 16.4% of the assemblage exhibit edge damage, and in BOS, the frequency is slightly higher with 21.7% (Table 9). SMONE shows no preference for shape, as edge damage occurs almost equally on point, blade and flake blanks. In BOS the points have the highest occurrence of edge damage traces with 9.4% (Table 9). This indicates a preference for pointed pieces being used as tools, which is confirmed by a chi-square test (χ^2 (1) = 11.56, $p < .05$).

SMONE shows the least amount of formal tools (0.7%) and edge damage (16.4%), whereas BOS exhibits higher frequencies of formal tools (2.8%) and edge damage (21.7%). The frequency of formal tools is very low and the higher amount of edge damage in both assemblages implies that mostly unretouched blanks were used as tools. In SMONE there is no preference of blank shape for the use as tools, but in BOS edge damage is dominantly seen on points.

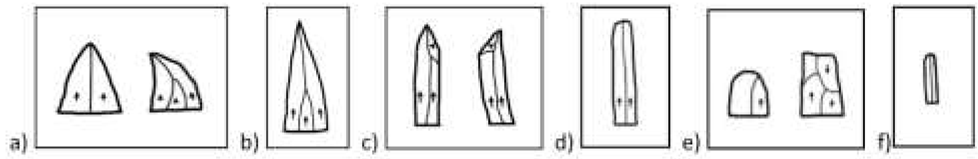

Fig. 7. End product types a) point type 1; b) point type 2; c) point type 3; d) blade; e) flake; f) bladelet.

Table 4
Point categories per assemblage (only complete points).

Point category/layer	Type 1		Type 2		Type 3		Total	
	n	%	n	%	n	%	n	%
SMONE	11	52.4%	7	33.3%	3	14.3%	21	100%
BOS	65	69.1.4%	20	21.3%	9	9.8%	94	100%
Total	76		27		12			

3.6. *Core analysis*

The purpose of this section is to describe the different core types and the related *chaîne opératoires* present in the analysed assemblages (see Figs. 15–16 and Tables 10–12). The core blanks are predominantly cobbles or cobble fragments (Table 10). Two of the cores with cobble origin also show pit marks, which evidence a primary use as a hammerstone. Additionally, debordants and flakes have been used as core blanks. There are some indeterminate cases where the core blank was unclear.

The cores (n = 65) have been classified into platform (n = 5), parallel (n = 18), bladelet core (n = 4), tested (n = 11) and indeterminate (n = 17) whereas 10 pieces are indeterminable fragments of cores (Table 11). A detailed description of core types is given below. Table 12 shows the core categories according to type, morphology, the orientation of negatives and the products removed.

3.6.1. *Type I: platform cores*

The type I cores comprises unidirectional platform cores with only one platform (n = 5; Table 11). The platform cores follow a type of volumetric system, in which predetermined products are removed in a recurrent manner. Most platform cores show a reduction surface "around a corner" (Conard, 2012), which resembles semi-rotational reduction. The geometry of the platform cores varies between pyramidal and prismatic (after (de Sonneville-Bordes, 1960; de Heinzelin de Braucourt, 1962; Brezillon, 1968).

In SMONE two cores are classified as type I. BOS comprises two type I platform cores with a prismatic morphology and parallel negative

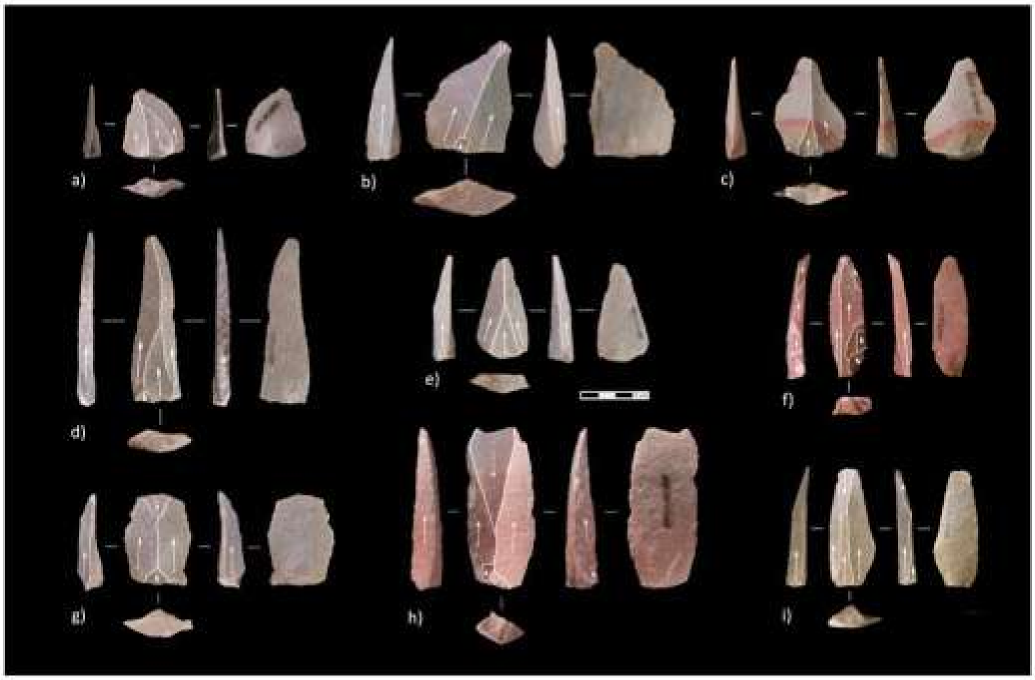

Fig. 8. KRM end products. All in medium grain quartzite; a) type 1 point #2563, BOS, Levallois-like; b) type 1 point #1595, BOS, with edge damage; c) type 1 point #1900, BOS, Levallois-like; d) type 2 point #1446, SMONE, Levallois-like; e) type 2 point #1498, SMONE, Levallois-like; f) type 3 point #467, SMONE; g) flake #255, SMONE; h) blade #3181, BOS, with edge damage; i) blade #1027, SMONE.

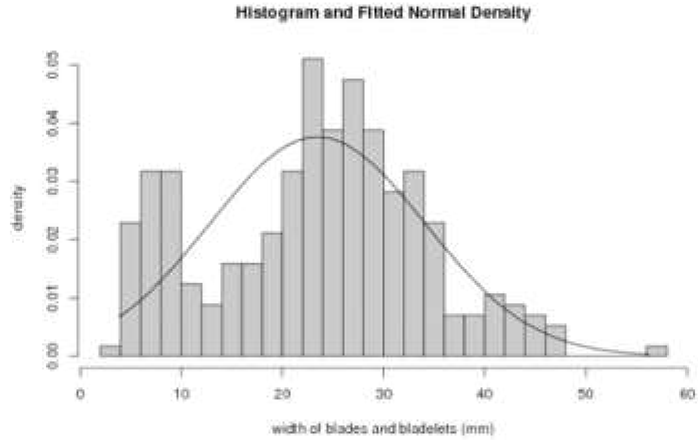

Fig. 9. Histogram showing the bimodal distribution of width (mm) of blades and bladelets. All assemblages are included (n = 284; 58 bladelets, 226 blades).

scars. Another platform core from BOS is pyramidal in shape with a convergent scar pattern. The product negative scars of type I cores are elongated and have either a blade or point shape (Figs. 15 and 22). The orientation of dorsal negatives of blanks supports a dominant unidirectional reduction (Table 8).

3.6.2. Types II and III: parallel regular cores

Parallel cores type II are rare with only two pieces found in BOS. Type III parallel cores are more numerous with two pieces in SMONE, three in BOS. The flatter core types II and III resemble parallel or Levallois-like cores. Most of these cores are flat in shape with a domed reduction surface, as typical for the Levallois method. The lateral convexity is frequently created by the production of debordants. Two of the cores have a convex lateral side created by a split cobble surface showing crushing and radiating marks from the point of impact (n = 1 in SMONE and n = 1 in BOS). This natural convexity of the core was used throughout the reduction, as even some cores in a relatively reduced stage still carry these distinctive marks (Fig. 6). The parallel cores can be divided into unidirectional parallel cores without an opposed platform, type II (n = 2, Table 11, Fig. 16), and distally prepared parallel cores with a second platform, type III (n = 5, Fig. 17). This distinction is made because different product shapes are possible for type III cores (see Fig. 22). The types II and III cores are mostly elongated and display mostly blade and pointed blade negatives.

3.6.3. Types IV and V: parallel cores with irregular scar pattern

Type IV parallel cores occur, with two pieces in SMONE and five cores in BOS (Fig. 18). They show dominantly unidirectional removals, whereas type V (n = 4) indicates a bidirectional reduction of end products (Table 12, Fig. 22). Type V cores are only present in BOS with four pieces (Fig. 19).

Both types have an irregular negative scar pattern indicating the removal of mostly flake sized products. Types IV and V show relatively shorter reduction surfaces, compared to types I–III. The negative scars on the cores are irregular in shape, including those indicating the removal of triangular flakes. The type V cores are comparable to type IV but have a second equally used platform. They are generally much reduced and have more inclined platform angles than any of the other core types.

Fig. 10. Bladelets. a) #10.16, medium grain quartzite, SMONE; b) #C1.4, medium grain quartzite, SMONE.

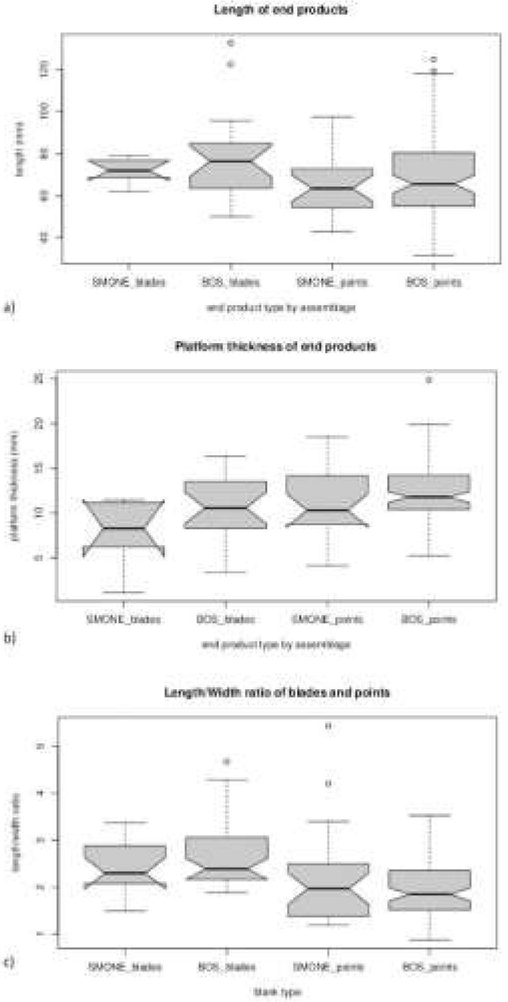

Fig. 11. Notched boxplot charts of a) length b) platform thickness and c) length/width ratio of blade and point end products in the different assemblages. (SMONE blades $n = 7$, points $n = 21$; BOS blades $n = 21$, points $n = 91$).

3.6.4. *Bladelet cores*

There is a persistent if small presence of bladelets in the assemblages (Table 2). There are a number ($n = 4$) of cores with bladelet scars (Fig. 20). The core blanks of the are chosen randomly, including one flake as blank, an exhausted core and two chunks. These cores have only been identified in BOS. The bladelet cores have a platform that is steeply angled to the production surface similar to those first described by de Sonneville-Bordes and Perrot (1954, p. 332) as carinated scrapers. The production surfaces of these cores are narrow, with 2–3 bladelet negatives directly adjacent or overprinting each other. One of the bladelet cores is created on a sizeable preparational flake with bladelet removals around a convex edge. This piece could be interpreted as a tool rather than a core, or even only as preparation of the dorsal edge. The specimen do not show any preparation or other characteristics, than bladelet negatives, however, it is interesting that bladelet production systems are frequently described for the Howiesons Poort (Wurz, 2000; Villa et al., 2005; Soriano et al., 2007, Soriano et al., 2015). The bladelets and bladelet cores found at KRM in the MSA II lower could indicate that this strategy of bladelet production has deeper roots in the South African MSA than formerly thought.

3.6.5. *Other core types*

Tested cores ($n = 11$) with only one or two removals are quite numerous. Some of these are on flakes and produced elongated products (e.g. two large cores on flakes in BOS). Others could be described as informal platform cores, as the cobble blank is reduced using one platform, e.g. four cores in BOS, two of which are made on quartz cobbles (Table 5). There are also several exhausted multidirectional cores or those in which the direction of removals is not clear ($n = 7$). All the cores in altered quartzite ($n = 4$) have such disintegrated surfaces that they are not possible to characterize further. Two cores on coarse Table Mountain Sandstone are indeterminate. Four cores are recycled, and the second generation of reduction is only an informal or opportunistic flake production (Fig. 21). This is only seen in BOS where, after the production of elongated blades and points, an informal opportunistic flake production can be observed on a number of cores. Two of these are on regular platform cores and in the other cases, the original core systematic is not clear. Additionally, there are also several core fragments ($n = 10$, 15%).

3.6.6. *Summary of cores*

It is hypothesized that most of the informative cores are part of one main reduction system. This system mainly includes unidirectional cores (55% of the SMONE cores and 24% of the BOS cores). Bidirectional cores are only seen in BOS and in a small amount (7%). The bladelet cores are also reduced unidirectionally but do not show any of the morphologies typical on the other core types. Bladelet cores are only found in the lower BOS assemblage, although bladelets occur throughout the analysed layers. Some cores have been systematically exploited and then a second generation of three or more small flakes have been removed opportunistically (Fig. 21). As mentioned above, this recycling of cores is only seen in BOS ($n = 4$). The reworking of cores into tools is another phenomenon seen on three pieces in BOS, as discussed above. This observed recycling of cores in the BOS layer into second generation cores and the transformation into heavy duty tools can be seen as a separate step of the *chaîne opératoire*.

3.7. *Synthesis*

Most of the informative cores follow a unidirectional prepared core system (Fig. 22, I–IV) that can be seen on 19 cores (19/65). In SMONE six cores and in BOS 13 cores belong to the unidirectional reduction system. In BOS, there is also a low amount of cores attesting a real bidirectional reduction with two opposed equally-used platforms. All of these cores show remaining cobble cortex on the non-active part, which is the back or undersurface of the core (see Table 10 for core blanks). For the terms "undersurface" and "back" see, e.g. Wurz (2002, p. 1004) and Soriano et al. (2007, p. 686). These cores can all be classified into platform and parallel cores (Tables 11 and 12). The platform cores (type I) relate to a semi-rotational reduction system on pyramidal or prismatic cores. The parallel cores (types II–V) conform to a Levallois-like system with products removed parallel to the intersecting plane between the reduction surface and undersurface (Conard et al., 2004). The relationship between the cores is inferred on from the characteristics of the core and end product morphologies, as no complete or incomplete core reduction could be refitted. Core types I–III carry elongated scar patterns that are regular in size and shape; type IV and V cores have flake sized negative scars, which are irregular in shape. Type V cores are not represented in SMONE. With this core typology in mind,

Fig. 12. Formal tools. All on medium grain quartzite; a) notched flake #2323, BOS; b) ventral scraper on thick debordant #3200, BOS (close up of retouch); c) denticulated blade #1633, BOS; d) notched blade fragment #2625, BOS; e) denticulated point #2234, BOS; f) lateral retouch on point #2340, BOS; g) distal notch on blade #1563, BOS.

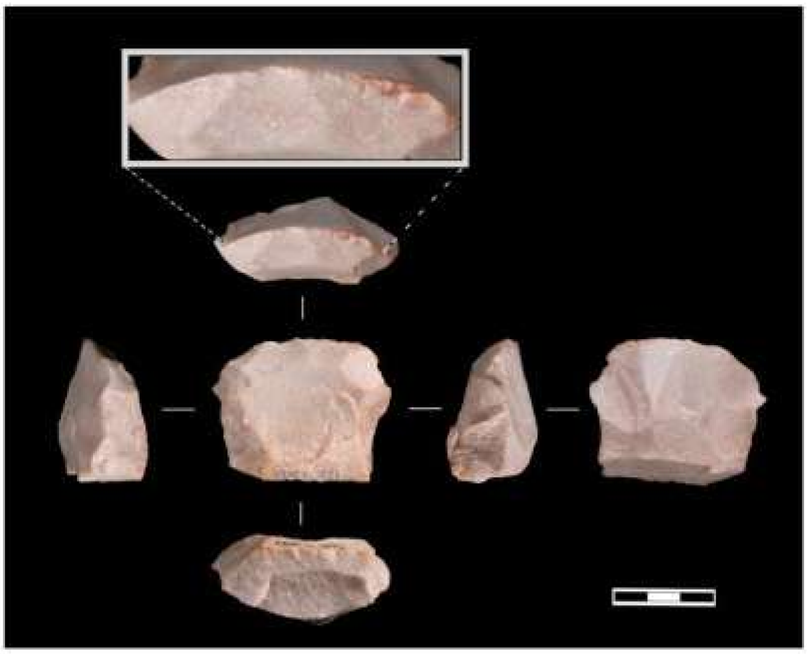

Fig. 13. Scraper on core. #1894, medium grain quartzite, BOS.

it is to mention however, that the differentiation between platform (type I) and parallel (types II–V) cores can be ambiguous, especially if a Levallois core geometry is combined with a semi-rotational ("around a corner") production surface (cf Conard, 2012, p. 245).

The described end product shapes can relate to different core types so that one shape can be produced by multiple core types. The blades are usually regular to very regular (Damlien, 2015) in their shape and negative scar pattern. They are most probably produced by types I to III cores (Fig. 22). Type 1 triangular pieces could be produced on any of the core types, but are, together with flakes, the main products of types IV and V cores, which only show flake sized negatives (Fig. 22). The broad variety of shapes (symmetric, asymmetric, skewed) of type 1 points can be explained by the irregular scar pattern of types IV and V cores. The type 1 points are most prevalent in BOS, and this assemblage also shows a higher amount of types IV and V cores (Table 11). Type 2 points can be correlated to core types I and II, platform and parallel cores, with a unidirectional reduction of regular elongated products (Fig. 22). This type is most common in SMONE. Type 3 is most likely produced by type III cores, which show a predominantly unidirectional reduction of regular elongated products but have distal preparation, necessary to create distal convexity to produce the pointed tip of the blanks. Flakes could be produced on any core type, but cores IV and V can only produce flake sized products. A bidirectional dorsal scar pattern is seen more often in BOS, which is in accordance with the frequency of bidirectional type V cores, which only appear in BOS (compare Table 11). However, types III and IV cores could also account for some of the pieces, as distal core preparation could infer a bidirectional scar pattern.

It is possible that when the platform cores type I were reduced in thickness, they transformed into parallel cores types II and III. As platform preparation and distal preparation continued, the parallel cores become shorter, resulting in cores types IV and V. Types IV and V cores possibly represent the last stages of the reduction system.

As the classification of cores into the presented types is fluid and based on the variety of end product shapes, the reduction is proposed to be a single related system with the aim of producing multiple end-product morphologies, including different point shapes, blades and flakes. Similar systems of "combined manufacture" have been described by Shimelmitz and Kuhn (2018, p. 7) for a recurrent Levallois system.

4. Comparison to MIS 5 sites from the southern Cape

The results of the new analysis of the KRM material are discussed here in the context of the broader MIS 5 southern Cape landscape. Other sites from the southern Cape, which are compared here, are Cape St. Blaize (Goodwin and Malan, 1935; Thompson and Marean, 2008), Pinnacle Point 13B (Thompson et al., 2010) and 5–6 (Brown, 2011) and Blombos (Douze et al., 2015) (Table A.10).

The Pinnacle Point sites are located on the southern coast of the Western Cape, very close to the shore. Its proximity to Klasies River and the well-dated MIS 5 assemblages make it a priority candidate for comparison. **Pinnacle Point 13B** (PP 13B) contains two large MIS 5c (OSL dating 94 ± 3 ka to 124 ± 5 ka) assemblages, each comprising more than a thousand artefacts > 10 mm (Thompson et al., 2010). They stem from different sections of the site (an Eastern and a Western area), which are not correlated. A small collection of MIS 5d (OSL dating 110 ± 4 ka) ($n = 47$) is from the Lower Roof Spall from the Eastern area, and the MIS 5e (OSL dating 125 ± 5 ka) assemblage ($n = 255$) is from the LC-MSA Northeastern section. In the technological analysis by Thompson et al. (2010) the term "detached pieces" is used in the sense of blanks in this paper; "end products" in Thompson include all points, blades and Levallois flakes, including debordants. Cores are described by a different typology, which mixes different approaches (Thompson et al., 2010), complicating inter-site comparisons. Based on the

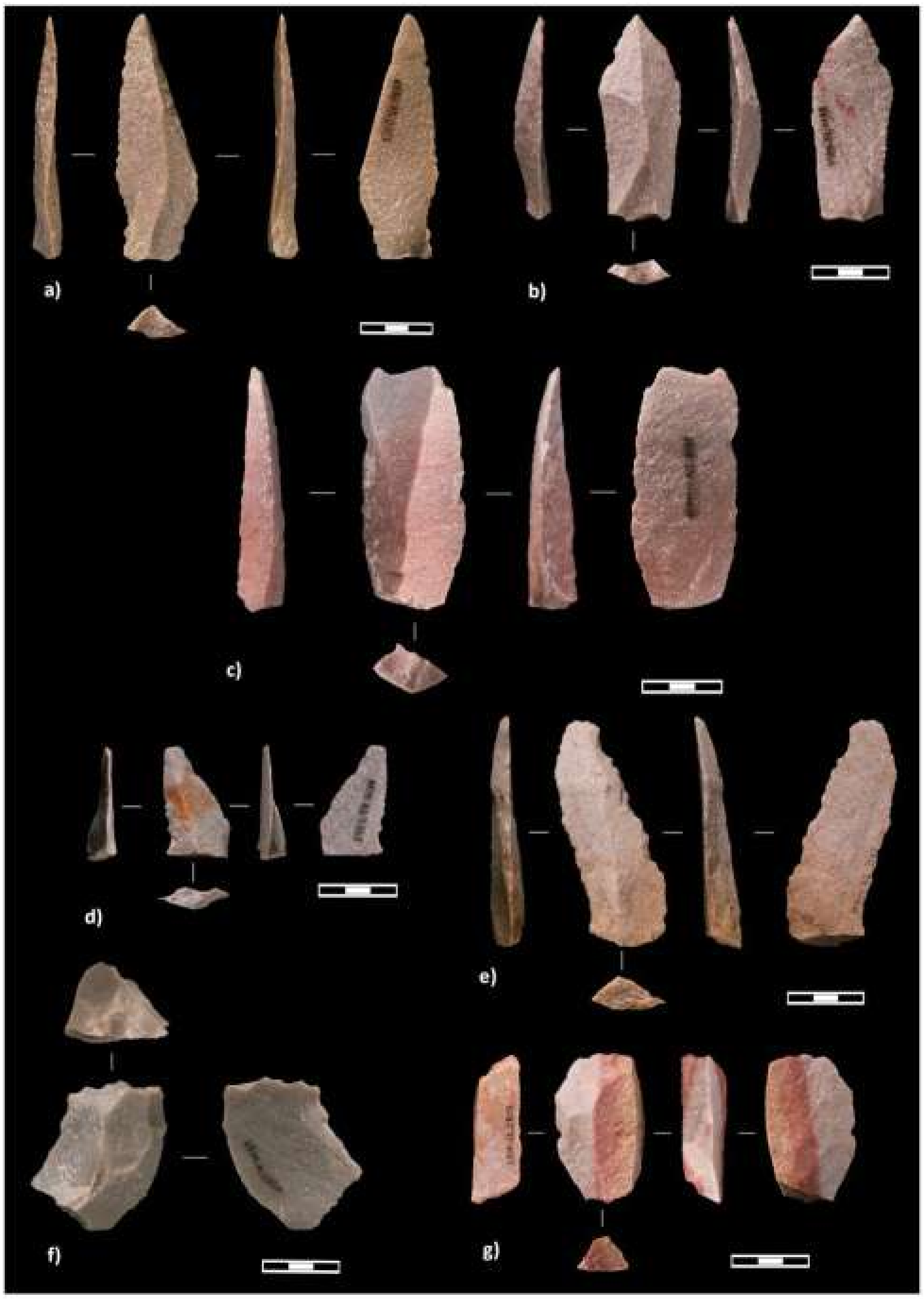

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Fig. 14. Edge damage. All on medium grain quartzite; a) damage on point #2353, BOS; b) damage on point #3138, BOS; c) damage on blade #3181, BOS; d) damage on point #2345, BOS; e) damage on blade #2185, BOS; f) scraper damage on flake #2957, BOS; g) scraper damage on flake debordant #2809, BOS.

platform and parallel core descriptions and drawings, a dominantly unidirectional reduction system for points (converging scar pattern) and blades (parallel scar patter) can be deduced. There is also a high amount of "prepared cores" with a centripetal pattern.

The most apparent similarities between the PP 13B and KRM assemblages is the use of quartzite as primary raw material, with 83% at PP 13B and 80.4–90.8% at KRM. Cobble cortex is visible on 17.5% from all artefacts from PP 13B compared to 28.4–38.7% at KRM. Thompson et al. (2010, p. 262) use the term "point" in the sense of convergent flake-blades, referring to Goodwin and van Riet Lowe (1929), although they also include asymmetrical pieces. The Pinnacle Point 13B points therefore either fit into the type 1 or 2 point category described for KRM. The proportion of blades to points at PP 13B shows mostly a higher amount of blades, except in the Western MIS 5c assemblage where points are a bit more frequent (10.9% of blanks on average). It is apparent, that the proportion of bladelet production is much lower at PP 13B than at KRM, but a minor bladelet component is evident. In contrast to the KRM assemblages discussed here, the blades and bladelets are described as having a uni-modal width distribution, which does not point towards a separate reduction sequence for the bladelets (Thompson et al., 2010). The formal and informal tool component at PP 13B is amalgamated but still shows very low numbers with an average proportion of 2% in relation to all debitage (no size cut-off, as opposed to KRM where the assemblage composition is analysed in relation to pieces > 20 mm).

The lithic material of **Pinnacle Point 5–6** (PP 5–6) was examined by Brown (2011). The early assemblages dating to MIS 5 b-a (OSL dating 86 ± 3 ka to 79 ± 3 ka) are so far only described in his PhD thesis. They belong to the LBSR stratigraphic unit and are subdivided into six occupational horizons. The uppermost occupation layer is called Jed/JR Quartzite and contains 925 lithic artefacts (there is no size cut-off). The other assemblages of LBSR only include less than a hundred lithic artefacts, which is why they are not included here (Brown, 2011). The main raw material is quartzite, and a high amount of artefacts show remaining cobble cortex. There are only seven cores, and most of them have been opportunistically exploited so that the systematic reduction is no longer visible. Three cores are attributed "single platform cores" (the terms are based on Volman (1978)) which are described by Brown (2011) as fitting the point-core definition of Wurz (2000). The blanks show dominantly unidirectional parallel and convergent dorsal scar patterns. Most end products are points (63%), followed by blades (37%), no flakes have been identified as such. Furthermore, there is a number ($n = 14$) of cortical debordants, which accounts for maintenance of lateral core convexity. 33% of the end products have a prepared faceted platform. The hypothesis is that the reduction system was mainly unidirectional (Brown, 2011). According to Brown (2011), there is only an informal tool component in the MIS 5 assemblages of PP 5-6.

The **Cape St. Blaize Cave** (CSB) is situated at the coast in the town of Mossel Bay. The MSA material was first described by Goodwin and Malan (Goodwin, 1930; Goodwin and Malan, 1935) in the 1930s. A more recent re-evaluation of the lithic material by Thompson and Marean (2008) produced different results compared to the initial analysis. As none of the papers defines what is meant by points (e.g. if blade dimensions are included, or if it is only for symmetrical flakes), the data of both analyses are given with Goodwin and Malan's data in brackets (Table A.10). It needs to be kept in mind that the excavations took place at an earlier time and there might be a sampling bias towards tools and complete artefacts, which could explain the very high percentages for retouched pieces and faceted platforms. Neither Goodwin and Malan (Goodwin, 1930; Goodwin and Malan, 1935) nor Thompson and Marean (2008) analysed the assemblages in relation to reduction sequences, therefore only attribute data of cores and blanks can be presented here.

The raw materials are all from local primary and secondary sources. It is the first assemblage that has been attributed to the Mossel Bay techno-complex (Goodwin, 1930), which is characterized by a high amount of points and blades which are reduced in a Levallois-like system. Thompson and Marean (2008) describe the cores as radial cores, as well as blade and point cores. Contradictory to the previous studies, Thompson and Marean (2008) describe the frequency of blades higher than that of points, and flakes being the dominant blank type. Platform faceting is very common, with over 50%. The formal tools are mostly denticulates, notched pieces and retouched points. The described assemblages of KRM are characterized as belonging to the Mossel Bay techno-complex. However, the vague definition based on the CSB material makes a clear association difficult, as mentioned by Thompson and Marean (2008).

Blombos Cave (BBC) is situated on the south coast of the Western Cape. The material of the M3 phase is described in Douze et al. (2015) and dates to MIS 5 c-b (OSL and U/Th dating 101 ± 4 ka to 94 ± 3 ka (Tribolo et al., 2006; Douze et al., 2015). Like KRM, BBC is situated very close to beaches and rivers. The raw materials in the form of cobbles all stem from these local sources. However, the main raw material used is silcrete from secondary marine sources; quartzite and quartz only represent a minor component in the assemblage. The BBC lithic artefacts of the M3 phase comprise 3404 pieces > 2 cm (Douze et al., 2015). The reduction technique in both sites BBC and KRM is freehand percussion with a hard hammer (Douze et al., 2015). The main debitage products at BBC are triangular flakes encompassing 20% of all complete debitage. The triangular flakes exhibit more faceted (27%) and dihedral (27%) platforms than other blank shapes. The same pattern is seen at KRM, where points more often show faceted platforms (Table 6: 37.5% and 45.5% of faceted pieces are points in SMONE and BOS, respectively). Dihedral platforms, however, are scarce at KRM. The triangular flake end products at BBC are attributed to different reduction systems, and as described for KRM, the shapes between triangular flakes vary significantly especially in the broadness of the base and in their length. Three main triangular point morphologies are identified at BBC in the M3 phase. *Déjeté* points, which are axially asymmetrical, have short and large bases and thick plain or dihedral platforms, are related to discoid/inclined reduction methods, but also to parallel centripetal or unidirectional methods. At KRM no *déjeté* points occur. At BBC the second category of elongated thinner triangular flakes exists. They are axially more symmetrical points with Levallois points representing the most standardised within this class. These are linked to parallel unidirectional reduction, including parallel/Levallois-type methods. At KRM some types 1 and 2 points resemble these Levallois triangular flakes, and it is surmised that they have been produced using a similar parallel unidirectional method. The third type at BBC comprises triangular blanks originating from core maintenance and preparation phases and they are very variable in shape. At KRM there also triangular blanks from preparational phases, but they are not included in the end product morphologies.

At KRM it is proposed, that a combined manufacture of multiple end product shapes existed in one core reduction system. For this reason, we

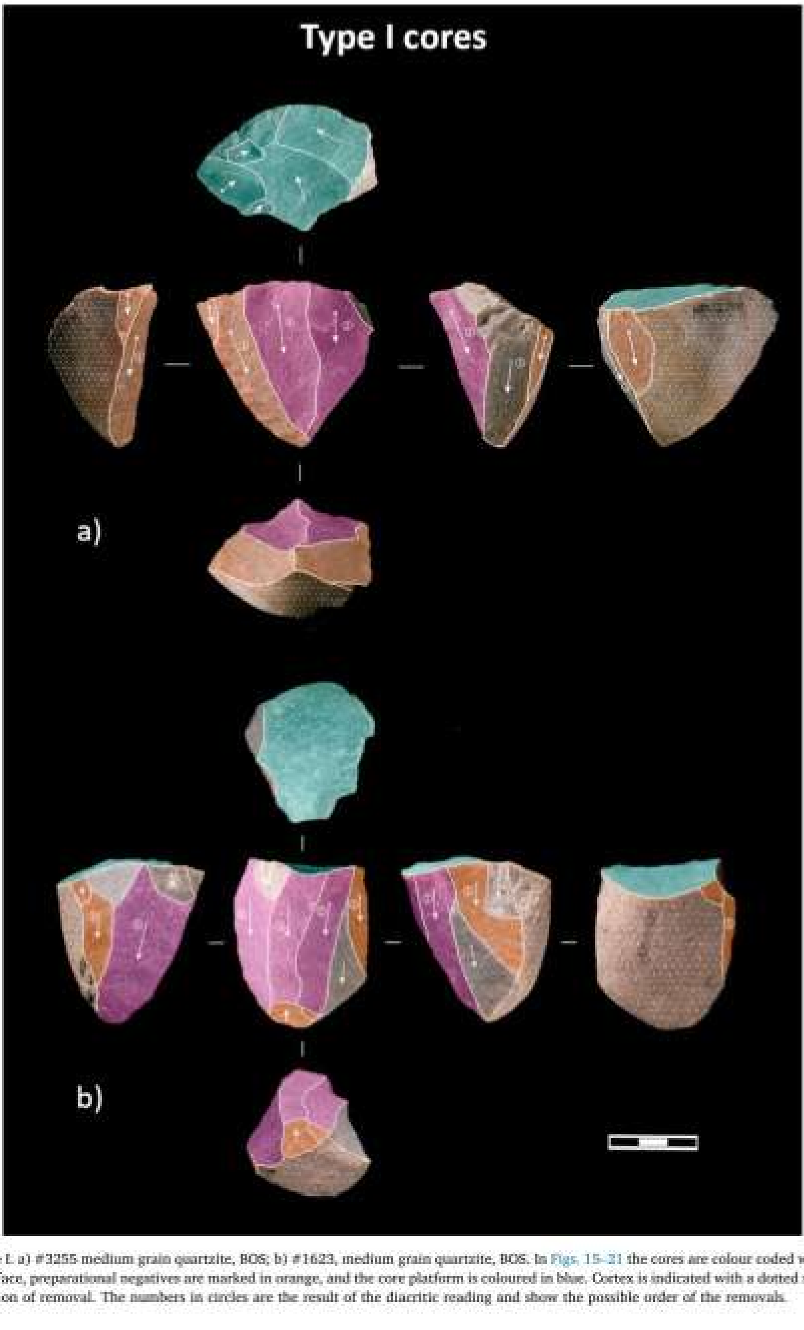

Fig. 15. Cores type I. a) #3255 medium grain quartzite, BOS; b) #1623, medium grain quartzite, BOS. In Figs. 15–21 the cores are colour coded with pink indicating the production surface, preparational negatives are marked in orange, and the core platform is coloured in blue. Cortex is indicated with a dotted surface. The arrows indicate the direction of removal. The numbers in circles are the result of the diacritic reading and show the possible order of the removals.

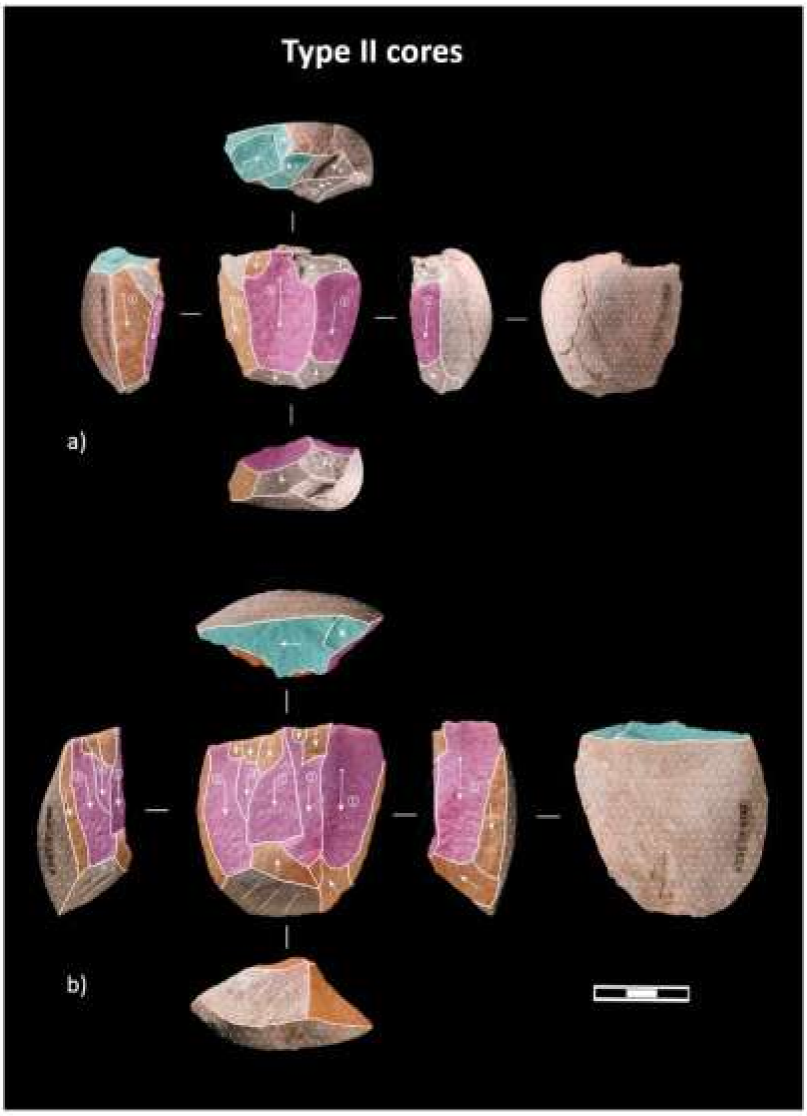

Fig. 16. Core type II. a) #2967, medium grain quartzite, BOS; b) #2556, medium grain quartzite, BOS.

established a new taxonomy of end product morphology to do justice to the high variability, which includes shapes different point types, blades and flakes.

The unidirectional and unidirectional convergent cores described by Douze et al. (2015, p. 13) are comparable to the KRM cores of types II, III and IV, which are also parallel and mostly unidirectional. One bidirectional-opposed core that follows the same system as the other parallel cores is also described (Douze et al., 2015, p. 13), which is similar to the type V cores seen at KRM. The reduction method is therefore quite similar between BBC and KRM. However, KRM shows more variability in the core morphology in the unidirectional system and exhibits more bidirectional reduction. Furthermore, BBC shows

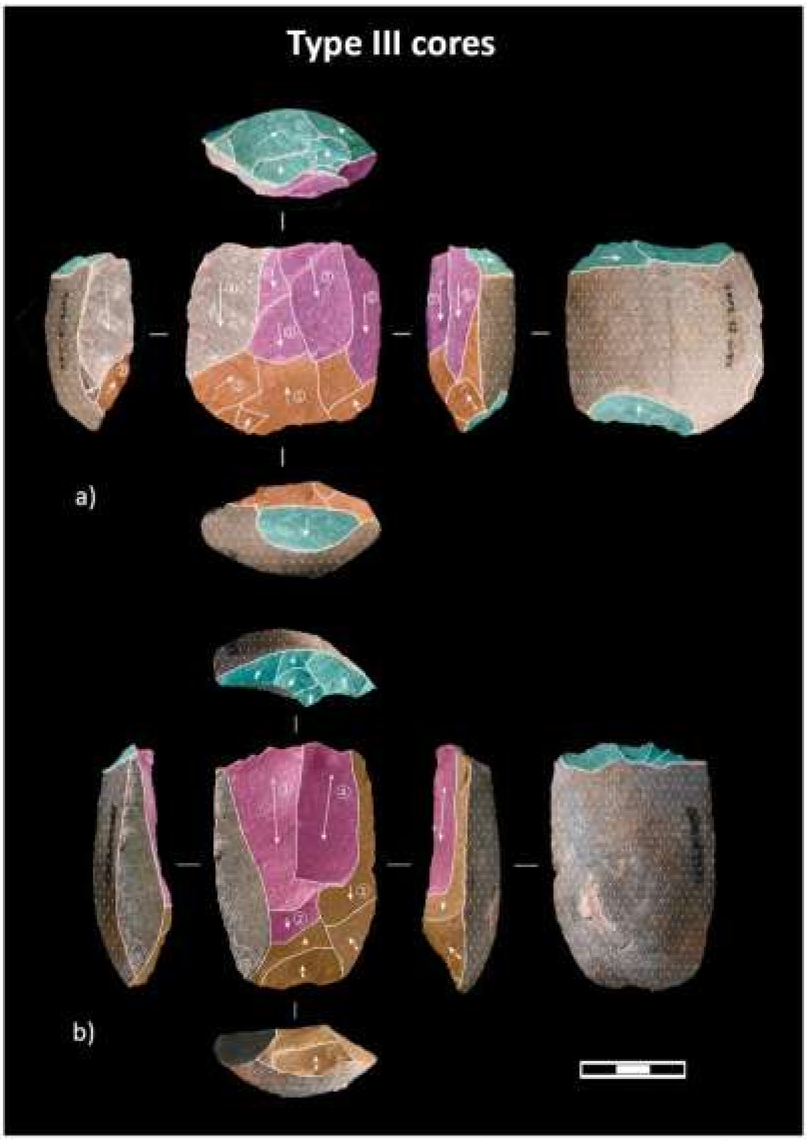

Fig. 17. Core type III. a) #2044, medium grain quartzite, BOS; b) #2397, medium grain quartzite, BOS.

Fig. 18. Core type IV. a) #3241, medium grain quartzite, BOS; b) #1405, medium grain quartzite, BOS.

other reduction systems, like inclined and centripetal reduction, which is absent at KRM.

The blade-sized pieces (2:1 ratio) at BBC make up 8% of complete blanks; they are not distinguished into pointed or other shape. At KRM the blades comprise 6.9% in SMONE and 12.9% in BOS. However, blade sized points occur with frequencies of 6.8% in SMONE and 7.5% in BOS, so the material of KRM shows more elongated pieces than that of BBC. Although blades are produced at BBC, the unidirectional cores are all shorter than wide, only showing flake sized negatives. The lateral convexities are established by common reduction of debordants (9.1% of blanks). The blanks show frequent platform preparation with faceting (15.7%), although the points are more often faceted (27%); the

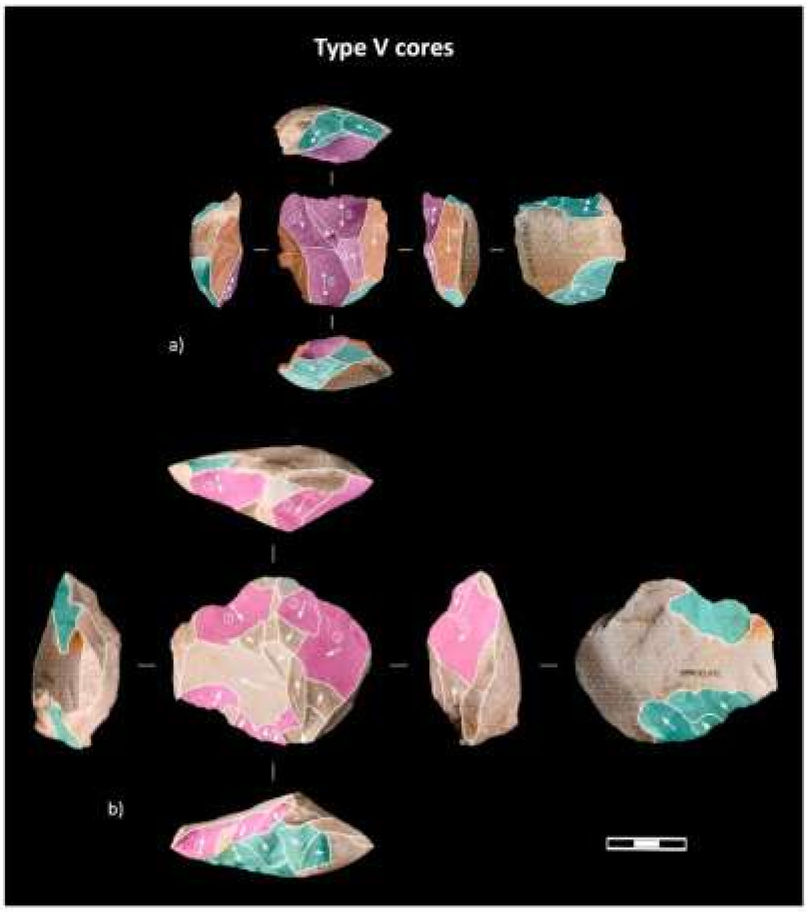

Fig. 19. Core type V. a) #1915, medium grain quartzite, BOS; b) #2173, medium grain quartzite, BOS.

same pattern is seen at KRM (Table 6: 37.5% and 45.5% of faceted pieces are points in SMONE and BOS respectively).

Similar to KRM, the frequency of formal tools is low with 2.3% at BBC. Unlike KRM, the proportion of edge modification by damage and use wear is low in the BBC assemblage (1.5%) as opposed to KRM where it is 16.4% in SMONE and 21.7% in BOS. Nevertheless, unmodified blanks are also interpreted to be used as tools (Douze et al., 2015, p. 6).

4.1. *Common trends and variability between MIS 5 assemblages*

The similarities between sites on the southern Cape have been referred to before (Wurz, 2013; Mackay et al., 2014; Douze et al., 2015). Typical characteristics are the dominant use of local raw materials, a direct hard hammer internal percussion technique, a low frequency of formal tools with denticulates and notches prevailing and common platform faceting. Local raw materials comprise about 90–100% in all assemblages; the rock type can differ between available sources of quartzite and silcrete. The presented MIS 5 assemblages a direct internal percussion with a hard hammer is described, e.g. by the presence of common *siret* fractures and hammer stones. The amount of tools is commonly very low in MIS 5. Most assemblages have tool frequencies around 2%. Nevertheless, PP13B MIS 5c West exhibits 4% tools and the most extensive tool component (12.8%) is found in CSB (following Thompson and Marean, 2008). However, as mentioned above, CSB is most probably affected by collection bias so that tools might be overrepresented. Another similarity between the presented assemblages is a frequent faceting of platforms. The frequency varies from 15% up to 52%.

Fig. 20. Bladelet cores of BOS. All on medium grain quartzite; a) #2718, BOS, core on chunk; b) #3268, BOS, core on flake fragment or chunk; c) #2879, BOS, possible core on flake.

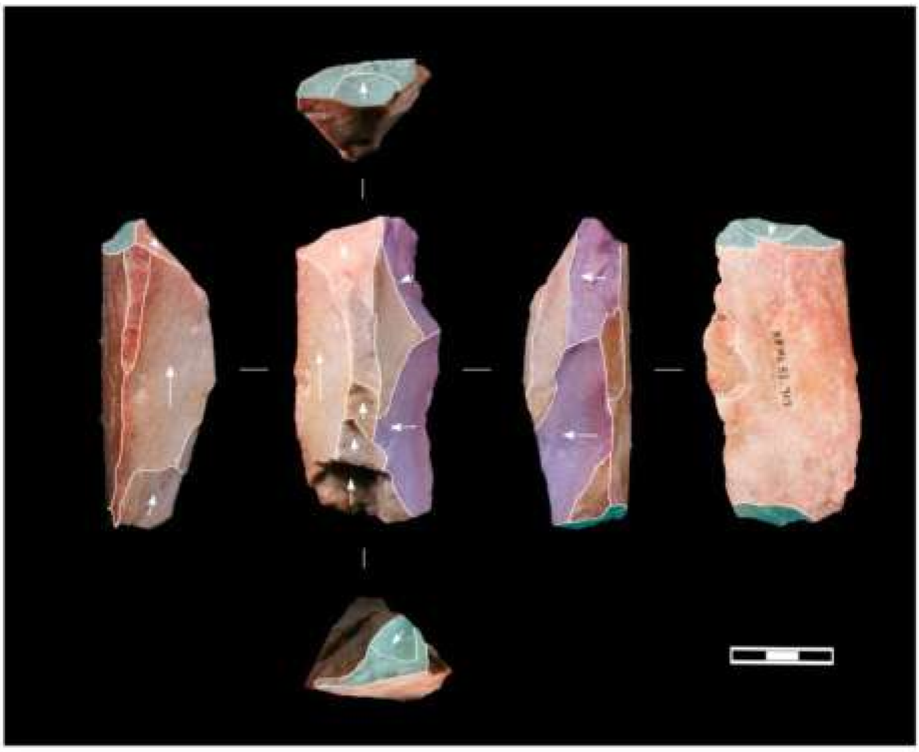

Fig. 21. Core #717 of BOS (on medium grain quartzite) with secondary orthogonal informal flakes in purple overprinting a systematic reduction (opposed platforms of first generation core in blue).

Differences in technology are seen in reduction sequences and the shape of end products. As for reduction systems, a unidirectional reduction is seen at all sites, however additional co-existing reduction systems differ. The described unidirectional reduction systems are on parallel and platform cores. At KRM a complementary bidirectional reduction is seen, whereas the other sites mostly display a centripetal reduction (Levallois and inclined). The reduction systems allow for some differentiation, which can be further defined by the blank morphologies. Point and blade production seem to differ in frequency. Dominant blade production is only seen at CSB (following Thompson and Marean (2008)). More focus on the point production is seen at BBC, KRM and PP5-6. The PP13B assemblages show an equal production of both points and blades.

This attests, that although MIS 5 technology on the southern Cape show many similarities, variation exists in the reduction systems which leads to different frequencies of end product shapes. A more detailed comparison of short term developments combined with refined dating at each site could reveal possible further relatedness or variety.

5. Discussion

Both KRM assemblages discussed here share characteristics with the MSA II or Mossel Bay techno-complex, previously described by Wurz (2000; 2002). One main reduction system is found in the assemblages discussed here, a unidirectional parallel system for the production of mainly points, but also blades. This fits as well with the description of Wurz's analysis of the larger MSA II assemblage at KRM. Additionally, a bidirectional parallel reduction is seen in one of the assemblages, BOS; and a bladelet component occurs in both assemblages, a phenomenon not previously described for the Klasies River MSA II assemblages. A more detailed degree of variability through time is furthermore evident in this analysis, due to the more refined focus used here. A summary of the comparison between the assemblages with the statistical values is provided in Table A.9.

Technologically, SMONE exhibits a distinct character that differentiates it from BOS. SMONE has significantly fewer cores as confirmed by a chi-square test ($p < .05$). They seem to be smaller and lighter than in BOS (although only marginally significant, see Table A.9). SMONE also has a significantly richer flake component than BOS (χ^2 (1) = 4.31,

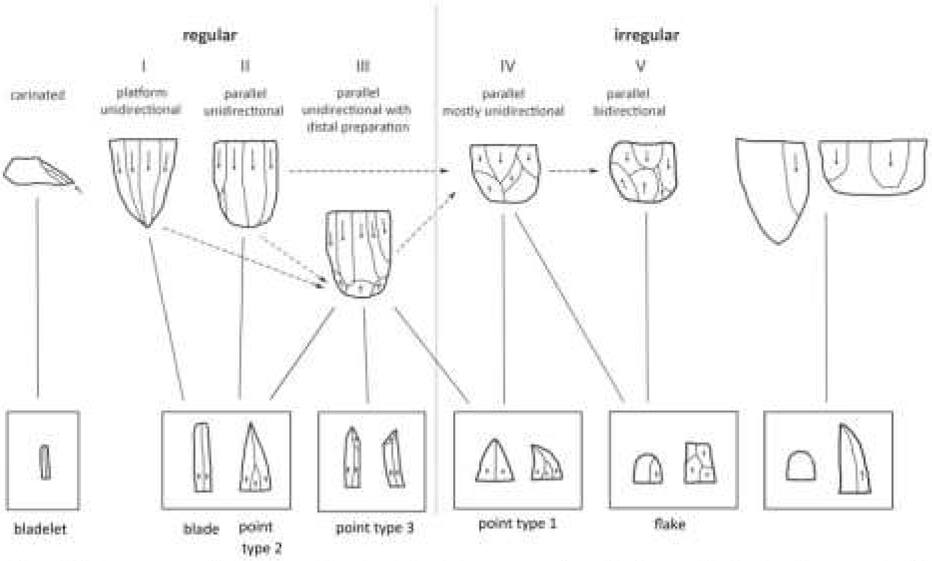

Fig. 22. Scheme of different core types with the corresponding product shapes. Core types are illustrated at the top, and end product shapes are at the bottom. The lines indicate which core types produced which types of end products. The cores are divided into types with a regular organization of negatives and those with irregular organization. The bladelet cores on the left are related to bladelet production. Core types I–V form the main reduction system. The main reduction system entails unidirectional prepared cores for the production of triangular flakes, elongated points and blades. (The pointed end products indicated in blue are, from the left, point types 2, 3 and 1; as discussed in more detail above). Apart from this, there are a few cores which are tested, indeterminate or with only a single product removed. They are grouped under "other". The dotted arrows are hypothetical connections in the main core reduction system.

$p < .05$), although points and blades are more frequent in BOS (points: $\chi^2(1) = 7.16$, $p < .05$; blades $\chi^2(1) = 3.90$, $p < .05$). Bladelets also occur significantly more frequently in SMONE ($\chi^2(1) = 17.5$, $p < .05$), although they occur in the absence of bladelet cores.

Furthermore, the SMONE tool component is significantly smaller ($\chi^2(1) = 8.91$, $p < .05$) and less variable than in BOS, comprising only of denticulate and notches. No scrapers or lateral retouch have been observed, and the edge damage frequency is also half as frequent as in the BOS layers. The technological characteristics of the blanks and cores also differ between SMONE and BOS. Core types II and V are not present in SMONE. The end product platforms are significantly less frequently faceted than in the BOS layer ($\chi^2(1) = 4.21$, $p < .05$). However, the blank platforms of SMONE show more informal faceting ($\chi^2(1) = 5.41$, $p < .05$). The external platform angle of the blades shows a significant difference between the layers attested by a Mann-Whitney *U* test ($U = 436$, $p < .05$). The products of BOS are heavier, especially the points ($U = 436$, $p < .05$).

These differences seen between SMONE and BOS justify their division into separate layers. Although we have shown, that statistically significant differences between the layers exits, the dorsal scar patterning on end products for all the assemblages shows predominately unidirectional patterns, and the dimensions of cores and end products

Table 5
Number and percentage of complete end products and the average of length (mm), width (mm), thickness (mm) and weight (g).

Measurement/end product	Complete end products		Length	Width	Thickness	Weight
	n	%	Average (mm)	Average (mm)	Average (mm)	Average (g)
Point						
SMONE	21	53%	66.4	32.7	12.1	21.7
BOS	92	68%	67.4	36.8	13.3	29.7
Blade						
SMONE	7	17%	72.3	27.5	11.6	24.0
BOS	21	14%	82.0	29.8	12.4	30.4
Flake						
SMONE	12	30%	49.3	33.8	11.2	17.8
BOS	19	18%	58.8	39.2	13.9	37.3

Table 6
Platform types of end products (n) with total values in per cent (%) (of proximally preserved pieces).

Platform type/ end product	Plain	Facetted	Informal facet	Dihedral	Cortical	Shattered	Total
Point							
SMONE	–	9	10	–	1	1	21
BOS	2	65	20	2	2	1	92
Blade							
SMONE	1	2	2	–	–	1	6
BOS	–	14	4	2	–	1	21
Flake							
SMONE	1	2	5	1	–	1	11
BOS	3	7	5	2	2	1	20
End product fragment							
SMONE	2	11	14	–	2	1	30
BOS	13	57	31	–	4	2	107
Total %							
SMONE	5.9%	35.3%	45.6%	1.5%	4.4%	5.9%	100% (n = 68)
BOS	7.5%	59.6%	25.0%	2.5%	3.3%	2.1%	100% (n = 240)

Table 7
Proximal preparation of the dorsal edge of the platform of end products (n) with total values in per cent (%) (of proximally preserved pieces).

Proximal preparation/ end product	None	Longer removals along scar ridges	Step flaking and trimming	Trimming and rubbing	Total
Point					
SMONE	10	5	6	–	21
BOS	49	11	29	3	92
Blade					
SMONE	4	1	1	–	6
BOS	11	2	8	–	21
Flake					
SMONE	5	–	6	–	11
BOS	10	2	8	–	20
Blank fragment					
SMONE	17	–	11	3	31
BOS	42	14	49	1	106
Total %					
SMONE	52.2%	8.7%	33.3%	4.3%	100% (n = 69)
BOS	46.9%	12.1%	39.3%	0.2%	100% (n = 239)

Table 8
Orientation of dorsal negative scars of complete end products.

Orientation of dorsal negatives	SMONE		BOS	
	n	%	n	%
Unidirectional convergent	3	8.3%	20	15.0%
Unidirectional parallel	3	8.3%	14	10.5%
Unidirectional	8	22.2%	23	17.3%
90% unidirectional	9	25.0%	15	11.3%
Uni- or bidirectional	6	16.7%	26	19.5%
Bidirectional	6	16.7%	31	23.3%
Orthogonal	–		2	1.5%
Multidirectional	–		1	0.8%
Indeterminate	1	2.8%	1	0.8%
Total	36	100%	133	100%

Table 9
Tool types. Amount (n) with percentages in relation to all pieces > 20 mm (%).

Tool type/assemblage	SMONE		BOS	
	n	%	n	%
Denticulate/notched piece	4	0.7%	15	1.2%
Point	2	0.4%	2	0.2%
Blade	–		4	0.3%
Flake	2	0.4%	10	0.8%
Scraper	0	–	8	0.6%
Point	–		1	0.1%
Blade	–		1	0.1%
Flake	–		1	0.1%
Core	–		4	0.3%
Combination notched/scraper	0	–	3	0.2%
Flake	–		3	0.2%
Lateral retouch	0	–	9	0.7%
Point	–		6	0.4%
Blade	–		1	0.1%
Flake	–		2	0.2%
Total formal tools	4	0.7%	35	2.8%
Edge damage	100	16.4%	270	21.7%
Point	24	3.9%	117	9.4%
Blade	24	3.9%	71	5.7%
Flake	22	3.6%	35	2.8%
Indet fragment	30	4.9%	47	3.8%
Total	104	17.1%	305	24.5%

Table 10
Core blank types (n) per layer.

Core blank	SMONE	BOS
Debordant	1	7
Flake	2	4
Cobble	6	35
Hammerstone	1	1
Indeterminate	1	7
Total	11	54

Table 11
Core types. Number and per cent by layer.

Core types	SMONE		BOS	
	n	%	n	%
Platform	2	18.2%	3	5.5%
Type I				
Parallel unidirectional				
Type II	–	0%	2	3.7%
Type III	2	18.2%	3	5.5%
Type IV	2	18.2%	5	9.3%
Parallel bidirectional				
Type V	–	0%	4	7.4%
Bladelet	–	0%	4	7.4%
Recycled	–		4	7.4%
Exhausted	1	9.1%	6	11.1%
Tested	2	18.2%	9	16.7%
Altered surface	–		4	7.4%
Indeterminate	–		2	29.7%
Fragment	2	18.2%	8	14.8%
Total	11	100%	54	100%

are similar. The same core reduction system is also seen in both layers. This justifies the classification into a common techno-complex, the MSA II.

All assemblages at KRM comprise an expedient (cf Binford, 1977; Kuhn, 1995, p. 26) technology. At KRM the expediency is evident by on-site manufacture, the use of local raw materials, no raw material selection for tool production, some cores are not completely exhausted, and the dominance of unretouched blanks. SMONE, however, may be described as more expedient than the BOS assemblage, as there are fewer tools and less investment in producing the artefacts, as evident in the lower degree of faceting of platforms. The lighter products in SMONE could relate to sorting and some rolling, as observed for the larger excavation of layer 17a by Singer and Wymer (1982). However, the technological differences, the lack of bidirectional exploitation and lesser preparation of the platforms are harder to explain through taphonomic factors. The recycling of cores and big flakes into second generation cores or tools in BOS can be seen as an indication of opportunistic utilisation.

These differences can also be interpreted in the context of provisioning systems (e.g. Kuhn, 1995; Mackay et al., 2018). Two distinct provisioning systems occur, provisioning of individuals and provisioning of place (Kuhn, 1995). Individual provisioning systems prepare mobile individuals for unreliable resource availability. Such toolkits for individual provisioning mostly include cores, from which tools can be manufactured as needed, and formal multi-purpose tools, which can be resharpened after use (Kuhn, 1995; Mackay et al., 2018).

A site relying on provisioning of place exhibits less evidence for mobility over long distances as evident in the absence of exotic raw materials and on-site production and discard of tools. On-site manufacture is visible by the presence of multiple cores and debitage recording different stages of the reduction sequence. Place provisioning is also characterized by prolonged or re-occurring occupations of a site and therefore, predictable resources close by (Kuhn, 1995; Mackay et al., 2018). In the KRM assemblages discussed here, local raw materials are used and reduced on-site, as indicated by the presence of cobbles, cortical flakes, cores and small debitage. Some of the cores are discarded without being fully exhausted (e.g. the type I platform cores in Fig. 8). The end products show a high variety in size and shape. The use of unretouched blanks as tools and only a small amount of formal retouch shows minimal input into the production of tools. The formal tools indicate that tools were not resharpened or recycled after use, but discarded. Therefore it might be that tools were produced for a short life cycle and not with the intention of transport or the equipment of individuals, implying low mobility of the group. The scarcity of retouched pieces in the South African early MSA is sometimes interpreted as a missing final phase of tool production following Geneste (1985), with only early and middle phase present (see, e.g. Goodwin and Malan, 1935; Marean et al., 2004, p. 48). In the case of KRM, however, the unretouched points have been used as tools, and the last phase is therefore not missing. Following Kuhn (1992, 1995) it is suggested that KRM during MIS 5 for the assemblages discussed here, functioned as a residential site with provisioning of place.

Regarding provisioning and mobility in the greater landscape, the southern Cape sites show similar patterns to KRM. As described above, the presented sites conform to most characteristics which imply provisioning of place behaviour at a residential site (following Kuhn (1995)). This could mean that during MIS 5, the population of the southern Cape followed a place provisioning strategy.

6. Conclusions

This study reports on the recently excavated KRM lithic material from layers SMONE and BOS from the SASL sub-member dating to between 100 and 110,000 years ago. Like previous studies on similarly aged material from KRM, the results indicate that a Levallois-like unidirectional reduction system was primarily used (Wurz, 2000, 2002). However, our analysis further details the various stages of this reduction sequence, not been described before. The semi-rotational platform cores and flat parallel cores, grouped into types I–V, have been shown to be most likely different parts of this reduction strategy. The in-depth study of the end products indicates that point shaped end products, including pointed flakes and blades dominate, a finding resonating with the previous analyses of broadly contemporaneous material from KRM (Wurz, 2000, 2002). Here it is also shown that three distinct types of points occur, also relating to different stages of reduction. A smaller blade component has been identified before (Wurz, 2000, 2002), and this analysis also confirms this. However, flakes as end products have not been previously described before, and it is shown here that whereas they are a consistent feature in the two assemblages studied, they are most frequent in SMONE. The correlation of core reduction sequences and end product morphology indicates a fluid system that aims for a combined manufacture of a variety of end product shapes. Another novel finding is the identification of a bladelet component in the assemblages, with bladelets especially frequent in SMONE. The formal tools, consisting of denticulates, notched tools and scrapers, occur in low frequencies, as at other MIS 5 MSA assemblages from South Africa.

Table 12
Core taxonomy for the KRM cores.

Core type (method)	Systematic reduction			Other
	I Platform	II–V Parallel	Bladelet cores	Tested, recycled, exhausted, altered, indeterminate, fragment
Sub-type (morphology)	Pyramidal, prismatic, semi-rotational pyramidal, semi-rotational prismatic	Flat, natural lateral convexity (split cobble blanks)		
Orientation of production	Unidirectional (I)	Unidirectional (II–IV), bidirectional (V)	Unidirectional	Unidirectional, bidirectional multidirectional, indeterminate
Products	Blade, flake, point, bladelet	Flake, point	Bladelet	Flake, point, blade

They occur in addition to a more significant component of unretouched blanks with edge damage.

There are apparent differences between the SMONE and the BOS layers. This is especially seen in the different types of cores, and the frequency of different blank and end product types. Cores are more frequent in BOS, and core types II and V and bladelet cores only occur in BOS. More points and blades are present in BOS, whereas SMONE shows more focus on flakes and bladelets. Additionally, the blanks in BOS have more faceted platforms, and points are heavier than in SMONE. The formal tools are more frequent in BOS, as well as cores and hammerstones. This reflects differences in technological choices, and it may also reflect more ephemeral occupation in SMONE. This study shows the advantages of undertaking a detailed analysis of relatively small depositional units to investigate behavioral developments.

The material discussed here provides new information about the technological succession during MIS 5 at KRM. Moreover, it contributes to the understanding of the technology in the southern Cape region and ultimately of Southern Africa. Although there exist local differences regarding reduction sequences and end product morphologies between the southern Cape sites, the similarities indicate common technological elements and place provisioning systems.

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Appendix A

Table A.1
Appearance of bulbs of proximally preserved debitage.

Bulb	SMONE		BOS	
	n	%	n	%
Well-defined	24	7.6%	70	11.2%
Defined	171	54.1%	383	61.5%
Removed	–	0%	2	0.3%
Poorly-defined	75	23.7%	130	20.9%
Absent	46	14.6%	38	6.1%
Total	316	100%	623	100%

Table A.2
Appearance of a ring crack of proximally preserved debitage.

Ring crack	SMONE		BOS	
	n	%	n	%
Circle	117	44.5%	522	87–1%
Half circle	90	34.2%	68	11.4%
None	56	21.3%	9	1.5%
Total	263	100%	599	100%

Table A.3
Maximal platform thickness average of proximally preserved debitage in mm.

Platform thickness average	SMONE		BOS	
	n	(mm)	n	(mm)
Blade (n = 239)	60	8.84	179	9.90
Bladelet (n = 18)	9	4.66	9	3.98
Point (n = 255)	52	8.21	203	11.79
Flake (n = 818)	309	10.77	509	9.65
Total	430	8.58	900	10.23

Table A.4
External platform angle average of proximally preserved debitage in °.

EPA average	SMONE		BOS	
	n	(°)	n	(°)
Blade	41	80.5°	122	87.5°
Bladelet	6	77.2°	3	75.0°
Point	40	78.3°	161	87.4°
Flake	216	85.6°	319	86.1°
Total	303	79.5°	605	87.1°

Table A.5
Appearance of lips of proximally preserved pieces.

Lip	SMONE		BOS	
	n	%	n	%
None	208	76.8%	531	89.7%
Traceable	53	19.6%	51	8.6%
Well defined	10	3.7%	10	1.7%
Total	271	100%	592	100%

Table A.6
Maximum dimension and weight of cores.

Core measurements	Number	Max. dimension	Weight
	n	(mm)	(g)
SMONE	11	62.19	92.31
BOS	54	68.56	121.94
Total	65	67.40	116.55

Table A.7
Shapes of complete/almost complete flakes.

Flake shapes		
	SMONE	BOS
Flakes	131	191
Rectangular	40	68
Round/oval	23	36
Expanding	18	35
Sub-parallel	6	7
Irregular	44	45

Table A.8
Platform type of different blank types of proximally preserved blanks.

Platform type/blank type	Plain	Informal facet	Faceted	Cortical	Dihedral	Shattered	Total
SMONE	122	91	47	25	14	10	309
Point	5	17	12	4	1	2	41
Blade	6	20	12			2	40
Bladelet	4	1	1	1			7
Flake	107	53	22	20	13	6	221
BOS	202	155	174	41	23	18	615
Point	19	41	91	3	4	4	162

(continued on next page)

Table A.8 (*continued*)

Platform type/blank type	Plain	Informal facet	Faceted	Cortical	Dihedral	Shattered	Total
Blade	25	37	53	2	3	2	122
Bladelet	2			1		1	4
Flake	157	77	30	35	16	11	326
SMONE	39.5%	29.4%	15.2%	8.1%	4.5%	2.3%	100%
BOS	32.8%	25.2%	28.3%	6.7%	3.7%	2.9%	100%

Table A.9
Comparison between the KRM assemblages summarising the differences. Tests for normality was done for the continuous variable with a Shapiro-Wilk test (W). For normal distributions, the difference between the layers was tested with independent-samples t-tests (t). For data with non-normal distributions, Mann-Whitney U tests (U) were performed. An alpha level of.05 for all statistical tests is used. For t-tests and M-W tests, all p-values represent one-tailed tests. Chi-square tests (χ^2) were used for categorical data, with a degree of freedom of 1 (d = 1). (*significant).

Differences between assemblages		SMONE	BOS	S-W test for normality	t-Test or M-W and χ^2	statistical significance
Assemblage composition	Amount of types	Less points (19.6%)	More points (33.9%)		χ^2 = 7.16, p .008*	Significantly different
		Fewer blades (6.9%)	More blades (12.9%)		χ^2 = 3.90, p .048*	Significantly different
		More flakes (71.4%)	Less flakes (53.2%)		χ^2 = 4.31, p .038*	Significantly different
		More bladelets (7.8%)	Less bladelets (3.3%)		χ^2 = 17.05, p < .001*	Significantly different
		Less cores (1.8%)	More cores (4.3%)		χ^2 = 7.30, p .007*	significantly different
	Small debitage	77.2%	69.2%		χ^2 = 8.17, p .004*	significantly different
Cores	Core types	I, III, IV	I–V, bladelet cores			
	Core size	Smaller average max. dimension: 62.19 mm	Bigger average max. dimension: 68.56 mm	SMONE W = 0.96, p .846 BOS W = 0.97, p .164	t (66) = −1.34, p .092	Not significant
		Lighter Average weight of 92.31 g	Heavier average weight 121.94 g	SMONE W = 0.66, p < .001* BOS W = 0.87, p < .001*	U = 221, p .058	Not significant
	Recycling of cores	No recycling (n = 0)	More recycling (n = 7)			
Tools	Tool type frequency	Denticulate/notch (100%), Scraper (0%), Lateral retouch (0%)	Denticulate/notch (42.9%), Scraper (31.4%), Lateral retouch (25.7%)			
	Tool frequency	0.7% less frequent	2.8% more frequent		χ^2 = 8.91, p .003*	Significantly different
	Edge damage frequency	16.4% less frequent	21.7% most frequent		χ^2 = 3.55, p .059	not significant
	Hammerstone frequency	0.5% less frequent	2.0% more frequent		χ^2 = 6.17, p .013*	significantly different
End products	EPA of points and blades	Narrow average EPA on points: 78.3°	Wider average EPA on points: 87.4°	SMONE W = 0.96, p .401 BOS W = 0.82, p < .001*	U = 1251.5, p .397	Significantly different
		Narrow average EPA on blades: 80.5°	Wider average EPA on blades: 87.5°	SMONE W = 0.93, p 0.164 BOS W = 0.88, p < .001*	U = 436, p .004*	Significantly different
	Platform type	Less faceting (35.3%)	More faceting (59.6%)		χ^2 = 4.21, p .040*	Significantly different
		More informal faceting (45.6%)	Less informal faceting (25.0%)		χ^2 = 5.41, p .020*	Significantly different

(*continued on next page*)

Table A.9 (*continued*)

Differences between assemblages	SMONE	BOS	S-W test for normality	t-Test or M-W and χ^2	statistical significance
	Fewer dihedral platforms (1.5%)	Some dihedral platforms (2.5%)		$\chi^2 = 0.24$, p 0.622	Not significant
Proximal preparation	Some rubbing (4.3%)	Less rubbing (0.2%)		$\chi^2 = 1.62$, p .203	Not significant
	Less invasive preparation (longer removals along scar ridges) (42%)	More invasive preparation (longer removals along scar ridges) (51.4%)		$\chi^2 = 0.51$, p .476	Not significant
Platform thickness (average mm)	Thinner platform on points: 8.2 mm	Thicker platform on points: 11.8 mm	SMONE $W = 0.97$, p .743 BOS $W = 0.89$, p .099	t (138) = −1.10, p .137	Not significant
	Thinner platform on blades: 8.8 mm	Thicker platform on blades: 9.9 mm	SMONE $W = 0.90$, p .429 BOS $W = 0.96$, p .516	t (98) = 1.32, p .096	Not significant
	Thicker platform on flakes: 10.8 mm	Thinner platform on flakes: 9.7 mm	SMONE $W = 0.97$, p .550 BOS $W = 0.94$, p 0.034*	$U = 433$, p .087	Not significant
Weight	Points are lighter (average weight 21.7 g)	Points are heavier (average weight 29.7 g)	SMONE $W = 0.93$, p .164 BOS $W = 0.86$, $p < .001$*	$U = 733$, p .038*	Significantly different
	Blades are lighter (average weight 24 g)	Blades are heavier (average weight 30.4 g)	SMONE $W = 0.84$, p .116 BOS $W = 0.93$, p .124	t (28) = −0.97, p .171	Not significant
	Flakes are lighter (average weight 17.8 g)	Flakes are heavier (average weight 37.3 g)	SMONE $W = 0.95$, p .685 BOS $W = 0.88$, p .0285584*	$U = 69$, p .074	Not significant
Dimensions	Points are narrower (32.7 mm)	Points are wider (36.8 mm)	SMONE $W = 0.94$, p .296 BOS $W = 0.91$, $p < .001$*	$U = 687$, p .034*	Significantly different
	Points are thinner (12.1 mm)	Points are thicker (13.3 mm)	SMONE $W = 0.97$, p .729 BOS $W = 0.97$, p .045*	$U = 764$, p .061	Not significant
	Blades are narrower (27.5 mm)	Blades are wider (29.8 mm)	SMONE $W = 0.91$, p .403 BOS $W = 0.98$, p .884	t (28) = −0.74, p .232	Not significant
	Blades are thinner (11.6)	Blades are thicker (12.4 mm)	SMONE $W = 0.90$, p .343898 BOS $W = 0.97$, p .749	t (28) = −0.83, p .208	Not significant
	Flakes are narrower (33.8 mm)	Flakes are wider (39.2 mm)	SMONE $W = 0.97$, p .879 BOS $W = 0.96$, p .702	t (28) = −1.32, p .099	Not significant
	Flakes are thinner (11.2 mm)	Flakes are thicker (13.9 mm)	SMONE $W = 0.96$, p .851 BOS $W = 0.96$, p .551	t (28) = −1.70, p .050	Not significant
Dorsal scar patterning	Mostly unidirectional (63.9%)	Mostly unidirectional (54.1%)		$\chi^2 = 0.30$, p .585	Not significant
	Less bidirectional (16.7%)	More bidirectional (23.3%)		$\chi^2 = 0.48$, p .487	Not significant

Table A.10
Comparative table of MIS 5 assemblages from the southern Cape. The abbreviation ni stands for no information.*(% of complete blanks).

Site	Assemblage	MIS	Dating	Raw materials		% triangular flakes*	% blade sized points*	% blades*	% flakes*	% bladelets (of all debitage > 20 mm)	% faceted platforms (of pieces with preserved platforms)	% tools (of all debitage > 20 mm)	% edge damage (of all debitage > 20 mm)	Tool types	Source
Klasies River	SMONE	MIS 5c-d		100% local: quartzite (92%), quartz (7%), sandstone, silcrete (< 1%)	Unidirectional parallel system (parallel and platform cores)	9.6%	8.6%	6.9%	71.4%	7.8% (including < 20 mm)	15.2%	0.7%	16.4%	Denticulate, notch	this paper
	BOS	MIS 5c-d		100% local: quartzite (84%), quartz (15%), sandstone (1%)	Unidirectional parallel system (parallel and platform cores)	16.8%	7.5%	12.9%	53.2%	3.3% (including < 20 mm)	28.3%	2.8%	21.7%	Denticulate, notch, scraper, lateral retouch	
Pinnacle point 13B	SBS/URS (East)	MIS 5e	94 ± 3 ka OSL	> 90% local: quartzite (84.9%), quartz (11.5%) < 10% non-local: silcrete (2.7%)	Unidirectional system (platform and parallel cores)	7.2% (flake- and blade-sized points of complete and broken blanks and chunks)		11.5% (of complete and broken blanks and chunks)	55.9% (of complete and broken blanks and chunks)	0.5%	27.5%	2.1% incl. < 20 mm		Bulbar thinning, notch, backed, denticulate, burin-like retouch	Thompson et al. (2010), Jacobs (2010)
	LBS1 and UDBS Unit (West)	MIS 5e	99 ± 4 ka, 124 ± 5 kaOSL	> 90% local: quartzite (80.8%), quartz (13.3%) < 10% non-local: silcrete (3.9%)	Unidirectional system (platform and parallel cores)	12.7% (flake- and blade-sized points of complete and broken blanks and chunks)		9.8% (of complete and broken blanks and chunks)	49% (of complete and broken blanks and chunks)	0.8%	23.7%	4% incl. < 20 mm		Bulbar thinning, notch, backing, denticulate, burin-like retouch	
	Lower Roof Spall	MIS 5d	110 ± 4 ka OSL	> 90% local: quartzite (88.1%), quartz (9.5%) < 10% non-local: silcrete (2.4%)	Unidirectional system (platform and parallel cores)	2.4% (flake- and blade-sized points of complete and broken blanks and chunks)		4.7% (of complete and broken blanks and chunks)	54.8% (of complete and broken blanks and chunks)	0%	28%	0% incl. < 20 mm		–	
	LC-MSA Upper/ Middle	MIS 5e	125 ± 5 ka OSL	85.7% local: quartzite (77.9%), quartz (7.8%), 12.6% non-local: silcrete	Unidirectional system (platform and parallel cores)	8.7% (flake- and blade-sized points of complete and broken blanks and chunks)		13% (of complete and broken blanks and chunks)	57.6% (of complete and broken blanks and chunks)	0.9%	26.3%	1.7% incl. < 20 mm		Bulbar thinning, notch, backing, denticulate, burin-like retouch	
Pinnacle Point 5-6	LBSLR Jed/ JR Quartzite	MIS 5a-b	86 ± 3 ka - 79 ± 3 ka OSL	Quartzite (95%), silcrete, chert, hornfels, quartz	Unidirectional	63% (points of end products)		37% (of end products)	ni	ni	33% (of complete blanks)	0%	3.8% incl. < 20 mm	–	Brown (2011)
Cape St Blaize	C1–4 and CU	MIS 5	–	100% local: quartzite (92%), silcrete, calcedony, hornfels, shale, quartz	Radial cores, blade and point cores (Goodwin: flake cores, Levallois or disc cores)	7.7% (probably including fragments) (Goodwin: 61.2%)	ni	22.8% (probably including fragments) (Goodwin: 18.6%)	52.6% (probably including fragments) (Goodwin: 18.1%)	ni	51.9%	12.8% (Goodwin: 5.8%)	ni	"General retouch", notch, denticulate, backing (Goodwin: Oak leave points, retouch on points)	Thompson and Marean (2008), Goodwin and Malan (1935)
Blombos	M3 phase	MIS 5c-b	101 ± 4 ka - 94 ± 3 ka OSL, U/Th	100% local: silcrete (65%), quartzite (19%), quartz (17%), other (1%)	Unidirectional parallel, centripetal parallel, inclined	20%	No differentiation to blades	8%	72%	0%	15.7%	2.3%	1.3%	notch, denticulate, scraper, short retouch, borer, burin	Douze et al. (2015)

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Coastal adaptation at Klasies River main site during MIS 5c-d (93 - 110 000 years ago) from a southern Cape perspective.

Content

Coastal adaptation at Klasies River main site during MIS 5c-d (93 – 110 000 years ago) from a southern Cape perspective

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Abstract

Coastal adaptation in the southern Cape can be seen around 100 000 years ago in sites such as Klasies River, Blombos Cave, and Pinnacle Point, representing the occupation of a new niche by *Homo sapiens* in this region. However, there is relatively little information available on the details involved in fully entering this niche from a regional perspective. At Klasies River main site (KRM), evidence for coastal adaptation occurs in early MIS 5. Here we explore the variability in shellfish exploitation and how it links to lithic technology, in deposits dating to ca. 93-110 000 years ago. We compare this to broadly contemporaneous assemblages from Pinnacle Point 13B and Blombos Cave. The lithics in all the layers investigated here have been produced according to a unidirectional reduction system, but the lowermost assemblages contain more small debitage and bladelets, but no tools. The 110 ka layers are associated with a lower shellfish density, a more diverse range of shellfish species and a higher lithic density. This points to a lesser dependency on shellfish coinciding with higher mobility in the lower layers. For the younger MIS 5c layers higher volumes of shellfish and the dominance of certain species is evident. The lithics show that all the stages of the reduction system are present and tools are produced and used on-site. This indicates a residential (provisioning of place) occupational strategy. Compared to other sites on the southern Cape coast, KRM shows exceptionally high densities in lithic artifacts while the shellfish densities are comparable to the Blombos M3 phase. The results of the analysis of the shellfish and lithic densities, technological patterns, and shellfish species exploited at Klasies River, Blombos

Cave and Pinnacle Point, demonstrate a more diverse onset and expression of coastal adaptation during early MIS 5 than apparent from current literature.

Keywords: coastal adaptation, MIS 5, Klasies River main site, southern Cape, Middle Stone Age

Introduction

Middle Stone Age (MSA) modern humans in Africa, as well as Neanderthals in Europe, exploited marine resources and occupied coastal landscapes for over 100 000 years (ka), from MIS 6–3 (see e.g. Kyriacou et al. 2014, 2016; Parkington 2003, 2010; Steele and Klein 2008; Will et al. 2019). Coastal adaptation is signified by the regular consumption of marine resources acquired through systematic hunting, gathering (Will et al. 2016), scavenging, and chasing of birds and other species (Jerardino 2016). Coastal adaptations imply systemic and planned utilization of coastal resources (e.g., Jerardino 2016; Klein et al. 1999; Marean 2014, 2016; Will et al. 2016, 2019). There are different degrees of systematic exploitation of coastal resources, with some only recognizing 'coastal adaptation' when the use of coastal resources is "transforming" in the sense that adaptation revolved around the sea (Marean 2016:7). Coastal adaptation also means the introduction of a new ecological niche (d'Errico et al. 2017).

South Africa, specifically the Cape area, contains much of the evidence for MSA coastal adaptations in Africa, as discussed by several recent reviews (Jerardino 2016; Klein and Bird 2016; Marean 2014; Will et al. 2015, 2016a, 2019). Most of these localities preserved evidence dating to between 110 ka and 50 ka (MIS 5–3) (Will et al. 2019). Coastal adaptation prior to 110 ka occurs only at a handful of sites. The earliest coastal occupation is from Pinnacle Point Cave 13B (PP13B), dating to ca. 164 ka which falls within MIS 6 (Marean 2010, 2016). Marean (2016) proposed that Pinnacle Point and the now-submerged Paleo-Agulhas Plain were a refugium for early modern humans during harsh climatic conditions with unpredictable food resources (Marean 2016, 5). Other pre 110 ka sites with shellfish are KRM and Ysterfontein 1 (Avery et al., 2008; Wurz, 2012), both described as early 'true shell middens' (Klein and Bird 2016: 200). Sites with shell-rich deposits in the 110 – 50 ka time bracket from the Cape include MIS 5-3 deposits at KRM (Deacon and Wurz 2005; Langejans et al. 2012), Blombos Cave

(Henshilwood et al. 2001; Langejans et al. 2012), Klipdrift Shelter (Henshilwood et al. 2014) and Pinnacle Point (Marean 2010; Jerardino and Marean 2016). Coastal adaptations in Africa "consistently show that MSA hunter-gatherers collected predominantly large individuals from a narrow range of shellfish (i.e. limpets and mussels) living in the upper reaches of the intertidal zone" (Will et al. 2019, 14). In the MSA, shellfish exploitation was accompanied by substantial amounts of large mammals , including Cape fur seals, sea birds, tortoises, and ostrich eggs (Bird and Klein 2016).

The consumption of coastal resources, especially for the MSA Cape coastal sites, has received much attention for the possible evolutionary advantages that it may confer concerning the evolution of *Homo sapiens* (Will et al. 2019). Shellfish is rich in iodine, iron and Omega 3 fatty acids such as docosahexanoic acid (Broadhurst et al. 2002; Crawford et al. 1999; Cunnane et al. 1993; Parkington 2003), nutrients important in supporting brain function (e.g. Cunnane 2010; Kyriacou et al. 2014, 2016). It has been hypothesized the increase of such nutrients may have played a role in the development of technological innovations occurring on the Cape coast (Parkington 2010, but see Klein and Bird 2016). Another hypothesis is that the coastal Cape Floristic region, with its diversity of fauna and flora, specifically geophytes combined with dense beds of shellfish played key role in the evolution of humans' unique capacity for culture (Marean 2016). The shift to the exploitation of these dense and predictable resources around 110 ka might have triggered territoriality and aggressive defense, which, from the perspective of Behavioral Ecology lead to selection for the uniquely human traits of prosociality and cooperation (Marean 2016).

KRM, one of the most extensively researched palaeoanthropological and archaeological localities in South Africa, preserves evidence of coastal adaptation (Deacon and Geleijnse 1988; Klein and Bird 2016; Singer and Wymer 1982; Wurz et al*.* 2018) from around ca. 120 – 43 ka (see Wadley 2015 and Grine et al. 2017 for recent syntheses of the ages). Although KRM contains mainly MSA evidence, it was also occupied between ca. 4.8 and 2.3 ka resulting in large shell middens on top of the MSA deposits in Cave 1 (Binneman 1995; Nami et al. 2016; Singer and Wymer 1988). The shellfish exploitation of the MSA deposits has been described in several publications (Dusseldorp and Langejans 2003; Langejans et al. 2012, 2017; Thackeray 1988; Wurz 2012; Will et al. 2016, 2019) and for LSA by Voigt (1982) and Binneman (1995). This body of data shows that the shellfish species exploited through time varied, but that *Perna perna* always remained a favored species. The palaeoenvironment and distance of the site to the coast played a role in which shellfish species were targeted (Dusseldorp and Langejans 2013). Seal hunting and some fishing formed part of the coastal adaptation (Van den Driesch 2004; Van Niekerk 2011). The distance from KRM to the shore was at its maximum during MIS 4, but for many periods, especially during MIS 5e-a, the coast was never more than ca. 2 km away (Langejans et al. 2012; Shackleton and Van Andel 1986). This implies easy access to the coast, as near-coastal zones up to ca. 10 km wide are thought to be accessible during a normal day's foraging (e.g. Bigalke 1973). At KRM the numerous faunal remains indicate that the consumption of shellfish and other coastal resources was accompanied by significant reliance on faunal resources throughout (Klein 1976; Van Pletzen et al. in press). The occurrence of starch parenchyma in hearth ashes (Larbey et al. 2019) provides direct evidence for the plant component of the diet. Deacon (1993) suggested that plant remains, especially geophytes, played an essential role in the diets of the KRM coastal dwellers.

The lithic technology at KRM reveals changing strategies through time with the MSA I covering the earliest period (MIS 5e-d), followed by MSA II lower and upper that occurred during the rest of MIS 5.. In the early lithic technologies prepared core technologies were used to produce unretouched quartzite point and blade end products (Wurz 2002; Brenner and Wurz 2019). The MIS 4 Howiesons Poort reflect more diverse raw material exploitation, and a focus on smaller blades sometimes retouched into notched and geometric retouched artifacts (Wurz 2002; Villa et al. 2010). The MIS 3 post-Howiesons Poort sees a return to the production of larger quartzite products reminiscent of the MIS 5 artifacts (Wurz 2002; Villa et al. 2010). The Later Stone Age Wilton related to the 'Kabeljous' culture comprises an expedient quartzite technology associated with thick backed scraper-knives, sometimes termed giant crescents (Binneman 1995; Singer and Wymer 1982).

This paper focuses on the interval of time around 110 ka as this is touted as the 'watershed' period after which coastal adaptation became more prevalent on the Cape coast (Marean 2016; Will et al. 2019). The lithic technology described from layers SMONE to SBLS has essentially the same character of the MSA II lower dating to MIS 5c-d described in Brenner and Wurz (2019) and Wurz (2002). It predominantly follows a unidirectional reduction system for the production of point and blade products. The cores are characterized by a Levallois-like core preparation on parallel cores or semi-rotational platform cores. Brenner and Wurz (2019) added more detail to the lithic patterning from layers SMONE to BOS One & Two. It was shown one *chaîne opératoire* was used to create a variety of end products, which are mostly triangular flakes. Apart from this reduction system, an informal bladelet reduction method was identified with some bladelet cores and bladelets.

As detailed information from this time is lacking, we discuss the evidence for coastal foraging dating to between 110 and 93 ka from recently excavated layers from the Witness Baulk in Cave 1, KRM. Shellfish foraging forms only one part of coastal adaptation, but it is frequently discussed without integration with other aspects of the lithic economy (but see Marean 2010; Wurz 2012; Will et al. 2013 for discussing shellfish and lithic assemblages in combination). As for the shellfish data, lithic technological patterning for the 110 ka phase at KRM is known only for lumped data from extended time periods (e.g. Wurz 2002; 2012, but see Brenner and Wurz 2019). Here we would like to bridge the gap between shellfish exploitation and other aspects of coastal foraging through a detailed analysis of change through time in two aspects of coastal economy, lithic technology, and shellfish exploitation, from sequential layers dating to between MIS 5c-d (93-110 ka). We then compare this to the same find categories of broadly contemporaneous assemblages from Blombos Cave (BBC) and PP13B in order to contribute to a better understanding of coastal adaptation at the critical 110 ka phase in the southern Cape. We address lithic and shellfish density, lithic technology, shellfish diversity, and opercula size differences through time.

Sea level and paleoenvironment

We discuss here how the major trends in lithic technology and shellfish exploitation from KRM MIS5c-d compare to assemblages from PP13B and BBC M3. This is a period that was marked by fluctuating sea levels and environments.

During the MIS 5e highstand (ca. 120 ka) Cawthra et al. (2018, 169) calculated a sea level of +6.3 m from offshore sequences around Great Brak, Mossel Bay area. They noted regressive events during MIS 5d (ca. 117–119 ka) with sea levels of -26 to -29 m with a further "short-lived" regression of sea levels to around -36 m that occurred around 110 ka. This was followed by transgression to a "short-lived" still stand of -25 m at ca. 107–108 ka (Cawthra et al. 2018, 170). Sea levels rose again to -24 m at 93.9 ± 5 ka, in MIS 5c, although the OSL ages for this unit might be 'underestimated' (see also Compton 2011). During MIS 5c and 5b (96-82 ka) there were further regressions, from ca -37 to -72 m, and sea levels only rose again at the end of MIS 5b (to -37 m) (Cawthra et al. 2018, 170). The distance to the coast for KRM, PP13B, and BBC would have been differently affected during this period as the topography of the ocean floor influences the degree of coastline regression. The steep cliff characterizing the coastal plain of Plettenberg Bay to KRM, for example, allowed the shoreline to remain within 2.02 – 2.32 km during the regressive phases of MIS 5c-d (Langejans et al. 2012, 92). For the BBC M3 phase the distance to the coast was, on average, 2±2 km, but never exceeded a maximum of 4.1±2 km (Fisher et al. 2010: 1395). Fisher et al. (2010: Table 1) argue that PP13B was only 0.08 km from the seashore during MIS 5e. The plain opened up by 1-4 km in MIS 5c, which means the shore was relatively close to PP13B during most of MIS 5

Palaeoenvironments fluctuated in concert with the sea levels. At KRM, the microfauna indicates moist environments and more closed vegetation patterns (Avery 1982, 1987; Nel 2013; Nel et al. 2018). The large mammal fauna for the MIS 5c-d Singer & Wymer layers 17a and b (Klein 1976) and the Deacon MSA II lower layers indicate that grazers decrease while mixed feeders and browsers increase (Van Pletzen 2000; Van Pletzen et al. in press). For the Pinnacle Point area, Braun et al. (2019, 281) note that during most of MIS 5, the vegetation was dominated by C3 plants and stratiform winter rainfall. However, during a short episode at ca. 106–107 ka, evidence for mixed vegetation and increased convective summer rainfall are present. For PP13B a more closed vegetation and fynbos biome indicated by micromammal assemblage characterized the early MIS 5 replacing grasslands and open vegetation of the preceding period (Matthews et al. 2009, 2011; Braun et al. 2019). Micromammals indicate no significant changes but rather consistency during MIS 5 with the same species throughout which are catholic in their habitat, indicating a diverse environment (Matthews et al. 2009, 110). The same trend is seen in the faunal record of PP13B, which evidences the same species diversity during all MIS 5 deposits, pointing towards a wetter grassland (Rector and Reed 2010, 347). The paleoenvironment around BBC during the MSA is generally described as grassier than the present fynbos biome (Henshilwood et al. 2001). The Cape zebra in M3 also suggests arid conditions (Nel 2007). The shellfish give a "small cold water signal" (Langejans et al. 2013, 26).

Figure 1. Map of South African MIS 5 sites mentioned in thsi paper. Blombos Cave (BBC), Pinnacle Point (PP), Klipdrift Shelter (KDS), Klasies River main site (KRM), Ysterfontein 1 (YF 1) (adapted from Brenner and Wurz 2019).

The sample

Recent excavations directed by Wurz started in 2015, with a focus on the Witness Baulk in the center of Cave 1, and are ongoing. The excavations continue from earlier fieldwork lead by Deacon (Deacon and Geleijnse 1988; Deacon 1995), going deeper into the layers belonging to the MSA II lower or Mossel Bay techno-complex (Singer and Wymer 1982; Wurz 2002) not excavated by Deacon. Overall, the MSA II at KRM consists of more than 10 meters of deposit, but all of the lithic material from these deposits have been grouped within a single phase, with two sub-stages (Wurz 2002), MSA II lower and MSA II upper. The lithic and shellfish materials are from square C1, 50 x 50 cm. This square was selected for this analysis as all of the layers are well preserved in this location, whereas most of the layers in the SASL sub-member thin out towards the western part of the Witness Baulk, towards squares A1-3 (Figure 1). Four layers (Brenner and Wurz 2019; Wurz et al. 2018) have been excavated. The uppermost layer SMONE (Shell Midden One) is a tumble layer which is 5 cm thick in the western part of the Witness Baulk and thickens towards the east, with the thickest part in square C1 (Brenner and Wurz 2019). Below this the BOS (Black Occupational Soils) layers occur with a matrix of dark moist clayey soil. These deposits consist of well-preserved evidence of human occupation, and represent a palimpsest with most of the archaeological remains occurring in primary position, although much winnowing of the soil matrix took place resulting in finds tightly 'stacked' (Brenner and Wurz 2019). The layers have been excavated as spits as a strategy to interrogate the site formation processes for this layer. The data for BOS One & Two are combined (Brenner and Wurz 2019), and BOS Three forms a further spit. The SBLS (Silty Black Soil) layer is the lowermost deposit described in this paper and, so far, has only been excavated in the South-East part of the excavation area. This layer consists of dark silty soils, with clay patches devoid of archaeological material forming in some areas. All of the layers contain lithics, abundant well preserved fauna and microfauna, and shellfish. There is a significant presence of tufa material and flowstone in BOS One to Three. No intact hearths are preserved in SMONE and BOS, but large patches of leached ash occur, especially in the BOS layers. In contrast, hearths with preserved ashes occur in the SBLS layer. In BOS quartzite blocks of varying sizes, many of these in red hues, indicate that they were heated, and may have been used in cooking methods (Bentsen and Wurz 2017, 2019; Pickering pers comm. 2019, report in progress). SMONE is estimated to date to MIS 5c, at around 93–106 ka (Wurz et al. 2018) while the BOS and SBLS layers are dated to MIS 5d at approximately 110 ka as indicated by stalagmite material occurring at the interface of SBLS and BOS Three dated by uranium-series method (Brenner and Wurz 2019).

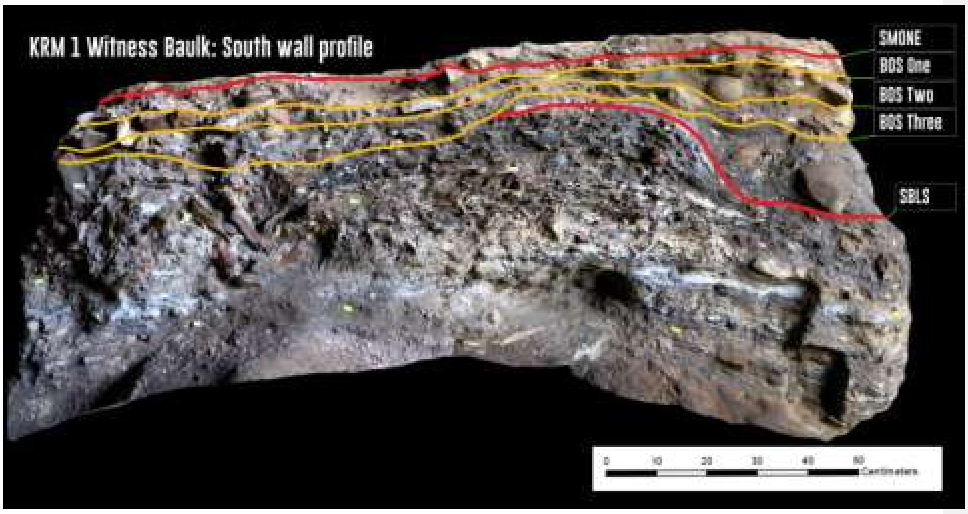

FIGURE 2. STRATIGRAPHY OF THE 2015–2018 EXCAVATION OF THE WITNESS BAULK AT KRM CAVE 1 (ADAPTED FROM BRENNER AND WURZ 2019).

The volumes of deposit excavated for Square C1 separately, and all squares combined (A1-C3 for SMONE and BOS, C1-3 for SBLS) are presented in Table 1. The highest volume of deposit for Square C1 was excavated from SMONE and BOS Three and comparable amounts for BOS One & Two and SBLS.

TABLE 1. KRM VOLUMES OF DEPOSIT

Square	**SMONE** m^3	**BOS One & Two** m^3	**BOS Three** m^3	**SBLS** m^3
C1	0.02	0.01	0.03	0.01
All Squares (A1-C3)	0.05	0.08	0.25	0.02*

*only squares C1-C3

Methods

All finds including lithics, faunal material, shellfish, ochre, heated quartzite, and tufa >2 cm have been piece plotted.

Lithics

The small lithic debitage was retrieved after dry sieving with 5 and 2 mm meshes, followed by wet sieving with 0.5 mm mesh. For the lithics, a *chaîne opératoire* approach has been adopted in combination with attribute analysis (see Brenner and Wurz 2019). The assemblage composition is presented with the categories of the different blank shapes, cores, chunks, hammerstones, cobble/pebble fragments and small debitage <2 cm. Raw materials have been visually inspected. For the weight determination a digital scale was used and dimension measurements on the lithics >2 cm have been recorded with a digital caliper. The typology for cores and blanks is detailed in Brenner and Wurz (2019). Technological categories of blanks include end products, and preparational flakes such as debordants or core-edge-flakes, core-surface-management flakes, platform shaping flakes, decortification flakes and *entames* (first flakes). End products are defined here as blanks that show symmetrical edges and regularity in their dorsal negative scar patterns. Some of these may have been the intended products of the reduction sequence (following Brenner and Wurz 2019; Douze et al. 2015). Other technologically informative pieces include debordants, core management, and decortification flakes (Brenner and Wurz 2019). Debordants are core edge flakes, which mostly show one cortical side. Core surface management flakes and platform shaping flakes are for the preparation and restoration of the removal surface and the core platform edge. Decortification flakes show a mostly cortical dorsal surface and prepare the cobbles to be set up as cores. An *entame* is a first flake that has a fully cortical platform and dorsal surface. Flaking debris >2cm and indeterminate fragments have been grouped in one technological category. Retouched tools and edge damaged pieces have also been recorded with their specific attributes.

Shellfish

Marine shellfish was identified to species, the minimum number of individuals (MNI) were calculated, and the shells were weighed using a digital scale. It is judicious to establish both MNI and weight values because using only one criterion may lead to underrepresentation or possible overrepresentation of some species (see Henshilwood 2008; Langejans et al. 2013). The maximum diameter of *Turbo sarmaticus* (alikreukel) opercula was measured using a digital caliper. No complete specimens of limpets and *Perna perna* (brown mussel) species were available to measure as most of the specimens are decomposed and highly fragmented.

The MNI values for alikreukel was fewer based on counts of apices and opercula, with the highest value given by MNI. In terms of weight for this species, both opercula and shell were combined. Columella parts were used to establish the MNI values for whelks and top shells (*Diloma sinensis*, *Burnupena limbosa*). The MNI of species such as *Haliotis midae* (abalone) and limpets (*Scutellastra cochlear*, *Scutellastra argenvillei*, *Scutellastra longicosta,* and *Cymbula oculus*) was determined using their apices. The MNI of the giant chiton *Dinoplax gigas* was derived by counting front, back, and middle plates, and middle plates were divided by six. The highest total for the three categories was taken as the MNI (Ryano et al. 2019). The hinges of bivalves brown mussel and *Donax serra* (white mussel) were counted and divided by two to get their MNI counts. We also mention quantities of the giant land snail *Cochlitoma zebra* (previously *Achatina zebra*; http://www.marinespecies.org/aphia.php?p=taxdetails&id=1058530), as this is one of the most numerous species in these layers (Supplementary Figure 1). Its MNI was determined by counting the columella for this species while weight included all available specimens, columella, and other fragments. They may have been consumed or their presence can be interpreted in relation to site formation processes, but a full exposition of these hypotheses is outside the scope of this article.

Shellfish subsistence

Shellfish density is calculated as kilogram of shellfish divided by cubic meters of sediment (kg/m^3) (Henshilwood et al. 2001; Langejans et al. 2012; Thackeray 1988; Will et al. 2019). The shellfish density for layers BOS One & Two (105.3 kg/m^3) is the highest followed by SMONE (90.3 kg/m^3). The density of shellfish for layer SBLS is 43.3 kg/m^3 while BOS Three is the least dense layer (13.3 kg/m^3) (Table 3, Figure 3).

TABLE 2. KRM SHELLFISH DENSITY FOR SQUARE C1

	SMONE	BOS One & Two	BOS Three	SBLS
Shellfish weight in g	1987.3	999.94	362.21	365.6
Volume of deposit m^3	0.02	0.01	0.03	0.01
Shellfish density (kg/m^3)	90.3	105.3	13.3	43.3

The MNI and weight values for each species and their percentage frequencies (based on layer totals) are presented in Table 3. Barnacles are excluded in this analysis as they presumably entered the site attached to the bigger shells (see Langejans et al. 2017). Rare (< 4 of total MNI) species were combined. These data show that in the topmost layer, SMONE, the most abundant species both in terms of % MNI and % weight are alikreukel followed by brown mussel, abalone, and top shells. Other species are only marginally represented in this layer. In layer BOS One & Two, there is some change in shellfish representation with brown mussel now the most abundant, followed by alikreukel (41.9%, 24.3% in terms of weight), but with whelks added (10.6% of weight). However, MNI values provide a different impression for layer BOS One & Two. Brown mussel (39.8%) is still dominant, but the next most frequent species are whelks *(21.1%)*, top shells *(15.5%)*, and the turban shell alikreukel (13.7%) (Table 12). In Layer BOS Three a different composition is evident as alikreukel again becomes dominant both in terms of MNI and weight, at 45.6% and 56.4%, respectively. Brwon mussel is the second most dominant species in this layer. Whelks*,* top shells, limpets (*C. oculus),* and *Patella sp*. are also represented, but in lower quantities (Table 3, Figure 3). The MNI of three species (giant chiton, white mussel, and limpets (*S. argenvillei)*) represent 1.5% each while their contribution in terms of weight is only around 1% when combined. Layer SBLS also shows a different composition. Here the dominant species is brown mussel (36% and 31.6%) but followed, in decreasing order of abundance, by top shells (22%, 9.3%), alikreukel (12%, 13.3%), *Patella sp.* (8%, 24.3%) and whelks (6%,9.2%) (Table 3) in terms of both MNI and weight. *C. oculus* limpets (6%, 5.4%) and giant chiton (4%, 3.5%) are also well represented in layer SBLS, more so than in the other layers. Four species (*Aulacomya atra*, *Turritela cerinifera*, *Bulli sp*., and *S. barbara*) are combined into 'other', and their representation is proportionately higher in the three lowermost layers than in SMONE (Figure 3).

TABLE 3. SQUARE C1 SHELLFISH MNI AND WEIGHT AND THEIR PERCENTAGE FREQUENCIES PER LAYER TOTAL

Layers	**SMONE**				**BOS One + Two**				**BOS Three**				**SBLS**				**Total**			
Species	MN	%M	g	%g	MN	%M	g	%g	MN	%M	g	%g	MN	%M	g	%g	MN	%M	g	%g

	I	NI			I	NI			I	NI			I	NI			I	NI		
Dinoplax gigas	-	-	-	-	3	1.9	11	1.1	1	1.5	0.4	0.1	2	4	12.7	3.5	6	1.3	24.1	0.7
Turbo sarmaticus	94	47.5	1036.0	52.1	22	13.7	243	24.3	31	45.6	204.42	56.4	6	12	48.5	13.3	133	29.1	1388	38.9
Cymbula oculus	1	0.5	11.79	0.6	1	0.6	84.51	8.5	3	4.4	25.59	7.1	3	6	19.7	5.4	8	1.8	141.59	4.0
Diloma sinensis	1	0.5	9.3	0.5	34	21.1	105.5	10.6	10	14.7	36.6	10.1	3	6	33.7	9.2	48	10.5	185.1	5.2
Donax serra	1	0.5	5.6	0.3	1	0.6	2.6	0.3	1	1.5	1.1	0.3	1	2	11.1	3.0	4	0.9	20.4	0.6
Perna perna	82	41.4	453.8	22.8	64	39.8	419	41.9	14	20.6	56.1	15.5	18	36	115.4	31.6	178	38.9	1044.3	29.2
Haliotis midae	4	2.0	369.2	18.6	2	1.2	11.6	1.2	0	0.0	0	0.0	0	0	0	0.0	6	1.3	380.8	10.7
Scutellastra argenvillei	2	1.0	39.3	2.0	1	0.6	4.15	0.4	1	1.5	19.1	5.3	0	0	0	0.0	4	0.9	62.55	1.8
Burnupena limbosa	10	5.1	11.11	0.6	25	15.5	66.8	6.7	4	5.9	10.3	2.8	11	22	34	9.3	50	10.9	122.21	3.4
Scutellastra longicosta	1	0.5	0.3	0.0	2	1.2	8.2	0.8	0	0.0	0	0.0	1	2	1.2	0.3	4	0.9	9.7	0.3
Patella sp.	1	0.5	49.8	2.5	2	1.2	41.31	4.1	2	2.9	6	1.7	4	8	8.7	24.3	9	2.0	185.81	5.2
Other	1	0.5	1.12	0.1	4	2.5	2.27	0.2	1	1.5	2.6	0.7	1	2	0.6	0.2	7	1.5	6.59	0.2

Total	198	100.0	1987.3	100.0	161	100.0	999.94	100.0	68	100.0	362.21	100.0	50	100	365.6	100.0	457	100.0	3571.2	100.0

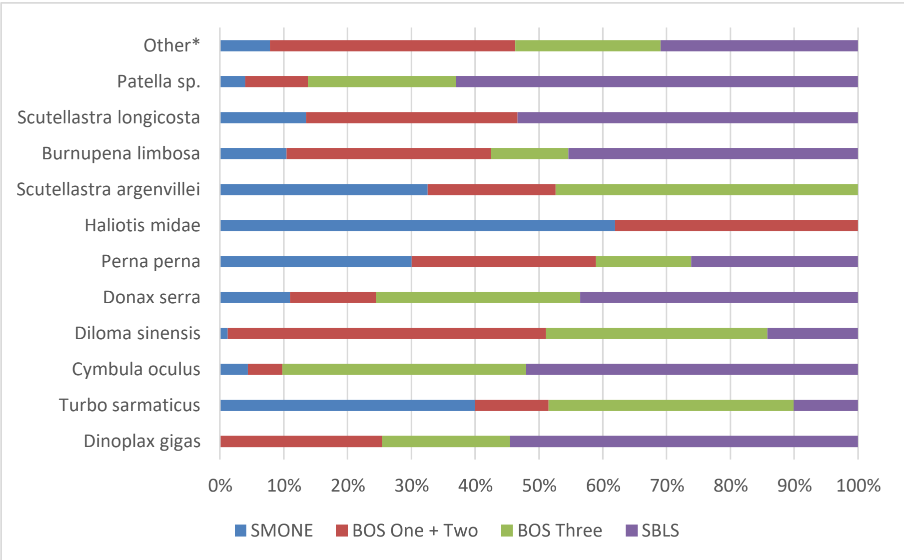

FIGURE 3. MNI PERCENTAGE FREQUENCIES OF SHELLFISH SPECIES IN THE MSA LL LOWER, SASL SUB-MEMBER CAVE 1 WITNESS BAULK, KRM. THE SPECIES ARE ARRANGED ACCORDING TO THEIR RANKING BASED ON HANDLING COSTS (E.G. LANGEJANS ET AL. 2012).

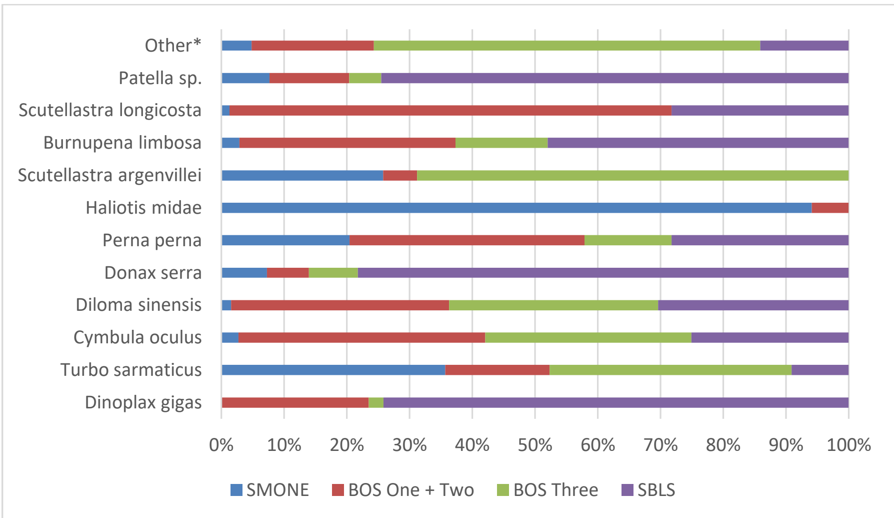

FIGURE 4. WEIGHT PERCENTAGE FREQUENCIES OF SHELLFISH COMPOSITION IN THE MSA II LOWER, SASL SUB-MEMBER, CAVE 1 WITNESS BAULK, KRM THE SPECIES ARE ARRANGED ACCORDING TO THEIR RANKING BASED ON HANDLING COST (E.G., LANGEJANS ET AL. 2012).

Giant land snails (*C. zebra*) may also have contributed proteins if consumed. Some analysists believe that they were collected for subsistence during prehistoric times (e.g., at Haua Fteah in Libya, Barker et al. 2012). However, our observations suggest that its inclusion in the site is post-depositional. Unlike the shellfish, the remains of this species are not affected by fires, and some of the shells are complete, in contrast to the fragmentary state of the marine shellfish. We briefly mention the varying proportions of giant land snails here, as this may indicate differences in site formation and post-depositional processes. Giant land snails constitutes 5.7% and 30.0% of MNI and weight respectively in layer SMONE, 4.2% and 11.9% in layer BOS One & Two, 10.5% and 36.3% in layer BOS Three while its presence decreases noticeably in layer SBLS (2% and 6.9%) (Supplementary Figure 1). Layer SBLS stands out as containing much less giant land snails than the other layers and SMONE and BOS Three showin the increased degree of fragmentation.

Alikreukel opercula lengths

Summary statistics of the lengths of alikreukel opercula lengths are presented in Table 4. The median value shows that there is no variation in the size of alikreukel collected by the occupants of three layers (SMONE, BOS Two, and BOS Three) while the opercula from layer SBLS are smaller than in the other layers (median = 27 mm). This is likely because of the small sample size (n = 3) in this layer.

TABLE 4. SUMMARY STATISTICS OF ALIKREUKEL OPERCULA FROM SQUARE C1 AT KRM

Variables	SMONE	BOS Two*	BOS Three	SBLS
Mean	35.7	38.3	37.2	29.3
Median	36	38	37.5	27
Standard Deviation	4.7	2.6	4.8	7.8
Range	21	10	18	14.99
Minimum	23	32	24	23
Maximum	44	42	42	37.99
Frequency	49	11	20	3

*There were no complete opercula for BOS One

Lithics

Lithic density

Lithic density of South African MSA depostis has been expressed by various measures, e.g., Marean (2010) (n/m³ and g/m³), Mackay (2006) (g/m³), Wadley et al. (2016) (n/l). We report the densities as artifact number per liter (after Wadley et al. 2016) as n can be more straightforwardly related to the lithic assemblage composition (Table 6).

SMONE and BOS One & Two have similar densities of artifacts per liter in square C1. BOS Three is slightly denser with lithics, but SBLS shows by far the highest density of lithics with 2475 lithics in 8.5 l of deposit.

TABLE 5. KRM LITHIC DENSITY FOR SQUARE C1

	SMONE	BOS One + Two	BOS Three	SBLS
lithic artifacts n	1087	467	1684	2475
liter*	22	9.5	27.3	8.5
artifact density	49.41	49.16	61.68	291.18

* liter is used here instead of m³ as in Table 1 to facilitate comparison with other lithic analyses.

Lithic technology

The raw material composition is mostly the same between the layers, with only slight fluctuations (Supplementary Table 1). Layer SBLS has the highest amount of medium-grained quartzite, which is of good knapping quality and less coarse-grained material such as Table Mountain Sandstone (the parent rock of the cave). The high amount of small debitage, between 67% and 92% (Table 6) and the relative abundance of cortex (Supplementary Table 2: 18-30%) indicate on-site knapping in general, although hammerstones are only found in SMONE and BOS One & Two (Table 3). Layers SMONE and SBLS have somewhat lower amounts of cortex (18 and 22%) than the BOS layers (28 and 30%).

There are changes through time in terms of the assemblage composition. The amount of small debitage (pieces <20mm) varies between the layers. It is highest in SBLS (Table 6: 92%), related to a significantly higher artifact density generally in SBLS (Table 1). Although there is a small bladelet component in all the assemblages, the numbers are higher in the lower two layers, BOS Three and SBLS (complete bladelets and bladelet fragments constitute 8% and 5 % of the assemblage in BOS Three and SBLS respectively). It is noticeable that in the BOS One & Two assemblage the frequency of cores and hammerstones is the highest, but there is the least small debitage. The blank classes including points, blades, bladelets, and flakes, show similar frequencies throughout the layers.

Table 6. 2015-2018 sample assemblage composition for square C1 with a percentage of assemblage >2cm. Percentage in brackets relates to the grand total (including small debitage).

Assemblage composition	SMONE		BOS One + Two		BOS Three		SBLS		Total	
	n	%	n	%	n	%	n	%	n	%
point	20	7%	15	9%	22	7%	15	8%	70	7.3%
blade	5	2%	9	6%	10	3%	1	1%	24	2.5%
bladelet	2	1%	1	1%	4	5%	1	1%	7	0.7%
flake	65	23%	28	18%	53	17%	40	20%	193	20.2%
point/blade fragment	30	10%	23	15%	67	21%	38	19%	156	16.3%
bladelet fragment	0		0		11	3%	8	4%	19	2.0%
fragment	71	26%	25	16%	79	25%	59	30%	231	24.2%
core	8	3%	9	6%	8	3%	2	1%	27	2.8%
chunk	75	26%	30	19%	55	17%	29	15%	189	19.8%
hammerstone	2	1%	9	6%	0		0		11	1.2%
cobble/pebble	6	2%	7	4%	8	3%	6	3%	27	2.8%
Total > 2cm	**284**	**100%**	**156**	**100%**	**317**	**100%**	**199**	**100%**	**956**	**100%**
small debitage	803	(74%)	311	(67%)	1684	(84%)	2276	(92%)	5074	(84.1%)
Grand total	**1087**	**(100%)**	**467**	**(100%)**	**2001**	**(100%)**	**2475**	**(100%)**	**6030**	**(100%)**

Supplementary Table 3 shows the frequency of technological categories per assemblage The blanks of each layer are predominantly end products (Supplementary Table 3: 32.1-58.6%, see also Table 5), with BOS Three and SBLS comprising fewer end products compared to the upper layers. The amount of debordants is highest in BOS One & Two. SBLS has the most numerous core surface management flakes and platform shaping flakes. Decortification flakes are present throughout but are most numerous in the BOS layers. The amount of dorsal cortex mirrors the pattern of the decortification flakes, as the BOS layers show higher frequencies of flakes with remaining cortex (Supplementary Table 2). *Entames* are almost absent, with only one piece each in BOS Three and SBLS.

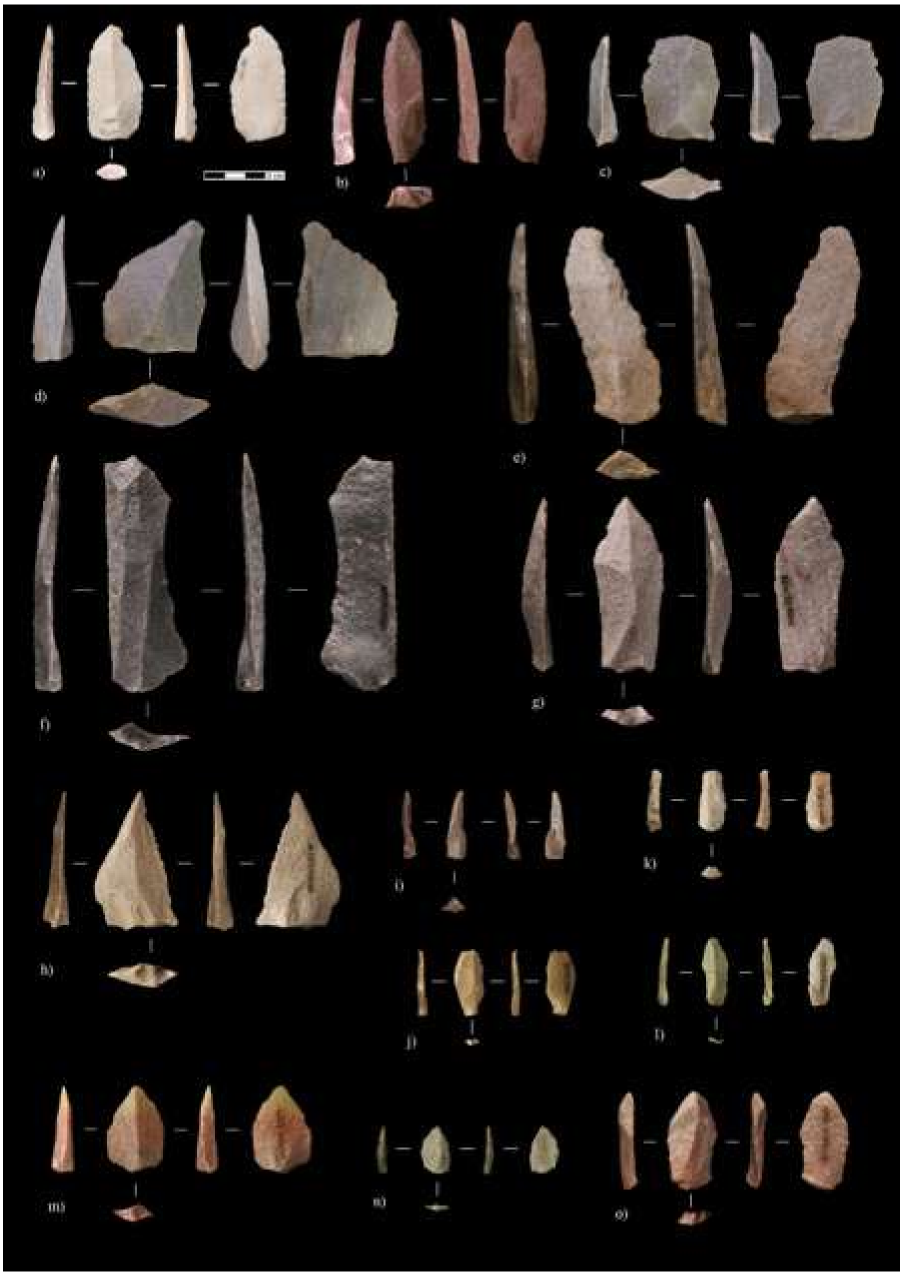

FIGURE 5. KRM LITHIC MATERIAL FROM SMONE: A-D), BOS ONE & TWO: E-G), BOS THREE: H-J) AND SBLS: K-O).

In Supplementary Tables 4 and 5, the dimensions of the blanks are compared between the layers. In all the layers, points have thicker platforms than blades. The external platform angle (EPA) stays the same throughout blank types and layers (between 80 and 90°). BOS One & Two exhibits the heaviest blanks (Supplementary Table 5), and the points and flakes are also longer, wider and thicker compared to all other layers. SMONE and BOS Three have similar blank dimensions. SBLS has a distinct pattern of blank dimensions, as all the blanks are lighter, shorter, narrower and thinner than in any layer above (although there are no complete blades). Additionally, the platforms of points, blades, bladelets, and flakes are thinner than in any assemblage above (Supplementary Table 4). This could relate to a "downsizing" or perhaps maximizing the raw materials during SBLS, which also includes the most small debitage. See Supplementary Table 5 for technological length (mm), maximum width (mm), maximum thickness (mm) and weight (g) of blanks by type.

Tools are divided into formal tools, which show distinct and intentional edge retouch, and edge damaged pieces with irregular damage, which might have been caused by use (Brenner and Wurz 2019; Douze et al. 2015). The formal tools are scarce throughout the sequence, with 1% in SMONE and BOS Three and 3% in BOS One & Two, but absent in SBLS (Supplementary Table 6). Edge damage is much more frequent than retouched tools (especially in SMONE and BOS One & Two), with SBLS also showing the least edge damage compared to the other layers.

Reduction method

In SMONE and BOS One & Two, the orientation of dorsal negatives on end products is most frequently unidirectional (Supplementary Table 7: 65-73%). However, BOS Three and SBLS show less unidirectional orientation, but most of the dorsal scar patterns fall into the category where dorsal negative orientation is indeterminate. A clear bidirectional scar pattern is seen in comparable frequencies throughout the sequence (10-18% of end products).

The cores are described following Conard et al. (2004) with parallel cores exhibiting two volumes, one for preparation and one for the reduction of products, and the production surface parallel to the plane of intersection, and platform cores, some of which follow a volumetric system (Supplementary Table 8). However, the differentiation between parallel and platform cores can be ambiguous if the reduction is semi-rotational (Conard 2012). The core types comprise mostly parallel cores, with BOS Three showing the highest amount of parallel cores. Platform cores are less frequent and completely absent in SBLS. BOS One & Two has the highest amount of indeterminate cores, where the surface is too altered (probably due to post-depositional processes) to indicate further characterization. This layer also has the most initial and multidirectional cores, which implies a stronger focus on opportunistic reduction (see Brenner and Wurz 2019).

The differences between the layers are subtle, but they are more apparent in the lowest layer, SBLS. Layer SMONE has slightly more flakes and chunks than the other layers. In other respects, the upper layers, SMONE and BOS One & Two are more similar to each other compared to the lower layers, displaying a lower artifact density with less small debitage, the presence of hammerstones while bladelets are almost absent. A higher frequency of end products and edge damage characterizes these two layers.

In the underlying layer BOS Three, the artifact density is slightly higher, as is the frequency of small debitage. The bladelet component is the highest with 8%. End products and edge damaged pieces are slightly less numerous than in the upper layers. The blank dimensions (Supplementary Table 5) are very similar between the SMONE and BOS layers, with BOS One & Two showing the heaviest and biggest products.

SBLS shows the most dissimilarity in the lithic material. The artifact density is five times higher than in the upper layers, and the small debitage makes up more than 90% of the assemblage. Bladelets occur with a frequency of 5%. End products and edge damaged pieces are least common in this layer, and tools are entirely absent. Furthermore, the blanks exhibit much smaller dimensions in regards to length, width, thickness, weight, and platform thickness compared to the upper layers. All blanks are lighter, narrower, and thinner; points, blades, and flakes have thinner platforms, and points and flakes are much shorter.

Discussion: A broader comparison to southern Cape sites

The shellfish exploitation and lithic manufacture from the three sites discussed here were behaviors expressed within a changing southern Cape coastal landscape during MIS 5c-d. We firstly use density as one of the measures to compare the assemblages. After that, we discuss how the assemblages from KRM analyzed here compare to the two relevant phases at PP13B and the M3 phase at BBC in relation to shellfish exploitation and lithic technology. The latter provides information on provisioning systems, which Mackay et al. (2014; 2018) propose to be an essential piece of the puzzle to characterize MSA occupations. Kuhn (1995) defines provisioning of place and provisioning of individuals as the two extremes on a continuous range. Place provisioning infers long-term or repeated occupation of a site with predictable resource availability (Kuhn 1995; Mackay et al. 2018). On-site manufacture of implements with cores that are made from local raw material or have been transported to the site characterize place provisioning. Depending on the use of the site the implements are used and discarded on-site or transported to logistical camps.

Individual provisioning is seen in an environment with unpredictable resources, where transport and mobility are more important. The shape and size of implements are therefore more regulated, and tools have to be able to fulfill multiple tasks. Cores are transported so that implements can be manufactured when needed. Archaeologically, small amounts of manufacturing and repair debris are left on-site with implements and cores transported further. Here we also use the shellfish data to provide insight into subsistence behavior that might further inform on residential patterns. A comparison of the lithic technologies of KRM SMONE – BOS One & Two to other southern Cape sites, including PP13B and BBC M3 is detailed in Brenner and Wurz (2019, Supplementary Table 10), and therefore only some aspects are mentioned here in this comparison.

Lithic and shellfish densities

We use the density measures discuss here with caution as Jerardino (2016a, b), for example, notes that matrices, preservation, and mesh sizes differ during data recovery, and deposition rates are not constant. The size of the group that occupied a particular site and their frequency of occupation also affect the relevance of density comparisons. Notwithstanding these concerns, using density as one of the measures to investigate coastal adaption allows us to compare our data to other similar studies (e.g., Dusseldorp and Langejans 2013; Will et al. 2016a, 2019).

In Table 7, shellfish and lithic densities of KRM layers SMONE – SBLS and broadly contemporaneous layers from BBC and PP13B are compared (see Supplementary Material Table 9 for details of the layers and dates). The lithic density of the KRM MIS 5c-d layers discussed here is much higher than the broadly contemporaneous M3 phase from BBC and PP13B layers. Although the lithic density at BBC is somewhat higher than at PP13B, it is still much lower than all the layers at KRM. This points to much more intensive knapping activity at KRM than at the other two sites. The shellfish density at KRM is also much higher than at PP13B for all the layers concerned. Layer SMONE has a similar shellfish density as BBC M3, also dating to MIS 5c. However, the earlier BOS One & Two layer has a higher density, and lower densities are present in the lowermost layers, BOS Three and SBLS.

Table 7. PP13B, BBC, and KRM MIS 5c-d lithic artifact and shellfish densities

	PP13B				BBC	KRM			
assemblage	**MIS 5c (91-99 ka)**	**MIS 5d (99-111 ka)**	**MIS 5e (111-125 ka)**	**MIS 6 (125-195 ka)**	**M3 Phase MIS 5c**	**SMONE**	**BOS One & Two**	**BOS Three**	**SBLS**
lithic artifacts n	2703	42	231	1939	3404	1087	467	1684	2475
liter	1605	548	918	859	1140	22	9.5	27.3	8.5
lithic artifact density n/liter	**1.68**	**0.08**	**0.25**	**2.26**	**2.99**	**49.41**	**49.16**	**61.68**	**291.18**
shellfish kg	3.48	2.07	0.55	0.19	98.22	1.90	1.00	0.60	0.37
m^3	1.605	0.548	0.918	0.859	1.140	0.022	0.010	0.027	0.008
shellfish density kg/m^3	**2.2**	**3.7**	**0.6**	**0.2**	**86.16**	**90.3**	**105.3**	**13.3**	**43.3**

Pinnacle Point 13 B data set: Supplementary Tables 9 and 12 contains the dates and data for the shellfish (Jerardino and Maran 2010) and lithic densities (Thompson et al. 2010). Time frames and the numbers of lithic artifacts are from Thompson et al. (2010). Shellfish weights are from Jerardino and Marean (2010).
Blombos data set: From the M3 phase, CGAA, CGAB, CGABh1, CGAC, CH, CIA, CIB, CIBh2, CJ, CK/CL, CM, CN/CO, CP, and CP. The numbers of lithic artifacts are from Douze et al. (2015). The volumes of deposit and shellfish weights are from Langejans et al. (2012). We used the most detailed dataset but note that in BBC M3 the shellfish density is reported as 68.4 kg/m^3 by Henshilwood et al. (2001, 441) and Dusseldorp and Langejans (2013, Table 2). In Langejans et al. (2012, Table 8), it is reported as 86.14 grams per liter.

KRM shellfish and lithic material

Our results of the analysis of the shellfish from the recently excavated layers from the Witness Baulk by Wurz, add detail to the other descriptions of the coastal adaptation of this phase at KRM (Dusseldorp and Langejans 2013; Langejans et al. 2012, 2017; Thackeray 1988; Will et al. 2016, 2019). Figures 2 and 3 and Supplementary Table 13 indicate changes within MIS 5c-d. Layer SMONE, the youngest layer, reflects a high shellfish density, comparable to the M3 phase of BBC (Table 7). It also has the most limited range of shellfish species and is dominated by alikreukel and brown mussel. Even though abalone occurs in relatively low amounts, it is best represented in SMONE and does not occur in BOS Three and SBLS. BOS One & Two has the highest shellfish density and brown mussel dominates, followed by high frequencies of alikreukel. This indicates the presence of a more rocky shore during these periods. All the species from KRM in this study are catholic, but the absence of cold-water indicators suggests that temperatures were probably warm. SMONE and BOS One & Two conform to the definition of coastal adaptation for MIS 5c as put forward by Will et al. (2019) as a narrow range of intertidal species occurring in high densities have been exploited.

The lithic technology for SMONE and BOS One & Two show the use of local raw materials, all stages of the reduction system are present, the production and use of tools/end products on-site, opportunistic behavior to quickly generate variable end products and quick discard of end products after use (Brenner and Wurz 2019). It is proposed that the cave was used for the manufacture and use of tools on-site, as suggested by the high amount of edge damage and the presence of all steps of the *chaîne opératoire*. Provisioning of place (see Kuhn 1995) has been suggested (Brenner and Wurz 2019). During these phases, high amounts of shellfish also suggests the use as a residential site. Layer BOS One & Two differs slightly from SMONE, as it shows more second-generation cores, which have been reused. This might relate to a more extended period of abandonment after the formation of this layer.

The shellfish exploitation and lithic material indicate changes in BOS Three and SBLS. There is a much lower shellfish density in these layers. In BOS Three alikreukel comprise more than half of the species, brown mussel is the least well represented, and there is a somewhat increasing diversity of species. BOS Three shows the same lithic reduction strategy as SMONE and BOS One & Two. However, a higher amount of small debitage and higher artifact density than the upper layers indicate a higher knapping intensity. There also seem to be slightly fewer end products and edge damaged pieces. This change together with a much lower density of shellfish indicates a change of site use. In sum, the elements of provisioning of place prevail, but the coast might have been further away, or the site was used primarily as a manufacturing site.

The shellfish density in SBLS is low, but not as low as in BOS Three. In this layer, the increasing diversity in species is especially apparent. Brown mussel comprises one-third of the shellfish, and proportions of *Patella sp*. are much higher than in the other three layers, both in terms of MNI and weight. The size of alikreukel (Table 4) is smaller in SBLS than in the above layers (although there is only a small sample size). The marginally represented white mussel is more visible in layers BOS Three and SBLS than in the SMONE and BOS One & Two layers. This might indicate a gradual change in the paleoenvironment towards an environment with the presence of sandy shores.

The lithic artifact density and blank size in layer SBLS are clearly different from the other layers analyzed here, suggesting downsizing or miniaturization during this time. Another prominent character of this layer is the high density of small debitage and the low amount of end products, edge damaged pieces, tools, and cores. This indicates knapping on-site but possibly subsequent transport of products and possibly also the cores. The low amount of edge damage also indicates that tools and end products were not primarily used on site. Although no tools or exotic raw materials occur, the pattern in SBLS shows more elements of provisioning of individuals compared to the upper layers. A lower amount of shellfish and a high diversity of them also indicates that during the accumulation of layer SBLS the cave was mostly used for knapping, and less for residential activities like food consumption.

Pinnacle Point 13B

PP13B MIS 5d-e (See Supplementary Table 9 for dates and layers)

At PP13B, the shellfish densities are much lower, particularly during MIS 6, MIS 5e, and 5d than at both KRM and BBC M3 (Table 7, Figure 6, Supplementary Table 9 and 13). The MIS 5e shellfish assemblage at PP13B is entirely dominated by brown mussel (89%) with less than 10% alikreukel. There is a marked change in preferred species during MIS 5d when white mussel becomes predominant (80%), but brown mussel and alikreukel are also exploited. During MIS 5, at PP13B a change from rocky to sandy shores is suggested from MIS 6 to MIS 5. No cold-water indicator species are found at PP13B, which implies warm temperatures (see Jerardino and Marean 2010).

The lithic density is also very low compared to KRM; it shows lowest values in MIS 5d and 5e also compared to other PP13B assemblages. The lithic technology and reduction sequence are described by Thompson et al. (2010) for all assemblages combined (MIS 6 - MIS 5c; no size cut-off). The main reduction sequence is unidirectional with blades and points, as well as Levallois flakes as end products. Local materials including quartzite and quartz dominate the raw material composition. MIS 5e shows the highest amount of silcrete (with cobble cortex). The MIS 5e assemblage includes four retouched artifacts, but cores are absent from this layer. The MIS 5d assemblage is very small with only 47 artifacts (Supplementary table 10), but it has the highest frequency of cores. No retouched pieces are present, which resembles KRM SBLS. Bladelets are present, but in low quantities (Supplementary Table 10).

The MIS 5d assemblage is too small to provide information on provisioning, but MIS 5e shows more elements of provisioning of individuals, which is seen in more use of silcrete (which might be non-local) and the absence of cores or hammerstones. The low densities of lithic artifacts and shellfish as well as, scarce retouch/edge damage do not indicate an intensive use of the site. PP13B might reflect only occasional visits.

PP13B MIS 5c Layers (See Supplementary Table 9 for dates and layers)

During MIS 5c density of shellfish (13.7 kg/m^3) is almost comparable to layer BOS Three at KRM, indicating an increasing reliance on mollusk resources (Table 7,

Figure 6). Alikreukel is present from MIS 5e through 5c assemblages, but it is most prevalent during MIS 5c (Supplementary Table 13). During MIS 5c, wite mussel still occurs in relatively high frequencies (54%), with brown mussel and alikruekel the next frequent species (Supplementary Table 13). Towards the end of MSA II, the coast thus became slightly more rocky as both brown mussel and alikreukel (Jerardino and Marean 2010) occur, but the high amount of white mussel further suggest sandy beaches.

For the MIS 5c lithic material at PP13B the density is very low, with 1.68 lithics per liter. The raw material is very similar to KRM, with local cobble quartzite being the dominant material. The PP13B MIS 5c assemblage composition shows many similarities to KRM, especially SMONE and BOS One & Two, with a low frequency of cores, tools and some isolated hammerstones. As there is no size-cut off at PP13B no statements about small debitage frequencies can be made. Thompson et al. (2010) group formal retouch and edge damage together , which means, while the amount of formal tools at KRM (SMONE - BOS Three) is comparable to PP13B MIS 5c, the amount of edge damage at KRM is higher, especially in SMONE and BOS One & Two.

A designation in terms of provisioning systems is complicated, as there is an absence of information on small debitage and detailed descriptions of reduction systems. The very low densities of shellfish and lithic artifacts do, however, indicate short-term visits and low occupation intensity.

Blombos Cave

The density of shellfish in the BBC M3 phase is similar to that of layer SMONE at KRM. Alikreukel dominates the assemblage at the BBC M3, making up 60% of the shellfish assemblage (Dusseldorp and Langejans 2013; Figure 6, Supplementary Table 12 and 14). The other highest represented species in terms of weight include giant chiton (13.4%) and limptes *S. argenvillei* (10%) and *C. oculus* (9.1%). These four species together comprise 88.4% of harvested species (Supplementary Table 13). Alikreukel is also the best-represented species in SMONE, but differently from BBC, brown mussel, and abalone are the next numerous. Smaller amounts of alikreukel also occur in the MIS 5c assemblages at

PP13B, but here, as discussed above, white mussel dominates. Compared to the pattern at BBC M3, both KRM and PP13B have higher amounts of brown mussel. At BBC M3, the presence of *Cymbula granatina,* though small, suggests cool temperatures (Langejans et al. 2012) while the shore habitats were rocky as indicated by species such as alikreukel, giant chiton, and brown mussel. This is the only site on the southern Cape coast for which cooler temperatures are indicated, per the influence of periodic upwellings of cold water off the Agulhas Bank (Cohen & Tyson 1995).

The lithic artifact density at BBC M3 is a bit higher than at PP13B, but much lower than for any of the layers at KRM. The lithic raw materials are all from local sources and include mostly silcrete, but quartzite and quartz also occurs. There are three reduction sequences identified at BBC. The dominant reduction system is a unidirectional system on parallel cores, which exhibit parallel or convergent negative scars. BBC differs from both KRM and PP13B in that a centripetal system on parallel cores and an inclined system exist as well. The main products are triangular flakes and some blades (Douze et al. 2015). Flakes are described as mostly preparational.

BBC M3 only shows a low frequency of cores and hammerstones but a high amount of small debitage (Douze et al. 2015; Supplementary Material Table 11). This distribution is comparable to the KRM assemblages BOS Three and SBLS. The one feature not present at BBC are bladelets, and although they are scarce at KRM, the lower layers BOS Three and SBLS show noteworthy frequencies of bladelets and bladelet fragments (5-8%). Bladelets, as mentioned above, also occur at PP13B. Flakes, as at PP13B, are more frequent in BBC than in KRM, and Levallois flakes are also scarce, as at PP13B MIS 5c. Similar to KRM and PP13B tools are rare at BBC. Edge damaged pieces have been recorded separately and make up only 1.3% of the assemblage, significantly less frequent than at KRM.

BBC might indicate specialized occupation or a processing site for the retrieval and consumption of shellfish and marine resources. A high amount of small debitage and some cores and hammerstones provide proof of knapping-activity. However, low artifact density does not infer intensive occupation. Low amounts of retouched and edge damaged pieces indicate furthermore that artifacts were not intensively used on-site. Lithics might have only been sporadically produced, maybe over multiple visits. The presence of the most variable technology with different reduction sequences present at BBC also implies multiple visits. This might reflect different groups of people visiting the site, as the pattern of reduction sequences is less consistent than at KRM and PP13B.

Although the reduction sequences differ, the assemblage composition of BBC and KRM BOS Three and also SMONE are similar. BBC M3 does follow a system of provisioning of place; it was, however, most probably used as a processing site, as densities of shells are much higher than those of lithics. This is also supported by the presence of several abalone specimens which have been described by Langejans et al. (2012, 91) as representing one collection event.

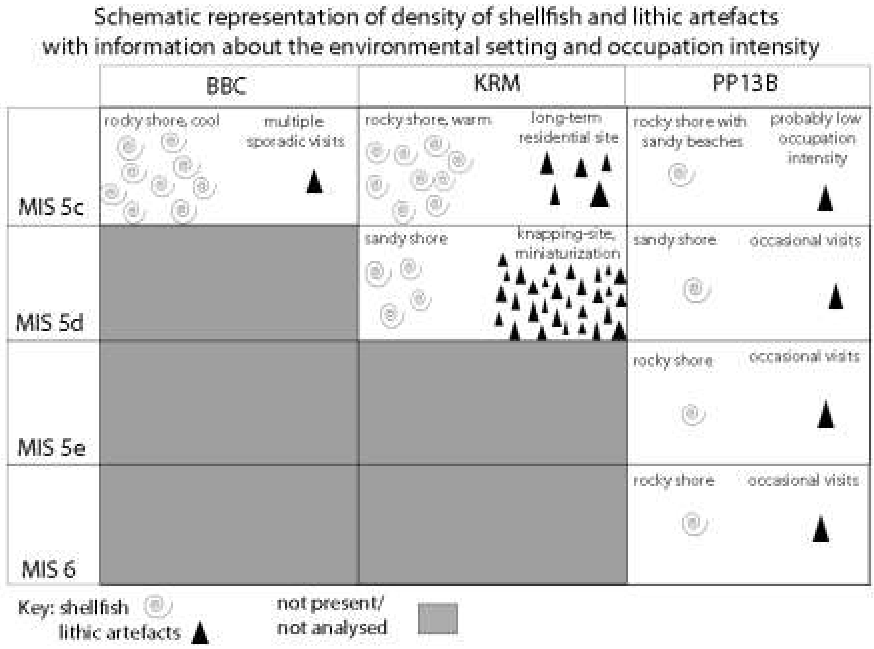

FIGURE 6. SCHEMATIC REPRESENTATION OF SHELLFISH AND LITHIC DENSITY AT BBC, KRM AND PP13B DURING THE DIFFERENT MIS. ONE SHELL SYMBOL REPRESENTS 10 KG/M³ OR, IN THE CASE OF JUST ONE SYMBOL, THE DENSITY IS >10 KG/M³. ONE LITHIC ARTIFACT SYMBOL REPRESENTS 10 N/L OR, IN THE CASE OF JUST ONE SYMBOL, THE DENSITY IS >10 N/L. ENVIRONMENTAL CONTEXT DERIVED FROM SHELLFISH SPECIES. OCCUPATION INTENSITY DERIVED FROM LITHIC ASSEMBLAGES.

CONCLUSIONS

A detailed perspective on shellfish utilization combined with data on lithics from around 110 ka, when coastal adaptation becomes a new widespread ecological niche on the southern Cape coast, is provided here. We investigated whether a comparison of the lithic technology and shellfish exploitation could provide new insights into occupational and residential strategies within the context of coastal foraging. We noted differences in artifact and shellfish densities, lithic technology, and shellfish exploitation that probably indicate changing provisioning systems and residential patterns through time and space during MIS 5 at KRM, BBC, and PP13B.

The degree of coastal adaptation is very variable throughout the sites explored in this paper. Our data demonstrate that hunter-gatherers of MIS 5d were less reliant on shellfish than those of MIS 5c. High amounts of shellfish during this time at KRM SMONE and BOS One & Two and the M3 phase at BBC indicate that the sites were used for food collection and consumption. At KRM the site also becomes more residential (provisioning of place) with more tasks being addressed regularly with stone tools in the upper layers SMONE and BOS One & Two. The same trend is seen at PP13B, though less pronounced, where more characteristics of provisioning of place are present in MIS 5c, whereas MIS 5d-e shows fewer of those elements.

The higher lithic densities at KRM compared to BBC and PP13B point towards different site functions or variable lengths of visits. BBC was probably experiencing shorter visits but with a higher focus on shellfish exploitation than KRM; more variable reduction sequences and a low density of lithics at BBC M3 also evidence this. PP13B shows low densities in both categories, shellfish and lithics. Infrequent and shorter visits of the cave might have generated this pattern.

Additionally, intense edge damage at KRM indicates high rates of lithics being used on-site in the SMONE and BOS layers. KRM MIS 5c was therefore definitely used as a long-term occupation with residential character. The older layer SBLS might have been used slightly differently, showing more intense knapping-activity with fewer elements of a residential site.

Although the densities are very different, the pattern of shellfish diversity and lithic technology at KRM and PP13B both point towards a change in mobility, which includes changes in provisioning systems. In the earlier phase MIS 5e-d hunter-gatherers seemed to be more mobile and only in MIS 5c is a more residential pattern seen.

We show that MIS 5 coastal adaptations at KRM and other broadly contemporaneous sites on the southern Cape coast fluctuate. The results of the analysis of the shellfish and lithic densities, technological patterns, and shellfish species exploited at Klasies River, Blombos Cave, and Pinnacle Point, demonstrate a more diverse onset and expression of coastal adaptation during early MIS 5 than apparent from current literature

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Supplementary Material

SUPPLEMENTARY MATERIAL TABLE 1. RAW MATERIAL COMPOSITION.

Raw material	SMONE		BOS One & Two		BOS Three		SBLS		Total	
	n	%	n	%	n	%	n	%	n	%
Quartz	4	1.4%	0		6	1.9%	3	1.5%	**13**	**0.8%**
medium-grain Quartzite	234	82.4%	127	81.4%	267	84.2%	181	91%	**809**	**84.4%**
Dissolved quartzite	9	2.5%	11	7.1%	11	3.5%	5	2.5%	**36**	**3.8%**
Table Mountain Quartzite	27	9.5%	16	10.3%	31	9.8%	6	3%	**51**	**5.3%**
Sandstone	8	2.8%	2	1.3%	4	1.3%	3	1.5%	**17**	**1.8%**
Shale	0		0		0		1	0.5%	**1**	**0.1%**
Silcrete	2	0.7%	0		0		0		**2**	**0.2%**
Total >2cm	**284**	**100%**	**156**	**100%**	**317**	**100%**	**199**	**100%**	**956**	**100%**
Quartzite <2cm	769	(70.7%)	287	(61.5%)	1618	(80.9%)	2224	(89.9%)	4798	(79.6%)
Quartz <2cm	34	(3.1%)	21	(4.5%)	66	(3.3%)	52	(2.1%)	173	(2.9%)
Other <2cm	0		3	(0.6%)	0		0		6	(0.1%)
Grand total	**1087**	**(100%)**	**467**	**(100%)**	**2001**	**(100%)**	**2475**	**(100%)**	**6030**	**(100%)**

SUPPLEMENTARY MATERIAL TABLE 2. AMOUNT OF DORSAL CORTEX ON BLANKS (INCLUDING FLAKES, POINTS, BLADES, BLADELETS AND FRAGMENTS).

Dorsal cortex	SMONE		BOS One & Two		BOS Three		SBLS		Total	
	n	%	n	%	n	%	n	%	n	%
0	232	82%	112	72%	224	70%	126	82%	694	75%
<50%	41	14%	34	22%	71	22%	30	15%	176	19%
>50%	9	3%	7	4%	17	5%	5	3%	38	4%
100%	2	1%	3	2%	7	2%	1	1%	13	1%
Total n with cortex cover	**52**	**18%**	**44**	**28%**	**95**	**30%**	**36**	**22%**	**227**	**25%**

SUPPLEMENTARY MATERIAL TABLE 3. TECHNOLOGICAL CATEGORIES OF COMPLETE AND FRAGMENTARY DETACHED PIECES >2CM.

Technological categories	SMONE		BOS One & Two		BOS Three		SBLS	
	n	%	n	%	n	%	n	%
end product	100	51.8%	41	40.6%	93	37.5%	52	32.1%
debordant	26	13.5%	23	22.8%	43	17.3%	21	13.0%
core surface managemant	29	15.0%	19	18.8%	58	23.4%	48	29.6%
platform shaping	4	2.1%	2	2.0%	9	3.6%	12	7.4%

decortification	10	5.2%	7	6.9%	18	7.3%	5	3.1%
entame (first)	0	0.0%	0	0.0%	1	0.4%	1	0.6%
flaking debris/ indet fragments	43	22.3%	9	8.9%	26	10.5%	23	14.2%
Total	193	100%	101	100%	248	100%	162	100%

Supplementary Material Table 4. Mean platform thickness (mm), and EPA (°) of blanks by type (including bladelets <2cm).

	SMONE			BOS One & Two			BOS Three			SBLS		
	n	**pf thickness**	**EPA**	**n**	**pf thickness**	**EPA**	**n**	**pf thickness**	**EPA**	**n**	**pf thickness**	**EPA**
point	32	11.33	86	23	11.95	85	49	9.06	87	28	6.69	87
blade	23	7.15	80	25	10.24	88	50	7.12	88	26	5.05	88
bladelet	10	2.89	73	0			17	4.43	88	9	2.61	87
flake	134	8.89	77	53	12.31	88	132	6.98	87	99	4.24	87

SUPPLEMENTARY MATERIAL TABLE 5: MEAN VALUES OF TECHNOLOGICAL LENGTH (MM), MAXIMUM WIDTH (MM), MAXIMUM THICKNESS (MM) AND WEIGHT (G) OF COMPLETE BLANKS BY TYPE.

	SMONE					BOS One & Two					BOS Three					SBLS				
	n	length (mm)	width (mm)	thickness (mm)	weight (g)	n	length (mm)	width (mm)	thickness (mm)	weight (g)	n	length (mm)	width (mm)	thickness (mm)	weight (g)	n	length (mm)	width (mm)	thickness (mm)	weight (g)
point	20	66.9	33.3	13.4	26.8	16	68.1	36.4	13.5	33.4	22	57.2	27.9	10.9	24.9	15	31.8	19.4	7.3	5.8
blade	5	69.6	27.5	13.0	27.1	8	95.9	35.0	17.1	60.5	10	63.6	24.8	9.1	22.3	1	-	15.6	4.3	2.6
bladelet	2	29.0	6.7	6.8	1.7	0	-	-	-	-	5	26.2	9.1	4.9	1.0	1	33.0	12.8	3.8	1.4
flake	61	34.1	30.4	9.8	13.0	27	50.5	47.0	15.5	58.2	50	32.1	28.7	7.9	12.6	40	22.3	22.3	5.7	4.7

SUPPLEMENTARY MATERIAL TABLE 6. NUMBER OF TOOLS AND EDGE DAMAGED PIECES WITH PERCENTAGES OF ASSEMBLAGE >2CM IN BRACKETS.

Tools	SMONE	BOS One & Two	BOS Three	SBLS
formal tools	**2 (1%)**	**6 (3%)**	**4 (1%)**	**0**
denticulate/notch	2	2		
scraper		1	4	
retouch on point		2		
miscellaneous retouch		1		
edge damage	**60 (21.1%)**	**31 (19.9%)**	**51 (16.1%)**	**21 (10.6%)**

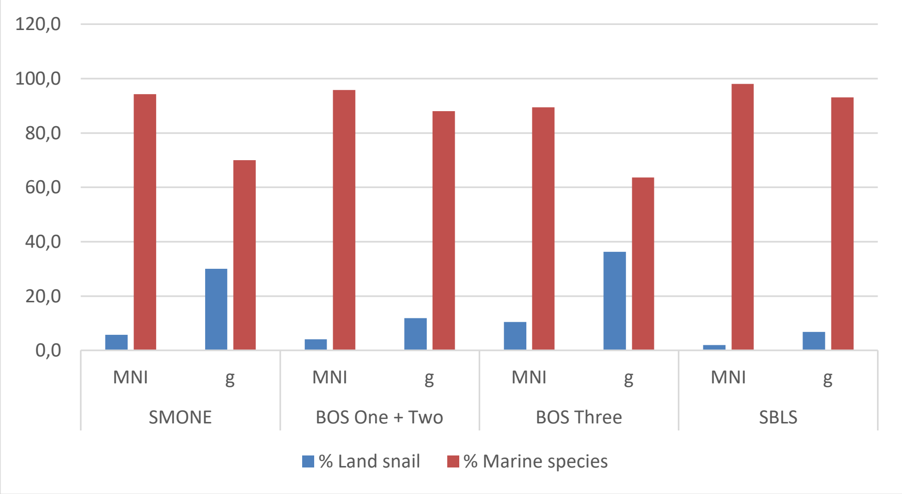
SUPPLEMENTARY MATERIAL TABLE 7. DORSAL NEGATIVE ORIENTATION OF END PRODUCTS.

Orientation of dorsal negatives	SMONE		BOS One & Two		BOS Three		SBLS	
	n	%	n	%	n	%	n	%
unidirectional	12	60%	7	39%	4	18%	2	20%
unidirectional parallel	0		3	17%	0		0	

unidirectional converging	1	5%	3	17%	2	9%	0	
bidirectional	3	15%	3	17%	4	18%	1	10%
indeterminate uni- or bidirectional	1	5%	2	11%	12	55%	6	60%
indeterminate	3	15%	0		0		1	10%
Total	20	100%	18	100%	22	100%	10	100%

Supplementary Material Table 8. Number of core types.

Core types	**SMONE**	**BOS One & Two**	**BOS Three**	**SBLS**	**Total**
platform	**2**	**1**	**1**		**4**
parallel	**3**	**2**	**5**	**1**	**11**
unidirectional	1	1	3	1	6
bidirectional	1	1	1		3
centripetal	1		1		2
initial	**1**	**2**			**3**
multidirectional	**1**	**2**			**3**
fragment	**1**		**2**	**1**	**4**
indeterminate		**2**			**2**
Total	**8**	**9**	**8**	**2**	**27**



Supplementary Material Figure 1. Comparative frequencies (MNI and weight in grams) of marine molluscs and land snail at square C1, KRM.

Supplementary Material Table 9. Pinnacle Point 13B shellfish and lithic densities per analytical Unit and stratigraphic Aggregate. Data from Jerardino and Marean (2016); Marean (2010) and Thompson et al. (2010).

Analytical Unit	Stratigraphic aggregate	Age range in ka	MIS designation	Shell fish				Lithics		
				shell fish density per analytical unit	Shell in gram	Shell in MNI	Density per MIS	Litre	Number of lithics	Density per age per area
West upper sand (A)	LB Sand 1	91-94	5c					992	1088	1 097

	DB Sand 2	91-102	5c							
	LB Sand 2	91-102	5c				13.7			
	DB Sand 3	91-102	5c	0.5	368.63	49				
East Area shell midden (B)	Shelly Brown Sand	91-98	5c	8.7	822.5	68		613	1615	2 635
	Upper Roof Spall	91-98	5c	4.5	2292.54	234				
	Lower Roof Spall	106-114	5d	3.7	2066.15	239	3.7	548	42	0.077
LC-MSA Upper (C)	LC-MSA Upper	115-133	May have 5c and 5e	3.5	155.63	35		918	231	0.252
LC-MSA Middle (D)	LC-MSA Middle	120-130	5e	2.3	398.13	53	5.8			
West Middle Sand (E)	LBG Sand	94-133*								
	DB Sand 4a	117-166	Likely early MIS 6							
	LBG Sand 2	117-166	Likely early MIS 6	0.03	30.1	11		327	431	1 318
West Lower Sand (F)	DB Sand 4b	152-166	Likely early MIS 6							
	LBG Sand 3	152-349	Likely early MIS 6							
	LBG Sand 4c	152-349	Likely early MIS 6							
	LBG Sand 4	152-349	Likely early MIS 6	0.01	1.77	1	0.33			
LC-MSA Lower (G)	LC-MSA Lower	153-174	early MIS 6	0.29	155.63	28		532	1508	2 835

- likely two occupations with a hiatus or truncation.Thompson et al. (2010) counts this as MIS 6

Supplementary Material Table 10. Pinnacle Point 13B Lithic assemblage composition (MIS 5c from Eastern and Western excavation area combined). Data from Thompson et al. (2010).

assemblage composition	MIS 5c		MIS 5d		MIS 5e	
	n	%	n	%	n	%
points/point fragments	254	9.1%	1	2.1%	20	8.7%
blades/blade fragments	274	9.8%	2	4.3%	28	12.1%
bladelets/bladelet fragments	27*	1.0%	0	-	2	0.9%
Levallois flakes	34	1.2%	0	-	6	2.6%
flakes/flake fragments	1401	50.0%	23	48.9%	120	51.9%
indeterminate fragments	722	25.8%	16	34.0%	55	23.8%
cores	77	2.7%	5	10.6%	0	-
hammerstones	12	0.4%	0	-	0	-
Total	2801	100%	47	100%	231	100%
tools (% of Total)	77	(2.7%)	0	(0%)	4	(1.7%)

* 10 of the bladelets were recovered from the 3 mm screen sample (Thompson et al. 2010: 368).

Supplementary Material Table 11. Blombos M3 phase lithic assemblage composition. Data from Douze et al. (2015).

assemblage composition	M3 phase (MIS 5c)	
	n	**%**
points	335	9.8%
blades	136	4.0%
bladelets	0	-
Levallois flakes	44	1.3%
flakes	1160	34.1%
fragments	1076	31.6%
cores	50	1.5%
hammerstones	2	0.1%
angular debris	575	16.9%
other (pebbles,...)	26	0.8%
Total >2cm	3404	100%
tools (included in Total >2cm)	123	2.7%
edge damage (included in Total >2cm)	44	1.3%
small debitage (% of Grand total)	14484	(81%)
Grand total	17888	(100%)

Supplementary Material Table 12. BBC M3 shellfish composition. Data from Langejans et al. (2012, Table 8).

Species/values	MNI	%MNI	gram	%g
Dinoplax gigas	298	12.5	13113	13.4
Turbo sarmaticus	836	35.1	54989	56.0
Choromytilus meridionalis	1	0.0	1	0.0
Cymbula oculus	394	16.6	8959	9.1
Diloma sp.	142	6.0	2299	2.3
Donax serra	2	0.1	2	0.0
Perna perna	281	11.8	872	0.9
Cymbula granatina	131	5.5	2558	2.6
Haliotis midae	28	1.2	5466	5.6
Haliotis spadicea	13	0.5	104	0.1
Scutellastra argenvillei	247	10.4	9783	10.0
Scutellastra tabularis	1	0.0	37	0.0
Scutellastra longicosta	2	0.1	25	0.0
Aulacomya ater	2	0.1	2	0.0
Scutellastra cochlear	2	0.1	8	0.0
Total	2380	100	98218	100

Supplementary Material Table 13. PP13B shellfish species composition per MIS. Data from Jerardino and Marean (2016).

MIS phases	MIS 5c				MIS 5d				MIS 5e				Early MIS 6			
Species/values	MNI	%MNI	g	%g	MNI	%MNI	gram	%g	MNI	%MNI	g	%g	MNI	%MNI	g	%g
Dinoplax gigas	1	0.3	7.24	0.2	0	0.0	0	0.0	0	0.0	0	0.0	1	3.1	5.64	3.2
Turbo sarmaticus	36	10.5	419.3	12.1	15	6.3	197.3	9.5	4	8.9	30.68	8.6	2	6.3	12.35	7.0
Choromytilus meridionalis	2	0.6	1.73	0.0	0	0.0		0.0	1	2.2	3.27	0.9	2	6.3	3.26	1.9
Cymbula oculus	3	0.9	11.76	0.3	1	0.4	8.59	0.4	0	0.0		0.0	0	0.0	0	0.0
Diloma sp.	1	0.3	4.76	0.1	1	0.4	5.38	0.3	0	0.0		0.0	0	0.0	0	0.0
Donax serra	150	43.9	1898	54.8	191	80.3	1652	80.0	0	0.0		0.0	2	6.3	3.31	1.9
Scissodesma spengleri	1	0.3	2.56	0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Perna perna	130	38.0	879.4	25.4	25	10.5	192.6	9.3	39	86.7	317.5	89.0	22	68.8	141.4	80.5
Cymbula granatina	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Haliotis midae	2	0.6	14.8	0.4	3	1.3	6.7	0.3		0.0		0.0	1	3.1	0.45	0.3
Haliotis spadicea	0	0.0	0	0.0		0.0		0.0		0.0		0.0	0	0.0	0	0.0
Scutellastra argenvillei	6	1.8	138.9	4.0	1	0.4	2.27	0.1	1	2.2	5.13	1.4	0	0.0	0	0.0
Scutellastra granularis	0	0.0	0	0.0		0.0		0.0		0.0		0.0	0	0.0	0	0.0
Scutellastra tabularis	6	1.8	81.35	2.4		0.0		0.0		0.0		0.0	1	3.1	9	5.1
Burnupena cincta	2	0.6	0.95	0.0	1	0.4	1.2	0.1		0.0		0.0	1	3.1	0.19	0.1
Scutellastra longicosta	1	0.3	0	0.0		0.0		0.0		0.0		0.0	0	0.0	0	0.0
Nucella squamosa	1	0.3	0.33	0.0		0.0		0.0		0.0		0.0	0	0.0	0	0.0
Total	342	100	3462	100	238	100	2066	100	45	100	356.6	100	32	100	175.6	100

Supplementary Material Table 14. Dominant shellfish species (85% and more) during MIS 5c-d in the southern Cape, South Africa at Klasies River, Blombos Cave, and Pinnacle Point Cave 13B. Data from Langejans et al. (2012) and Jerardino and Marean (2016).

	SMONE		BOS One + Two		BOS Three		SBLS		BBC M3		PP13B MIS 5c		PP13B MIS 5d		PP13B MIS 5e	
Species	g	%g	g	%g	g	%g	g	%g	g	%g	g	%g	g	%g	g	%g
Dinoplax gigas	-	-							13113	13.4	0	0	0	0	0	0
Turbo sarmaticus	1036	52.1	243	24.3	204.4	56.4	48.5	13.3	54989	56.0	419.3	12.1	197.3	9.5	30.68	8.6
Cymbula oculus			84.51	8.5	25.6	7.1			8959	9.1						
Diloma sinensis			105.5	10.6	36.6	10.1	33.7	9.2								
Donax serra											1898.4	54.8	1652.1	80.0		
Perna perna	453.8	22.8	419	41.9	56.1	15.5	115.4	31.6			879.4	25.4	192.6	9.3	317.51	89.0
Haliotis midae	369.2	18.6														
Scutellastra argenvillei									9783	10.0						
Burnupena limbosa							34	9.3								
Scutellastra longicosta																
Patella sp.							88.7	24.3								
Total Top 85% +		93.5		85.3		89.1		87.7		88.4		92.4		98.8		97.6
Total	1987.3	100	999.9	100	362.2	100	365.6	100	98218	100	3461.5	100	2066.1	100	356.6	100

Chapter 6: Submitted Paper #4

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Interglacial perspective on lithic technology from the MSA horizon of Florisbad.

Content

Interglacial perspective on the lithic technology from the MSA horizon of Florisbad

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Abstract

In recent years focus on the MIS 5 lithic technology in South African sites increased, however, most of the discussion revolved around Cape coastal or near coastal sites. The focus on coastal cave sites might have distorted understanding of inter-site patterning throughout the South African region. The re-examination of the open-air inland site of Florisbad with the well-dated MIS 5e "MSA horizon" is conducted with a technological approach. The findings are that multiple reduction systems existed which produce predetermined blank shapes, which are predominantly points and blades. A unidirectional recurrent reduction method was applied on parallel and platform cores. A ramification of the *chaîne opératoire* are the systematic removals from flakes used as core-blanks. Most of these cores-on-flakes are burin-cores, but also include truncated flakes with ventral reduction. It is further shown that recycling and re-use of lithic artefacts, such as cores-on-flakes and cores used as tools, suggests the horizon was exposed over longer periods of time and that the artefacts lying on the surface were used opportunistically. A technological comparison of MIS 5 sites from South Africa shows that similarities are found over long distances, for example between Florisbad and Klasies River. Although some regional patterning exists regarding tool types, there is a very high degree of technological similarity between assemblages. Similar reduction systems, blank shapes and tool types at Florisbad and Klasies River could mean that communication and knowledge transmission across the country already existed as early as MIS 5. It is highly likely that more extensive communication networks existed between groups than hitherto appreciated.

1. Introduction

Florisbad is located ca. 45 km north of Bloemfontein in the Free State Province, South Africa. The site is situated in the grasslands south of the Soutpan Lake and north of the Modder River. It is an open-air spring site, which comprises multiple spring mounds in more than 7 m of stratigraphy. Florisbad has been known since 1912 and has been intensively excavated and researched up to recent times. The site is famous for its Middle Pleistocene hominid remains (*inter alia* [1–4]) and *in-situ* Middle Stone Age (MSA) occupational horizons [5–11]. Dating with ESR and OSL methods indicate a tight age-span of 121 000 +- 6000 years ago for the MSA horizon [1], which places it in MIS 5e (following [12] for MIS boundaries). Extensive excavations have been performed by Clarke during 1981-1984, followed by Henderson from 1990 to 2001 [5,6,9].

Recent papers have focused on the site formation and paleoenvironment [10,13–18]. The micro-morphology of the MSA horizon establishes lake shore sediments with lacustrine and aeolian deposition [14]. Pollen of upland fynbos shrubs indicate rather cool condition [13]. The micro-vertebrates are consistent with the large mammal fauna and evidence an open treeless grassland [17]. Macro fauna evidences a wetland component in the Middle to Late Pleistocene [8,10,19–23]. This is supported by avian remains which indicate the presence of a large water body and open grasslands [16].

The MSA lithic material has been the focus of two PhD theses, by Kuman [11] and Henderson [8] and some publications [5,6]. Kuman conducted a detailed analysis on the lithic material, but only from the Clarke excavation [9]. Henderson included all lithics from 1981-1997 into her analysis, but her focus was mostly on the spatial distribution of artefacts and there is no detailed description of the lithics [8]. In this study a detailed analysis of all the artefacts from the MSA horizon, including unpublished material from the 2000-2001 excavations is undertaken. It has been almost 20 years since the lithics from this important site have been described. It is of interest to know how this compares to more recent technological studies, and the Florisbad material compares to MIS 5 assemblages from different parts of South Africa.

Inland open-air sites have been overlooked and form only a small part of the current literature, but are probably just as numerous, if not more so, as coastal sites. With the interior open-air site Florisbad, a more extensive impression of the lithic technology of the overall MIS 5 landscape in South Africa is drawn. Preliminary inferences on mobility and knowledge transmission patterns based on similarities in lithic technology are drawn.

2. Sample

The material analyzed in this study was made available by the Florisbad Quaternary Research Station and the National Museum in Bloemfontein. It stems from three excavations at Florisbad. The early excavations from 1981-84 have been directed by Clarke and Kuman and spanned ca. 8 by 20 m. Most of this excavation was focused on the area of the Main Excavation (Fig 1).

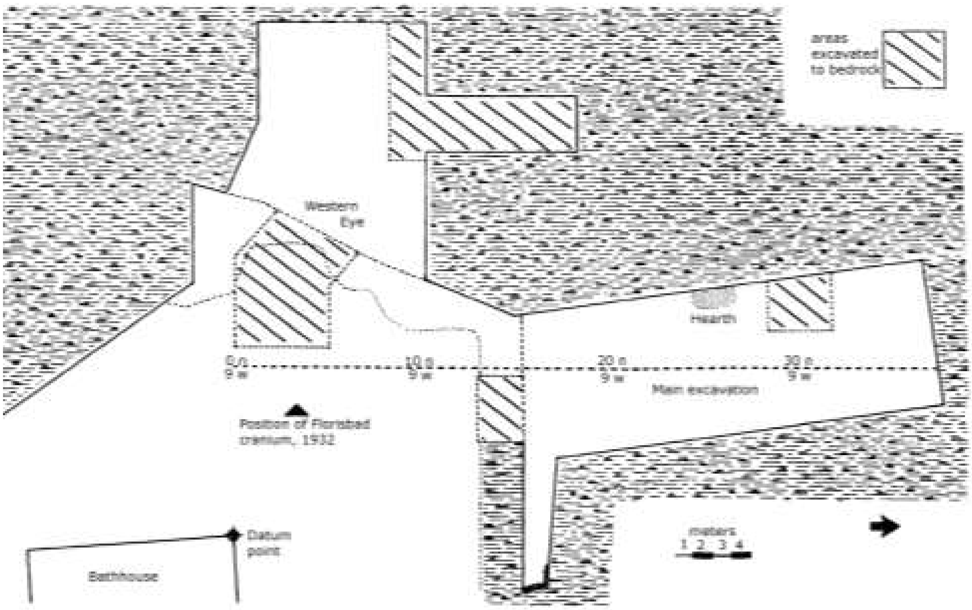

Fig 1. Excavation area of 1981-84 from Kuman ([9] p. 105, Fig 2).

The excavations by Henderson and Brink from 1990-97 took place in adjacent areas to the East of the Main Excavation (Fig 2). The further excavations from 1999-2001 opened a Foundation Trench, which started at the height of under

Unit G or just on top of Unit K covering both Main Excavation areas from the 1980s and 90s. The lithic material from these excavations is not described yet.

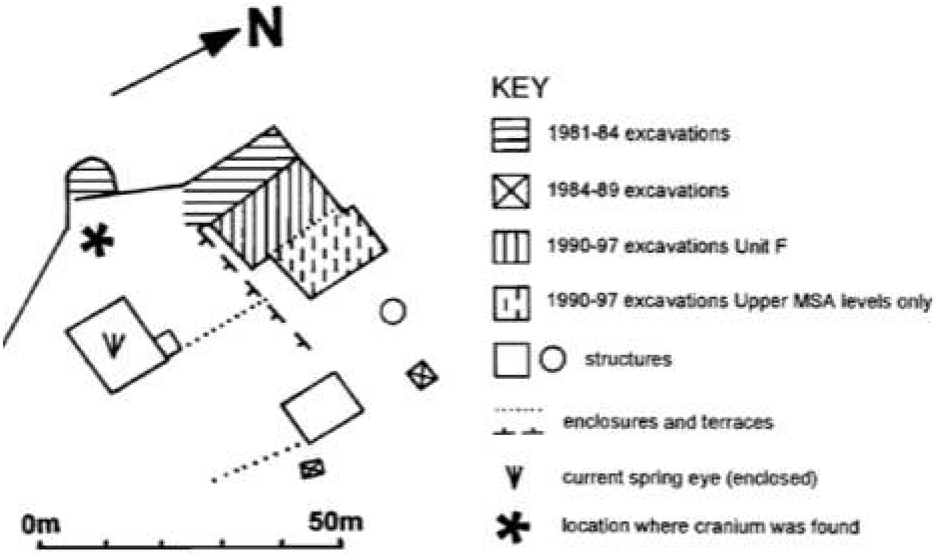

FIG 2. EXCAVATION MAP OF THE 1990-97 EXCAVATIONS FROM HENDERSON ([6] P. 28).

The stratigraphy of the MSA in the main excavation area includes sedimentological Units F to J. These Units are found between two "peat" layers numbered Peat 2 and Peat 3. Unit F is found below Peat 3 and yielded an OSL date of 121 000+-6000 ka [1]. Units F was found in both excavations, by both Kuman and Clarke and Henderson, over the whole extent of the area. Sedimentologically Unit F is a paleo-lake beach with fine white sands layered horizontally. It is described as a "mottled white and brown sand, although at the base, near the marker horizon, it was a marbled grey and white sand" [6]. The marker horizon or Unit G is situated below Unit F. Unit G is described as a "flame-structured unconformity" by Kuman and Clarke [9]. Unit G was used as a marker bed because it was found almost everywhere, except for some areas in the 90's excavation, where it disappeared [6]. Henderson [6] describes Unit G as varying between north and south of her excavation area. In the north it was a grey clay and in the south the sediment was dry black organic sands. Units H, I and J are only distinguished in the 80's excavation undertaken by Kuman and Clarke [9]. In the Main Excavation area of the 80's and in the later seasons of the 90s Unit H did not exist. Units I and J are described as grey organic deposits by Kuman and Clarke [9]. Henderson [6] lumped the Units I/J together, describing them as a marbled grey and white sand. Clarke only excavated up to Unit G in the main excavation area [5,9]. In the 1990-1997 excavations by Henderson Peat II (the same as Unit K) was reached, as is illustrated in the profile in Fig 4. In some instances Unit G and Peat II merge into each other (described in the excavation books), what is also shown in the profile presented by Henderson [6] (Fig 3).

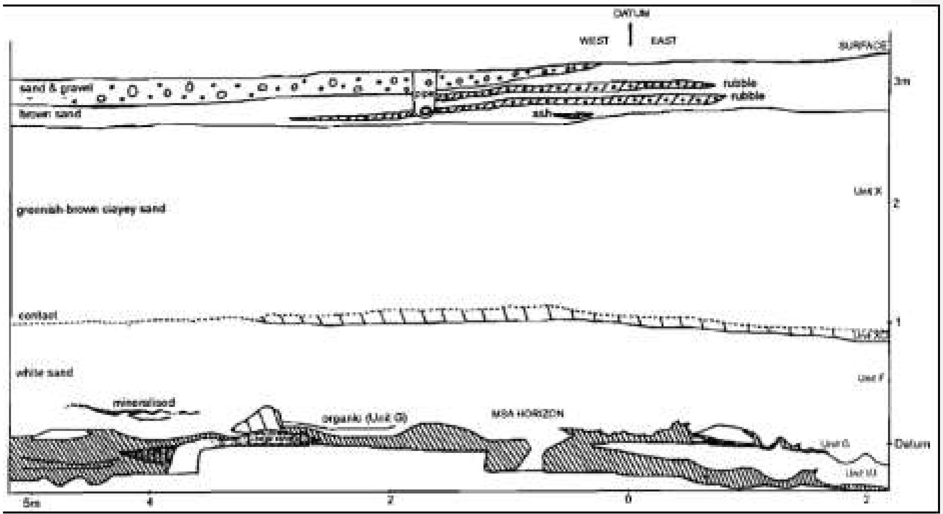

FIG 3. STRATIGRAPHY OF THE 1990-97 EXCAVATIONS FROM HENDERSON ([6] FIG 3).

Most of the MSA artefacts occured in Unit F [6,7 p. 36]. Unit G contained some MSA artefacts and the lower Units I and I/J also have MSA content [6,9], however Kuman [9] described Unit J as an empty layer without finds. Kuman [5,9] only refers to Unit F as the MSA occupation horizon, with some artefacts lying on top or in Unit G below. Henderson [6 p. 34-36] argues that the artefacts from the Units G and I/J in her excavation are part of the MSA horizon but have been exposed to post-depositional vertical movement. She provethis by conjoining lithic refits and articulated fauna spanning over a distance in vertical position [6]. Hence, Henderson includes all layers above Peat II to the MSA horizon, with Unit F just being one of the units, whereas Kuman defines only Unit F as the MSA horizon. In order to accommodate both of the approaches, only Unit F artefacts were analyzed from the 1981-1984 excavations, and for the 1991-2001 excavations all artefacts between Peat II and the top of Unit F were studied.

Material from both excavations is presented here together. All necessary permits were obtained for the described study, which complied with all relevant regulations

3. METHODS

The lithic material >2 cm is analyzed with attribute analysis and the *chaîne opératoire* approach [24–29]. With the *chaîne opératoire* approach, the life-cycle of artefacts is assessed, and primary core reduction sequences are put into context of the subsequent steps in the reduction process. A diacritic reading on cores and blanks informs about the sequence of removals.

The counts of the small debitage by raw materials is in Table 1. The raw materials were identified through visual inspection. Measurements of maximum dimension, technological length, width and thickness were taken using a digital calliper (following [25,28]). A goniometer was used to determine the external platform angle on blanks. Weight was measured with a digital scale. Apart from the general categories which are complete blank, fragment, core, hammerstone, chunk, and cobble/pebble, the blanks wereidentified into blank type such as point, blade, bladelet and flake, and the technological category was determined, including e.g., end product or core surface management. The blank type definitions were adopted from Brenner and Wurz [30]. Core types wereescribed according to Conard et al. [31] and Brenner and Wurz [30].

Kuman [11] and Henderson [8] used similar categories in their studies, however the blank types differ slightly. Kuman described flake-blades (pieces with blade dimensions, but no parallel dorsal scar ridges [11 p. 140]), irregular flakes, triangular flakes, and triangular blades. In Kuman's analysis the core categories multiple-platform irregular core, prepared core for triangular flakes and core on blade are used [11 p. 145]. Henderson used similar blank types as Kuman, but included bladelets as a separate type and excluded triangular blades. Her "points" were defined as retouched pointed blanks [6]. Henderson did not include a description of core types. The sample of the 'MSA horizon' presented here includes the artefacts from both excavations lumped together as one unit.

4. Results

4.1. Raw material

The dominant raw material at Florisbad is hornfels (96.4%, Table 1), which is present from light to dark grey colours. Patina is seen on many pieces of hornfels and some artefacts show dissolved surfaces, which are poorly preserved and crumbly. In some instances, a fresh break on such artefacts reveals that the material inside is still black and smooth, like fresh hornfels. Only few artefacts are made of quartzite (1.1%), dolerite (0.9%) and shale (0.6%). Sandstone (0.2%) and other raw materials (0.6%) are mostly present in the form of pebbles and chunks. One silcrete flake of green-gray colour is also present. Kuman [5] described the raw material of her sample as hornfels with two dolerite stone balls. Henderson [6,8] also only reports of hornfels artefacts.

Table 2. Assemblage composition of the MSA horizon (excluding Peat II) by raw material.

Assemblage composition	Raw material							
	Hornfels	Dolorite	Shale	Quartzite	Sandstone	Silcrete	Other	Total
blade	127	-	-	-	-	-	-	127
bladelet	45	-	-	-	-	-	-	45
point	188	-	-	1	-	-	-	189
flake	338	1	1	-	1	1	-	342
complete blanks	**698**	**1**	**1**	**1**	**1**	**1**	**-**	**703**
blade/point	309	-	-	-	-	-	-	309
bladelet	62	-	-	-	-	-	-	62
flake	274	2	1	-	-	-	-	277
indeterminate	151	3	1	3	-	-	-	158
fragments	**796**	**5**	**2**	**3**	**-**	**-**	**-**	**806**
core	**74**	**-**	**1**	**-**	**-**	**-**	**-**	**75**
hammerstone	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**1**
chunk	**87**	**6**	**5**	**5**	**1**	**-**	**3**	**107**
cobble/pebble	**6**	**4**	**2**	**10**	**2**	**-**	**8**	**32**
Total >2cm	**1662**	**16**	**11**	**19**	**4**	**1**	**11**	**1724**
small debitage <2cm	**916**	**1**	**-**	**1**	**-**	**-**	**-**	**918**
Grand total	**2578**	**17**	**11**	**20**	**4**	**1**	**11**	**2642**
small pebbles	**1**	**-**	**-**	**3**	**-**	**-**	**27**	**31**

4.2. Knapping technique

Only one hammerstone with clear pecking marks was retrieved from this sample of the lumped MSA horizon (Fig 4). Four additional cobbles could have been used as a hammer. The percussion technique is hard hammer, direct, internal percussion , as is evidenced by prominent bulbs with visible Hertzian cones, circular cracked impact points, and an absence of lips on the majority of artefacts. Kuman [11] and Henderson [8] also described one hammerstone in their samples, but the inference on percussion technique is absent.

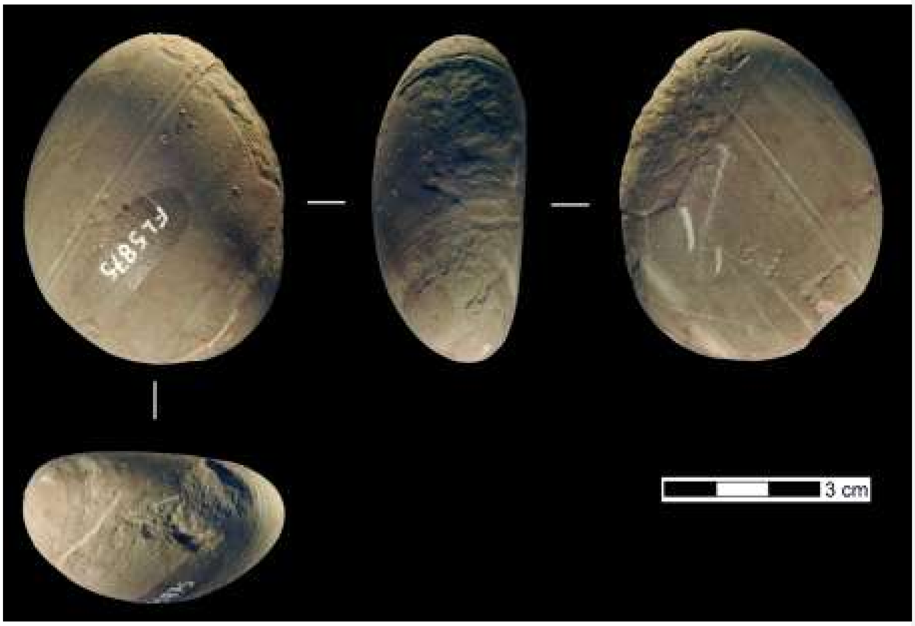

Fig 4. Hammerstone from the MSA horizon.

4.3. Assemblage composition

4.3.1. Tools

Table 3. Formal tools and edge damage by artefact category; percentage of all pieces >2 cm.

Tools	blade N	blade %	bladelet N	bladelet %	point N	point %	flake N	flake %	core N	core %	chunk N	chunk %	Total N	Total %
denticulate	3				2								5	
notched piece	1												1	

lateral retouch	3				5								8	
side scraper	2								2				4	
end scraper	1												1	
misc retouch					1		4				1		6	
formal tool	**10**	**0.6%**	**0**	**-**	**8**	**0.5%**	**4**	**0.2%**	**2**	**0.1%**	**1**	**0.1%**	**25**	**1.4%**
edge damage	**37**	**2.1%**	**4**	**0.2%**	**39**	**2.3%**	**24**	**1.4%**	**2**	**0.1%**	**1**	**0.1%**	**107**	**6.2%**
Total	**47**	**2.7%**	**4**	**0.2%**	**47**	**2.7%**	**28**	**1.6%**	**4**	**0.2%**	**2**	**0.1%**	**132**	**7.7%**

Formal tools are rare with 1.4% of the assemblage, as is common in MIS 5 assemblages in South Africa. Blades and points with lateral retouch, followed by pieces with miscellaneous retouch, denticulates/notched pieces and scrapers (Fig 5). Miscellaneous retouch is predominantly seen on flakes, whereas denticulation and notching is only present on blades and points. Side scrapers are present on two blades and two recycled cores. All of the scrapers are thick and the retouch is stepped with an angle of almost 90°. One blade has very fine retouch on the convex distal end, resembling an end scraper. More common than retouch is edge damage (Table 2) with 6.7% of the assemblage >20 mm comprising such pieces. Edge damage might be the product of use or post-depositional processes, but it is however interesting, that predominantly blades and points show edge damage. It is therefore inferred here that blades and points were the preferred blanks types for tool use. Kuman [5,11] and Henderson [6,8] also report low frequencies of formal tools (2.5% and 0.6%). Kuman includes the tool types cutting tool (with dorsal-ventral edge wear), side scraper and burin, whereas Henderson reports of burins, denticulates, points and scrapers. Here, burins are interpreted as cores (see 4.4.3. below). Henderson [6 p. 40] refers to a frequency of 4.9% utilization damage in the whole assemblage (including 1-2 cm debitage), whereas Kuman [5 p. 1421] reports 7.1% edge damaged flakes of pieces >2 cm. The results in this study fall in between the earlier estimates for tool and edge damage frequency.

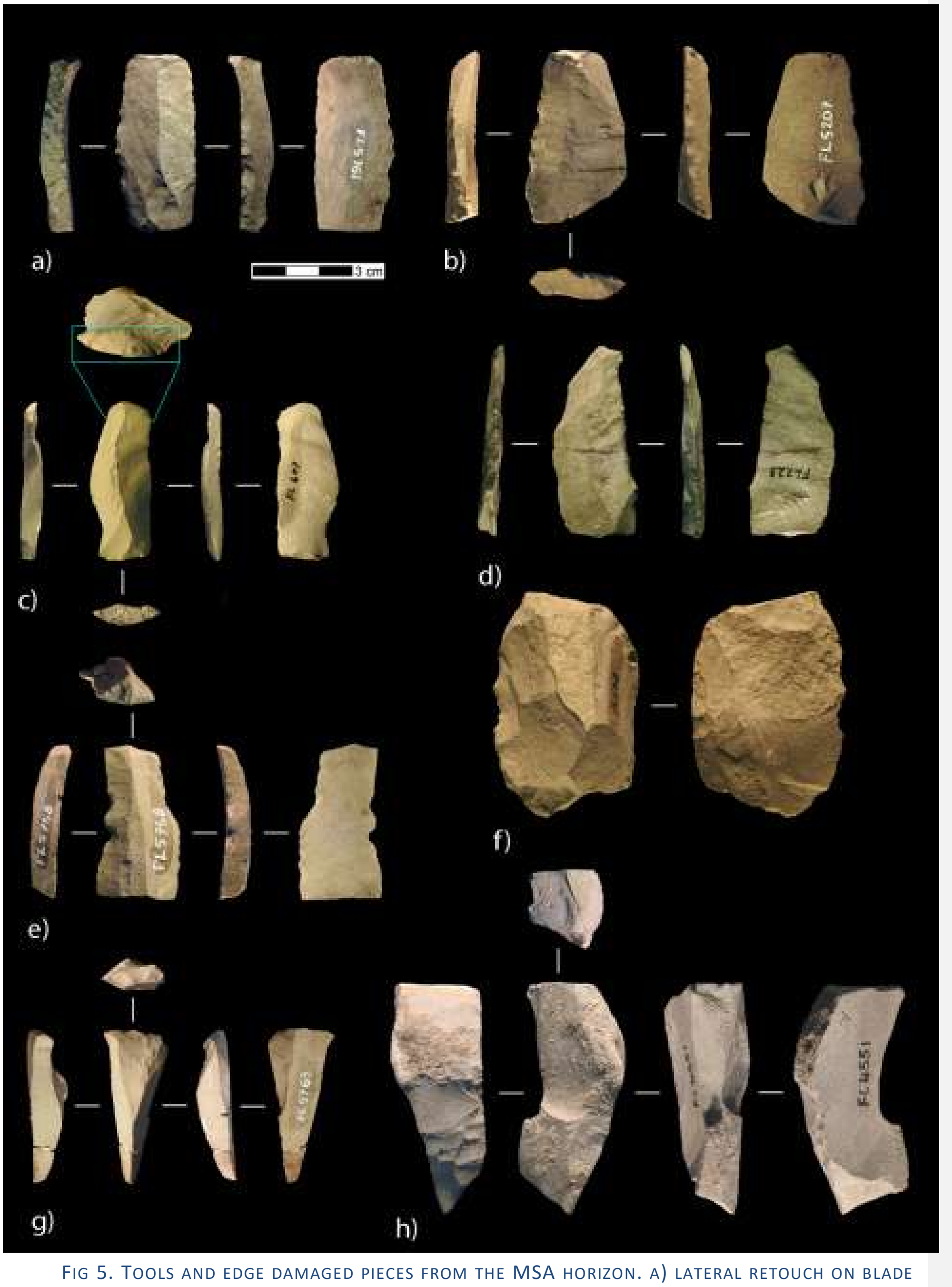

Fig 5. Tools and edge damaged pieces from the MSA horizon. a) lateral retouch on blade #FL5761, b) lateral retouch FL#5207, c) end scraper #FL607, d) lateral retouch/backing on blade #FL223, e) notched blade fragment #FL5758, f) scraper use on core #FL598, g) scraper retouch and burination on triangular blade #FL5763, h) scraper use on core #FL4551.

4.3.2. BLANKS

There are four types of blanks: blades, bladelets, points and flakes. Blades are elongated blanks with a length-to-width-ratio of 2:1. The lateral edges of blades are parallel to sub-parallel and some blades show a pointed distal end (Fig 6). This blade definition is similar to the description of "flake-blades" described by Kuman and Henderson. in their analyses the frequency of flake-blades is 21% of complete blanks and 17% of complete and fragmentary blanks respectively [6,11 p. 147]. This is comparable to the blade frequency in this study (19%). Bladelets have the same characteristics as blades, but have a maximum width of 12 mm (following [32,33]). Henderson also distinguished bladelets, which comprise 6% of the blanks in her study (including fragments) [6]. This is similar to the 6.5% bladelet frequency calculated for the study here. Points show convergent edges forming a triangular blank shape; they can exhibit flake-dimensions or blade-dimensions. This is also described by Kuman [11], who defines triangular flakes and triangular blades as separate blank types; together they make up 18% of complete blanks. Henderson [8] only has a category of triangular flakes, which exhibits a lower frequency of 5%. Points in this study make up 26% of the complete blanks (Fig 7).

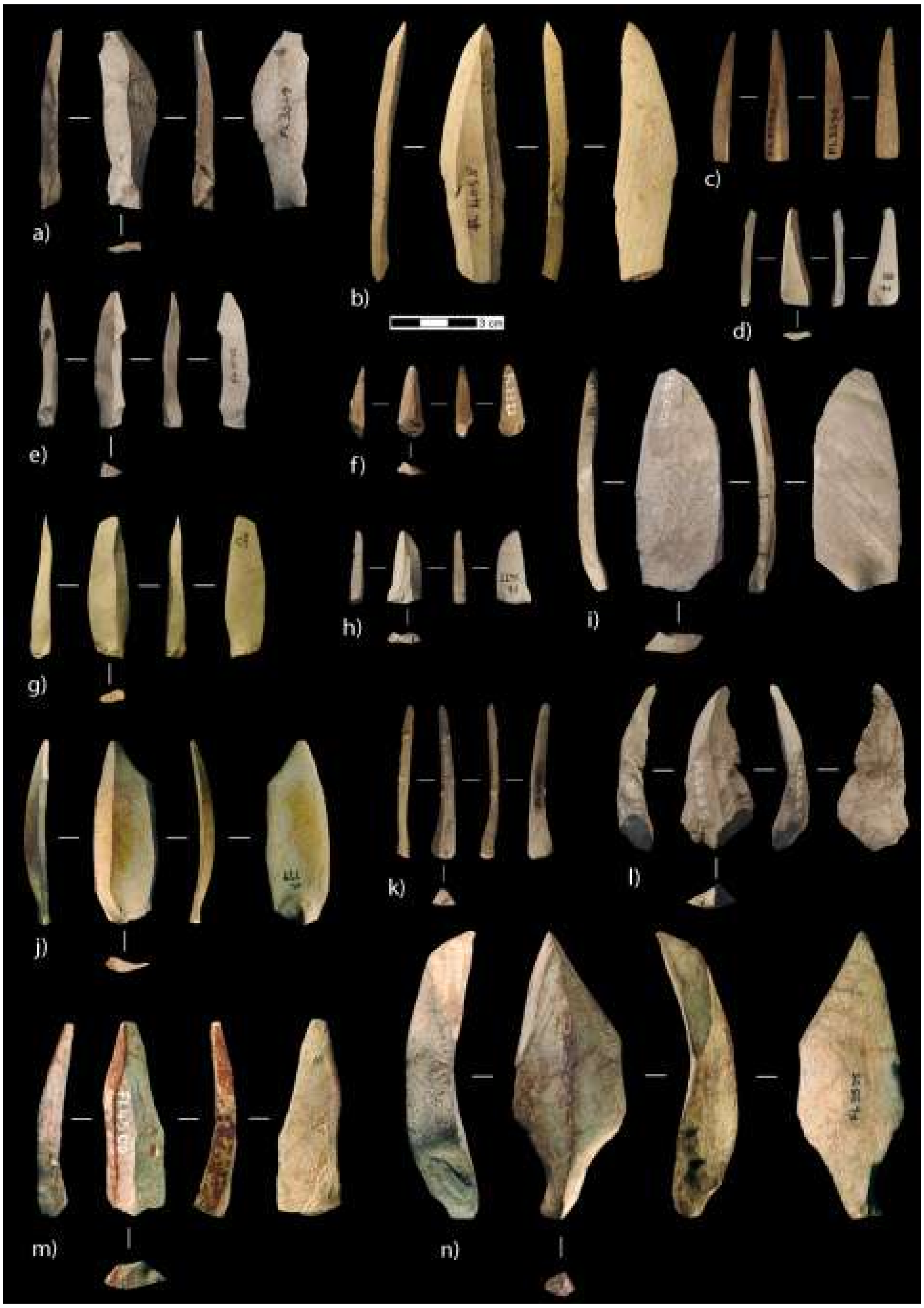

FIG 6. BLADES FROM THE MSA HORIZON. A) BLADE #FL3649, B) POINTED BLADE #FL4058, C) POINTED BLADELET FRAGMENT #FL3596, D) TRIANGULAR BLADELET #FL991, E) POINTED BLADELET #FL1042, F) TRIANGULAR BLADELET #FL3323, G) BLADE #FL1046, H) TRIANGULAR BLADELET #FL1677, I) POINTED BLADE WITH RETOUCH ON DISTAL RIGHT EDGE #3003, J) POINTED BLADE #FL774, K) BLADELET #FL4992, L) TRIANGULAR BLADE #FL4485, M) TRIANGULAR BLADE #FL4500, N) POINTED BLADE #FL3595.

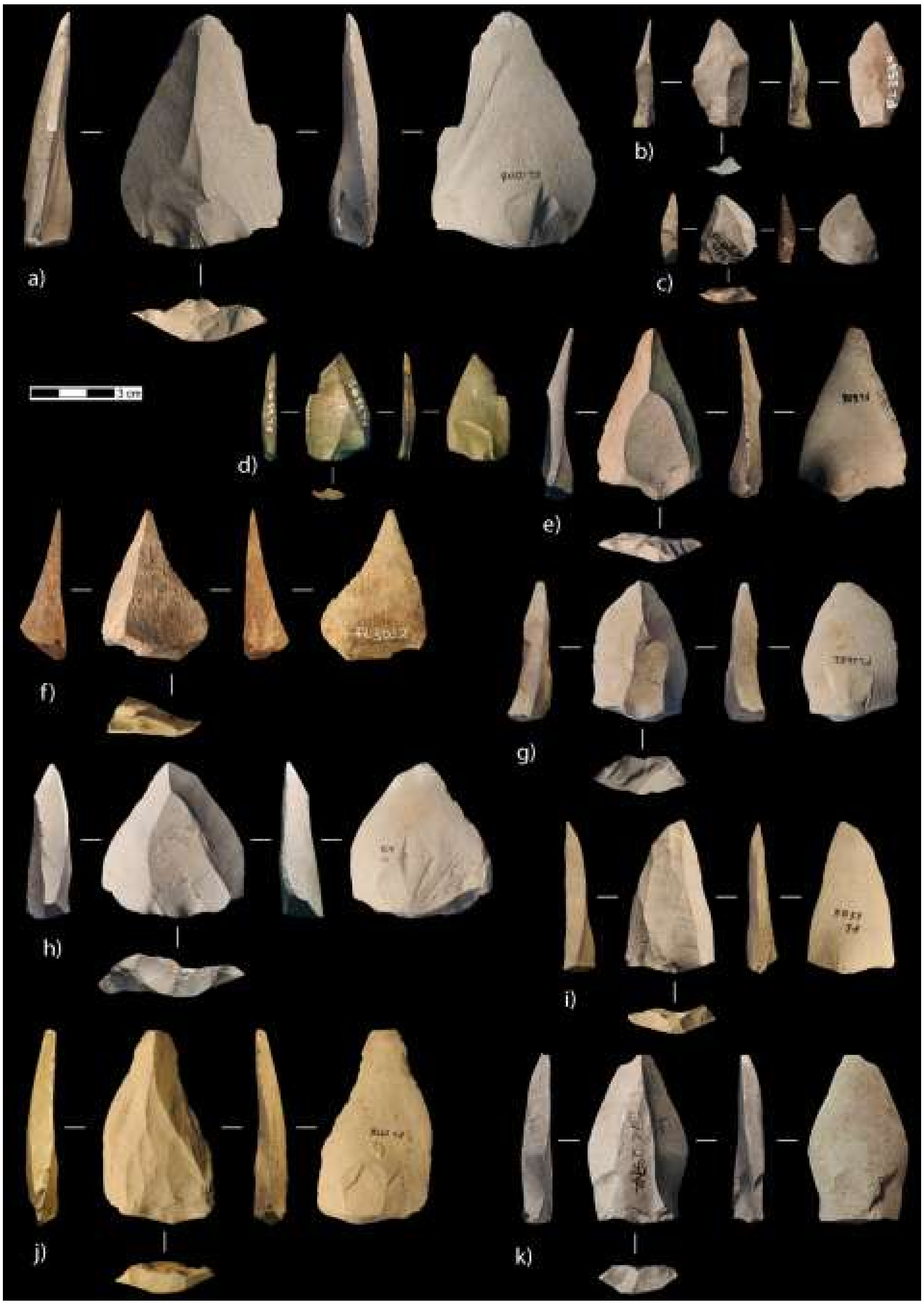

Fig 7. Points from the MSA horizon. a) triangular flake #FL1008, b) triangular flake #FL3540, c) triangular flake #FL5489, d) triangular flake #FL3509, e) triangular flake #FL606, f) triangular flake #FL3032, g) triangular flake #FL1682, h) triangular flake #FL678, i) triangular flake #FL1508, j) triangular flake #FL1776, k) triangular flake #FL2974.

Table 4. Mean values of weight (g), length (mm), width (mm), depth (mm) and EPA (°) for complete blanks by blank type.

	N	mean weight (g)	mean length (mm)	mean width (mm)	mean thickness (mm)	mean EPA (°)
point	175	9.9	44.65	25.47	8.65	87
blade	130	11,5	54.23	20.70	9.35	88
bladelet	44	0,9	29.69	9.59	4.80	86
flake	323	8.1	31.48	27.18	8.06	87

Flakes are most numerous (48% of complete flakes) and are of lighter weight compared to other blank types (Table 3). They also have a rather short and wide morphology. Blades are less frequent (19%); they are the heaviest blank type (11.5 g) and show long, narrow and thick mean dimensions (Table 3). Bladelets are the least numerous (6.5%) and seem to be, just like the blades, rather thick compared to their width. Bladelets are the lightest blank type and have mean technological lengths of 2.97 cm. This fits with thicker blade and bladelet products from burin-core reduction discussed below. Points are the second most frequent blank type. The mean measurements for points lie between the mean values for blades and flakes (Table 3). External platform angles (EPA) have comparable similar mean values for all blank types, with bladelets showing slightly more acute EPAs. The platforms are dominantly plain (Table 4: 53%), but 35% show faceting. Dihedral platforms are sparse with 5%, and cortical platforms almost absent with only 1% (Table 4). Kuman's analysis comprised a frequency of 26% multiple faceted platforms and 49% plain platforms [11 p. 145]; "turned" platforms (4%) and "two-facets" platforms (21%) are the other platform preparations Kuman describes, those can be related to diheral and informlly faceted platforms presented here.

Table 5. Platform type by blank type of pieces with preserved platform (N and %).

	blank type									
	blade		bladelet		point		flake		Total	
platform type	N	%	N	%	N	%	N	%	**N**	**%**
faceted planar	77	8%	21	2%	57	6%	88	9%	**243**	**26%**
facetet convex	16	2%	1	<1%	30	3%	36	4%	**83**	**9%**

informal facet	6	1%	2	<1%	8	1%	16	2%	**32**	**3%**
dihedral	3	<1%	2	<1%	14	1%	25	3%	**44**	**5%**
plain	98	10%	32	3%	80	9%	284	30%	**494**	**53%**
plain + shattering	3	<1%	1	<1%		0%	8	1%	**12**	**1%**
shattered	2	<1%	1	<1%	3	<1%	9	1%	**15**	**2%**
cortical	2	<1%	2	<1%	2	<1%	5	1%	**11**	**1%**
Total	**207**	**22%**	**62**	**7%**	**194**	**21%**	**471**	**50%**	**934**	**100%**

Table 6. Technological categories by blank type of complete pieces.

Technological category	point	blade	bladelet	flake	Total
end-product	138	68	32	62	300
plunging distal preparation	7	14	2	50	73
debordant cortical	13	17	0	12	42
debordant other	4	3	2	4	13
core-surface-management	23	15	5	128	171
platform shaping	1		1	16	18
decortification flake		1		16	17
flaking debris	1		2	34	37
Total	**187**	**118**	**44**	**323**	**672**

Blanks have been divided into the technological categories: end-products, plunging flakes for distal preparation, debordants or core-edge flakes, core-surface-management flakes, platform shaping flakes, decortification flakes and flaking debris. End-products are interpreted as the desired products, as they show regular morphologies and dorsal scar ridges. They are most frequent with 45% of all complete pieces (Table 5).

Core-surface-management flakes are the second most numerous technological category with 25%. They are removed to create guiding scar ridges on the removal surface of the core or to renew the whole removal surface. Surface-management flakes are the most common type of core preparation. Plunging pieces with thick distal ends establish distal convexities and, with 73 pieces they are common in the assemblage (11% of complete blanks). ; however. Debordants mostly show one fully or partly cortical side, but can also show a steep lateral side, for instance with orthogonal negatives from the core edge. They are most commonly elongated with blade or point morphologies. Debordants are continuously removed during core reduction and have a frequency of 8%. Some debordants show edge damage, testifying that they were also used as tools.

Platform shaping flakes are mostly removed orthogonally to the removal surface of the core, and correct the removal angle of the platform edge. Their morphology is crest-like, but real crests for the preparation of laminar production are not present. Only 18 platform shaping flakes could be identified (3%), which indicates, that platforms might more commonly be prepared by platform trimming. Decortification flakes show cortex cover over most of the dorsal surface. They prepare the cobble or piece of raw material for the use as a core. They are scarce in the assemblage (3%), which implies minimal input into the setting up of cores. Flaking debris are small flakes (but > 2cm) which are probably waste from knapping (6%).

BLANK PRODUCTION

Points are produced by multiple reduction sequences including unidirectional reduction on platform and parallel cores. Only a few of the points can be undoubtedly assigned to one of these systems, as both reduction systems can produce points of similar morphology. However, characteristic Levallois points are present and stem from a parallel reduction.

Blades have also been produced with more than one reduction system. Parallel unidirectional reduction of blades is the most common; however, a laminar reduction from platform cores is also present. Blades from both reduction systems can exhibit similar morphologies, but strongly curved profiles, especially in the distal part, indicate laminar production. On the other hand, hinge terminations are mostly seen in parallel reduction. A few blades are produced by burination, these show characteristic narrow and thick sections (<2:1 width-thickness-ratio) and mostly hinge terminations.

Bladelets are also produced by burination and additionally, by a separate bladelet reduction system. Burin-spall bladelets show the same characteristics as burin-spall blades, but a maximum width of 12 mm (following [32,33]). Burin-spalls are mostly bladelets, but some blades are also present (Fig 8). All burin-products show a hinge termination (if the distal end is preserved). Some bladelets are twisted, and others have curved or straight profiles. The platforms are predominantly flat. First burin spalls exhibit a central ridge on their dorsal side, which is the lateral edge of the flake-core. The following products exhibit varying dorsal scar patterns, but mostly long triangular scars.

FIG 8. BURIN-SPALL BLADES AND BLADELETS FROM THE MSA HORIZON. A-C) BLADELET BURIN-SPALLS #FL1510, #FL4778, #FL770, D-E) BLADE BURIN-SPALLS WITH EDGE DAMAGE ON DORSAL RIDGE (EARLIER LATERAL EDGE OF THE BURIN-CORE) #FL1924, #FL2747.

There are also bladelets which are not produced by burination, but by a separate reduction system. Here, narrow platform and parallel cores are reduced to manufacture bladelets, that are thinner compared to width. Bladelets of this reduction system are also less prone to have hinge terminations.

Flakes are mostly produced by parallel reduction systems, but can also occur in laminar platform core reduction, especially as core maintenance flakes. Only a few flakes (n=3) show characteristics of a Levallois flake with facetted platforms and multiple dorsal negatives.

4.3.3. CORES

Kuman's analysis [11 p. 145] only contained ten cores. Seven of these were "multiple platform irregular cores", two were "prepared cores for triangular flakes", and one is described as a "core on a blade". Henderson [6,8] found 63 cores but did not categorise them further. In this study, 75 cores are present and most of them show a systematic reduction on platform and parallel cores and cores-on-flakes (Table 6).

TABLE 7: CORE TYPES WITH SUB-CATEGORIES.

Core types	N sub-categories	N	%
prismatic[a]	5		
semi-rotational prismatic[b]	8		
pyramidal[c]	3		
semi-rotational pyramidal	6		
platform		**22**	**29%**
unidirectional	7		
unidirectional convergent	4		
bidirectional	4		
bidirectional convergent	1		
bladelet	1		
parallel		**17**	**23%**
burin-core-on-flake	10		
parallel on ventral side	4		
bladelet (not burin)	2		
dorsal on fragment	1		
core-on-flake		**17**	**23%**
multiple platform		**5**	**7%**
fragment		**4**	**5%**
initial		**3**	**4%**
irregular		**7**	**9%**
Total		**75**	**100%**

[a] including 1 bidirectional
[b] 2 bidirectional
[c] 1 bladelet core

Platform cores are mostly reduced in a semi-rotational manner. Only a few platform cores are in a state that is not exhausted, and these specimens show a clear volumetric approach for blade and blade-sized point production (Fig 9). The more reduced cores are indistinguishable between platform and parallel cores but show a removal surface around-a-corner (semi-rotational) (Fig 10). The true parallel cores are reduced parallel to the plane of intersection between reduction surface and under-surface. Most of the parallel cores show recurrent unidirectional reduction (Table 6: N=12/18), but five cores exhibit bidirectional reduction from opposing platforms. About one-third of parallel cores show convergent scar patterns for the production of triangular blanks. Preparation on platform and parallel cores is seen in the form of platform preparation, preparation of lateral and distal convexities, and preparation of scar ridges.

Only one Levallois core exhibits centripetal preparation with unidirectional reduction. In total, four typical Levallois cores are identified in the parallel core category. All of them exhibit recurrent reduction, with mostly convergent scar ridges. Two Levallois cores are bidirectional with opposed platforms. One platform and one parallel core exhibit only bladelet reduction. However, bladelet negatives are found in combination with other negative scars on multiple cores.

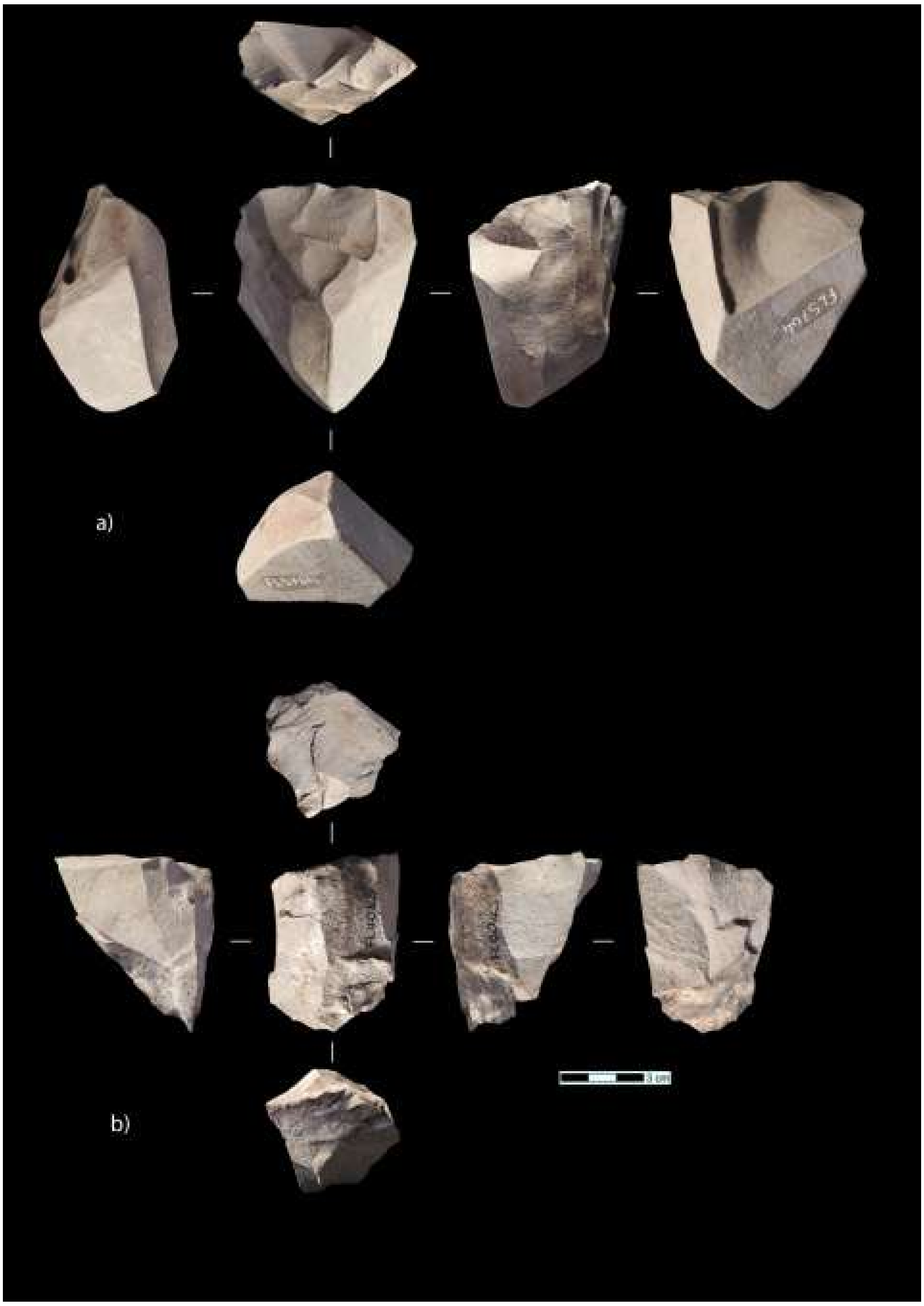

FIG 9. FLORISBAD CORES FROM THE MSA HORIZON. A) PYRAMIDAL PLATFORM CORE (TYPE I IN [30] TYPOLOGY) #FL3764, B) PRISMATIC PLATFORM CORE (TYPE I IN [30] TYPOLOGY) #FL4045.

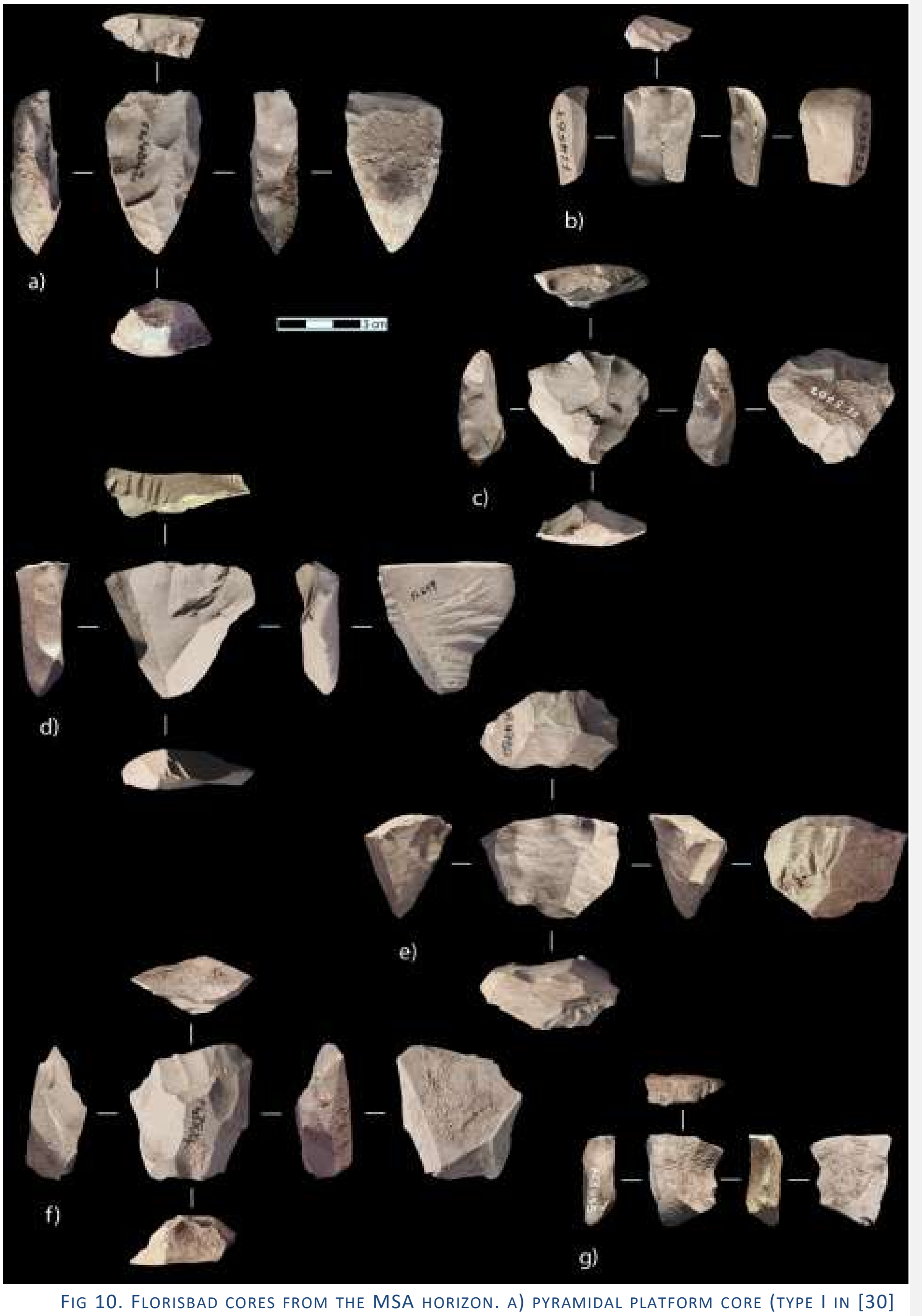

FIG 10. FLORISBAD CORES FROM THE MSA HORIZON. A) PYRAMIDAL PLATFORM CORE (TYPE I IN [30] TYPOLOGY) #FL4842, B) UNIDIRECTIONAL PARALLEL CORE (TYPE II IN [30] TYPOLOGY) #FL4567, C) UNIDIRECTIONAL CONVERGENT PARALLEL CORE (TYPE III IN [30] TYPOLOGY) #FL5707, D)

UNIDIRECTIONAL CONVERGENT PARALLEL CORE (TYPE II IN [30] TYPOLOGY) #FL649, E) UNIDIRECTIONAL PARALLEL CORE WITH DISTAL PREPARATION (TYPE IV IN [30] TYPOLOGY) #FL4780, F) UNIDIRECTIONAL PARALLEL CORE WITH DISTAL PREPARATION (TYPE IV IN [30] TYPOLOGY) #FL3824, G) UNIDIRECTIONAL PARALLEL BLADELET CORE #FL3445.

Cores-on-flakes (23% of cores) occur in a multitude of shapes, but the common feature is that a flake was re-used as a core-blank. Cores-on-flakes exist since the Lower Palaeolithic (e.g., Revadim in Israel [34]). At Florisbad, two structured strategies of cores-on-flakes are identified. The most common sub-category of cores-on-flakes are burin-cores (Table 6: N=10/17). The phenomenon of burin-cores is well described for the Middle Palaeolithic (e.g., Hummal in Syria [35,36], Obi-Rakhmat Grotto in Usbekistan [37–39]) and Upper Palaeolithic (e.g., Kara-Bom in Syberia [40]). In the case of Florisbad, the burin-cores-on-flakes show multiple negatives/burinations on one end (proximal or distal) of a blank (mostly blades and points). The negatives are predominantly on the sides of the flake, but can also be invasive on the ventral surface (Fig 11). Because of this invasive reduction, the pieces are identified as cores, although usage as a tool cannot be excluded, as no use-wear analysis was conducted. The products of burin-cores are mostly bladelets, but also blades. Two unidirectional bladelet cores-on-flakes, which are not removed with a burin method, are also present (Fig 11).

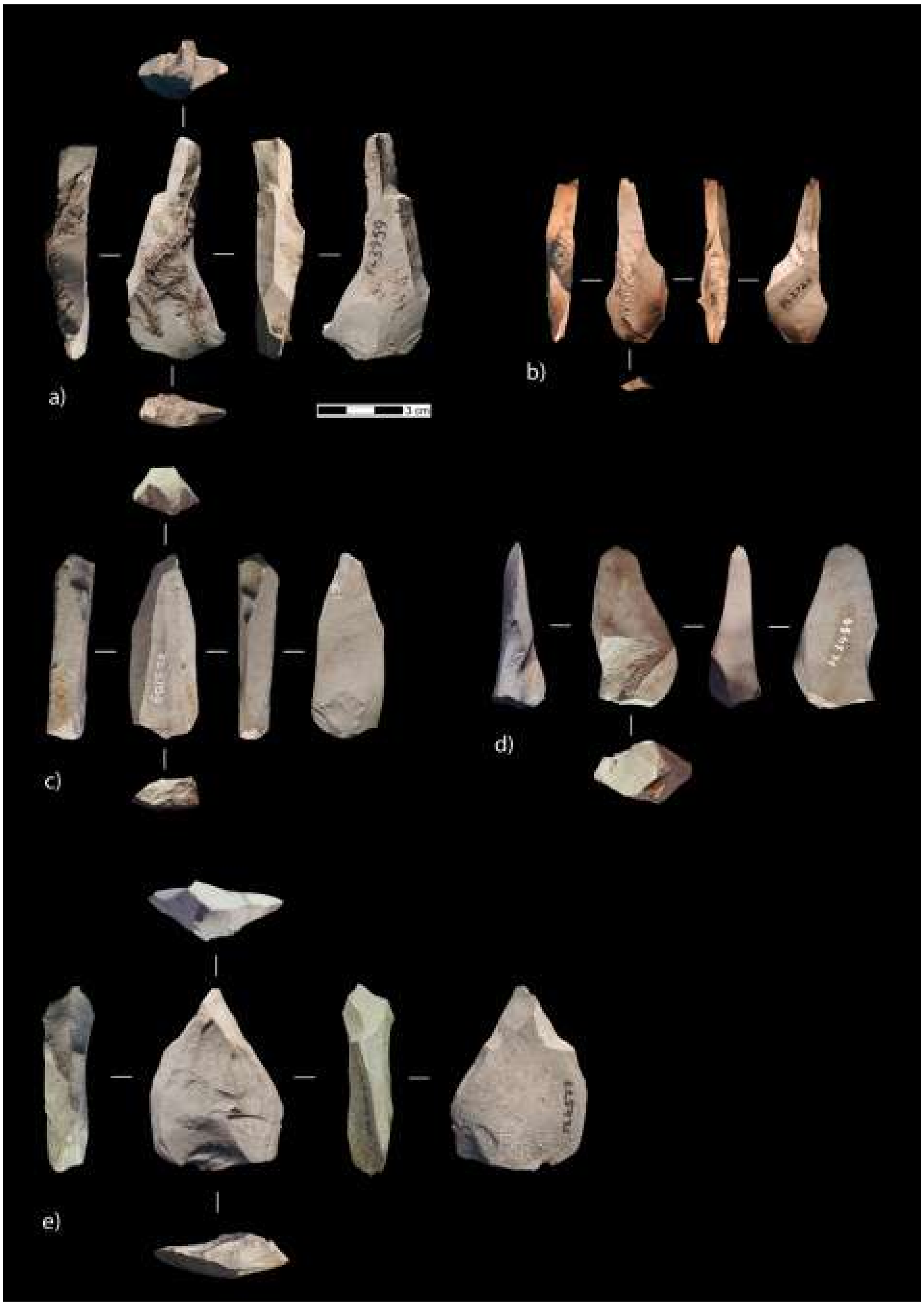

FIG 11. FLORISBAD CORES FROM THE MSA HORIZON. A) BURIN-CORE-ON-FLAKE #3959, B) BURIN-CORE-ON-FLAKE #2745, C) BURIN-CORE-ON-BLADE #3109, D) CORE-ON-FLAKE WITH TWO BURINATIONS #3489, E) BURIN-CORE-ON-FLAKE #4577.

Another strategy of cores-on-flakes is a parallel unidirectional reduction mostly on truncated blanks. Most of the parallel cores-on-flakes only exhibit secondary reduction on the ventral face of a flake. One core-on-flake shows removals only on the dorsal surface of the core-flake. The products are either struck from a truncation of a flake fragment (Fig 12) or from the existing platform but on the ventral side (Fig 12). Although some of the cores-on-flakes are truncated, there are only two specimens, which fall into the definition of truncated-facetted or Nahr Ibrahim pieces [35,41–43]. Predominantly the platforms/truncations are not prepared.

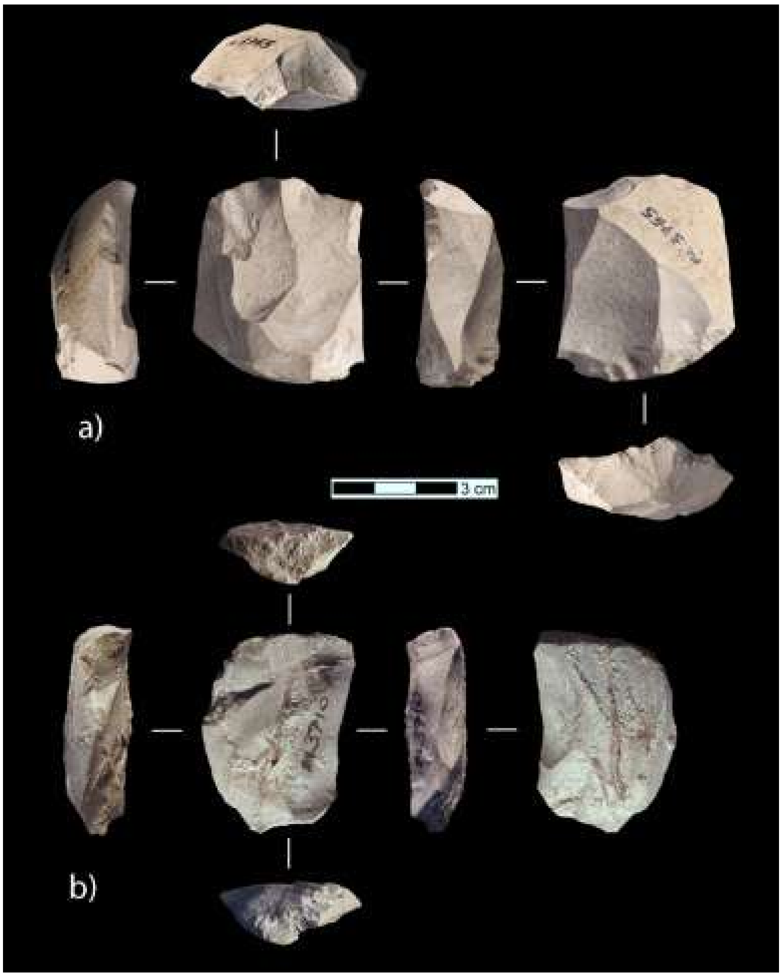

FIG 12. FLORISBAD CORES FROM THE MSA HORIZON. A) CORE-ON-FLAKE WITH PARALLEL REDUCTION ON VENTRAL FACE (TRUNCATED-FACETED) #FL3755, B) CORE-ON-FLAKE ON TRUNCATION WITH PARALLEL REDUCTION ON VENTRAL FACE (WITH CEMENTED SEDIMENT CRUST) #FL3710.

There is no preference towards the distal or proximal end of the blank to be used for flake production. This is true for both, the parallel cores-on-flakes and the burin-cores-on-flakes"The decision seems to be based on thickness. Therefore plunging flakes with a thick distal end are reduced on the distal part, and flakes, where the bulb is the thickest part, are worked on the proximal end.

4.4. *CHAÎNES OPÉRATOIRES*

There are two primary reduction sequences which are both unidirectional. One is a parallel system on Levallois-like cores (N=12), and the other is a laminar system on platform cores (N=19). Both reduction sequences produce elongated products, which are blades, triangular blades and triangular flakes [44]. Apart from this, bidirectional reduction is seen on some of the parallel (N=5) and prismatic cores (N=3).

The reduction methods described above are only part of the whole *chaîne opératoire* as re-use and recycling of pieces, including blanks, cores, and chunks, can be seen in multiple ways. The recycling of cores and chunks into tools, is rarely seen on 0.3% of the assemblage. Cores-on-flakes are not interpreted as a form of recycling, as raw material sources were close and plentiful [6 p. 39]. There was, therefore, no pressure of maximising the output of raw material. Wojtczak [35,41] describes cores-on-flakes as a sub-division in the reduction sequence for the Hummalian assemblage in Hummal, Syria. In the case of Hummal.; The cores-on-flakes are interpreted as a ramification of the *chaîne opératoire*, rather than a case of recycling. The same can be said for the Florisbad material, where several cores-on-flakes are present, which are either reduced in a similar way as the parallel cores (in a unidirectional manner) and produce the same (predetermined) blank shapes.

Hovers [43] interprets cores-on-flakes from the Levantine Mousterian slightly differently, namely as a separate operational sequence which starts with the selection of flakes as cores [45]. This view can be applied to the burin-cores, which are reduced with a different strategy. The burin-cores also produce highly specific blank shapes, which are included in the general repertoire by a separate *chaîne opératoire*. It is unclear if the re-used flakes were picked up and used as cores in the same time as the flake was produced, or if it was only picked up during a much later occupation.

Kuman [5,11] also describes cores-on-flakes in the Unit F assemblage; however, burins fell in the category of tools, whereas in this study, they are interpreted as burin-cores. With this distinction, the technological repertoire of the Florisbad occupants shows a wider range of core reduction methods and desired blank shapes than noted by Kuman [5,11] and Henderson [6,8].

5. Summary and site function

The results here show the complete *chaînes opératoires* used during the accumulation of the MSA horizon, adding more perspectives to Kuman's study of the Florisbad Unit F lithics. With the inclusion of material from the Henderson excavation, a more detailed description of the lithic technology is possible. This entails that laminar products, both blades and bladelets, are manufactured in two reduction systems. One is performed on parallel and platform cores which are reduced with a recurrent unidirectional method, in this reduction system triangular blanks are also produced. The other reduction system uses burin-like blows on cores-on-flakes which produce laminar products with specific thickness-to-width ratio and predominant hinge terminations. The main difference compared to earlier studies is the inclusion of burins into the core category, as opposed to categorising them as tools. It is shown here that burin-cores are a systematic and frequent feature of the assemblage. The kind of reduction illustrated on multiple burin-cores indicate a primary function as cores. In addition to the expedient character already described by both Kuman [5,11] and Henderson [8], the frequency of opportunistic behaviours such as re-use and recycling is shown here. This includes the use of flakes as core blanks and the use of cores as tools.

All steps of the reduction sequence with small knapping-debitage are found in this assemblage, and implements have been used on-site. The faunal remains indicated that the site was a butchering and processing site [5,8,10,11]. Kuman and Henderson deduced from the lithic material that the site was used for multiple short occupations [6,8,11]. Brink and Henderson [23] inferred from the spatial distribution of faunal remains, lithics and a hearth that different activity zones existed in specific areas of the site. They determined that the consumption of prey, including marrow extraction, was focused around the hearth area. The processing and main butchery area was located about 10 m to the east of the hearth [23]. They also found a concentration of lithics interpreted as a knapping spot close to the hearth (Fig 13). Lithic refits were only found in either the knapping area at the hearth, or in the concentration further east, where the processing was happening. No refits between these locations could be made [23 p. 14].

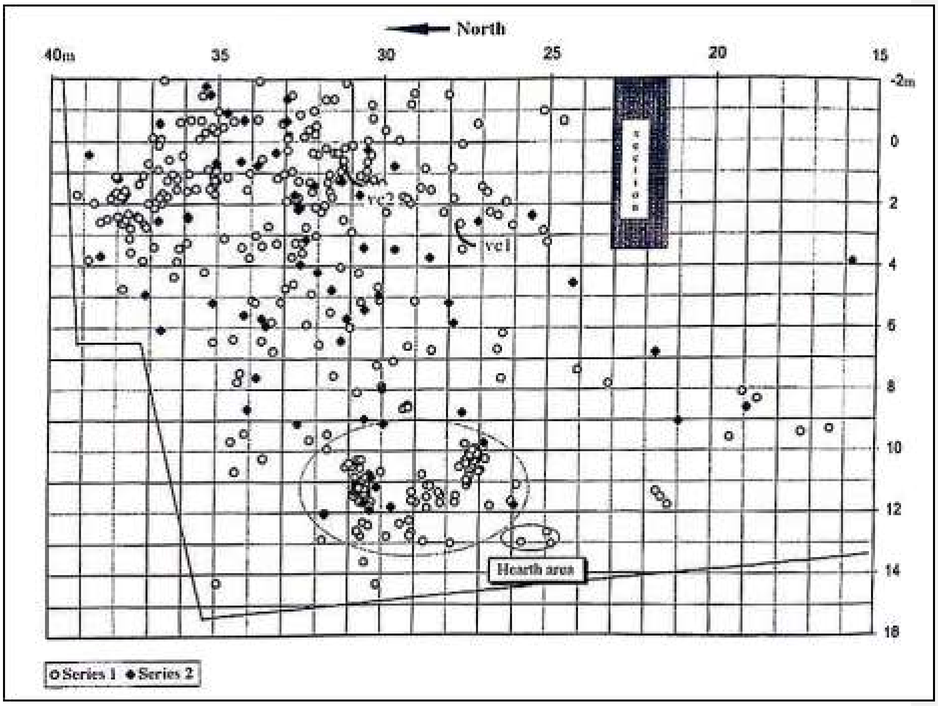

FIG 43. FLORISBAD MSA HORIZON. SPATIAL DISTRIBUTION OF MACRO DEBITAGE (EMPTY DOTS) AND CORES (FILLED DOTS) WITH THE HEARTH AREA, FROM BRINK AND HENDERSON [23 FIG 11].

The presentstudy supports the inference of a processing site. Tools were produced to be used immediately. The variety of blank shape and dimensions might further relate to opportunistic production of tools needed at hand. This variety may also be related to shorter visits over a long period of time, and various groups of people visiting the site. The high amount of re-use, as is seen in recycling cores into tools or using flakes as cores, mainly may be associated with multiple visits. The sub-step of recycling and re-use is not relatable to specific provisioning systems, but instead to the site function [35,46]. As tools were most likely produced and used on-site and the function of the site was primarily processing, interpretation about provisioning systems is less relevant [46].

6. Discussion: Comparison to other MIS 5 assemblages in the South African landscape

In order to understand possible mobility and transmission of information processes in MIS 5, an inter-assemblage comparison is essential [47]. Here I provide a comprehensive summary of the main technological characteristics of South African MIS 5 sites, adding to the growing body of literature on this topic [11,48–57] (see S1 Text for a description of the technology).

Table 8. MIS 5 sites discussed in this study with their setting, region, rainfall zone and MIS 5 sub-stage (if possible)

site	setting	region	rainfall zone	MIS 5 sub-stages
Florisbad	interior open-air site	Free State	summer rainfall	MIS 5e
Border Cave	interior cave site	KwaZulu-Natal	summer rainfall	MIS 5-6
Bushman Rockshelter	interior rock shelter	Limpopo	summer rainfall	MIS 5
Sibudu Cave	interior rock shelter	KwaZulu-Natal	summer rainfall	MIS 5
Klasies River main site	coastal cave site	Eastern Cape	year-round rainfall	MIS 5c-d
Pinnacle Point 13B	coastal cave site	Western Cape	year-round rainfall	MIS 5c, d, e
Pinnacle Point 5-6	coastal cave site	Western Cape	year-round rainfall	MIS 5a-b
Cape St. Blaize	coastal cave site	Western Cape	year-round rainfall	MIS 5
Blombos Cave	coastal cave site	Western Cape	year-round rainfall	MIS 5b-c
Die Kelders 1	coastal cave site	Western Cape	winter rainfall	MIS 4-5
Ysterfontein 1	coastal rock shelter	Western Cape	winter rainfall	MIS 5
Hoedjiespunt	coastal open-air site	Western Cape	winter rainfall	MIS 5

1				
Diepkloof Rockshelter	interior rock shelter	Western Cape	winter rainfall	MIS 5d
Putslaagte 8	interior rock shelter	Western Cape	winter rainfall	pre-MIS 4, MIS 5-6

Lithic analysis in South Africa has changed over the last 20 years in its approach to understanding technology rather than describing the typology. However, depending on the researcher, different variables are used for analyses. This study refers to the most recent descriptions of MIS 5 assemblages [30,48,51,52,55–64] and the older analysis of Border Cave as essential data were not reported in more the recent literature [65]. One of the problems of inter-site comparison are ambiguous terms, e.g., the term "point" is traditionally used for retouched triangular blanks, with an undertone of its use as a spear or arrowhead. Over time, the term has been used with different meanings, especially in some literature of the MSA, where unretouched convergent flakes and blades have also been included as points (e.g. [66–68]).

The assemblage descriptions in S1 Text are given with the most detail possible according to the categories. The different MIS 5 assemblages of a site are described separately in S1 Table with their age and MIS 5 sub-stage. The name of the techno-complex or industry is provided from the relevant literature. Raw material information is divided into local (<20 km) and non-local (>20 km) sources. The dominant *chaînes opératoires,* as well as those of a secondary character, are described. The knapping technique is either directly taken from the literature, or assumed from descriptions of frequent *siret* breaks, bulbs of percussion and lips (information in brackets stems from publications that are not explicit about the knapping technique). S1 Table also includes the frequencies of cores, the different blank shapes, facetted platforms, tools and edge damage. By comparing these parameters, it is evaluated how similar/dissimilar the MIS 5 sites in different regions and settings are.

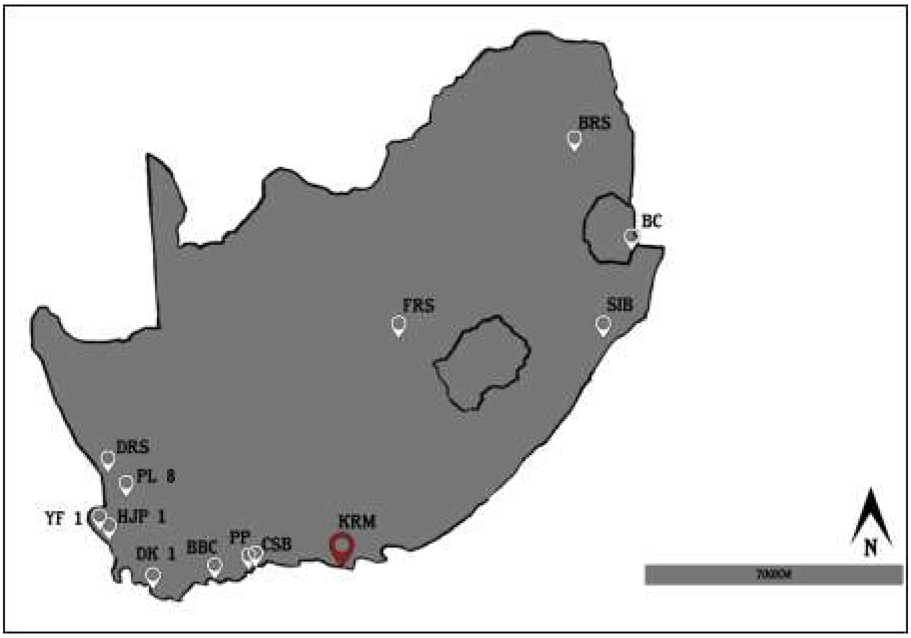

FIG 54. MAP OF SOUTH AFRICA WITH SITES MENTIONED IN THIS PAPER. BLOMBOS CAVE (BBC), BORDER CAVE (BC), BUSHMAN ROCKSHELTER (BRS), CAPE ST. BLAIZE (CSB), DIE KELDERS 1 (DK 1), DIEPKLOOF ROCKSHELTER (DRS), FLORISBAD (FRS), HOEDJIESPUNT 1 (HJP 1), KLASIES RIVER (KRM), PUTSLAAGTE 8 (PL 8), PINNACLE POINT (PP), YSTERFONTEIN 1 (YF 1).

The dates for the presented sites vary between MIS 5a to MIS 5e. Die Kelders 1 has younger dates between MIS 5 and 4; however, no MIS 4 tool types are present, so it is hypothesised here that the assemblage covers MIS 5. The sites encompass different environments (coastal and inland) and settings (cave and open-air). This study builds on previous ones partly exploring similarities in lithic material over South Africa [47,48,53]. Common characteristics in all the assemblages are known to be the dominant use of local raw materials, a direct hard hammer internal percussion technique, a low frequency of formal tools with denticulates/notches and scrapers prevailing and common platform faceting (frequency can vary from 10% up to 52%, S1 Table) (see e.g. [51,53,69,70]). Some sites differ slightly, but in general, this pattern can be applied to all MIS 5 assemblages discussed in this paper.

Local raw materials comprise about 90-100% in all assemblages. The rock type can differ between available sources of quartzite, silcrete, quartz, dolerite and hornfels. Exceptions to this trend is the pre-Still Bay type Lyn at Diepkloof with 17% of raw material stemming from exotic sources more than 30 km away. Slightly higher percentages of non-local raw materials with the furthest outcrops in 10-30 km distance are found at HDP1 AH III and in the Pinnacle Point 13B MIS 5e assemblage.

For most MIS 5 assemblages a direct internal percussion with a hard hammer is described. in some cases, this percussion technique is implied by the presence of common *siret* fractures and hammerstones. At Sibudu a soft stone hammer in combination to hard hammer is assumed. Only Hoedjiespunt 1 and the Bushman Rockshelter lower layers display the use of bipolar percussion on quartz, although other raw materials are reduced with a handheld direct percussion technique. This shows widespread use of the same percussion technique with an adaptation for quartz in some localities.

The amount of formal tools is known to be very low in MIS 5. Most assemblages have tool frequencies of ca. 2%. However, some assemblages contain more tools (> 5%); those are Bushman Rockshelter upper, Sibudu, Cape St. Blaize and Diepkloof type Lyn.

Regional patterning of tools types has been described by multiple authors [53,61,69] and the comparison here confirms this. For the west and south coast denticulates and notches have been identified as the most common tool type during MIS 5 (e.g. [53]). As illustrated in Table A1, these tool types are commonly paired with scrapers and laterally retouched pieces, less common are burins, backed pieces and *pièces esquillées*. The only exception in this area is Diepkloof type Lyn, which includes bifacial pieces. An interior site with a comparable toolkit to the eastern and western coast is Florisbad. The inland sites in the north-east of South Africa exhibit a different formal tool composition. Uni- and bifacial pieces are only seen at Border Cave, Bushman Rockshelter and Sibudu.

6.1. Blank production

Variation is seen in different *chaînes opératoires* and the preferred shape of end-products. The three dominant types of end-products identified are elongated pieces (blades and triangular blades), triangular flakes, and flakes. Every MIS 5 assemblage is either focused on only one of these blank types, or two blank types with varying relation to each other. Depending on the preferred blank type different *chaînes opératoires* are used. Elongated products are most commonly produced with a unidirectional parallel reduction strategy, as seen at Diepkloof pre-Still Bay, Bushman Rockshelter layer 28, Sibudu A-C layers and possibly Ysterfontein 1. Triangular flakes are also produced with a unidirectional reduction on parallel cores (Blombos, Pinnacle Point 5-6). A combination of elongated products and triangular flakes, both produced with unidirectional parallel reduction systems are present at Klasies River SMONE-SBLS, Pinnacle Point 13B MIS 5c-e, Cape St. Blaize, Diepkloof MSA-Mike and Florisbad. Triangular flakes produced by inclined/discoid or centripetal reduction, are prevalent only at Putslaagte 8 MIS 5-6. For the production of flakes, a centripetal reduction on parallel cores and inclined reduction are the most common strategies. This is seen at Die Kelders 1 layer 6 East and West, Border Cave BACO-A-D and Hoedjiespunt 1 AH I-III. Hoedjespunt 1 and Putslaagte 8 pre-MIS 4 are the only assemblages with frequent bipolar reduction (on quartz).

The production of triangular flakes seems to be concentrated on the southern Cape with two outliers, which are Diepkloof MSA Mike on the western coast and Florisbad in the Free State, these sites also exhibit triangular flake production. A production of bladelets is seen in a few assemblages across the landscape, but only at Florisbad, Bushman Rockshelter and Klasies River frequencies higher than 5% are present [30,61] (S1 Table).

Following Wallace and Shea [71], expedient or opportunistic core technology is linked to decreased mobility or rather sedentism. In their definition, expedient technology is characterised by being highly wasteful, producing no specific blank shape or size, needing limited effort and little technical knowledge. In this study, it is argued that although expedient and opportunistic behaviour is seen, the technical know-how and the desire to produce specific blank shapes are present.

The case of Florisbad shows, that the core blank and preparation was not as crucial as the blank shape. Blank morphology was, therefore, the main objective of the Florisbad knappers, cores are variable as seen in the platform and parallel cores and cores-on-flakes. One blank shape could only be achieved by burination of flakes, and those are at least half as thick as wide (<2:1 width-thickness ratio).

In order to achieve these blanks, the *chaîne opératoire* was expanded with burin-cores.

Most MIS 5 sites show characteristics of expedient reduction technology. The core reduction method seems rather opportunistically chosen to produce a specific shape of blank, as seen at Blombos M3, where triangular flakes are produced by multiple core reduction sequences, and at Hoedjiepunt 1 where flakes are the main product, but three different core reduction methods were used, including bipolar, inclined and parallel reduction.

The MIS 5 assemblages of all sites show a pattern of rather expedient technology with the dominant use of local raw materials and a low amount of formal tools. For some sites, a system of place provisioning was established (e.g. Klasies River [30]). Expedient technology and place provisioning both point towards decreased mobility.

6.2. Similarities over far distances

A high degree of similarity between assemblages from sites far apart as Florisbad and Klasies River is astonishing. The Klasies River MSA II has close similarities to the Florisbad MSA horizon in many respects: a unidirectional parallel reduction method, similar product types, namely elongated products as well as triangular flakes, and similar tool types. This could mean, that communication and knowledge transmission across the country already existed as early as MIS 5, as during MIS 4. This is indeed interesting, as most MIS 5 sites (including FRS and KRM) express expedient technology, which is characteristic of decreased mobility [71]. One way of resolving might be to look at the site function. Klasies River was identified as a residential site with more extended and repeated visits. Florisbad, on the other hand, was used as a processing site for hunting and butchering and therefore repeated but short visits. Florisbad is one of only a few open-air sites during MIS 5, and it is only due to its position at a spring with constant sedimentation that such a securely dated living floor exists in an open-air site.

Contradictory to other studies, I found a high degree of similarity between sites of different regions of the country. Florisbad lies in the summer rainfall zone, and it is an open-air processing site. Klasies River is a residential cave site on the southern Cape and is located in a year-round rainfall zone. It is interpreted that site location, setting and function was not a determining factor for the technological choices of early modern humans. It is also apparent, that although regional patterning in lithic technology exists to some extent [53,61,69,70], Florisbad demonstrates that these patterns might not be as confined as thought.

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Supplementary Material

S1 Table. Comparative table with lithic assemblages of South Africa dating to MIS 5 according to Rainfall Zones (after Mackay et al. 2014). Ni for no information in the literature.

Site - setting	Assemblage	MIS	dating	techno-complex	raw materials	main chaîne opératoire	other chaînes opératoires	knapping technique	% cores[b]	% triangular flakes[a]	% triangular blades[a]	% blades[a]	% flakes[a]	% bladelets[b]	% faceted platforms[c]	% tools[b]	% edge damage[b]	tool types	source
Summer Rainfall Zone																			
Florisbad - interior open-air site	MSA A-horizon	MIS 5e	121± 6 ka OSL		100% local: hornfels (96%), <1% dolerite, quartzite, shale, sandstone, silcrete	unidirectional parallel system, unidirectional laminar system on platform cores	burin-cores, cores-on-flakes	Free-hand hard hammer internal direct percussion	4.3%	3.2%	13.5%	20.5%	58.9%	6.2%	35%	1.4 %	6.2%	denticulate, lateral retouch, side scraper, notch, end-scraper	this paper
Border Cave - interior cave	4 WA	MIS 5-6		MSA 1/ Pietersberg	100% local: hornfels (40%), rhyolite (40%), basalt (18%), quartzite (2%)	Levallois for flakes and blades	-	(Hard hammer direct percussion)	>1%	ni	ni	5% (of all lithics > 2cm)	25% (of all lithics > 2cm)	ni	present	ni	ni	ni	Backwell et al 2018
	5 BS	MIS 5-6		MSA 1/ Pietersberg	100% local: basalt (35%), hornfels (25%), rhyolite (18%), calcedony (4%), quartzite (1%)	Levallois for flakes and blades	-	(Hard hammer direct percussion)	ca. 1%	ni	ni	1% (of all lithics > 2cm)	21% (of all lithics > 2cm)	ni	present	ni	ni	ni	
	BACO A-B	MIS 5-6	older than 80–122 ka ESR	MSA 1	100% local: rhyolite (78%), quartzite (14.9%), calcedony (5.6%), quartz (0.1%)	irregular cores, radial/discoid cores, adjacent platform cores	plain platform cores	(Hard hammer direct percussion)	0.8%	4.5%	0%	6.9%	88.6%	-	ni	0.2 % incl. <20 mm	ni	scraper, retouch on point, bifacial and unifacial point, burin	Beaumont 1978, Grün & Beaumont 2001
	BACO C-D	MIS 5-6	older than 80–122 ka ESR	MSA 1	100% local: rhyolite (70.7%), quartzite (16.4%), calcedony (9.5%), quartz (0.2%)	irregular cores, adjacent platform cores, radial/discoid cores	-	(Hard hammer direct percussion)	1.1%	5.9%	0%	7.2%	86.9%	-	ni	0.2 % incl. <20 mm	ni	backed piece, scraper, retouch on point, bifacial and unifacial point, burin	
Bushman Rockshelter - interior rockshelter	upper phase '21'	MIS 5	73 ± 6 ka, 91 ± 10 ka OSL	Pietersburg	100% local: hornfels, quartz, quartzite, other	discoid, centripetal and unidirectional Levallois, semi-prismatic platform cores	-	Hard and soft hammer	ni	ni	ni	ni	ni	ni	"often faceted"	8.3 %	ni	convergent and lateral scrapers, bifacial piece, *Kostienki* tool	Porraz et al. 2015
	lower phase '28'	MIS 5	75 ± 6 ka, 97 ± 10 ka OSL	Pietersburg	100% local: hornfels (66%), quartz, quartzite, other	unidirectional and centripetal Levallois, semi-prismatic platform cores	bipolar	Free-hand hard hammer internal direct percussion, bipolar (only on quartz)	0.6%	0.7% (complete and fragmentary)	ni	30% including laminar flakes (complete and fragmentary)	50.1% (complete and fragmentary)	19.1% (complete and fragmentary)	8 - 12.5%	5.2 %	present	end-scraper, scraper, notch, denticulate	Porraz et al. 2018
Sibudu - interior rockshelter	ADAM	MIS 5	older than 77.2±2 .1 ka OSL	pre-Still Bay	100% local: dolerite (90.3%), quartzite (4.6%), hornfels (2%), sandstone (1.5%), quartz	Laminar unidirectional with lateral crest on parallel cores	bipolar	only for blades: hard and soft hammer internal	0.6%	3.2% (complete and fragm	ni	29.6% (complete and fragmentary)	66.8% (complete and fragmentary)	0.4%	5.4% (all layers combined)	6.9 % (of debitag	ni	Unifacial pointed forms, scrapers, bifacial tools (including	Schmidt et al. 2019

					(1.4%), chert (0.3%)			direct percussion		entary)						e <3 cm)		serrated pieces), denticulates	
	ANNIE	MIS 5	older than 77.2 ± 2.1 ka OSL	pre-Still Bay	100% local: dolerite (86.6%), quartzite (6.3%), sandstone (3.3%), hornfels (2.7%), quartz (0.9%), chert (0.1%)	Laminar unidirectional with lateral crest on parallel cores	bipolar	only for blades: hard and soft hammer internal direct percussion	1.3%	3.0% (complete and fragmentary)	ni	23.8% (complete and fragmentary)	73.0% (complete and fragmentary)	0.2%	5.4% (all layers combined)	6.9 % (of debitage <3 cm)	ni	Unifacial pointed forms, scrapers, bifacial tools (including serrated pieces), denticulates	
	BART	MIS 5	older than 77.2 ± 2.1 ka OSL	pre-Still Bay	100% local: dolerite (84.4%), sandstone (6.1%), quartzite (4.2%), quartz (3.8%), hornfels (1.6%)	Laminar unidirectional with lateral crest on parallel cores	bipolar	only for blades: hard and soft hammer internal direct percussion	1.3%	2.3% (complete and fragmentary)	ni	22.1% (complete and fragmentary)	75.6% (complete and fragmentary)	0.0%	5.4% (all layers combined)	7.8 % (of debitage <3 cm)	ni	Unifacial pointed forms, scrapers, bifacial tools (including serrated pieces), denticulates	
	BEA	MIS 5	older than 77.2 ± 2.1 ka OSL	pre-Still Bay	100% local: dolerite (81.4%), sandstone (8.3%), quartzite (5.1%), quartz (2.9%), hornfels (1.5%), chert (0.7%)	Laminar unidirectional with lateral crest on parallel cores	bipolar	only for blades: hard and soft hammer internal direct percussion	0.4%	1.3% (complete and fragmentary)	ni	24.0% (complete and fragmentary)	74.3% (complete and fragmentary)	0.4%	5.4% (all layers combined)	10.4% (of debitage <3 cm)	ni	Unifacial pointed forms, scrapers, bifacial tools (including serrated pieces), denticulates	
	CASPER	MIS 5	older than 77.2 ± 2.1 ka OSL	pre-Still Bay	100% local: dolerite (78%), sandstone (11.7%), quartzite (6.2%), quartz (2.6%), hornfels (0.8%), chert (0.8%)	Laminar unidirectional with lateral crest on parallel cores	bipolar	only for blades: hard and soft hammer internal direct percussion	0.2%	0.2% (complete and fragmentary)	ni	27.5% (complete and fragmentary)	72.1% (complete and fragmentary)	0.2%	5.4% (all layers combined)	9.2 % (of debitage <3 cm)	ni	Unifacial pointed forms, scrapers, bifacial tools (including serrated pieces), denticulates	
	CHANTAL	MIS 5	older than 77.2 ± 2.1 ka OSL	pre-Still Bay	100% local: dolerite (73.4%), sandstone (14.6%), quartzite (9.3%), quartz (1.6%), hornfels (0.9%), chert (0.2%)	Laminar unidirectional with lateral crest on parallel cores	bipolar	only for blades: hard and soft hammer internal direct percussion	0.7%	1.0% (complete and fragmentary)	ni	30.8% (complete and fragmentary)	67.8% (complete and fragmentary)	0.4% (complete and fragmentary)	5.4% (all layers combined)	8.5 % (of debitage <3 cm)	ni	Unifacial pointed forms, scrapers, bifacial tools (including serrated pieces), denticulates	
Year-Round Rainfall Zone																			
Klasies River main site - coastal cave	SM ONE	MIS 5c-d	-	Mossel Bay/ MSA II/ MSA 2b	100% local: quartzite (92%), quartz (6%), sandstone, silcrete (<1%)	unidirectional system (parallel and platform cores)	-	Free-hand hard hammer internal direct percussion	1.8%	9.6%	8.6%	6.9%	71.4%	7.8%	15.2%	0.7 %	16.4%	Denticulate, notch	Brenner and Wurz 2019, Brenner et al. in press
	BOS One & Two	MIS 5c-d	-	Mossel Bay/ MSA II/ MSA 2b	100% local: Quartzite (86%), quartz (13%), sandstone (1%)	unidirectional system (parallel and platform cores)	some bidirectional parallel cores	Free-hand hard hammer internal direct percussion	3.6%	18.8%	13.1%	11.2%	56.7%	3%	23.6%	2.8 %	31%	Denticulate, notch, scraper, lateral retouch	
	BOS Three (only 1 square)	MIS 5c-d	-	Mossel Bay/ MSA II/ MSA 2b	100% local: quartzite (98%), quartz (2%), sandstone	unidirectional system (parallel and platform cores)	some bidirectional parallel cores	Free-hand hard hammer internal direct percussion	0%	13.4%	11.5%	11.5%	57.5%	8%	14.5%	1.3 %	16.1%	scraper	

	SBLS (only 1 square)	MIS 5c-d	-	Mossel Bay/ MSA II/ MSA 2b	100% local: quartzite (97%), quartz (2%), sandstone (2%), shale (<1%)	unidirectional parallel system	-	Free-hand hard hammer internal direct percussion	0%	17.5%	8.8%	1.8%	70.2%	5%	7.8%	0%	10.6%	-	
Pinnacle Point 13B - coastal cave	SBS/ URS (East)	MIS 5c	94 ± 3 ka OSL		>90% local: quartzite (84.9%), quartz (11.5%) <10% non-local: silcrete (2.7%)	Unidirectional system (platform and parallel cores)	Centripetal (parallel)	(Hard hammer direct percussion)	1.4% incl. <20 mm	7.2% (flake- and blade-sized points of complete and broken blanks and chunks)		11.5% (of complete and broken blanks and chunks)	55.9% (of complete and broken blanks and chunks)	0.5%	27.5%	2.1% incl. <20 mm		bulbar thinning, notch, backed, denticulate, burin-like retouch	Thompson et al. 2010, Jacobs et al. 2010
	LBS 1, UDBS Unit (West)	MIS 5c	99 ± 4 ka, 124 ± 5 ka OSL		>90% local: quartzite (80.8%), quartz (13.3%) <10% non-local: silcrete (3.9%)	Unidirectional system (platform and parallel cores)	Centripetal (parallel)	(Hard hammer direct percussion)	5.6% incl. <20 mm	12.7% (flake- and blade-sized points of complete and broken blanks and chunks)		9.8% (of complete and broken blanks and chunks)	49% (of complete and broken blanks and chunks)	0.8%	23.7%	4% incl. <20 mm		bulbar thinning, notch, backing, denticulate, burin-like retouch	
	Lower Roof Spall (East)	MIS 5d	110 ± 4 ka OSL		>90% local: quartzite (88.1%), quartz (9.5%) <10% non-local: silcrete (2.4%)	Unidirectional system (platform and parallel cores)	Centripetal (parallel)	(Hard hammer direct percussion)	11.9% incl. <20 mm	2.4% (flake- and blade-sized points of complete and broken blanks and chunks)		4.7% (of complete and broken blanks and chunks)	54.8% (of complete and broken blanks and chunks)	0%	28%	0% incl. <20 mm		-	
	LC-MSA Upper/ Middle	MIS 5e	125 ± 5 ka OSL		85.7% local: quartzite (77.9%), quartz (7.8%) 12.6% non-local: silcrete	Unidirectional system (platform and parallel cores)	Centripetal (parallel)	(Hard hammer direct percussion)	0% incl. <20 mm	8.7% (flake- and blade-sized points of complete and broken blanks and chunks)		13% (of complete and broken blanks and chunks)	57.6% (of complete and broken blanks and chunks)	0.9%	26.3%	1.7% incl. <20 mm		bulbar thinning, notch, backing, denticulate, burin-like retouch	
Pinnacle Point 5-6 - coastal cave	LBSLR Jed/ JR Quartzite	MIS 5a-b	86 ± 3 - 79 ± 3 ka OSL		Quartzite (95%), silcrete, chert, hornfels, quartz	Unidirectional	discoid; multi-directional	(Hard hammer direct percussion)	0.1% incl. <20 mm	63% (points of end products)		ni	ni	ni	33% (of complete blanks)	0%	3.8% incl. <20 mm	-	Brown 2011
Cape St Blaize - coastal cave	C1-4 and CU	MIS 5	-	Mossel Bay	100% local: quartzite (92%), silcrete, calcedony, hornfels, shale, quartz	radial cores, blade and point cores (Goodwin: flake cores, Levallois or disc cores)	-	(Hard hammer direct percussion)	8.1% incl. <20 mm	7.7% (probably including fragments)	ni	22.8% (probably including fragments)	52.6% (probably including fragments)	ni	51.9%	12.8%	ni	"general retouch", notch, denticulate, backing	Thompson & Marean 2008,
Blombos - coastal cave	M3 phase	MIS 5c-b	98 ± 5 - 82 ± 4 ka OSL		100% local: silcrete (65%), quartzite (19%), quartz (17%), other (1%)	Unidirectional parallel system, centripetal parallel system, inclined system	multidirectional	Free-hand hard hammer internal direct percussion	1.5%	20%	No differentiation to blades	8%	72%	0%	15.7%	2.3 %	1.3%	Notch, denticulate, scraper, short retouch, borer, burin	Douze et al. 2015
Winter Rainfall Zone																			
Die Kelders 1 - coastal cave	layer 4	MIS 4-5	67.9 ± 5.1 - 104.5 ± 6.3 ka OSL		100% local: quartzite (80.2%), quartz (17.5%), silcrete (2.3%)	uni- and bidirectional system (platform and parallel cores), centripetal reduction (radial cores)		(Hard hammer direct percussion)	0%	ni	ni	0.4% "flake-blades" of debitage incl. <20 mm	ni	ni	ca. 1/3	0.1 % incl. <20 mm	ni	Notch, denticulate, lateral retouch, scraper	Thackeray 2000; Schwarcz & Rink 2000

	layer 6	MIS 4-5	69.4 ± 5.9 - 97.9 ± 8.3 ka OSL		100% local: quartzite (62.5%), quartz (34.5%), silcrete (0.3%)	uni- and bidirectional system (platform and parallel cores), centripetal reduction (radial cores)		(Hard hammer direct percussion)	0.3%	ni	ni	0.4% "flake-blades" of debitage incl. <20 mm	ni	ni	ca. 1/3	0.2 % incl. <20 mm	ni	Notch, denticulate, lateral retouch, scraper	
	West Upper layer 6	MIS 4-5	-		100% local: quartzite (86.4%), quartz (11.6%)	radial cores		(Hard hammer direct percussion)	0.1%	ni	ni	2.3%"flake-blades" of complete blanks	97.7%	ni	15-20%	0.4 % incl. <20 mm	0.3-8.0%	Notch, denticulate, lateral retouch, scraper	Avery et al. 1997, Thackeray 2000
	West Lower layer 6	MIS 4-5	-		100% local: quartzite (90.9%), quartz (9.1%), silcrete (2%)	radial cores		(Hard hammer direct percussion)	0%	ni	ni	0% " flake-blades" of complete blanks	100%	ni	15-20%	0% incl. <20 mm	0.3-8.0%	Notch, denticulate, lateral retouch, scraper	
	East layer 6	MIS 4-5	-		100% local: quartzite (82.4%), quartz (15.2%), silcrete (2.4%)	radial cores		(Hard hammer direct percussion)	1.0%	ni	ni	6.5% " flake-blades" of complete blanks	93.5%	ni	15-20%	ni	0.3-8.0%	Notched, denticulate, lateral retouch, scraper	
	layer 8	MIS 4-5	-		100% local: quartzite (39.2%), quartz (60.7%), silcrete (0.1%)	uni- and bidirectional system (platform and parallel cores), centripetal reduction (radial cores)		(Hard hammer direct percussion)	0.2%	ni	ni	0.3% "flake-blades" of debitage incl. <20 mm	ni	ni	ca. 1/3	0.2 % incl. <20 mm	ni	Notch, denticulate, lateral retouch, scraper	Thackeray 2000; Schwarcz & Rink 2000
	layer 10	MIS 4-5	99.4 ± 4.7 - 160.0 ± 8.0 ka OSL		100% local: quartzite (60.3%), quartz (35.9%), silcrete (3.9%)	uni- and bidirectional system (platform and parallel cores), centripetal reduction (radial cores)		(Hard hammer direct percussion)	0.5%	ni	ni	1.7% "flake-blades" of debitage incl. <20 mm	ni	ni	ca. 1/3	0.3 % incl. <20 mm	ni	Notch, denticulate, lateral retouch, scraper	
	layer 12	MIS 4-5	63.5 ± 3.8 - 102.7 ± 7.6 ka OSL		100% local: quartzite (41.7%), quartz (24.5%), silcrete (33.8%)	uni- and bidirectional system (platform and parallel cores), centripetal reduction (radial cores)		(Hard hammer direct percussion)	2.0%	ni	ni	3.4% "flake-blades" of debitage incl. <20 mm	ni	ni	ca. 1/3	1% incl. <20 mm	ni	Notch, denticulate, lateral retouch, scraper	
	layer 14	MIS 4-5	-		100% local: quartzite (68.8%), quartz (30.8%), silcrete (0.4%)	uni- and bidirectional system (platform and parallel cores), centripetal reduction (radial cores)		(Hard hammer direct percussion)	0.3%	ni	ni	1.1% "flake-blades" of debitage incl. <20 mm	ni	ni	ca. 1/3	0.5 % incl. <20 mm	ni	Notch, denticulate, lateral retouch, scraper	
Yster-fontein 1 - coastal cave/rockshelter	groups 1-13	MIS 5	120.6 ± 6.6 ka, 132.1 ± 8 ka OSL		100 % local: silcrete (47%), clacrete (30.3%), dolerite, quartz, diorite, shale, granite, quartzite	Uni- and bidirectional system (platform and parallel cores), parallel centripetal system	discoid cores	Free-hand hard hammer internal direct percussion	1%	"almost no points" (Douze et al. 2015)	ni	14.8%	85%	ni	15% ("mostly informal")	2.2 % incl. <20 mm	-	denticulate, notch, scraper	Halkett et al. 2003; Avery et al. 2008; Wurz 2012
Hoedjies-punt 1	AH I	MIS 5	130-100 ka ESR,		>90% local: Quartz (76.6%), calcrete, quartz porphyry	Inclined, bipolar platform, parallel cores	-	Hard hammer percussion;	2.8%	0%	0%	2.3%	97.7%	0%	5.8%	4%	-	Denticulate, side scraper, minimal	Will et al. 2013;

- coastal open-air site			U-Th		<10% non-local (10-30 km): silcrete, other			bipolar (only on quartz)										retouch, notch	Dating: Yoshida 1996; Woodborne 2000
	AH II	MIS 5	130-100 ka ESR, U-Th		>90% local: Quartz (91%), calcrete, quartz porphyry <10% non-local (10-30 km): silcrete, other	Bipolar, inclined, parallel cores	-	Hard hammer percussion; bipolar (only on quartz)	3%	0% (n=1)	0%	3%	97%	0%	4%	4.7 %	-	Denticulate, minimal retouch, notch, scraper, lateral retouch on blade	
	AH III	MIS 5	130-100 ka, ESR, U-Th		83% local: Quartz (61%), calcrete, quartz porphyry 17% non-local (10-30 km): silcrete, other	Inclined, bipolar, parallel cores	-	Hard hammer percussion; bipolar (only on quartz	2.9%	0%	0%	7.1%	92.3%	0% (n=1)	5.1%	4.1 %	-	Denticulate, minimal retouch, notched, scraper	
Diepkloof - interior rockshelter	Pre-Still Bay type Lyn	MIS 5d	100 ± 10 ka	pre-Still Bay	83% (sub-)local: Quartzite (65%), quartz (12%), "Y-B silcrete"(6%) 17% exotic: silcrete (15%), hornfels (2%),other	centripetal parallel system, unidirectional	-	Free-hand hard hammer internal direct percussion	1.5%	5.9%	No differentiation to blades	14.3%	77.6%	2.2%	13.3%	9.8 %	ni	Scraper, denticulate/notch, bifacial pieces, *piece esquillée*, marginal retouch	Porraz et al. 2013a, 2013b
	MSA Mike	MIS 5d	107 ± 11 - 100 ± 10 ka		>90% (sub-) local: quartzite (86%), quartz (8%), "Y-B silcrete" (2%) <10% exotic: silcrete, hornfels, other	unidirectional parallel system (Levallois), unidirectional laminar system on platform cores	centripetal parallel (Levallois), *accourcis* point reduction	Free-hand hard hammer internal direct percussion	3.3%	17.8%	No differentiation to blades	13.4%	67.7%	1.1%	20.1%	3.2 %	ni	marginal retouch, denticulate/notch, scraper, *pièce esquillée*	
Putslaagte 8 - interior rockshelter	**FOB SS spit 6-8**	pre MIS 4	>76 ka OSL	denticulate MSA ?	100% local: hornfels, quartzite, quartz, silcrete (<10%)	bipolar, Levallois	-	(Hard hammer direct percussion)	5.7%	present	ni	5-10% laminar products	ni	0%	10-20%	5%	present	denticulate, *pièce esquillée*	Mackay et al. 2015
	FOB SS spit 9-14	MIS 5-6	>76 ka OSL	early MSA	100% local: hornfels, quartzite, quartz, silcrete (<10%)	discoid	Levallois	(Hard hammer direct percussion)	2%	"prevalent"	ni	0-10% laminar products	ni	0%	10-20%	2.6 %	present	denticulate	

[a] of complete blanks
[b] of all debitage >20 mm including fragments
[c] of preserved platform

S1 Text. MIS 5 lithic technology by site. Literature compilation

Border Cave

Border Cave has been excavated in the 1970's and the analysis of the lithic material is Beaumont's master thesis from 1978 [1]. Here the layers BACO (Basal Complex) A-D are discussed, as these have been dated to MIS 5-6 with ESR [2]. The BACO layers stem from excavation area 3A and 3B, and are situated underneath layer 4 WA. All material dated below 4 BS including 4 WA and BACO is attributed as belonging to the MSA 1 techno complex (following Volman [3]) or the Pietersburg [4]. The recent paper by Backwell and colleagues [4] is a preliminary study of the newly excavated material. It discusses layers 4 WA and 5 BS with some technological descriptions. The raw material is all from local sources, however, the composition is equally hornfels, basalt and rhyolite. The reduction strategy follows the Levallois method for flakes and blades with a number of typical Levallois points [4]. Blades are depicted as a prominent characteristic of the assemblages. Interestingly, a bladelet component is also described for these layers [4].

In Beaumont's study [1] basalt and hornfels are missing from the raw material composition, with rhyolite being the dominant material. All materials identified are from local sources. Beaumont [1] describes most of the cores as irregular, only a small number was identified as radial prepared or adjacent platform cores. The radial prepared cores include discoid cores and parallel cores for blade or point production [1]. Both the amounts of points and blades are rather low compared to the flakes. This makes it more comparable to the EBC MIS 6 assemblage, than to any of the MIS 5 assemblages.

The tools are made up of scrapers, retouched points, as well as unifacial and bifacial points. In the lower BACO C, there are also a number of backed pieces. Burins are rare but present throughout [1].

Bushman Rockshelter

New excavations at Bushman Rockshelter (BRS) from 2015-2016 have uncovered new material dating to MIS 5. The OSL dating yielded two different ages for each of the assemblages, depending on the mineral used. Quartz provided a date of 73± 6 ka for the Upper Pietersburg and 75± 6 ka for the lower Pietersburg; feldspar had older results dating the upper part to 91± 10 ka and the lower part to 97± 10 ka [5].

The raw materials used are all from local sources, either primary or secondary. The hornfels comprises the dominant material, followed by quartz and some other fine-grained materials. The main reduction technique is direct hard hammer internal percussion, as shown by the absence of lips, no preparation of dorsal overhang and the platform thickness of blanks. However, in the upper phase some soft hammer percussion marks are present, and in the lower phase bipolar-on-anvil technique was used to reduce quartz (in the upper phase no differentiation in the exploitation of hornfels and quartz is described).
There is less detailed information for the upper Pietersburg, so the description here focuses mainly on the lower Pietersburg. Porraz and colleagues [5] assume the existence of two separate reduction sequences for laminar products; one is a unidirectional Levallois system with orthogonal or centripetal preparation, the other one is a semi-prismatic volumetric system. There are only three cores that fall into these systems, but the blanks support this categorization. The laminar products are characterized by parallel edges and only few pieces with convergent edges, trapezoidal sections and a straight profile. 12.5% of blades (and 10% of laminar flakes, for definition see [5]) have faceted platforms, but only 8% of the flakes. There is also a high amount of bladelets (19.1%), which represents the biggest bladelet component described for MIS 5 assemblages so far. However, the size distribution from blades to bladelets is continuous, which could mean, they stem from the same reduction sequence [5]. Flakes are the most common blank type, but only a low percentage are triangular (0.7%). Flakes are either from preparation in the laminar reduction sequence, or from separate reduction sequences, such as centripetal Levallois or bipolar reduction.
Tools are quite frequent at Bushman with 8.3% in the upper Pietersburg and 5.2% in the lower Pietersburg. The tool types vary from other MIS 5 sites: The upper phase includes a high amount of lateral and convergent scrapers, as well as bifacial pieces; the lower phase comprises a large proportion of end-scrapers, as well as some denticulates/notches and other scrapers. The raw material for all end-scrapers is hornfels and they show a high incidence of platform faceting (48%). This indicates a selection of raw material and focus on preparation for the production of end-scrapers. The high proportion of use-wear (40%) and traces of resharpening show a

clear preference for these tools. End-scrapers in MIS 5 context have only been described for Apollo 11 in Namibia.

Sibudu Cave

The Sibudu assemblages of ongoing excavations from layers D-A are dated to 77.2 ± 2.1 ka with OSL and the lithic technology has recently been described [6]. The Sibudu assemblages all comprise high artefact numbers, however only layers C-A are described in regard to blank type frequencies, therefore, these assemblages are shown separately in Table 6. All raw materials are available in local sources and dolerite is the dominant material. A laminar reduction system was identified, which involves the preparation of the lateral core edge with a crest. Although the unidirectional laminar system on parallel cores shows similarities to other MIS 5 assemblages with a blade component, the preparation with a lateral crest is in contrast to debordants, which are commonly seen in sites like Florisbad, Klasies River or Pinnacle Point. Additionally, a bipolar reduction method is present. The knapping technique involves hard and soft stone hammer with internal direct percussion. The products are mainly blades (22-31% of complete and fragmentary debitage) with very few triangular flakes (1-3%). The high amount of flakes can be partially explained by the intensive core-preparation. Bladelets are present bur very scarce. Tools are quite frequent compared to other MIS 5 sites with 6.9-10.4% of the assemblage. The tool types comprise unifacial pointed tools, scrapers, bifacial tools, serrated pieces and denticulates. Facetted platforms are scare in inter-site comparison with only 5.4%. All assemblages comprise more than 90% small debitage (<30 mm) and a high proportion of cortex covered pieces (>50%), which implies a residential site function [6]. The features of the reduction system with includes a high amount of core preparation, and the larger tool component indicate a more curated character of technology. Furthermore, hornfels is the preferred raw material for retouch, although its overall frequency is low. This selection for higher quality but scarce raw material, is an indication for provisioning of individuals.

Pinnacle Point 13B

The Pinnacle Point sites are located on the southern coast of the Western Cape. Its proximity to Klasies River and the well dated MIS 5 assemblages make it a priority candidate for comparison. Excavations at Pinnacle Point 13B took place from 2000-2006 [7]. Pinnacle Point 13B contains two large MIS 5c assemblages, each comprising more than a thousand artefacts >10 mm. They stem from different sections of the site (an Eastern and a Western area), which are not correlated. A small collections of MIS 5d (n=47) is from the Lower Roof Spall from the Eastern area, and the MIS 5e assemblage (n=255) is from the LC-MSA Northeastern section. In the technological analysis by Thompson [7] the term "detached pieces" is used in the sense of blanks in this paper; "end products" in Thompson include all points, blades and Levallois flakes. Cores are described by a unique typology, which mixes different approaches [7], complicating inter-site comparisons. Based on the platform and parallel core descriptions and drawings, a dominantly unidirectional reduction system for points (converging scar pattern) and blades (parallel scar patter) can be deduced. There is also a high amount of "prepared cores" with centripetal pattern.

The quartzite is the main raw material with 83%. Cobble cortex is visible on 17.5% of all artefacts. The proportion of blades to points shows mostly a higher amount of blades, except in the Western MIS 5c assemblage where points are a bit more frequent (10.9% of blanks on average). The number of bladelets very low and the blades and bladelets are described as having a unimodal width distribution, which does not point towards a separate reduction sequence for the bladelets. The formal and informal tool component is amalgamated but still shows very low numbers with an average proportion of 2% in relation to all debitage (no size cut-off).

Pinnacle Point 5-6

The lithic material of Pinnacle Point 5-6 was examined by Brown [8,9]. The early assemblages dating to MIS 5 b-a are so far only described in his PhD thesis. They belong to the LBSR stratigraphic unit and are subdivided into six occupational horizons. The uppermost occupation layer is called Jed/JR Quartzite and contains 925 lithic artefacts (there is no size cut-off). The other assemblages of LBSR only include less than a hundred lithic artefacts, which is why they are not included here [8]. A high amount of blanks and cores show remaining cobble cortex. There are only seven cores and most of them have been opportunistically exploited, so that the systematic reduction is no longer visible. Three cores are attributed "single platform cores" (the terms are based on Volman [10]) which are described by Brown [8] as fitting the point-core definition of Wurz [8,11]. The blanks are better candidates to establish reduction sequences. The blanks show dominantly unidirectional parallel and convergent dorsal scar patterns. Furthermore, there is a number (n=14) of cortical debordants, which accounts for maintenance of lateral core convexity. Interestingly, platform rubbing is also seen on some of the blanks; and 33% of the blanks have a prepared faceted platform. The hypothesis is that the reduction system was mainly unidirectional [8]. According to Brown [8] there is only an informal tool component in the MIS 5 assemblages of Pinnacle Point 5-6.

Cape St. Blaize

The Cape St. Blaize Cave is situated at the coast in the town of Mossel Bay. It is the first assemblage that has been attributed to the Mossel Bay techno-complex [12], which is characterized by a high amount of points and blades which are reduced in a Levallois-like system. The MSA material was first described by Goodwin and Malan [12,13] in the 1930s. A more recent re-evaluation of the lithic material by Thompson and Marean [14] produced different results compared to the early analysis. The raw materials are all from local primary and secondary sources. Thompson and Marean [14] describe the cores as radial cores, as well as blade and point cores. The formal tools are mostly denticulates, notched pieces and retouched points. There are very high percentages of retouched pieces and faceted platforms.

Blombos Cave

Blombos Cave (BBC) is situated on the South Coast of the Western Cape. The material of the M3 phase is described in Douze et al. [15] and OSL and U/Th dates provide a frame of 98 ± 5 - 82 ± 4 ka, which falls into MIS 5 c-b [16]. The raw materials in the form of cobbles all stem from these local sources. However, the main raw material used is silcrete from secondary marine sources; quartzite and quartz only represent a minor component in the assemblage (Table 16). The lithic artefacts of the M3 phase comprise 3404 pieces >2 cm [15]. The reduction technique is freehand percussion with a hard hammer [15]. The main debitage products are triangular flakes encompassing 20% of all complete debitage. The blade-sized pieces (2:1 ratio) make up 8% of complete blanks, they are not distinguished into triangular blade or blade. The reduction sequences used to attain points are mostly parallel systems, with a focus on unidirectional reduction; but centripetal and inclined reduction could also produce points. Although blades are produced, the unidirectional cores are all shorter than wide, only showing flake sized negatives. The lateral convexities are established by common reduction of debordants. The blanks show common platform preparation with faceting (15.7%), although the points are more frequently faceted (27%).

There is a low frequency of formal tools with 2.3% and edge damage with 1.5%. Nevertheless, unmodified blanks are interpreted to be used as tools [15].

Die Kelders 1

Die Kelders 1 is situated on the southern tip of the Western Cape. The material discussed here was excavated during 1992-93, but some part of the material of layer 6 is from earlier excavations (1969-1973). There are six occupational layers (layer 4, 6, 8, 10, 12, 14) with sterile layers in between them. All of the deposits have been dated by multiple techniques to 60-80 ka [17–20]. Thackeray [21] analysed the lithic material by layer. In her study, there are also some artefacts in the sterile layers, although they are much more infrequent than in the occupational layers. Here, only the occupational layers are discussed. The material includes small debitage, which is collected from 12 and 3 mm screens. There is no information on the frequency of pieces >20 mm, as there is no size cut-off. This may influence the percentages compared to other sites dramatically in making the numbers very low. Blades are not distinguished from "flake-blades", which are elongated flakes with mostly 2:1 length-width-ratios, but not exclusively. Symmetric convergent flakes are categorized as "convergent", but there are no total numbers given. Some pieces fit into the category of debordants, with a cortical side and "flake-blady" dimensions [21]. The flake-blade production is interpreted as the main aim at Die Kelders 1. Flake-blades show considerably more faceting of the platform (50% of proximally preserved flake-blades) than flakes (20% of proximally preserved flakes), which supports this.

Cores on quartzite are mostly flat single-platform cores, which might also be parallel cores deduced from the drawings. Cores on silcrete can either be blade cores with unidirectional reduction or exhausted cores that show a radial negative scar pattern. Quartz cores always present radial reduction. The silcrete and quartz cores are mostly small in size.

The reduction technique is not expressively described, but common *siret* fractures are mentioned, hence hard hammer percussion is assumed. Edge damage has been observed for the early excavated material (0.3-8%) [19], but it was not recorded systematically for the later material [21]. Retouched artefacts are present in percentages from 0.1 - 1% of total lithics.

Ysterfontein 1

The Ysterfontein 1 site is situated in the Western Cape on the west coast. Excavations were conducted from 2002-2008. They assume the site was once a calcrete rockshelter [22]. The shell rich artefact accumulation is described as a shell midden [10,23]. Multiple dating methods have been applied, putting the age between 119 - 46 ka, but OSL ages of 120.6 ± 6.6 ka and 132.1 ± 8 suggest an older age. Avery et al. [23] also use intertidal shells in the assemblage as an indicator that the shoreline must have been closer than 10 km from the site. This means that the formation of YFT1 must have been before 71 ka. The artefacts include animal bones, shells, stone artefacts, as well as hearth features. The material is grouped into 13 stratigraphic units, but the similarity between the groups is high. The lithic assemblages are under study by Sarah Wurz, although a preliminary report by Wurz [24] and an early analysis of the 2002 excavated material conducted by Volman [22] exist so far. Wurz [24] focused on the technology of the in total 17 000 lithic pieces. The main result is, there is a flake producing technology with 85% flakes of all detached pieces. Blades almost make up 15%, their shape is very similar to the flakes though, with a rectangular outline and a distal width as big or bigger than the proximal width [24]. The dominant cores are platform cores with uni- and bidirectional scar patterns, although most products show a unidirectional dorsal scar pattern [24]. There are also abundant parallel two-volume cores, which show a multidirectional systematic reduction. Only three discoidal cores could be identified. The amount of formal tools is comparable to other MIS 5 sites with 2.2%; they include denticulates, notched pieces and scrapers. Silcrete was selected for the manufacture of tools, although it also is the dominant raw material in the assemblage [24].

Hoedjiespunt 1

The open-air shell-midden site of Hoedjiespunt 1 (HP1) is situated on the Western Coast of South Africa. Its current elevation is 15 m asl [25]. There exist some dating attempts with ESR and U-Th techniques, but the stratigraphic setting is most convincingly setting the site occupation into MIS 5, possibly MIS 5e [25–27]. The lithic material discussed here stems from the 2011 excavations and comprises three archaeological horizons (AH I-III). In total 3307 lithic artefacts have been analyzed by Will [25], of which 1212 lithics are >20 mm. At HP1 two reduction techniques have been used, bipolar on anvil technique, as well as hard hammer direct percussion [25]. The only raw material that was knapped with bipolar on anvil technique is quartz. This is also the dominant raw material. The other raw materials are calcrete, silcrete, quartz porphyr and minor frequencies of other materials. Silcrete is non-local to HP1, as it only occurs in outcrops 10-30 km distance. Quartz and calcrete are local materials and are present in the form of cobbles.

Flakes are the main blank type with >90% of the blanks. Different core reduction systems have been used to produce a range of flakes shapes. A combination of bipolar cores, inclined or discoid cores and parallel cores have been described for all the layers. Additionally, some platform cores have been identified in the AH I and II. There is a small blade component throughout the HP1 sequence, with a maximum of 7.1% in AH III [25]. However, no cores have been identified that show blade negatives, and it stays unclear if the parallel system was used to produce the blades. The tool types include denticulates, notched pieces, scrapers and lateral retouch on blades.

Diepkloof Rockshelter

Diepfkloof Rockshelter (DKR) is an inland site situated in the Western Cape, although it is only 14 km from the current coast. It falls within the Winter-Rainfall zone and the local environment is semi-desertic with mostly fynbos vegetation. The elevation of DKR is 120 m a.s.l. Archaeological research started in the 1970s, but the material described here stems from more recent excavations that took place from 1998-2013. The stratigraphy measures 3 m of deposit, which is mostly MSA with some LSA on the top. With the dating methods TL and OSL, a timeframe between MIS 5d and MIS 3 could be established [28]. The site shows quite early dates for the Still Bay and HP. Nevertheless, the assemblages of the MSA Mike and possibly the pre-Still Bay type Lyn fall into MIS 5 and are contemporary with the Klasies River material discussed here [28,29]. The MSA-Mike is a 15 cm thick layer, that was dated with OSL to an age between 107 ± 11 and 100 ± 10 ka [28]. The pre-Still Bay type Lyn occurs in a 10 cm layer, which dates to 100 ± 10 ka[28].

Local quartzite is the dominant raw material, although the material at DKR comes from primary sources, as opposed to the secondary cobble sources at KR. The two assemblages from DKR show a prevailing technique in hard hammer internal percussion.

Different reduction sequences have been identified: The two most frequent systems are a unidirectional Levallois system and a unidirectional laminar reduction on semi-prismatic cores. Next to these, there is also centripetal Levallois reduction and a distinct sequence for the production of *accourcies* points.

In both assemblages, flakes are the most common blank type. A high amount of blades (13-14% of the assemblage) and the described reduction sequences indicate a preference for elongated products. The amount of points is different between the assemblages, with a low amount in Pre-Still Bay Lyn (5.2%) and a high amount in MSA-Mike (17.2%). As for the production of bladelets, both assemblages show an existing bladelet component.

MSA-Mike shows a high distinction of prepared platforms between points and other blank shapes. The proportion of formal tools is low in MSA-Mike (3.2% of assemblage) with denticulates and notches as the prevailing tool types. The Pre-Still Bay, however, shows a higher percentage with 9.8% tools, and it also includes bifacial pieces [30].

Putslaagte 8

The rock shelter site Putslaagte 8 (PL8) is situated in the interior of the Western Cape. Recent research by Mackay and colleagues [31] provide insight into the lithic technology of the pre-MIS 4 layers. The geological layer FOBSS is subdivided into spits, and all deposits below spit 5 have a minimum age of > 75.5 ± 6. Spits 6-8 are correlated to MIS 5 and spits 9-14 are most probably older falling into MIS 5-6. The raw materials are of local sources, which are either pebbles from the adjacent Putslaagte river or eroding pebbles from conglomerates. The most abundant raw material is hornfels, followed by quartzite. Lower amounts of quartz are also present and silcrete appears in some spits, but only in very low numbers [31]. The technology for the upper spits is tentatively called "Denticulate MSA" because there is a high number of tools (5%) which are mostly denticulates. This assemblage is characterized by bipolar and Levallois technology. The products include flakes, Levallois points, convergent flakes and blades. There is also a high incidence of faceted platforms with 10-20%. The lower assemblage from spits 9-14 is characterized by discoid cores, but there is also a Levallois component displayed by

Levallois points. The convergent flakes and Levallois points are prevalent in this assemblage, but other flakes and laminar products are also present. Facetted platforms are as frequent as in the upper assemblage. The tools form a small part with only 2.6% and mostly denticulates. Edge damage is described throughout the PL8 sequence but not quantified [31].

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Chapter 7: Discussion and Conclusion

This thesis investigates the lithic technology of Klasies River and Florisbad in the context of intra-site variation, residential patterns and provisioning systems. In addition, the development of coastal adaptation at Klasies River is examined. Communication patterns in the South African landscape during MIS 5 are explored with inter-site comparisons. The focus is on the integration of the Klasies River and Florisbad data with other sites.

The research questions and aims of this PhD thesis have been addressed in-depth and are summarized below.

The first aim was to provide a detailed perspective on the Klasies River lithic material. Papers #1, #2 and #3 (chapters 3-5) comprise the relevant data. It was shown that throughout the layers SMONE to SBLS, one main reduction system prevailed. This was a mostly unidirectional recurrent reduction on parallel and platform cores. For an adequate description of the core reduction sequence, a new core taxonomy was created, that focuses on the slight distinctions between the Klasies River cores. The end products show a variety of morphologies from triangular flakes, over triangular blades to parallel blades and pointed blades. The blank types were classified in order to address these different shapes, which include three different point types. The complete *chaîne opératoire* could be reconstructed. Although a common reduction method could be seen throughout the sequence, statistically significant differences could be identified between layers. These are for example, visible in changing dimensions and weights of blanks. A bladelet component is visible throughout the layers but is more dominant in the lower layers. From the lithic technology and assemblage composition, the provisioning system at Klasies River could be established. The site shows predominantly features typical for provisioning of place in a residential site setting. In the lowest layer SBLS, however, a slight change is visible, that points towards a more mobile provisioning system (cf. Kuhn 1995) and probably less residential use of the site. This is seen in the miniaturisation of lithics with an abundance of bladelets. SBLS also shows the least evidence for on-site use of artefacts with lower frequencies of tools and edge damage. The lithic material in SBLS indicates a primary site use for knapping activities.

The second aim was to answer the question of how the material from Klasies River fits into the southern Cape landscape. Previous studies have presented strong similarities between southern Cape sites during MIS 5 (e.g. Mackay et al. 2014; Douze et al. 2015). The comparison in paper #2 between Klasies River, Blombos Cave, Cape St. Blaize, Pinnacle Point 13B and Pinnacle Point 5-6 showed that, although similarities exist, the technologies also exhibit distinct differences. The predominant blank product morphology range from triangular flakes to blades and multiple different reduction systems were used at the southern Cape.

A third aim was to integrate the lithic technology at Klasies River with shellfish utilisation and provide a perspective on coastal adaptation at the site during MIS 5. In paper #3, the shellfish data was compared to the lithic material. The main result was that Klasies River exhibited high densities of both find categories by the volume of deposit. The shellfish volumes are highest in the upper layers and only show a narrow range of intertidal species. Coastal adaptation can, therefore, be inferred for MIS 5c (SMONE and BOS One & Two), although the use of coastal resources is already visible in MIS 5d. From the lithic material, we could infer a residential site character with provisioning of place for the upper layers. During MIS 5c the site was therefore probably used as a long-term occupation with habitual collection and consumption of shellfish. In the earlier phases, the lithic material is denser and shellfish is less numerous but shows a greater variety of species. This can be related to a different site use during MIS 5d with a less residential character.

Aim four involved comparing these aspects of coastal adaptation at Klasies River to Pinnacle Point 13B and Blombos Cave. If the densities are compared Blombos shows a high shellfish density, whereas all the layers at Pinnacle Point 13B only exhibit minor densities. In regard to shellfish density, Blombos and Klasies River MIS 5c are comparable. Nevertheless, the lithic densities vary greatly between Klasies River and the other two sites. Both Pinnacle Point 13B and Blombos only show very low lithic artefact densities. This points towards a more specialised occupation at Blombos with a focus on shellfish collection and consumption and minor knapping activity. During MIS 5d Klasies River has a greater variety in shell species compared to MIS 5c, this is however not seen at Pinnacle Point 13B. At Pinnacle Point 13B marked differences in species frequency occur between MIS 5e and the later MIS 5. The low densities in both shellfish and lithic artefacts suggest a different site function for Pinnacle Point 13B, which might relate to shorter visits and high sedimentation rates. In conclusion, coastal adaptation along the southern Cape seems to be very variable and might relate to site function.

The fifth aim of this thesis was to provide a detailed view of the lithic technology from the Florisbad MSA horizon. Paper #4 examines the material from two different excavations, which, in its entity, has not been described in-depth before. The result of this study was that a more complex *chaîne opératoire* existed at Florisbad than so far described. A unidirectional recurrent reduction system, very similar to the one at Klasies River, is identified. A number of platform cores resemble volumetric laminar reduction, which exists alongside a Levallois-like reduction with parallel and convergent products. Additionally, cores-on-flakes are present in frequent numbers. A particular type of cores-on-flakes are burin-cores. The burin-cores produce thick and narrow blades and bladelets, which are distinctly different from other laminar products at Florisbad. A versatile repertoire of blank shapes is present, which is probably the result of repeated short visits to the site.

The sixth research aim was to embed Florisbad into the landscape of South Africa during MIS 5. With its location in the interior of South Africa, Florisbad is an important locality to assist in inferring possible communication and mobility. Paper #4 addresses this issue in the discussion section. Regional patterning based on tool types has been constituted before, roughly grouping the north-eastern area of South Africa, the southern Cape and the Western Cape (e.g. Mackay et al. 2014; Porraz et al. 2018). Different reduction systems and product shapes have also been acknowledged before by multiple authors (e.g. *ibid*; Will et al. 2013;

Douze et al. 2015; Schmid et al. 2019). In this paper, the topic of expediency as an indicator of decreased mobility (Wallace and Shea 2006) is also touched upon. Based on a literature review, most MIS 5 lithic assemblages exhibit expedient and opportunistic behaviour, which would relate to decreased mobility during MIS 5 in general. The result of this study is therefore surprising, as it can confirm a high degree of similarity between sites, that are from different regions of South Africa. The lithic technology including core reduction method, product shapes and tool types from Klasies River and Florisbad are very comparable. This could mean a long-distance communication system was reaching from the southern coast to the interior of the Free State Province. Early MIS 5 knowledge transmission and mobility systems need to be further investigated.

The research conducted during this PhD contributes to the understanding of MIS 5 lithic technology and how it fits within the broader contexts of coastal adaptation. This study also adds to the knowledge about relationships between different sites in the South African landscape.

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APPENDIX

TABLE A1. ATTRIBUTES USED FOR THIS ANALYSIS

Attribute	Manifestation	Definition
layer	HHH-BASE, SMONE, BOS One & Two, BOS Three, SBLS	stratigraphic position
square	A1-C3	Square defined by the measurement grid
ID	integer	unique Plot ID Number given in the field
raw material	quartzite; quartz; shale; CCS; hornfels; other	based on visual inspection
texture	very fine; fine; medium; coarse	based on visual inspection
colour	Munsell colours	
burnt	not burnt; burnt; probably burnt	red colour does not necessarily mean burnt
general category	core; flake; blade; bladelet; point; chunk; piece of raw material; hammerstone; grindstone; angular debris	cores: complete and fragments of cores points: all convergent pointed flakes, even if they have blade dimensions blades: "In its most basic technological sense, a flake is a blade if its edges and arises are parallel and its length is at least equal to twice its width" (Crabtree, 1972) bladelet: “A narrow parallel-sided flake with a length greater than twice the maximum width and a width of less than 12 mm” (Deacon, 1984: 525) (This also follows Tixier 1963; de la Pena & Wadley 2014; Morgado & Pelegrin 2012) Table in Pargeter & Redondo (2016) flakes: any piece that has a distinguishable ventral and dorsal face, excluding other blank categories chunk: lacking platform and distinguishable ventral and dorsal face. Shott (1994: 70) calls it flaking debris or shatter. raw material: cobble or pebble of raw material with no or minimal knapping hammerstone: usually cobbles or pebbles with pecking or crushing marks grindstones: possible grindstones with a smooth surface angular debris: non-artefactual
reduction sequence	cobble of raw material, preparation of cobble, core, core preparation, blank production, ustilization of blank, tool, broken tool	the last step of the reduction sequence seen in the piece. Use wear features or informal tools are in the categroy of "utilization of blank".
percent cortex	0-100%	0% = no cortex, 50% = whole dorsal surface, 100% = pebble/cobble
cortex type	cobble; outcrop; patinated	patinated: heavily patinated from long exposure before knapping

ochre	y/n	adhering residues
ash or charcoal	y/n	adhering residues
weight (g)	continuous	
maximal dimension	continuous	
technological Length (mm)	continuous	length measured as the maximum distance from the proximal to distal end along a line perpendicular to striking platform width. (Andrefsky 2005: 100)
maximum width (mm)	continuous	
maximum thickness (mm)	continuous	
width at 1/2 length (mm)	continuous	
thickness at 1/2 length (mm)	continuous	
external platform angle	continuous	for blanks: The angle formed by the intersection of the striking platform and the dorsal surface of the detached piece (Andrefsky 2005: 255). for cores: the EPA is measured on the last negative.
BLANKS		
blank type	blade, bladelet, flake, fragment	As in "general category", but broken pieces are fragments.
percent completeness	0-100%	
completeness	complete, proximal frag, medial frag, distal frag, lateral frag, indeterminate frag, siret, proximal lateral, distal lateral, medial lateral, lateral prox medial, almost complete	
shape	converging, expanding, parallel, rectangular, round/oval, sub-parallel, irregular, indet, skewed convering	description of lateral edge continuity. own figure
dorsal cortex	< 50%, > 50%, 100%	
cortex area	lateral, distal, whole dorsal surface	
flake termination	feather; hinge; step; overshot (plunging)	(See Figure 3) Feathered terminations thin out continuously; step terminations are abrupt (like a break); hinge terminations turn away from the objective piece; plunging terminations turn toward the objective piece. Cotterell and Kamminga (1990:145).
bulb	absent, defined, poor-defined, well-defined, not applicable, removed, shattered	Soriano et al. 2007: 689. A shattered bulb is in other articles called detached bulb (Damelien 2015) or splintered bulb.

impact point/ ring crack	whole circle, half circle, no, na	Soriano et al. 2007: 689
lip	well defined, traceable, no lip, na	Soriano et al. 2007: 686, table 6 (none, small or large lip)
hertzian cone	y/n	
lancet fissures	y/n	lancet fissures on the ventral face
bulb scar	y/n	negtive scar on the bulb, not connected to the impact point. ("*Esquillement du bulbe*" after Inizian et al. 1999)
ripple marks	y/n	ripple marks on the ventral face
proximal preparation	none; trimming; longer removals along scar ridge; relief of impact point by lateral removals; rubbing; trimming and rubbing; stepflaking; trimming and stepflaking	Soriano et al. 2007: 689
platform type	cortical, plain, dihedral, facetted planar, facetted convex, informal facet, plain and shattered, shattered, indeterminate, na	Inizan et al. (1999: 136) (See Figure 2)
facet count	continuous	number of facets on the platform. Only well defined facets, preferably with a neg bulb
platform width (mm)	continuous	
platform thickness (mm)	continuous	
platform shape	linear, punctiform, rectangular, round/oval, pointed-oval, triangular, chapeau/winged, indeterminate, irregular, na	Soriano et al. 2007: 689; Inizan et al. 1999: 136
platform completeness	0-100%	
internal platform delineation	regular curve; overhanging curved platform; overhanging clear relief of the bulb; double curve with 2 impact points; straight; irregular	Soriano et al. 2007: 689
platform formation	one big removal not connected to impact point;several scars on the lateral edge;one small scar at the apex;two scars on the lateral platform;one scar on the lateral platform;trimming and stepflaking on the platform from the dorsal face, facets on top of prev negative	description of flake scars or facets that formate the platform
number of dorsal scars	integer values	no proximal preparation and size cut off <1cm
orientation of dorsal negatives	unidirectional, bidirectional, opposing, convergent, centripetal, irregular, multidirectional, 90% unidirectional, indeterminate bi- or unidirectional, indeterminate	the real orientation of negatives, no infered technology

dorsal scar pattern	platform thinning flake; central arris; skewed arris; parallel scars; short triangular scar; long triangular scar; multiple scars; multiple platform scars; converging in the middle; step flaking scars; skewely converging, convergent scar ridges; lateral arris	Wurz 2000 modified
bipolar technology	y/n	implied bipolar knapping technique
levallois technology	y/n	implied Levallois reduction method
curvature	straight; curved along distal part; curved along proximal part; curved along the whole length; twisted	Högberg 2016: table 2 (withouth curved along medial part, but with the characteristic twisted)
regularity	irregular, regular, very regular	based on Damlien (2015). irregular: irregular lateral edges and dorsal ridges regular: parallel lateral edges or ridges very regular: parallel lateral edges and ridges
technological category	end product; debordant fully cortical; debordant partly cortical; debordant other; crest; piece with indet dorsal face; platform shaping; core management surface; entame (first); flake with blade removals; decortification flake; flaking debris	end product: pieces with regular shape and dorsal scar pattern. debordant: core edge flake crest: specific core preparation decortification flake: with >50% dorsal cortex cover flaking debris: small and thin, includes burin spalls and retouch flakes.
CORES		
core type	parallel; platform; bipolar; inclined; initial; multidirectional; irregular; fragment	See chapter 2.2.3. core nomenclature.
sub-category	pyramidal; semi-rotated pyramidal; prismatic; semi-rotational prismatic; flat; informal	this sub-category of cores is used to describe the volumetric concept and shape of cores. The terms pyramidal or prismatic do only describe shape, not the amount of platforms or the direction of removals.
degree of reduction	0-33%; 33-67%; 67-100%	Degree of reduction along a spectrum between Initial and exhausted cores (Conard et al. 2004:16). Initial: 67-100%, exhausted: 0-33%
direction of removals on the surface	bifacial (inclined only); centripetal (3 or more); opposing (bidirectional); single (1 only); unidirectional (>1); unifacial (inclined only)	Based on the removal scars of end products.
degree of knapping along circumference	0-90°; 90-180°; 180-270°; 270-360°	Degree to which knapping has occurred along the circumference of the plane of intersection of Inclined and Parallel cores, a continuous variable ranging between 0° and 360°

core blank	cobble; pebble; split cobble; split pebble; flake; other; indeterminate	pebbles are < 5 cm, anything bigger is a cobble.
core on flake category	debordant; other	
number of removal surfaces	integer values	
product	blade; bladelet; flake; point; indet	based on principle and preceding scars, all combinations are possible
number of striking platforms	integer values	
orientation of striking platforms	adjacent, alternating, opposed, indeterminate, irregular, other	
formation of 1st striking platforms	1 flake;2 flakes;more than 2 flakes;1 blade;2 blades;more than 2 blades;1 flake+1 blade;multiple blades and flakes;plain;crushed;cortical	description of the platform
formation of 2nd striking platforms	1 flake; 2 flakes; more than 2 flakes; 1 blade; 2 blades; more than 2 blades; 1 flake+1 blade; multiple blades and flakes, plain;crushed;cortical	description of the platform
1st platform preparation	trimming and stepflaking on all edge; trimming and stepflaking on lat platform; little trimming; none	proximal platform preparation
2nd platfrom preparation	trimming and stepflaking on all edge; trimming and stepflaking on lat platform; little trimming; none	proximal platform preparation
technique	bipolar; bipolar?; handheld; indet	percussion technique
cortex area	<50% undersurface/back; >50% undersurface/back; 100% undersurface/back; no; undersurface and part of upper surface; irregular	amount and area of cortex
eshausted core	y/n	
2nd generation core	y/n	core that was primarily remduced with another method and then re-used
number of negatives	integer values	number of product negative scars
number of negatives >15mm	integer values	all negative scars > 15 mm
principle scar lenght (mm)	continuous	maximum scar length of last negative
principle scar width (mm)	continuous	maximum scar width of last negative
2nd external	continuous	if 2nd platform is present

platform angle		
3rd external platfrom angle	continuous	if 3rd platform is present
TOOLS		
tool type	formal tool, informal tool, GST, indet	GST: hammerstone or grindstone
preservation	complete, nearly complete, fragment, indet	preservation of the tool (might not be the same as blank)
tool description	backed blade, backed bladelet, backed piece, backed point, burin, denticulate, grindstone, hammer, hammer/grindstone, lateral retouch, notched piece, miscellaneous ret, scraper, unifacial point, unifacial tool, *pièce esquillé*	tool typology for formal tools
retouch description	denticulation, notched, coarse, fine, irregular, backed, edge damage, stepped, scalar	type of retouch edge damage: use-wear or taphonomy (not always discernible with 10x magnification)
retouch location	all edges, surface, prox, dist, lat both, lat left, lat right, lat indet, lat + dist, lat ri + dist, lat le + dist, lat + prox, lat ri + prox, lat le + prox	the piece is oriented with the dorsal face up und the proximal end directed towards the person.
retouch face	dorsal, ventral, both, indet	
shoulder modification abrasion	y/n	steep shoulder part by abrasion
shoulder modification gloss/ polishing	y/n	shiny shoulder part by polishing

Table A2. Comparison of different core nomenclatures used for MSA cores

Core Nomenclature	Conard et al. 2004: 15-16	Wurz 2000: 60-61, 173-174	Volman 1981: 20-21, 316	Singer & Wymer 1982: 43-47	Wurz 2002: 1004	Thompson et al. 2010: 365	Douze et al. 2015: 6, 8, 10, 14	Wilkens et al. 2014: 11-12
Parallel	√						√	√
Inclined	√						√	√
Platform	√							√
Levallois-like prepared cores for points or blades		√						
Preforms		√						
Irregular		√		√		√		
Core fragment		√				√		

Initial	√							
Multidirectional	√						√	
Bipolar	√						√	
Indeterminate fragment	√						√	
Pyramidal cores					√			
Flat cores					√			
Conical or cone-like cores		√						
Undeveloped				√				
Tortoise				√				
Discoidal			√	√				
Single platform core			√	√				√
Double platform core				√				√
Opposed platform			√					√
Adjacent platform			√					√
Cylinder core			√					√
Minimal core			√			√		√
Radial core			√					√
Change of orientation			√					√
Point core						√		
Blade core						√		
Prepared core						√		
Biface						√		