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A shape to the microlithic Robberg from Elands Bay Cave (South Africa)

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ABSTRACT

Elands Bay Cave (EBC) is a key South African site allowing discussion of technological change and adaptations that occurred from the Upper Pleniglacial to the Holocene. In 2011, we set out a new field campaign aiming to clarify the nature and chronology of the earliest Robberg occupations at the site, a technocomplex whose appearance closely relates to the Last Glacial Maximum. Our results document the appearance of the Robberg technology at ca. 19 398–18 790 cal BP, succeeding a phase commonly referred to as the Early Later Stone Age. In this paper, we further develop the definition of the Robberg by providing a technological and functional study of the MOS1 lithic assemblage at EBC, dated to 14 605–14 278 cal BP. Our results show that EBC occupants dominantly selected local quartz in addition to heat-treated silcrete that was introduced from distances greater than 30 km. Robberg inhabitants applied different reduction strategies combining bipolar/anvil and soft stone hammer percussion. Reduction sequences were oriented toward the production of a set of small artefacts (< 25 mm long) that can be generically classified as bladelets. The low incidence of retouched forms and the absence of geometrics, together with our functional study, testify to a flexible composite microlithic technology. We also discuss the raw material provisioning strategies of EBC Robberg inhabitants and develop the question of the intra- and inter-assemblages variability. Finally, we attempt to discuss its temporal trends and conclude on the originality of the Robberg technology within the context of other Late Pleistocene microlithic traditions.

KEY WORDS: Later Stone Age, Robberg, Last Glacial Maximum, bladelets, microlithic technology, projectile, hafting, silcrete heat treatment, use-wear analysis.

The Robberg technocomplex, first recognized at Rose Cottage Cave (see Wadley 1996), was initially defined at Nelson Bay Cave on the Robberg Peninsula (Klein 1974; Deacon 1978). It represents a bladelet tradition whose appearance is conventionally associated with the regional beginning of the Later Stone Age (LSA) in southern Africa (Deacon & Deacon 1999; Mitchell 2002; but see Villa et al. 2012). Because the Robberg seems to coincide with the Last Glacial Maximum (LGM), this technology has been viewed as an innovation selected by groups in a context of unpredictable resources (e.g. Deacon 1983; Deacon 1988, 1990; Mitchell 1988a; Wadley 1993).

The LGM is referred to as the maximum global ice volume of the Late Pleistocene (Ehlers & Gibbard 2007). It corresponds to a cooling of about 5°C (20–33 % lower than present average temperatures; Mix et al. 2001) and marks an intensified aridity that substantially modified the paleoenvironmental conditions. But the timing and ecological impact of the LGM, centered around 21 ka cal. BP (Mix et al. 2001), varied significantly (Clark et al. 2009). Southern Africa, composed of multiple biomes, provides one good context in which to assess the nature of behavioral changes and adaptations that might have occurred at the onset of the Pleniglacial.

The oldest Robberg occupations presently known in South Africa date back to ca. 23–22 ka cal. BP and extend throughout different biomes, from the Western Cape to Limpopo (Beaumont 1981; Deacon 1984; Mitchell 1988a, b, 1990, 1995; Wadley 1993, 1996; Deacon 1995; Lombard et al. 2012; Loftus et al. 2016). Current 14C dates suggest an occurrence of the Robberg in the LGM and Late Glacial (LG), with the most recent occupations that would have persisted until the Holocene at ca. 11–10 ka cal. BP (Wadley 1993, 1996; Mitchell 1995, 2002).

Although establishing the chronology of the Robberg has benefited from more recent studies and excavations, its regional variants and temporal developments remain uncertain. Regional adaptations related to, for example, geological contexts have been noticed (Mitchell 1988b). And there are diachronic changes that have been observed in raw material preferences at sites such as Boomplaas (Deacon 1984) and Putslaagte 8 (Mackay et al. 2015), in the way bladelets were used at Sehonghong (Mitchell 1995), as well as in the morphologies of the bladelets that were produced at Sehonghong (Pargeter & Redondo 2015). But the nature of these changes and their significance still require clarification.

Studies document Robberg populations exploiting a wide range of mineral, botanical and faunal resources (Deacon 1984; Wadley 1993; Mitchell 2005). Robberg populations used bone tools (Deacon 1984; Mitchell 1995; Wadley 1996) and also symbols for communication, as documented by the presence of engraved ostrich eggshells (Schweitzer & Wilson 1982) and beads made from ostrich egg and marine shell (Deacon 1976; Deacon 1984; Wadley 1996; Manhire 1993). The finding at Sehonghong, within the Drakensberg range, of a marine bead (Mitchell 1995, 2002) suggests long distance circulation or the existence of extended regional networks between groups during the Robberg. But the most distinctive feature typifying the Robberg is its lithic technology.

The Robberg yielded a microlithic technology based on unmodified bladelets that were produced from single platform cores (Deacon 1984; Wadley 1993; Mitchell 1995; Parkington 1990). We acknowledge the existence of a rich literature and discussion on the definition of a microlithic industry (e.g. Elston & Kuhn 2002). By microlithic, we here mean a technology that is based on diminutive blanks (bladelets or small flakes), with or without their transformation into geometrics. In that sense, we establish consecutively a distinction between microlithic tools and ‘microliths’, the latter corresponding to a formal tool category represented by geometric miniaturized forms (see Tixier 1965; Barrière et al. 1969).

Authors have recognized different reduction strategies during the Robberg, with emphasis being put on the standardization of the products and on the common use of bipolar percussion. Formal tools are very rare and generally composed of lightly modified bladelets, sometimes backed, together with a corpus of scrapers and denticulates. Though the spread of the Robberg technology might be associated with a decisive change in hunting techniques (e.g. Deacon 1983; Mitchell 1988c), pioneer functional studies document bladelets that were involved in both hunting and domestic activities (Binneman 1997; Binneman & Mitchell 1997). Additionally, and diagnostically, black organic adhesives found on Robberg products suggest that they were used as inserts as part of a composite technology (Binneman & Mitchell 1997).

The aim of this paper is to provide further insight into the Robberg technology by focusing on the lithic assemblages from Elands Bay Cave (EBC), located on the West

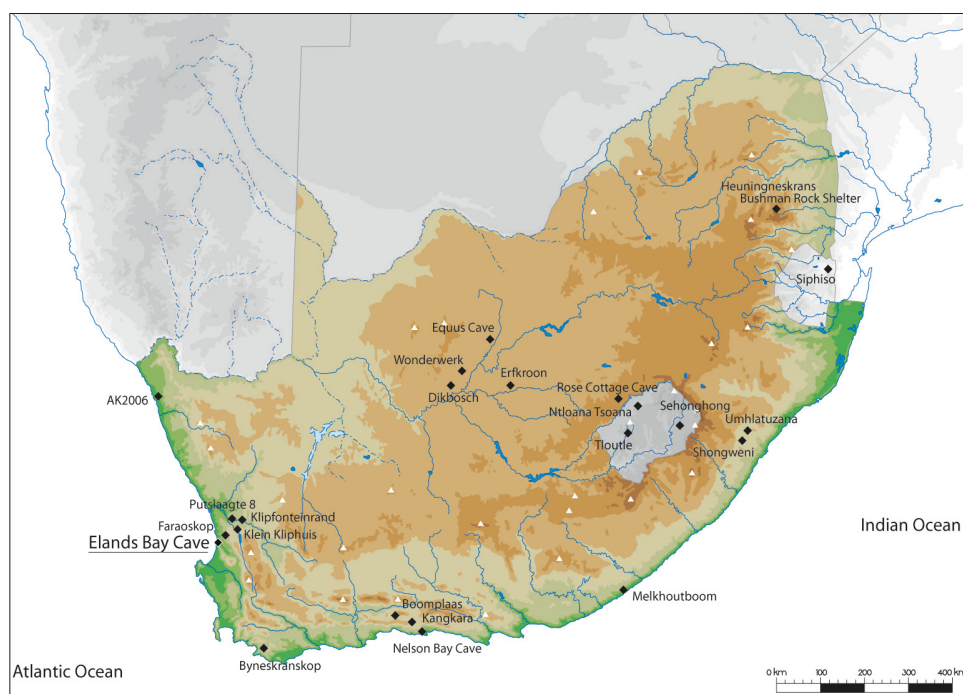


Fig. 1. Location of Elands Bay Cave (West Coast of South Africa) and of the main Robberg Sites.

Coast of South Africa. We first clarify the scenario and chronology of the appearance of the Robberg at EBC, and then conduct technological and functional analyses of one Robberg layer dating to ca. 14.5–14 ka cal BP. We fuel the question of the intra- and inter-assemblage variability of Robberg lithic assemblages and discuss the temporal evolution of this technocomplex. Our conclusions highlight the Robberg as an original and southern African trajectory within the context of Late Pleistocene microlithic technologies.

THE LATER STONE AGE RECORD AT ELANDS BAY CAVE

EBC is located on the current Atlantic coast about 200 km north of Cape Town (Western Cape, South Africa; Fig. 1). It is a large shelter opening to the west and located on a promontory of the Table Mountain Group, a few hundred meters southward of the natural lake (vlei) that formed at the Verlorenvlei River mouth. EBC is within an area rich in Holocene occupations as recorded at Tortoise Cave, Dunefield Midden and other sites including Diepkloof Rock Shelter that is located about 15 km eastward.

The main excavations at EBC were undertaken in the 1970s by John Parkington (Parkington 2016 this issue). He exposed a ca. 3 m deep sequence with the upper part being the remnant of a Holocene shell midden. The set of 14C dates indicates several pulses of human occupations from the end of the late Pleistocene to the late Holocene (Tribolo et al. 2016 this issue), with first occupations being Middle Stone Age (Schmid et al. 2016 this issue). Major climatic changes are documented throughout the sequence, indicating important modifications in the topographic setting of the area. At

the maximum glacial, local data suggest that the coast moved ca. 20–30 km away from its present location (Jerardino et al. 2013; Porraz et al. 2016 this issue).

The EBC LSA record has been well studied, with some of the main questions being related to Holocene coastal changes and adaptations (e.g. Parkington 1976, 1981, 1988; Parkington et al. 1988; Woodborne et al. 1995; Jerardino et al. 2013). The quality of organic preservation has allowed the recovery of a large set of botanical remains (Cowling et al. 1999; Parkington et al. 2000; Cartwright et al. 2016 this issue) but also a range of bone tools and food remains. Most spectacular is the presence of large adhesive artefact and adhesive imprints on tools recovered from Holocene layers (Charrié-Duhaut et al. 2016 this issue). Another important contribution is the analysis by Orton (2006) that has provided the first lithic overview of the LSA sequence at EBC, in which he observes changes in raw material procurements and lithic technology as well as some atypical features with regard to similarly dated assemblages.

While the terminal Pleistocene to Holocene record from EBC has received much attention, there are uncertainties regarding the nature and chronology of human occupations during the LGM, supposedly the period reflecting the technological succession from the Early LSA (ELSA) to the Robberg. It was with the intention to clarify the chronology and the contact between the ELSA and the first Robberg occupations at EBC that we decided to reopen the site in April 2011 (Porraz et al. 2016 this issue).

FIRST ROBBERG OCCUPATIONS AT ELANDS BAY CAVE

Parkington's 1970s excavation focused on the removal of the upper layers across a large surface of the shelter and on the preliminary exploration of the lower layers by opening a test pit of 5 m². In 2011, this test pit was reopened and worked on the east profile, where the deposits were most clearly stratified (Miller et al. 2016 this issue). We excavated a sequence of ca. 150 cm deep, uncovering LSA, ELSA and MSA occupations (Fig. 2), until bedrock was reached.

Schematically, the deposits of the test pit can be subdivided into 3 main sedimentary parts consisting, from the top to the bottom, of (1) a dominant anthropogenic matrix with combustion features, (2) a dominant geogenic matrix with isolated combustion features and (3) a thick accumulation of plaquettes overlying a blackish, moist sediment. The LSA from our 2011 excavation is strictly associated with the ca. 55 cm thick sedimentary part (1). During excavation, (1) was subdivided into two stratigraphic phases that received the letters D and F respectively.

Both stratigraphic phases are characterized by a relatively low density of lithic artefacts and the absence of organic material (see Miller et al. 2016 this issue). Phase D includes the stratigraphic units (SUs) Delport, Dennis, Denver and Dorothee. The excavation yielded 271 lithic artefacts > 20 mm, most of which are small quartz and silcrete bladelets (Fig. 3). Phase F, starting with the SU Faël, yielded 430 lithic artefacts > 20 mm. This latter phase mostly contains quartz flaking, bipolar technology and denticulates that are reminiscent of ELSA occupations (see Synthesis & Porraz et al. 2016 this issue for further descriptions).

To secure the chronology, charcoal samples were collected from the profile section at the end of the excavation: 2 samples from within phase D (S-101 and

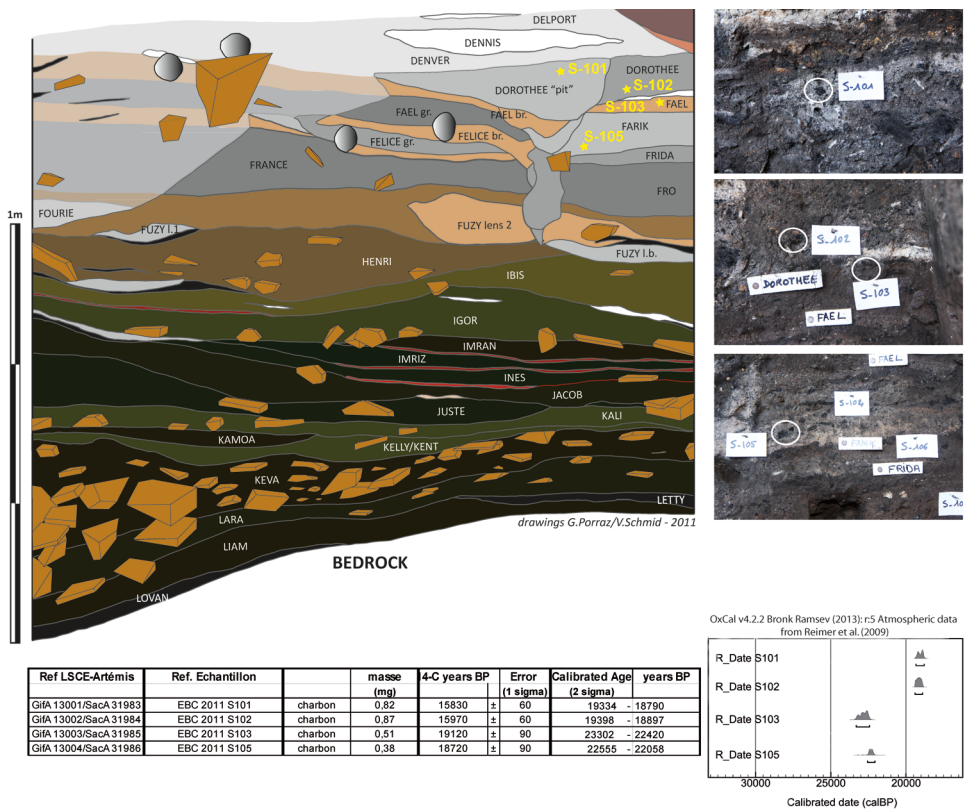


Fig. 2. Western stratigraphic profile of Elands Bay Cave (2011 excavation), location of 14C samples (S-101 to S-104) and calibrated dates. The grey shade (top left) indicates post-depositional modification of the stratigraphy.

S-102) and 2 samples from the upper part of phase F (S-103 and S-105). The results are consistent and indicate an initial Robberg occupation at EBC dating to an interval between 19 398–18 790 cal. BP and a final ELSA occupation dating to an interval of 23 302–22 058 cal BP (Fig. 2). At EBC, the Robberg and the ELSA are separated by a hiatus in sedimentation and in human occupation that lasted for about 2500 years.

THE LITHIC TECHNOLOGY OF THE MOS1 ROBBERG AT ELANDS BAY CAVE:
ANALYTICAL BACKGROUND

Because our 2011 excavation was limited and recovered only a small collection of lithic artefacts and because the correlation with the 1970s excavation could not be totally secured, we focus in the present study on the lithic assemblage from layer MOS1 that was excavated in the 1970s. MOS1 represents the oldest Robberg occupation extensively excavated by Parkington. It directly overlies our phase D. It was published as layer 20 by Parkington (1984; Fig.4) and as part of the phase A by Orton (2006). MOS1 is described as a loamy matrix with isolated hearths and is directly dated (Pta 4321: 13 600 ± 600 uncal BP) to 14 605–14 278 cal BP (calibration intcal13).

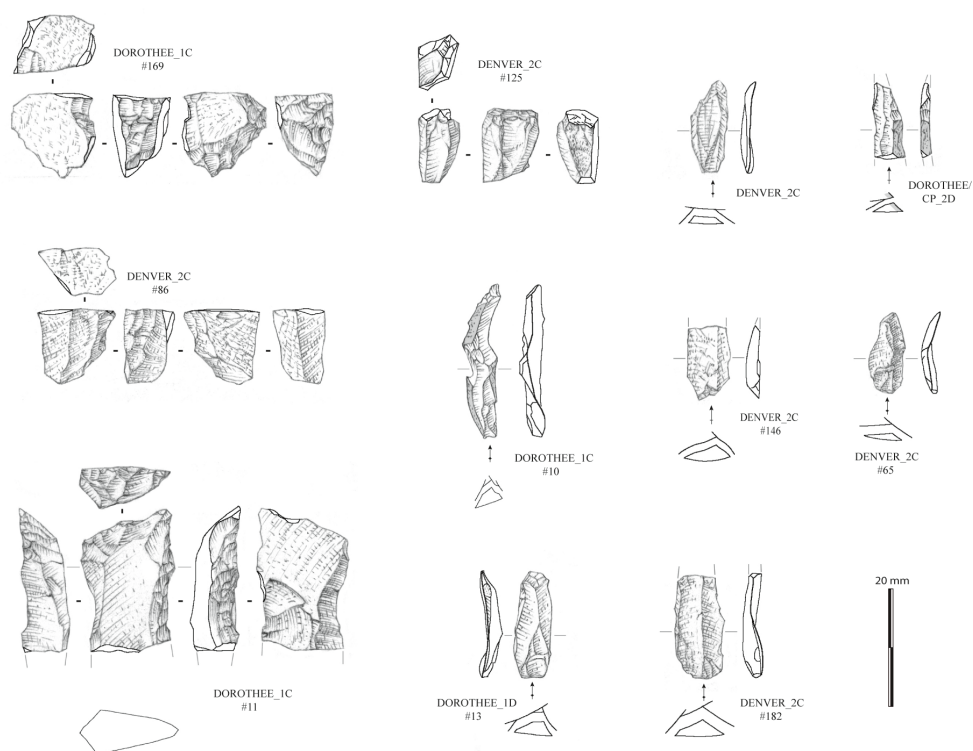


Fig. 3. 2011 lithic collection from the earliest Robberg occupations at Elands Bay Cave. #169, #86 (silcrete) and #125 (chert) are bladelet cores (to notice the dimensional homogeneity at their stage of discard), #11 is a reduced scraper with bladelet removals on its narrow side. The other products are all bladelets in silcrete except #146 (quartz). All silcrete products have been heat treated (drawings by M. Grenet).

Principles and methods

Our analytical procedure follows the general principles of the *chaîne opératoire* (Leroi-Gourhan 1964–65; Tixier 1980; Geneste 1992; Boëda et al. 1990), the aim being to inscribe each artefact within a succession of technological events from the acquisition of the rock to the use of the tool and its discard. The nature of the analysis itself is descriptive and purports to assert a craft knowledge. The interpretations behind this knowledge, in terms of variability and diversity, relate to a theoretical background that varies depending on the analysts and the research questions (Fig. 5).

The analytical background of lithic technological studies is based on one basic principle: the fracture of conchoidally fracturing rocks is subject to three constraints that dictate the way the fracture propagates. These three main physical constraints are: (1) the mechanical properties of the rocks (elasticity, hardness, homogeneity, fracture toughness, etc.), (2) the geometric shape of the volume (including longitudinal and transversal convexities, number of surfaces and angles of intersections) and (3) the application of the force (type and nature of the contact in terms of mode of application and of motion). Once these constraints are assimilated by the knapper, they become

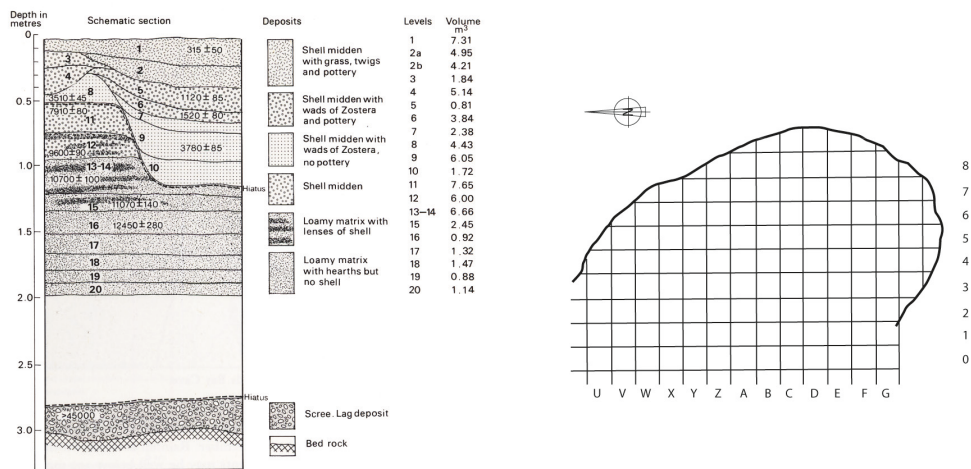


Fig. 4. Stratigraphy (after Parkington 1984) and grid of the 1970s excavation at Elands Bay Cave.

rules. With these rules in mind, it is thereafter possible to control and anticipate the fracture (i.e. notion of predictability and intentionality).

The intention is to manufacture a tool. A tool is an object defined by its efficiency, its kinetics as well as by its ergonomic and non-utilitarian aspects (Fig. 5). Schematically, a tool associates two main parts: a transformative part that is intended to be in contact with the worked material and a passive part that is intended to be handled/hafted (see Lepot 1993; Boëda 2001; 2013; Conard et al. 2012). Tools vary in shape and volume, depending on the actions intended with them (motion of the user and properties of the worked material), the technical sub-systems (e.g. the mode of propulsion, the hafting structure), the body techniques and the beliefs of the tool-making populations.

However, understanding a tool itself also requires us to consider all the technical steps behind its manufacture. The manufacturing stages vary with the skill of the knapper, the geological resources available in the environment as well as with the system of subsistence and with the traditions of the group. Applying such a global technological

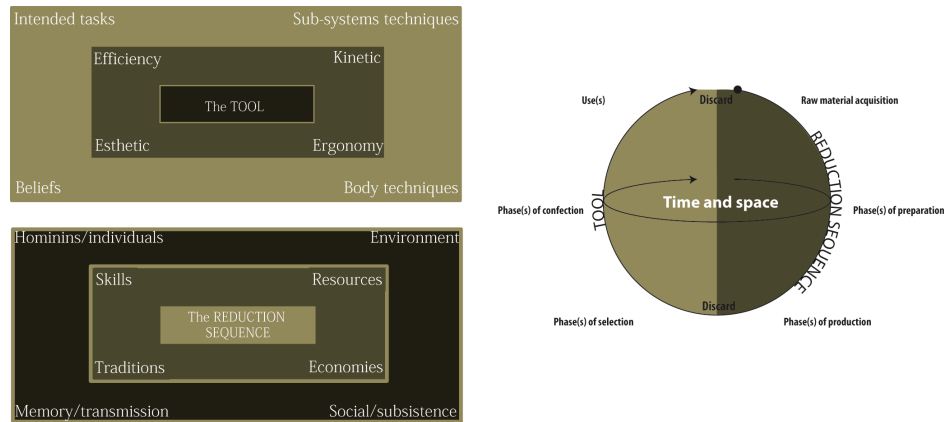


Fig. 5. Theoretical framework of the present technological study.

approach, the objective is to describe the different technical events that led to a lithic assemblage and to understand their associations and characteristics. Through a system of inferences (Gardin 2002), it is then possible to develop a narrative from a short- to a long-term perspective.

What raw materials were selected and for which raw material provisioning strategies?

Raw material characterization has a long history of research, targeting in particular to improve the sourcing of the rocks as well as their interpretative frameworks (e.g. Geneste 1992; Kelly 1995; Kuhn 1995; Féblot-Augustins 1997). The first analytical step is to characterize the geological environment to which populations had to adapt. In the context of EBC, the dominant geology is formed by the Table Mountain Group sandstone. EBC is formed in the lowest layer of the Table Mountain Series which is referred to as the Pickenierskloof Conglomerate. The pebble composition of this conglomerate is dominated by vein quartz, but it also includes a few fine-grained varieties of quartzite and chert.

Silcrete is locally available at the Verlorenvlei mouth. There it can be found as greyish hard silicified crust that, through experimental studies, has been found to be of rather low quality for knapping. The second nearest outcrop is the yellowish silcrete from Redelinghuys, located ca. 20 km eastward of EBC, along the Verlorenvlei. This silcrete is of medium knapping quality and presents a coarse grain-supported and heterogeneous texture. Silcrete of better knapping quality only occurs in more distant areas (Porraz et al. 2013). The first one is located north of Piketberg, ca. 40 km eastward of EBC: this silcrete presents a fine texture and is greyish with brownish features. The second silcrete can be found at the mouth of the Berg River, ca. 50 km southwards of EBC: this silcrete has a fine texture and is mostly shiny greyish to reddish. The third main area of silcrete distribution is located at the mouth of the Olifants river, ca. 70 km northward of EBC. Silcrete of this area is abundant in secondary position as pebbles that can be collected in alluvial terraces.

Hydrothermal vein quartz (henceforth only called ‘quartz’ for simplicity), quartzite, sandstone and silcrete represent the main regionally available raw materials. Hornfels occurs in minor amounts. So far, this rock has only been found within the terraces close to the Olifants river mouth, ca. 70 km northward of EBC.

Petrographic identifications were made at mesoscopic scale (10x–56x) using a regional geological database for comparison (see Porraz et al. 2013). Each lithic artefact was classified according to two criteria: the nature of the rock and, when present, the type of its surface or ‘cortex’ (weathered, rolled, fresh, indeterminate).

This technological study was completed by a detailed fracture surface analysis (Schmidt et al 2015) aiming to determine whether the silcrete component of the studied assemblage was heat-treated in the Robberg, as previously only documented in the regional MSA (Brown et al. 2009; Schmidt et al. 2015). During this analysis we identified three proxies: (1) Pre-heating removal scars: relatively rough fracture surfaces corresponding to the removal of flakes from unheated silcrete; (2) Post-heating removal scars: relatively smooth fracture surfaces that correspond to the removal of flakes from heat-treated silcrete; (3) Heat-induced-non-conchoidal (HINC) fractures: surfaces produced by thermal fracturing in a fire (sometimes termed overheating; Schmidt 2014). HINC fracture surfaces can be recognized due to their strong surface

roughness, the presence of scalar features on the surface and concave morphologies with frequent angular features. We only identify such a fracture surface as HINC when it is associated with a post-heating surface. Tempering-residue, a black organic tar (wood tar) produced by dry distillation of plant exudations during contact with glowing embers (Schmidt et al. 2015), might represent a fourth proxy but it has not been observed in the EBC collection.

To securely recognize pre- and post-heating scars on the EBC artefacts, we compared them with our reference collection of unheated and heat-treated silcrete from the region (Schmidt et al. 2013, 2015). The three heat treatment proxies were observed macroscopically and at a 10x magnification. Visual criteria were the surface roughness of removal scars and, in the case of HINC fractures, the presence of scalar features. No further equipment was used to measure flake scar roughness and no gloss-meter was used. The correct assignment of fracture surfaces to either pre- or post-heating fracture scars at EBC was verified with our experimental collection and aided by an 'internal calibration' (Schmidt & Mackay 2016). Such an internal calibration consists in first finding artefacts that show both smooth post- and rough pre-heating scars. The roughness of pre- and post-heating scars on other artefacts can then be compared with these 'diagnostic pieces' in order to verify their assignment to either heating proxy class. EBC artefacts that could not be clearly identified as belonging to one of the frequently occurring silcrete types and to which we could not find a clear match in the West Coast reference collection were left undetermined as to whether they were heat-treated or not.

What are the main core reduction sequences and for which technique(s)?

Our description of the lithics is based on an abundant literature combining both experimental and archaeological case studies (e.g. Tixier 1980; Pélegrin 1995; Inizan et al. 1999). The goal is to propose a scheme representing the different technical steps followed by the knapper. These steps are usually inferred from combining both 'mental' and 'physical' refitting.

A technological narrative implies a constant two way comparison between cores and products. We focused on all cores, cortical blanks, and all products that have, intentionally or accidentally, been taken away from a large portion of the core. This last category includes over-plunged blanks, débordant/ridge blanks and core tablets. At this stage of the study, the aim is to decode the geometry of the cores and their transformation from initial shaping to discard.

Our description starts with the identification of the block that was selected to be knapped. A block is defined by its size and shape, which can be angular or rounded, regular or irregular, symmetric or asymmetric. In the context of EBC, we defined four main types of blocks: rounded pebbles, irregular fragments, slabs and flakes. Subsequent to this, the aim was to describe the initial shaping, starting with the way the block was oriented. This shaping aims to set up the surface of removals by establishing the appropriate convexities and angles. The description of the main surface(s) of removals allows us to reach an initial understanding of the types of blanks that were produced, as well as of the rhythms of the production.

The characterization of the technique of detachment of the blanks combines observations on the cores and on the products (e.g. Soriano et al. 2007). It is based on

the description of the platform (plain or prepared, thickness, amplitude), of the ventral surface (lip, contact point, interference waves) and of the dorsal surface (abrasion, removals, etc.). This description goes together with the calculation of the platform angle which, in the present study, was only taken on the cores. Additionally, special attention was paid to possible signs related to the presence of anvil repercussions. The Robberg lithic assemblages were long associated with the use of bipolar percussion and recent works (e.g. de la Peña 2015) have shown how this technique varies together with body techniques and objectives. In our paper, we follow the terminology advocated by Callahan (1987), who established a distinction between bipolar percussion involving an axial percussion, and anvil percussion involving a more slanted percussion.

What are the main categories of blanks and for which functional purposes were they struck?

In terms of classification, we distinguished the blades from the flakes on the base of their dimensions and regularity: the category 'blade' includes all products with sub-parallel to convergent edges that are twice or more as long as wide. For all categories, and assuming that size matters, we distinguished the following groups: blades (≥ 15 mm wide), microblades (≥ 12 mm), bladelets (≤ 11 mm) and microbladelets (≤ 5 mm). Similarly, we distinguished flakes from micro-flakes (≤ 20 mm long).

One of our research questions implied by the study of the Robberg industry addresses size and morphology and how these two variables relate. We measured the length (within the axis of percussion), the breadth (at the middle of the piece) and the thickness (at the intersection between length and breadth) of all products.

To identify any morphological patterns within the bladelet reduction sequence, we subdivided blanks into three main classes: (1) parallel bladelets, with their proximal and medial parts being 'equally' wide; (2) triangular bladelets: convergent and symmetric bladelets with a proximal part wider than their medial part; (3) comma-like bladelets: convergent asymmetric bladelets, often twisted, with one convex edge and one concave edge. In addition, we identified trapezoidal bladelets (flakes with divergent edges) and naturally backed bladelets (asymmetric in section).

Regarding the typological classification of the formal tools, we followed a simple subdivision into three categories that distinguish modified bladelets (regardless of the type of modification), products with notches/denticulations and scraper-like tools that are not of bladelet proportions.

For the functional study, we combined the observation of macroscopic edge damage features with the search for microscopic use-wear traces (see Semenov 1964; Keeley 1980). The contact between a tool and a given worked material chemically and mechanically modifies the edge and surface of the tool creating a specific set of use-wear traces. These modifications are visible under low magnifications as scars, fractures, edge rounding, and under the microscope where polishes, striation and micro edge rounding can be observed. Combined, they are reliable indicators of the nature of the material worked and of the actions performed.

Artefacts were first examined using a binocular microscope (Olympus, magnifications up to 100X) and then using a metallurgical incident light microscope equipped with Differential Interference Contrast (DIC) objective (Olympus, magnification up to 200x), following the standard procedures used in use-wear analysis (e.g. Plisson 1985; Gonzalez-Urquijo & Ibanez-Estevéz 2004). Photomicrographs were taken with a

digital camera Canon EOS 600D. Interpretations of the functionality of stone tools are based on a large experimental reference collection of use-wear traces recorded on tools made from different raw materials and based on both African Stone Age and European Paleolithic replications (Igreja 2009; Igreja & Clemente-Conte 2009; Igreja & Porraz 2013; Porraz et al. 2015).

Given that much effort has already been expended to establish Diagnostic Impact Fractures (DIFs), shown through experiments (Fischer et al. 1984; Lombard 2005; Lombard & Pargeter 2008; Iovita et al. 2014), as well as possible effects of taphonomic disturbance on stone tools, we use the main DIF breakage types that have been commonly recognized as projectile impact damage based on the morphology of fracture initiation and termination (Fischer et al. 1984; Hayden 1979): step terminating bending fractures; spin-off fractures > 6 mm; bifacial spin-off fractures and impact burinations. Step terminating fractures and spin-off fractures have been referred to as the primary DIF types to identify the potential use of stone tipped weaponry (Lombard 2005; Lombard & Pargeter 2008; Villa et al. 2009). Snap, feather and hinge terminating fractures and tip crushing are recorded during macrofracture analyses to describe the complete range of damage seen on a tool. Such damage can result from a variety of other activities (such as trampling and knapping) and should not be used alone as potential indicators of projectile impact.

TECHNOLOGICAL AND FUNCTIONAL ANALYSIS OF THE MOS1 ROBBERG

Our sample (Table 1) represents 4263 lithic artefacts coming from the squares A2, A3, B2, D2, C2 and Z3 (Fig. 4) and includes 106 pieces originating from layer DS03 (square E4). MOS1 and DS03 were excavated at different times (in 1978 and 1970 respectively) and different areas, but field and technological observations support the hypothesis that they originate from the same archaeological horizon. All deposits were dry sieved with a 3 mm mesh.

Fragments (i.e. pieces that could not be assigned to any other technological category) ≤ 20 mm comprise the vast majority of our sample with a total of 3077 pieces: they represent 41 % of the silcrete and as much as 75 % of the quartz. The following observations and calculations exclude all fragments ≤ 20 mm and are based on a total collection of 1186 lithic artefacts.

What raw materials were selected and for which raw material provisioning strategies?

The collection is predominantly composed of quartz (82 %), which is available in the direct environment of the shelter. Most quartz pebbles are semi-spherical with mean sizes ranging from 5 to 15 cm long. The proportion of cortical flakes (ca. 10 %), the high number of cores, the number of small fragments and small flakes (Table 1) suggest that quartz was introduced as pebbles and exploited *in situ*. This raw material category includes a small proportion of well crystallized quartz or rock crystal (< 2 %).

The second main raw material in the lithic collection is silcrete (15 %). Our study allows us to distinguish two main categories.

- (1) The first is represented by a yellowish coarse-grained silcrete, which represents 18 % of the silcrete collection. Seven cortical surfaces on a total of 11 pieces

TABLE 1
List of the MOS1 lithic assemblage from Elands Bay Cave (in bracket are the retouched pieces).

	Quartz	Local Silcrete	Exotic silcrete	Coarse Quartzite	Fine Quartzite	Chert	Hornfels	Undeterm.	TOTAL
Flakes	53 (3)	3	15 (2)	15	1	2	6 (1)	1	96 (6)
Blades (≥ 15 mm)	3	3	3	0	0	0	0	0	9
Micro-Blades (≥ 12 mm)	6	0	1	1	0	1	0	1	10
Bladelets (≤ 11 mm)	304 (12)	10	57 (8)	0	0	4	1	2	378 (20)
Micro-bladelets (≤ 5 mm)	238 (19)	8	36 (4)	0	3	4	0	0	289 (23)
Micro-flakes (≤ 20 mm)	105 (5)	5	30 (3)	1	1	3	0	0	145 (8)
Cores	63	1	3	0	0	1	1	0	69
Core-reduced pieces	136	1	0	0	0	1	1	0	139
Manuport	0	0	0	1	0	0	1	0	2
Fragments >20 mm	35	0	4	5	2	3	0	0	49
TOTAL	943 (39)	31 (0)	149 (17)	23 (0)	7 (0)	19 (0)	10 (1)	4 (0)	1186 (57)
Fragments ≤ 20 mm	2853	6	120 (2)	42	11	13	32	0	3077 (2)
TOTAL	3796	37	269	65	18	32	42	4	4263 (59)

were determinable and all show a weathered surface that documents their collection in a primary context. Macroscopically, this yellowish silcrete is similar to the one from Redelinguys located ca. 20 km eastward of EBC.

- (2) The second is classified as 'exotic'. Exotic silcrete varies macroscopically in colour and content of inclusions, suggesting that it originates from different sources. Cortical pieces that were determinable are represented by eight pieces (of a total of 11): five exhibit a weathered surface and three a rolled surface, indicating different places of collection (in primary and secondary contexts). Our present knowledge of the regional geology suggests these raw materials were collected and transported from distances greater than 30 km.

During our analysis, we identified all three heat treatment proxies described in section 4.2 (Fig. 6), but 16 artefacts (12 %) had removal scars that could not be clearly assigned to either pre- or post-heating removals. These groups, the total count and the relative percentages of artefacts in each group are summarized in Table 2. The percentages in these groups demonstrate that the majority of the silcrete artefacts were manufactured on heat-treated raw material. Depending on whether undetermined pieces are included in the calculation or not, 81–92 % of the artefacts were knapped from heat-treated silcrete, as indicated by the presence of post-heating removal scars. On 19 % of these heat-treated artefacts, rough pre-heating removal scars from before heat treatment are preserved alongside a second generation of smooth post-heating removal scars. The abundance of heat-treated artefacts that show HINC-fractures (9.4 %), i.e. that show traces of overheating after which knapping continued, reveals that heat induced failure occurred during the procedure of heat treatment. We notice some differences between the yellowish coarse-grained silcrete (assumed to be local) and the finer grained varieties. When separated from the total, it can be noted that 40 % of the local silcrete could not be determined as 'heated' or 'unheated'. Two hypotheses may explain this higher number of indeterminate pieces on this type of silcrete: the difference might be related 1) to an analytical bias due to the coarse nature of the first type or 2) to a different technological treatment applied to this silcrete type (local silcrete of poorer quality would have been less frequently heat-treated or not at all).

Our lithic collection allows us to develop two main observations about heat treatment. First, raw blocks and flakes were both heated by EBC inhabitants and selected as cores. The presence of HINC-fracture surfaces ($n = 10$) suggests that silcrete frequently broke during heat treatment and that this was not a criterion to discard the blocks. From this observation it may be inferred (cf. *infra*) that shaping of the volume before heat treatment was minimal, though some cores preserve pre-heating removals. The second observation is that the number of small thermal fragments and pot-lids is low in our collection, suggesting that heat treatment was not necessarily conducted on site.

Only three silcrete cores are present in our collection (one of local silcrete, two of exotic silcrete), which contrasts with the relative high number of bladelets, micro-flakes and small fragments (Table 1). This data suggest that silcrete was introduced in two main technological forms: 1) as end-products: this is suggested by the high number of bladelets and their petrographic diversity; 2) as cores: this is suggested by the number of fragments ≤ 20 mm that most likely originate from knapping. Following this assumption, the low number of silcrete cores in our collection may suggest that some cores were



Fig. 6. Silcrete products bearing various indications of heat treatment. #131 is a frontal bladelet core with surfaces suggesting the volume was partly shaped before heat treatment. #3 is a microflake. #114 is a microflake with microbladelets removals. #37 is a technical flake intended to shape the transversal convexity of a bladelet core. #161 is a bladelet. #136 is a bladelet core-tablet. #436 is a flake. #231 is a technical flake intended to correct a removal that hinged (from an opposed platform). #446 is a flake. #169 is an irregular bladelet with opposed incidental removals indicating the use of anvil percussion.

TABLE 2

Results of the analysis of the silcrete artefacts MOS1 layer from Elands Bay Cave. Percentages under 'Percent total' refer to the total of analysed artefacts in the layers, percentages under 'Percent det.' refer to all determinable artefacts in the given layer but exclude non-diagnostic artefacts. Percentages under 'Percent HT' refer to the number of heat-treated artefacts in the layer.

	Count	% Total	% Determined	% Heat-treated
Non-diagnostic artefact	16	12 %		
Not-heated artefacts	9	7 %	8 %	
Artefacts with post-heating surfaces <i>Of which:</i>	106	81 %	92 %	
<i>with both pre- and post-heating surfaces</i>	20			19 %
<i>with HINC-fracture surfaces</i>	10			9 %
TOTAL	131	100 %	100 %	

introduced into the site, exploited *in situ* and taken away to another site ('ghost cores'; Porraz 2008). To these lines of evidence we may add the introduction as well of a few large silcrete flakes that were potentially exploited both as tools and as cores.

The other raw materials compose 3 % of the collection. This category includes coarse-grained locally available quartzite of poor quality for knapping. This coarse-grained quartzite is dominantly represented by flakes ($n = 15/22$). The other categories of rocks are represented by chert and by another type of finer grained quartzite, which are both locally available. However, the small number of artefacts, their high macroscopic diversity and the total absence of cortical products suggest that chert and fine-grained quartzite might be of non-local origin. The last petrographic group is hornfels. This rock was collected from secondary contexts, as indicated by the presence of pebble cortex ($n = 4/5$), and likely originate from terraces ca. 50 km northward of EBC. Hornfels was discarded at the site as flakes and small fragments.

What are the main core reduction sequences and for which technique(s)?

The collection is characterized primarily by the production of small artefacts, i.e. (micro-)bladelets and micro-flakes (Table 1). Blades, microblades and flakes represent only a minor component of the industry and together compose less than 10 % of the collection (Table 1). Blades seem to have mostly originated from an initial stage of the production (61 % of the blades have a cortical surface). Some of the flakes derive from an independent and expedient reduction strategy, as suggested by the quartzite category, but no core supports this assertion.

Aside from the expedient flake production, we are inclined to identify five main reduction strategies (Table 3, Figs 7, 8). Our sample represents 67 cores to which we associate 147 bipolar cores. It includes 12 undetermined cores that represent fragmented pieces or putative 'preforms'.

The 'high-backed' bladelet cores

This category, also called wedge-shaped bladelet cores in Mitchell (1995), was initially defined by Deacon (1978). The terminology reflects some ambiguity surrounding these

TABLE 3
List of the MOS1 cores from Elands Bay Cave.

	Quartz	Local Silcrete	Exotic silcrete	Quartzite	‘Chert’	Hornfels	TOTAL
‘High-backed’ core	12	0	0	0	0	0	12
‘Narrow-sided’ cores	16	0	0	0	0	1	17
‘Frontal’ core	9	1	3	0	0	0	13
‘Conic’ core	4	0	0	0	1	0	5
Bipolar cores	8	0	0	0	0	0	8
Core-reduced pieces	136	1	0	0	1	1	139
Preforms & indetermined	12	0	0	0	0	0	12
TOTAL	197	2	3	0	2	2	206

pieces, initially called ‘high-backed scrapers’ due to the crushing along the platform that was similar to that along a scraper working edge (Deacon 1978).

The cores from our collection are all made from quartz ($n = 12$). EBC knappers preferentially selected quartz flakes that were produced by bipolar percussion. The knappers either oriented the flakes according to their long or short axis to position the removal surface. The shaping of the core consisted in the removals of two large flakes intended to flank the future removal surface, setting up the convexities of the core. The removal surface presents a conic shape and has a longitudinal convexity generally accentuated toward its base.

The reduction sequence can be considered as discontinuous, meaning that after the removals of a series of end-products, the knapper needed to reshape the surface in order to keep the same objective of production. The main products coming from this reduction sequence are bladelets. Direct observations on the (discarded) cores suggest final bladelets had a mean length between 8 and 11 mm and a mean breadth of 3 to 5 mm (Fig. 8). The conical shape of the surface did favour the production of bladelets that were pointed and slightly curved. From this reduction sequence, we expect to find three main categories of products: lateral flakes (for the transversal convexity), central bladelets (expected to be triangular) and lateral bladelets (expected to have a comma-like morphology). The platform is generally plain with mean angles ranging from 70 to 80°.

The ‘narrow-sided’ bladelet cores

This category corresponds to cores that have been exploited on their narrow surface (cores on edge). In our collection, they are all made of quartz ($n = 16$) except one made of hornfels. However, some technical products indicate that this reduction sequence also applied to silcrete.

The reduction sequence started with the selection of a quartz flake produced by bipolar percussion or, alternatively, by the selection of a slab with a triangular shape. The EBC knapper oriented the flake in order to locate the removal surface on its narrow side, generally in the longer axis. When necessary, a single (often partial) crest was realized to start or regularize the production. The shaping of the core could include

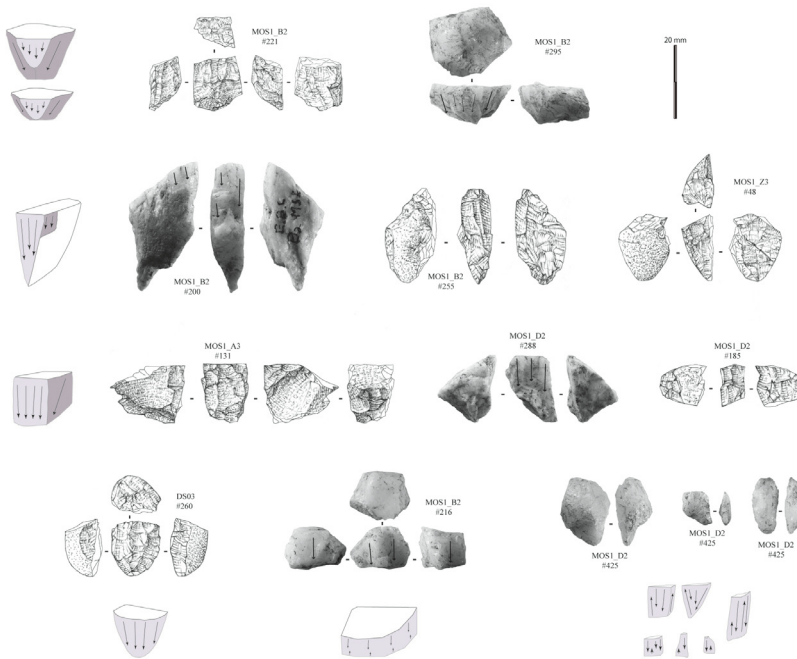


Fig. 7. Cores from the Robberg MOS1 lithic collection from Elands Bay Cave. #221 (silcrete) and #295 (quartz) represent ‘high-backed’ bladelets cores. #200, #255 and #48 (all in quartz) represent ‘narrow-sided’ bladelets cores. #131 (silcrete), #288 (quartz) and #185 (silcrete) represent ‘frontal’ bladelets cores. #260 (quartz) represents a ‘conic’ bladelet core. #216 (quartz) is a bipolar core. #425 (quartz) are bipolar-reduced pieces (drawings by Michel Grenet).

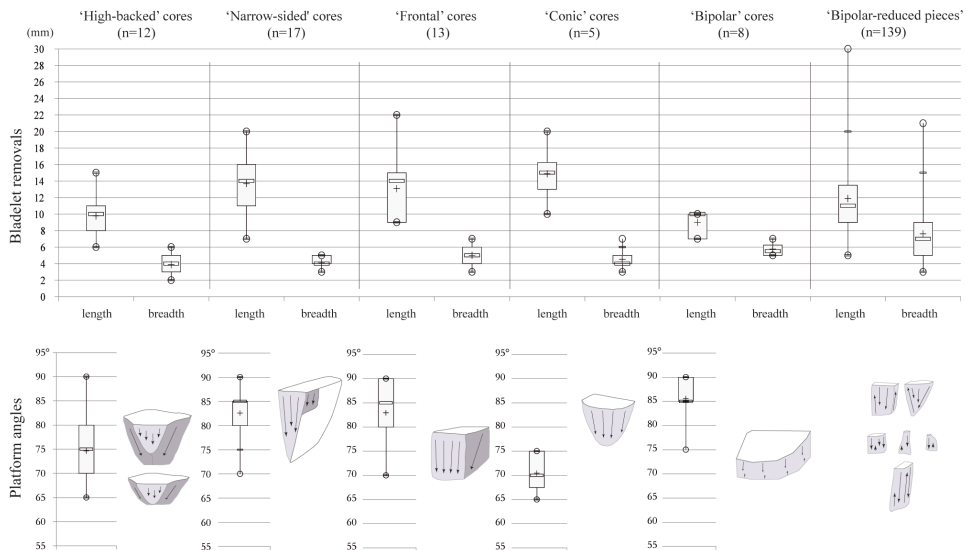


Fig. 8. Dimensional boxplots showing the variability within and between the individualized categories of cores.

some removals at its base, as illustrated by four cores. These removals at the base of the core, prior knapping, might have two purposes (not mutually exclusive): to facilitate the prehension of the core and/or to calibrate the length of the removal surface.

The general shape of the removal surface is 'conic'. The reduction progresses in the same axis all along the production, with one adjacent surface being partially invaded (1/3 prismatic). The reduction is continuous, meaning that the exploitation of the core doesn't require a new shaping after a series of removals. The control of the transversal convexity is managed by lateral bladelets (with often a cortical, a HINC-surface or a 'Kombewa' side) and the control of the longitudinal convexity by plunged products.

The bladelets are rectilinear and narrow; most of them present a triangular section and are pointed. The main morphology is expected to be parallel. The dimensions of the cores vary from 8 to 35 mm in length and 5 to 10 mm in breadth, but the removals do not always extend over the whole surface as indicated by the last removals: the dimensions of the bladelets range from 11 to 16 mm in length and 4 to 5 mm in breadth (Fig. 8). The platform is generally plain (one prepared and one cortical platform on a total of 16 cores) with mean angles between 80 and 85°. Some cores exhibit anvil scars at their base, suggesting they could have been held on a block while being knapped.

The 'frontal' bladelet cores

The 'frontal' bladelet cores share with the 'sided' cores the fact that for both the removal surface is located on the narrower surface of the core. But unlike the 'sided' cores, the frontal cores have a rectangular and 'flat' removal surface. Ten of these cores are made of quartz, four of silcrete.

The reduction sequence starts with the selection of a fragment or a large flake. The knapper oriented the fragment in order to exploit its narrower surface. When necessary, large flakes were detached to flank the main removal surface. The shaping of the core leads to create a removal surface that is relatively flat in its longitudinal and transversal sections. On four cores, we observe the presence of removals at the base of the core that we interpret as an option to calibrate the length of the removal surface (cf. *supra*).

The reduction sequence is continuous, meaning that the core doesn't need to be shaped after a first series of removals. The rhythm of the production keeps the surface more or less flat and doesn't invade largely the sides of the core. The convexities are controlled by the detachment of lateral bladelets and the use of bipolar technique. The bladelets coming from this reduction sequence are expected to be rectilinear with parallel edges and a triangular to trapezoidal section. Final bladelet removals are 9–15 mm long and 4–6 mm breadth. The platform is plain and has an angle bracketed between 80 and 90°. This reduction sequence implies the combination of bipolar and free hand percussion.

The 'conic' bladelet cores

The 'conic' bladelets cores might be considered as the most typical single platform cores with a semi-prismatic shape. This category includes five specimens, four made of quartz and one of chert.

The reduction sequence starts with the selection of a small block, a fragment or a flake. Little information about the initial shaping of the core can be inferred from our lithic assemblage. Some of these cores show orthogonal removals from their (raw) back

as well as from their base to set up the convexities, but the rhythm of the production seems to be firstly controlled by the removal of lateral and plunging bladelets. Most of these bladelets are slightly curved, with a triangular or a comma-like morphology. Final bladelet removals on the cores have a length between 13 to 16 mm and a mean width between 4 and 5 mm. The platform is kept plain and presents a mean angle of 70°.

The bipolar cores

The first group is composed of what we interpret as 'cores-to-cores' ($n = 3$, all in quartz). The reduction sequence starts with a selection of a pebble or a large fragment. These cores show different and independent removal surfaces that can give a polyhedral structure to the core at its stage of discard. Bipolar percussion is used to avoid problems of convexities. Regarding the general characteristics of our lithic assemblage, we interpret this reduction sequence as a way to fragment quartz pieces into smaller pieces intended afterwards to be exploited as cores.

The second group is represented by 'small-flake cores' ($n = 5$, all in quartz). The knapper starts by selecting a pebble, a slab or a large flake. There is no shaping of the core. The production starts directly by removing products on the thickness of the slab, progressively giving a semi-rotating structure to the core. The products are short, large and rectilinear, with a mean length between 7 and 10 mm and a mean breadth between 5 and 7 mm.

The third group is represented by the 'bipolar-reduced pieces'. The bipolar-reduced pieces form a large category that includes core reduced pieces and small and flat bladelet cores (Deacon 1984), *pièces esquillées* (Deacon 1978), 'rice-grain cores' and all other diminutive forms involving bipolar percussion. This category differs from the first two categories in their dimensions, their shapes as well as by the nature of the blanks that were produced, though they might represent one last stage in the reduction. This category represents the largest population of cores with 139 specimens, all except two being in quartz. These cores have either a plan-parallel or triangular shape and have a chisel-like platform. Removals on the cores show a 'radial' fracture, characteristic of bipolar production. Various blanks might have been selected to be exploited: flakes, small fragments as well as cores at their final stage of exploitation. The products show variability in shape, but are generally elongated. Though they are irregular, many of these products can be classified as (micro-)bladelets. The dimensional range of the last removals, as measured on the bipolar-reduced pieces, overlaps those from all other cores (Fig. 8).

The techniques of detachment

Authors have formulated different hypotheses regarding the nature of the techniques of detachment that were used by Robberg populations, but one agreement emerges from the literature, which is a common use of bipolar percussion. In the MOS1 assemblage, such evidence is indeed numerous. One interesting aspect regarding the use of this technique is that it was applied in different ways and for different purposes. Bipolar percussion appears for example to represent a common technique that was used to fragment quartz pebbles and to exhaust small cores. But anvil percussion was also regularly applied, as illustrated by the presence of anvil marks at the base of some bladelet cores. The common use of anvil percussion seems to have been a solution

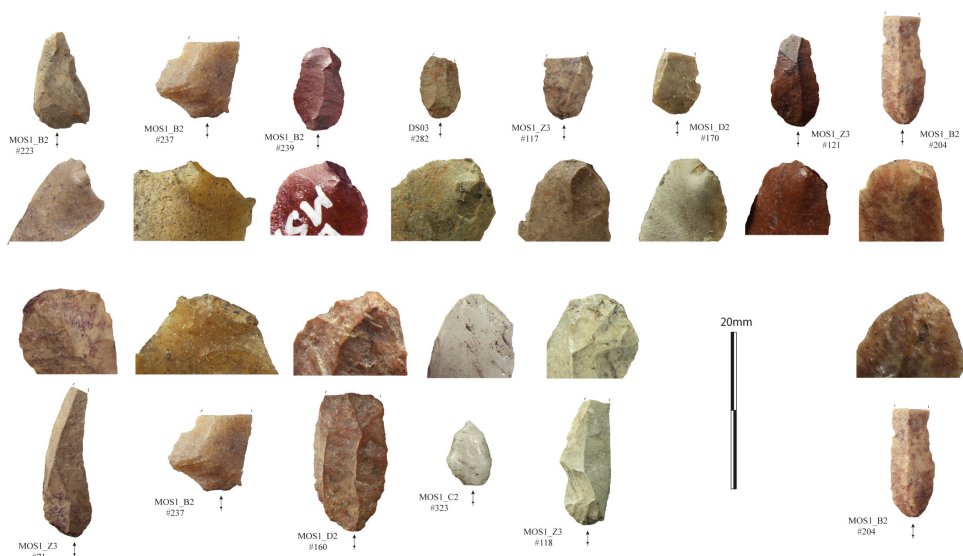


Fig. 9. Technical stigmata on the bladelets of the MOS1 Robberg from Elands Bay Cave (all in silcrete, except #323 in quartz). The presence of contact points (#223, #239, #282, #170, #121), of shattered bulbs (#282, #117) and shallow lips (#237, #204) together with the presence of intense abrasions (#71, #237, #160, #323, #118 and #204) suggest the application of a percussion slightly tangential with the use of (soft) stone hammer.

applied in response to different technical requirements: as a way to facilitate the support of small-sized bladelet cores, and as a way to correct accidents on the removal surfaces. Evidence of bipolar percussion is common among quartz pieces, but is also found on other raw materials including heat-treated silcrete. This technique cannot be interpreted as a direct adaptation to raw material properties; neither can it be related to a technical system that was predominantly oriented toward poorly standardized bladelets. This technique was part of the technical repertoire of the Robberg populations and contributes to define their technology.

Beside bipolar percussion, our observations on cores and bladelets lead us to reject the hypothesis of indirect percussion in favour of free hand percussion (Fig. 9). Abraded platforms indicate percussion that was intended to be marginal (a few millimetres inside); small contact points on the ventral faces indicate a localized contact (versus diffused); shattered bulbs indicate a hard contact and shallow lips indicate a percussion with a slightly tangential motion. All data converge to hypothesize the main use of soft stone hammer percussion to produce bladelets.

What are the main categories of blanks and for which functional purposes were they struck?

The reduction sequences were oriented toward the production of small blanks and notably of bladelets. The MOS1 bladelet corpus is composed of a majority of fragments that approaches 60 % of the population. Though the question related to the origin of these fractures requires further analyses, our preliminary observations allow us to propose that most breakages produced at the time of the knapping. The complete specimens

ANOVA Table for Length

	DDL	Sum of the squares	Medium Square	F value	p value	Lambda	Power
Rock 1	1	411,694	411,694	20,726	<,0001	20,726	,999
Residu	207	4111,775	19,864				

Table of means for Length

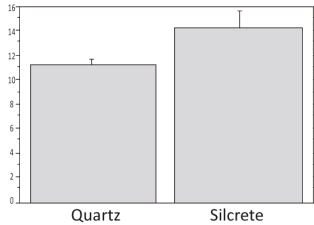
Effect: rock 1

	Number	Medium	Standard Dev.	Standard. Error
Quartz	134	11,287	3,296	,285
Silcrete	75	14,213	6,003	,693

Graphic of interactions for Length

Effect: Rock 1

Error Bar: interval of confidence 95%



PLSD test of Fisher for Length

Effect: Rock 1

Significant: 5%

	Mean diff.	Crit. Diff.	p value
Quartz, Silcrete	-2,926	1,267	<,0001

Table of means for Breadth

Effect: rock 1

	Number	Medium	Standard Dev.	Standard. Error
Quartz	134	5,910	2,194	,190
Silcrete	75	6,573	2,868	,331

Table of means for Thickness

Effect: rock 1

	Number	Medium	Standard Dev.	Standard. Error
Quartz	314	1,764	,907	,051
Silcrete	99	2,197	1,277	,128

Fig. 10. Data showing the dimensional means of quartz and silcrete bladelets from the MOS1 assemblage of EBC and statistical analysis discriminating the quartz and the silcrete bladelets (normality of the distribution verified).

document a mean length comprised between 8 and 16 mm (mean of 11.2 mm for the quartz and of 14.2 mm for the silcrete), a mean breadth comprised between 3 and 7 mm (mean of 5.9 mm for the quartz and of 6.5 mm for the silcrete) and a thickness centered around 2 mm (mean of 1.7 mm for the quartz and of 2.2 mm for the silcrete) (Fig. 10).

The dimensional analysis allows two main statements:

- (1) We observe a significant difference ($p < 0,0001$) between the dimensions of the bladelets in quartz and those in silcrete (Fig. 10). This difference is clear when focusing, for example, on the length, with the bladelets in silcrete being significantly longer (by 3 mm) than those in quartz.
- (2) Our study (Fig. 11) suggests that two silcrete populations can be statistically discriminated based on their length. The boundary between the two silcrete groups appears to be positioned between 13 and 15 mm, with one group of bladelets being ≤ 13 mm long and one group being ≥ 15 mm long.

The results of our dimensional analysis suggest a distinct raw material economy, between the quartz and the silcrete, and different reductions strategies within the silcrete. The implications are discussed further in the synthesis.

ANOVA Table
Breadth vs Length

	DDL	Sum of the squares	Medium Square	F value	p value
Regression	1	68,651	68,651	17,312	<,0001
Residu	70	277,217	3,96		
Total	71	345,778			

Regression coef.
Breadth vs Length

	Coefficient	standard error	standard. Coef.	t value	p value
cst. Term	2,928	,819	2,928	3,573	,0006
Length	,245	,059	,445	4,161	<,0001

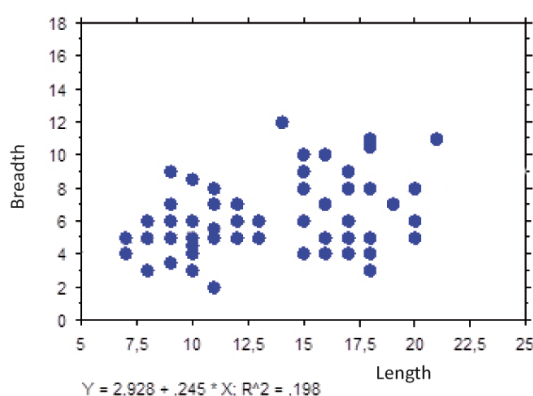


Fig. 11. Statistical analysis suggesting that two populations of silcrete bladelets can be discriminated based on their length (normality of the distribution verified).

The reduction sequences were oriented toward the production of small blanks with various morphologies (Fig. 12). Among the bladelets that could have been assigned to a morphological category (ca. 75 %), we observe a clear dominance of parallel bladelets (50 %) over the triangular (10 %) and the comma-like (5 %). Bladelets are dominantly rectilinear (62 %).

As well as the bladelets and the small flakes, there are a few blanks of bigger size represented by (micro-)blades and flakes. Blades and flakes do not show a high degree of preparation but all present regular edges. Interestingly, flakes often present a natural back opposed to a sharp edge.

The typological corpus of the MOS1 Robberg collection from EBC (Table 4) is characterized by three main characteristics:

- (1) The proportion of modified pieces is more important than initially assumed (ca. 5 % of the whole assemblage): 7 % of the bladelets and 4.5 % of the flakes are modified, composing ca. 10.5 % of all silcrete products and ca. 4 % of all quartz products. Within the modified bladelets corpus, we observe an interesting pattern related to the morphotypes that were selected, with the parallel bladelets being under-represented (only ca. 9 % of the modified bladelets) by comparison with the triangular morphology (14 % of the modified bladelets) and the comma-like morphology (22.5 % of the modified bladelets).

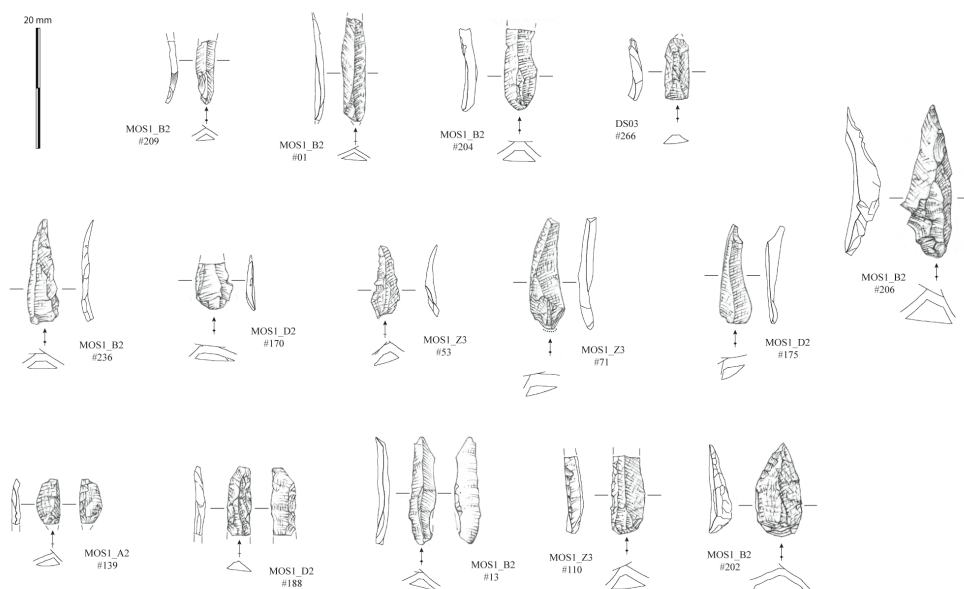


Fig. 12. Bladelets from the Robberg MOS1 lithic collection from Elands Bay Cave. #209, #01, #204, #13 #110 (all in silcrete) and #266, #139, #188 (quartz) are classified as 'parallel' bladelets. #236 (silcrete) and #170 (chert) are classified as triangular bladelets. #53 (quartz), #71 (silcrete) and #175 (chert) are classified as comma-like bladelets. #206 shows the preparation of a partial neo-crest. #139 (quartz), #188 and #13 (both silcrete) are ventrally blunted bladelets. #110 is a dorsally backed/blunted bladelet. #202 is a pointed retouched bladelet (drawings by Michel Grenet).

Out of a total of 47 bladelets, one originates from of a bipolar reduction sequence. We note also the high proportion of silcrete among formal tools (32 %) in comparison with the whole assemblage (15 %).

- (2) The second element that typified the typological corpus is the low degree of transformation that characterizes the modified pieces. The retouch is always limited to a small portion of the products and/or is never invasive. Some actions were intended to sharpen the tool while others seem to have been intended to blunt the edge. If we focus on the modified bladelets, we have to acknowledge the occasional difficulty in discriminating what derives from use and what originates from retouch. In our study, we grouped together all bladelets bearing edge modification, regardless of their origins. In the MOS1 Robberg assemblage, it would appear that the very limited retouch was aimed more at correcting deficiencies of morphology rather than to shape, curate or re-sharpen the blanks.
- (3) The third and last element that typified the typological corpus is the low diversity of the formal tools we identified. We separated 3 main categories which are 1) the modified bladelets, including blunted, backed and retouched specimens, 2) the notches and denticulates, and 3) the scrapers. The blunted bladelets represent bladelets that have been laterally transformed by a shallow and often irregular retouch, while backed bladelets have more

TABLE 4

List of the MOS1 modified pieces from Elands Bay Cave (in bracket: number of broken pieces).

	Quartz	Silcrete	hornfels	TOTAL
Modified bladelets - asymmetric	8 (2)	4 (1)	0	12 (3)
Modified bladelets - symmetric	18 (10)	6 (4)	0	24 (14)
Scrapers	3 (1)	4 (1)	1	8 (2)
Notches	6 (4)	2 (1)	0	8 (5)
denticulates	3 (3)	1 (1)	0	4 (4)
Fragment indetermined	1 (1)	2 (2)	0	3 (3)
TOTAL	39 (21)	19 (10)	1	59 (31)

regular and abrupt retouch. Modification of the bladelets occurs either laterally, or on the apex, but never on its base. Lateral modifications are always limited to one edge and are unifacial (ventral or dorsal) or bifacial. The notches ($n = 8$), the denticulates ($n = 4$) and the scrapers ($n = 8$) are dominantly of diminutive size but lack standardization; they were made on flakes and bladelets.

The present functional study rests on a total of 123 artefacts made of quartz and silcrete. The sample covered in particular the category of unmodified bladelets ($n = 94$) due to the high proportion of this class of artefacts, but it also includes modified bladelets ($n = 19$), flakes ($n = 6$), blades ($n = 2$) and *pièces esquillées* ($n = 2$). Overall, the edges and surfaces of artefacts are well preserved and allow for the use-wear analysis within reliable analytical conditions (Table 5). From the 123 artefacts analyzed, 62 show no signs of natural weathering but 18 exhibit edges and surfaces moderately damaged by post-depositional phenomena, presumably linked with a mechanical origin since the surfaces are marked by striae and flat bright polishes.

The analysis rests on a set of observations ranging from macro- to micro-traces. In our collection, three pieces show the presence of a black deposit that likely corresponds to remnant adhesive. Two of them show a black imprint with a diagonal distribution suggesting that only part of the edge was active (Fig. 13). One of these two examples is a silcrete lamellar flake with a trapezoidal morphology. Another piece with a similar morphology, but no black imprint, presents a polish on its proximal part that suggests a contact with a hard material that could originate from hafting.

Additional evidence on how the Robberg artefacts were hafted is indirectly inferred from the presence of macrofractures (Fig. 14). Four bladelets present typical fractures caused by longitudinal impact during use, indicating these bladelets were inserted axially. The morphology of the macrofractures suggests they likely result from a projectile impact. These bladelets have parallel or convergent edges: one is in quartz, three are in silcrete. None of these bladelets with macrofractures is modified.

The use-wear analysis brings decisive information on the function and economy of the blanks that were produced by the Robberg inhabitants of EBC, with 33 artefacts

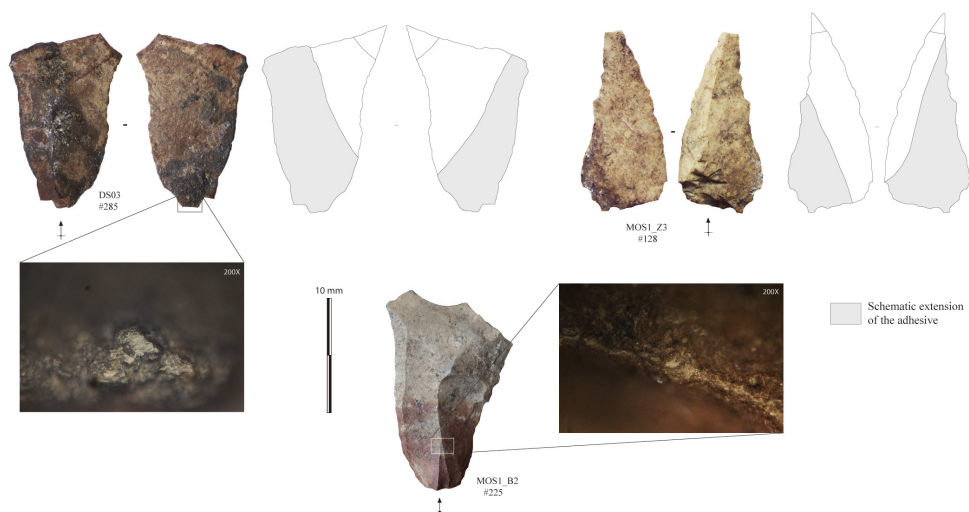


Fig. 13. Bladelets bearing evidences of hafting (all in silcrete). #285 presents a bifacial and symmetric black imprint as well as a polish of hard material contact that suggest the trapezoidal bladelet was hafted obliquely. #128 presents a shallow bifacial black imprint that suggests the asymmetric convergent bladelet was hafted obliquely. #225 presents a polish from a contact with hard material that likely originates from hafting. Notice the similar morphometric characteristics of #225 and #285.

bearing recognizable use-wear traces (Table 5). We can summarize our results into two main categories:

- (1) The bladelets (Table 5, Fig. 15). The result of the analysis shows that all different sorts of bladelets were used, regardless of their size, their morphologies and the delineation of their edges (from convex to concave and from irregular to regular). Bladelets testify mostly to processing activities, being primarily used as cutting tools ($n = 14$). These activities are related to the working of hard materials ($n = 4$) and soft materials ($n = 10$) such as hide processing. We notice that one blade shows use-wear traces consistent with a transversal motion on hard material.

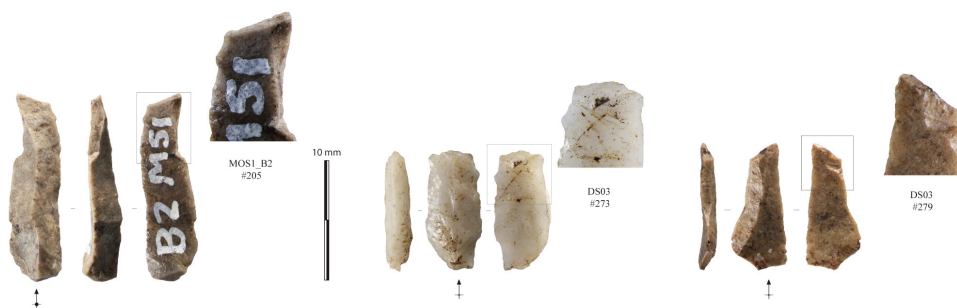


Fig. 14. Bladelets with fractures suggesting a possible projectile impact origin: #205 (silcrete) presents an impact burination; #273 (quartz) presents a bending fracture on its ventral surface; #279 (silcrete) presents a step-terminating fracture that continues parallel to the point's surface and terminates abruptly in a right angle break. Terminology according to Fisher et al. (1984).

TABLE 5
List and results of MOS1 Robberg pieces from Elands Bay Cave analyzed for use-wear traces. Bladelets were selected on the basis of the presence of macroscopic damage such as scars, edge rounding, fractures, potentially linked to tool use (in bracket: number of broken pieces).

				Worked materials and motions												
				Preservation			use-wear traces	longitudinal		transversal			percussion			
Type-techno.	total	good	weathered		soft	hard	hard	wood	undet.	hard	bone	Hafting	projectile impact	undet	Total	
Unmodified bladelets	94 (46)	46	48	16	6	3	-	-	2	-	-	1	2	2	16	
Modified Bladelets	19 (6)	10	9	8	4	1	-	-	-	-	-	1	2	-	8	
Flakes	6 (0)	3	3	6	2	2	1	1	-	-	-	-	-	-	6	
Blades	2 (2)	1	1	1	-	-	1	-	-	-	-	-	-	-	1	
Pièces esquillées	2 (0)	2	-	2	-	-	-	-	-	1	1	-	-	-	2	
Total	123 (54)	62	61	33	12	6	2	1	2	1	1	2	4	2	33	

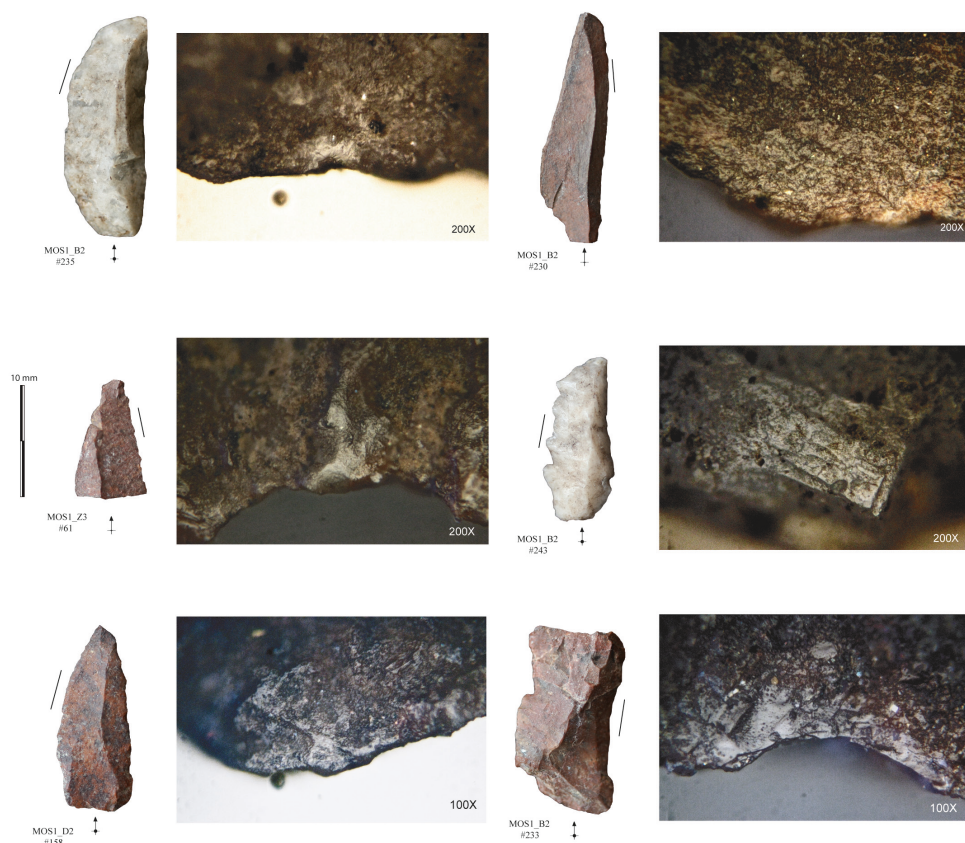


Fig. 15. Bladelets with microscopic use-wear traces. #235 (silcrete) presents a polish related with bone cutting (traces located on both sides of the used edge). #230 (hornfels) presents evidence of animal soft material cutting. #61 (silcrete) presents a polish associated with a slight edge rounding probably related to dry animal hide processing (fracture not morphologically characteristic). #243 (quartz) presents evidence of hard material cutting. #158 is a silcrete bladelet retouched on its right edge with evidence of soft material cutting on the unmodified edge. #233 (silcrete) presents evidence of hard material cutting (traces located on both sides of the used edge).

- (2) The flakes (Table 5, Fig. 16). Microscopic observations give clear evidence that small flakes were also part of the functional system of the Robberg groups. All six flakes examined show use-wear traces: one flake was used to scrape wood, one other to scrape hard materials, two testify to a longitudinal motion (e.g. cutting) on hard material and two testify of soft material cutting.

We may finally open a discussion on the bipolar-reduced pieces, or *pièces esquillées*, as the two bipolar-reduced pieces analyzed for use-wear show polishes related to percussive activities on bone (Fig. 16). The nature of the technical task to which this evidence of bone processing corresponds remains uncertain. Although speculating on its origin is very preliminary, the hypothesis of the use of bone as an anvil to fracture the cores seems unlikely. In this case, the contact between bone and tool is too brief and usually



Fig. 16. Flakes and pièces esquillées with microscopic use-wear traces. #436 (silcrete) presents evidence of hard material cutting. #3 (silcrete) presents evidence of soft material cutting. #439 (silcrete) presents evidence of hard material scraping. #84 (silcrete) presents evidence of hard material cutting (fracture not morphologically characteristic). #391 (quartz) presents evidence of wood scraping, to notice the presence of sparse microstriation running perpendicularly to the use edge. #31 (quartz) presents evidence of soft material cutting. #189 and #129 (both in quartz) are two pièces esquillées that present evidence of percussive motions on bone.

causes too much edge damage to allow the preservation of any polish. The observed polishes on the two bipolar-reduced pieces are easily recognizable and could derive from percussive motions (the object forcefully strikes another with the intent of cracking). Amongst a variety of technical methods to work bone, percussive activities played an important role being commonly linked to bone chopping/breaking (Semenov 1964; Skakun et al. 2011; de la Torre & Mora 2010). According to recent experimental results, bone cracking in particular tends to cause patches of polish located over the edges of the working surface (de la Torre et al. 2013).

SYNTHESIS ON THE ROBBERG FROM ELANDS BAY CAVE

The MOS1 technical system

The Robberg technology is based on the production of small products having a maximum length of 25 mm. These products can be generically referred to as bladelets and micro-flakes. We distinguished six different reduction sequences that were used to produce various morphologies. These reduction strategies are independent, meaning they have their own specific rules and geometries. Some cores have more than one surface of removals but a switch from one modality to the other has rarely been observed.

On the basis of our collection, we are inclined to highlight the following main operative steps:

- (1) The selection of the raw material and its fragmentation into smaller items. At EBC, the selection was oriented towards quartz and silcrete. Coarse-grained rocks such as local quartzite were barely exploited and only in an opportunistic way. Prior to knapping, EBC tool-makers fractured the rocks by bipolar percussion for quartz blocks and through heat treatment for silcrete. In the latter case, we do not question the intentionality of heat-alteration of the rocks for improving their flaking properties. Rather, we propose that heat treatment may have had a 'side effect': the more or less controlled pyrofracturation as an expected process. The presence of HINC-surfaces on 17 artefacts demonstrates that heat-induced breakage of silcrete was not a criterion for discard and even suggests the intentional use of pyrofracturation as already demonstrated for more recent contexts in Europe, Asia and Australia (Man 1883; Robinson 1938; Binford & O'Connel 1984; Guilbert 2003). Alternatively, flakes detached by free hand percussion on quartz and (pre)heated blocks were selected.
- (2) The setting up of the removal surface. The knapper had first to orientate the blocks in order to mentally visualize the future surface of removals. The knapper then had a series of available 'options' to apply in terms of the reduction strategy. But one decisive parameter that seems to transcend all options relates to the 'calibration' of the core. Indeed, we argue that the dimensional range of the bladelets was a decisive criterion at the time of production. Beside morpho-functional arguments (bladelets never exceeded 25 mm long), this hypothesis rests upon a) the existence of different populations of bladelets in terms of dimensions and b) the presence of removals at the base of some of the cores prior to the knapping. This set of observations

suggests the dimensions of the main removals surface, and especially its length, were a crucial parameter for the knapper at the time of setting up the volume of the core.

- (3) The combination of free hand and bipolar/anvil percussion. Anvil percussion was regularly used by Robberg inhabitants. The anvil percussion appears to represent an option intended to solve dimensional problems, i.e. to support the diminutive size of the cores during exploitation and to deal with issues of convexities (e.g. many cores, at their stage of discard, present platform angles bracketed between 80 to 90°). This technique was used regardless of the nature of the raw materials, though there is a stronger association with quartz (cf. the number of bipolar-reduced pieces). We argue that anvil percussion did relate to the diminutive size of the cores but also to a core configuration (geometry and dimensions) that was intended to remain 'stable' throughout the reduction. Size mattered for Robberg groups and anvil percussion was ideal to avoid major dimensional transformation throughout the reduction of the core. The absence of platform preparation and the rarity of core rejuvenation (only 12 core tablets in the whole assemblage) could be understood in such a technical context.
- (4) The modification of the blanks. EBC inhabitants benefited from a wide set of available morphologies, resulting from the application of different reduction strategies. As expected, we observe a difference between the tools made on bladelets and those made on flakes, dominantly represented by scrapers, notches and denticulates. More surprisingly, we observe that certain morphologies of bladelets (triangular and comma-like) were more frequently modified than others, while they compose a minor part of the production. Retouch on bladelets was light, sometimes very shallow, and oriented toward minor modifications of the blanks.
- (5) The microlithic system. We observe that all types of actions were carried out using microlithic blanks, i.e. by microflakes and (micro)bladelets that were dominantly used without any modification. The MOS1 lithic assemblage documents various actions and activities, from projectiles to scraping and cutting actions, though longitudinal motions are best represented in our studied sample. This large range of functions presupposes differences in the way the microlithic products were hafted. The presence of adhesive imprints together with macro- and micro-traces suggests blanks were glued into variable configurations: laterally, axially or obliquely. Bladelets and microflakes were part of a composite technology that seems to have structured the whole production (in terms of dimensions and morphologies of the inserts). Alongside microlithic products, larger blanks (microblades and flakes) appear to have played only a limited functional role.

Techno-economy of the MOS1 Robberg occupations

EBC inhabitants based their raw material provisioning strategies largely on the exploitation of local quartz pebbles. The second preferentially exploited raw material is silcrete. These two raw materials were exploited with similar objectives, but there are differences in the way they were introduced to the site. Quartz is immediately and

commonly available in the surroundings of the site: it was introduced into the shelter in its raw form and entirely exploited *in situ*.

The case is different for silcrete, which mostly originates from distances greater than 30 km. Based on the low number of thermal fragments in our collection, we suggest that silcrete might have been introduced into the site already heat-treated. Together with the low ratio of silcrete cores to silcrete bladelets (ca. 1/40) and with the high diversity of silcrete types, this suggests that the *chaîne opératoire* associated with silcrete was interrupted and fragmented in different places. Our current set of data indicates that EBC inhabitants introduced silcrete as bladelet cores (at different stages of their exploitation) and as (hafted) blanks (predominantly bladelets, but flakes as well). In that perspective, some products would have been transported out of EBC.

Although silcrete only composes 15 % of the lithic assemblage, this raw material appears to represent an important component as suggested by its proportion among the modified pieces (> 30 %). Also, we notice that silcrete bladelets were significantly longer than quartz bladelets. One interpretation would be to consider the influence of the raw material size on the dimensions of the blanks, but this argument does not conform to the assessment of the local geological context where quartz is largely available as blocks of appropriate dimensions. We rather interpret this difference in the context of different raw material economies (*sensu* Perlès 1991), potentially related to differences in mechanical properties.

The main goal of the MOS1 Robberg technological system was the production of small pieces. However, we observe the additional presence of a few larger products in the form of blades and flakes. While blades seem to originate from some initial stages of production, we argue that the larger flakes originate from independent reduction strategies. We observe two patterns for the production of flakes: a local and expedient production based on coarse-grained quartzite, and a non-local silcrete production with products being introduced from at least 30 km. Non-local flakes were used as tools but, additionally, were (later) exploited as cores.

Our functional analysis shows that all sorts of products were used, from bladelets to flakes and from first intention to technical products. These observations support the hypothesis that rocks were exhaustively used in a context of a fairly high economy. We may open a discussion on the bipolar-reduced pieces, as the two *pièces esquillées* analyzed for use-wear show polishes related to percussive activities on bone. Presently, we are tempted to see (some of) the bipolar-reduced pieces as ‘janus products’, potentially knapped with the intent of being used as a tool and with the intent of being fractured as a core, but only additional data can clarify this question.

The studied sample indicates a trend towards the preferential use of the bladelets with longitudinal actions, suggesting that the fresh cutting edges were the main functional part. But four bladelets indicate their probable use as projectiles. In contrast, flakes and blades were involved in a range of actions that were more diversified, including longitudinal but also transversal actions. But these preliminary ideas need to be tested by a more robust sample.

The MOS1 lithic assemblage documents groups that were collecting rocks from a large area of the West Coast, from the south to the east, as illustrated by silcrete, as well as from the north as showed by some pebbles. The raw material provisioning strategies as documented at EBC represents a flexible system, based on the exploitation

of locally available rocks (quartz being omnipresent in this area) and on the transport of a diversified tool-kit (small cores and hafted(?) small blanks) made of fine grained heat-treated silcrete. The pattern of rock procurement (*in situ* exploitation of local rocks, brief and various exploitations on non-local rocks, high macroscopic diversity of the rocks, isolated discarded finds) suggests that people were not radiating from EBC but were rather transiting from and to other places, as suggested by the identification of “ghost cores”. The techno-economic pattern indicates an intense exploitation of the raw materials, i.e. meaning that all sorts of products were usable. But we do not observe any technical or functional specialization in the activities recorded at EBC. More data are now required to state what the mobility system of the Robberg groups was and how these groups were using EBC within their foraging strategy.

A preliminary diachronic view

The lower Robberg occupations at EBC (the D phase) date back to 19 398–18 790 cal. BP and are separated from the MOS1 occupation by a hiatus of about 4000 years. These lithic assemblage however share some similarities. This starts with the raw material provisioning strategies that are based on the predominant exploitation of local quartz and the additional exploitation of silcrete (Table 6), with, however, a silcrete component that is slightly higher in the D phase (ca. 23 %). We note that in both assemblages, evidence of heat-treated silcrete is common.

Regarding the reduction sequences, our 2011 sample of the lower Robberg is small and doesn't allow the development of a robust description and comparison. However the few cores and blanks of our collection document a strict emphasis on the production of small blanks, predominantly bladelets and micro-bladelets. All the types of reduction strategies identified within the MOS 1 assemblage can be recognized in the D phase, though frontal bladelet cores and bipolar-reduced pieces are dominant.

The bladelets from the lower Robberg fit morphologically within the categories we defined for the layer MOS1. A few blades were found but they remain rare and flakes are mostly associated with the local quartzite, as observed in the MOS 1 assemblage. The typological corpus of the D phase is very limited and only represented by three pieces, including two modified bladelets with a shallow retouch and one silcrete flake intensively transformed (Fig. 3). We point to the presence of one macro-tool bearing a facet that suggests the sandstone pebble was used as an upper grinding stone.

Late Pleistocene occupations from EBC have been well studied and published by Orton (2006). The author has subdivided the sequence he studied into 9 periods. The ones of most interest for the present study are the period A assigned to a Robberg-like phase (dated to 13 600 uncal b.p., including the layer MOS1), the period B assigned to a Late Pleistocene microlithic phase (dating from 13 100 to 11 370 uncal. b.p.) and period C assigned to a transitional phase (dating from 11 050 b.p. and 10 550 uncal b.p.).

First, we have to acknowledge the existence of some differences between our results and the ones published by Orton (2006). The period A is said to contain no formal tools in silcrete, no clear bladelet cores as well as relatively few bladelets (10.5 % of all flakes and blades in Orton 2006). There is no direct explanation for the absence of silcrete formal tools and bladelet cores. But the difference in bladelet proportions between our two studies might find different explanations. For example, the fact that the phase A not only includes the MOS 1 assemblage but is based on a more diversified

TABLE 6
List of the 2011 lithic assemblage associated with the earliest Robberg Stratigraphic Units from Elands Bay Cave.

	Quartz	Local Silcrete	Exotic silcrete	Coarse Quartzite	Fine Quartzite	Chert	Hornfels	TOTAL
Flakes	14	4	11	19	2	0	0	50
Blades (≥ 15 mm)	0	0	3	0	0	0	0	3
Micro-Blades (≥ 12 mm)	3	0	2	1	0	0	0	6
Bladelets (≤11 mm)	20	3	28	0	0	1	0	52
Micro-bladelets (≤5 mm)	9	1	7	0	0	0	0	17
Micro-flakes (≤20 mm)	84	1	16	2	0	0	0	103
Cores	10	2	5	0	0	1	0	18
Core-reduced pieces	17	0	0	0	0	0	0	17
Manuport	0	0	0	0	0	0	0	0
Fragments >20 mm	6	1	3	0	0	1	1	12
TOTAL	163	12	75	22	2	3	1	278
Fragments ≤20 mm	294	0	25	2	1	0	0	322
TOTAL	457	12	100	24	3	3	1	600

sample can be an explanation of the differing proportions. Additionally, the difference can relate to the criteria of definition we applied to ‘fragments’. Indeed the proportion of bladelets appears to be inversely proportional to the proportion of ‘chips’ (Orton 2006): this certainly has a meaning in the sequence of changes recorded at EBC, but this should not be regarded as a difference between these two studies.

Orton’s study documents a progressive diminution of local quartz from the phase A to the phase C in favour of the coarse-grained local quartzite. This occurs in parallel to a decline in bladelet manufacture, which is interpreted by the author as a progressive transition toward the non-microlithic Oakhurst technology (starting at EBC from ca. 10 000 uncal. b.p.).

The site of EBC presents a discontinuous archaeological and sedimentological record. Changes in topography and landscape at the time of the LGM and during the LG likely explain the punctuated nature of the EBC record. After an ELSA phase dating back to ca. 23–22 000 cal BP, there is an initial Robberg pulse at ca. 19 000 and a second pulse of occupation at ca. 14 500 cal BP. It is as yet not easy to draw clear comparisons between the 19 000 and the 14 500 Robberg lithic technologies. We notice technological and typological differences (in terms of presence and absence of certain categories) but their meaning (changes in activities or temporal trend within the Robberg) is still not understood. Then, as demonstrated by Orton (2006) and suggested by Parkington (1988), EBC seems to record a gradual technological change from the Robberg to the early Holocene occupations.

AN OVERVIEW OF THE SOUTH AFRICAN ROBBERG TECHNOLOGY

Most studies acknowledge the difficulty in recognizing spatial and temporal trends within the Robberg lithic industries. Not all Robberg assemblages are identical to one another, but differences are minor and/or potentially related to specific geologies or site activities.

Robberg industries share a general pattern of rock selection oriented toward fine-grained rocks, quartz included. This varies regionally but mirrors the geological availabilities as emphasized by Mitchell (1988b): the author described the south eastern part of South Africa as chert dominated and the Western Cape area as quartz dominated. The present study of EBC, located in the second region, confirms the clear emphasis toward quartz but we acknowledge as well a selection and use of heat-treated silcrete that played an important role within the procurement strategies.

What unifies the Robberg is first its specific technology based on single platform cores oriented toward the production of (micro-)bladelets (Deacon 1978, 1984; Mitchell 1988c; Wadley 1996), with the common use of the bipolar/anvil technique interwoven with free hand percussion. Several bladelet reduction strategies have been recognized in the literature, although they have been differently described and often grouped into large categories, such as single platform cores and irregular forms, hiding potential differences. We can currently emphasize three main ‘types’:

- (1) The first type represents the bipolar-reduced pieces. This category includes different sorts of bipolar cores and varies regionally, but it is nonetheless documented throughout the sub-continent and can be considered as one characteristic of the Robberg technology.

- (2) The second type represents the high-backed cores, once interpreted as tools. This reduction strategy has been identified in several Robberg sites such as Nelson Bay Cave (Deacon 1978), Sehonghong (Binneman & Mitchell 1997) and EBC. Though their internal variability requires better description, the high-backed cores category might also represent one characteristic of the Robberg technology.
- (3) The third and last category is more heterogeneous as it includes various bladelets reduction strategies often classified as single-platform cores. At EBC, we subdivided this category into 3 distinct types (the 'narrow-sided', the 'frontal' and the 'conic' bladelet cores). Further studies will acknowledge the relevance or otherwise of these distinctions.

As a general statement, authors often describe cores with an initial shaping that has been limited. This is in agreement with our own study that suggests the reduction strategy is closely related to the morphology of the block *i.e.* selected by the knapper. At Sehonghong, Mitchell (1995) notes the frequent presence of crested bladelets, which would indicate the shaping of more specific core geometries. At EBC, crested bladelets have been identified mostly in the form of partial neo-crests (crests not intended to start the production but to correct the removal surface), which seems also to be the case at Sehonghong on the basis of published illustrations. At EBC, such technical products closely relate to 'narrow-sided' bladelet cores.

Core platforms were rarely prepared, as is illustrated by the dominant proportion of bladelets with plain butts such as at Rose Cottage Cave (Wadley 1993) and EBC. This interestingly goes with the rarity of core rejuvenation products, with the possible exception of Sehonghong (Mitchell 1995) although the ratio of core-tablets to cores remains relatively low (1/37). While the punch technique has been hypothesized, the evidence clearly favours the use of a direct and slightly tangential percussion with a soft stone hammer to produce bladelets. In addition, the use of bipolar knapping is documented in all Robberg sites. Interestingly, anvil percussion is documented in different contexts and applied to different raw materials, to different core geometries and at different stages of reduction.

Present studies show that the reduction strategies were not oriented toward blades but toward (micro)bladelets. Their proportions vary within and between sites, partly because of calculations based on different artefacts categories. The frequency of bladelets reaches up to 25 % at Rose Cottage Cave (Wadley 1996), varies from ca. 20 to 40 % of the lithic assemblages at Sehonghong (Mitchell 1995; Binneman & Mitchell 1997), represents ca. 20 % at Faraoskop (Manhire 1993) and ca. 16–19 % at AK2006/001 (Orton 2008). At EBC, bladelets form 55 % of whole blanks ≥ 20 mm. These variations relate firstly to analysts (see Pargeter & Redondo 2016) and have to be understood within a context that includes a substantial number of fragmented specimens as noticed at Rose Cottage Cave (Wadley 1996), AK2006/001 (Orton 2008) and EBC where 60 % of the bladelets are fragmented. The strong emphasis of Robberg technology on (micro)bladelets cannot be explained by any kind of raw material constraints or availabilities. The quasi-absence of macro-blanks (blades and flakes) defines a Robberg system that was fully microlithic.

No clear cut-size categories have been recognized within bladelets assemblages, though there are a few exceptions. Dimensional variations are generally viewed within a

continuous reduction sequence rather than as independent reduction strategies. So far, the significant differences we observed at EBC, suggesting the existence of different dimensional groups, find some parallels for example with the results published for Sehonghong (Pargeter & Redondo 2016). Further analysis will have to test and clarify the significance of these cut-size categories. However published data as well as our own study suggest the dimensions of the bladelets were a key parameter at the time of their production. At Nelson Bay Cave J. Deacon (1978) described the bladelets as no longer than 20 mm in length; at Sehonghong, Binneman and Mitchell (1997) described the bladelets as quite standardized in size, with mean length ranging from 12 to 24 mm and mean width from 4 to 8 mm; at Bloomplaas H.J. Deacon (1995) described the bladelets as less than 20 mm in length; at Byneskranskop 1 Pargeter (2012) described bladelets with length ranging from ca. 8 to 20 mm and mentioned a mean length of 17.5 mm at Rose Cottage Cave. At EBC, we found that the mean length of the bladelets is comprised between 8 and 16 mm and that complete specimens never exceed 25 mm. These metric data suggest some homogeneity between Robberg sites all over South Africa. This character, long noticed by J. Deacon (1978), Mitchell (1988a) and Wadley (1993), contributes to define the Robberg technology.

From the present literature it is clear that dimensions of the bladelets were a major technical and functional parameter. The possibility that cores were dimensionally calibrated, as hypothesized from the analysis of the MOS1 collection of EBC, seems a specific feature with no equivalent elsewhere. But what is worth mentioning in terms of 'calibration' is the possibility that some of the blanks were intentionally broken to fit the expected size. Intentional breaking might be exemplified by a few bladelets from EBC but this hypothesis requires further attention in order to discriminate intentional breaking from manufacture and post-depositional breaking. But at sites such as Sehonghong (Binneman & Mitchell 1997) and Rose Cottage Cave (Binneman 1997), the analysts mention the presence of several bladelets (hafted and used) with a proximal part that was removed by flaking.

In sites such as Sehonghong, it has been proposed that standardized bladelets were produced from highly distinctive forms of bladelet cores (Mitchell 1995). Standardization of Robberg products is reflected in their narrow dimensional ranges as well as by their morphologies. At EBC, we emphasize the production of three main morphologies of bladelets (parallel, triangular and comma-like), though we notice the clear emphasis on parallel bladelets. Data published by Binneman and Mitchell (1997) suggest bladelets with straight laterals were also dominant among the set of Robberg bladelets from Sehonghong. Similar observations have been made at Rose Cottage Cave (Wadley 1996) where regular parallel-sided bladelets form the main part of all bladelet morphologies.

Bladelets represent the main objective of Robberg production but the functional status of the (micro)flakes must not be underestimated. Flakes are regularly mentioned in Robberg lithic assemblages, though their technical and functional status is not always clearly addressed. At EBC, microflakes come largely from bladelet reduction strategies: either as an objective of production (documenting some latitude) or as technical operations. But two case studies differ. The first one relates to flakes that were produced on the coarse grained local quartzite: in that case, flakes result from an expedient reduction sequence and seem to answer immediate needs. The second example is

illustrated by the introduction of large flakes on fine-grained rocks. These large-flakes show no elaboration in their preparation and seem to have been preferentially transported as 'large' tools and/or cores. Our set of observations suggests the flake component is not a typical feature of the Robberg but is relevant while discussing techno-economic patterns.

The study of the MOS1 lithic collection from EBC shows that a wide range of products was used, regardless of their dimensions, morphologies and technical roles. Several authors have hypothesized the use of bladelets as projectiles (Deacon 1983; Parkington 1984). So far, macro-fractures interpreted as impact damages have not been recognized in many sites: one example potentially relates to a use as a component of a projectile weapon at Sehonghong (Binneman & Mitchell 1997), a few have been found at Nelson Bay Cave and Byneskranskop (Pargeter 2012). The new evidence from EBC, though limited, adds some substance to this hypothesis. All present examples document axial fractures suggesting bladelets were mounted in their longitudinal axis. The hypothesis of a concomitant use as barbs is not yet firmly supported by archaeological evidence.

Insights into Robberg hafting technology rest on the presence of black imprints interpreted as adhesive. Such imprints have been found on three products from EBC and on a large collection of artefacts ($n = 44$) from Sehonghong (Binneman & Mitchell 1997). If we consider the wide set of evidence (distribution of adhesives on the blanks together with the orientation of impact fractures and micro-wear residues), we can hypothesize a sophisticated composite technology where micro-blanks (bladelets and microflakes) were hafted in different ways: axially, laterally and obliquely. Additionally, some bladelets from Sehonghong ($n = 1$) and Rose Cottage Cave ($n = 13$) indicate they have been used on their two laterals suggesting they were turned in their haft/shaft (Binneman 1997; Binneman & Mitchell 1997).

Hafted microliths were not restricted to hunting activities. The use wear study performed at Sehonghong (Binneman & Mitchell 1997) and Rose Cottage Cave (Williamson 1996; Binneman 1997) clearly indicate that small blanks, predominantly bladelets, were involved in various motions (e.g. cutting, scraping) and on various worked materials (e.g. hide, vegetal material, bone). Similar conclusions have been reached at EBC, though the preliminary data suggest possible functional differences between the bladelets (predominantly involved in cutting activities on soft materials) and other blanks (involved in more diversified actions such as cutting and scraping, on soft and hard materials).

The Robberg lithic assemblages seem to indicate a need for fresh cutting edges. Binneman and Mitchell (1997) hypothesized that bladelets were short-lived single task tools, an idea that is supported by our analysis on EBC artefacts. But at the same time, several pieces of evidence indicate a fairly high degree of economy of the raw materials. This is, for example, suggested by some cores from Sehonghong that were used as tools, as well as by some bladelets that were used on both laterals and potentially turned in their haft (Binneman & Mitchell 1997). Such economizing of blanks compares well with our study from EBC.

Formal tools represent a minor component of Robberg lithic assemblages. This class of tools represents less than 1 % of the whole assemblage at sites such as Sehonghong (Binneman & Mitchell 1997), Faraoskop (Manhire 1993), AK2006/001G (Orton 2008),

Umhlathuzana (Kaplan 1989), Nelson Bay Cave (Deacon 1978) and Rose Cottage Cave (Wadley 1996). Our study from EBC differs substantially with a proportion of formal tools that reaches ca. 5 % of the whole assemblage ≥ 20 mm. We do not interpret this difference as a variation in site activities but rather see it as a difference in the way formal tools were recorded. Robberg assemblages, though they present a low degree of formal tools, often contain a fairly significant number of ‘modified’ pieces with edge scarring. These modifications are qualified as light nibbling (Mitchell 1995; Wadley 1996), shallow, expedient or blunting retouch (Wadley 1993, 1996) and are sometimes classified within the miscellaneous pieces (Orton 2008) or the utilized pieces (Binneman & Mitchell 1997). Robberg retouch is never invasive and its origin is sometimes questionable. In our study, it has been difficult to draw an analytical line between the different types of edge modifications. In search of a better analytical protocol, we decided to record all modifications, regardless of type, extension, invasiveness and origin. The retouch in Robberg assemblages, though it requires better description, can be considered as a technical pattern typifying this industry.

Within the formal typological corpus, the Robberg includes a range of modified bladelets, including backed bladelets. They are documented, for example, at Boomplaas, Nelson Bay Cave (Deacon 1984), Sehonghong (Mitchell 1995) and Rose Cottage Cave (Wadley 1996). However these backed bladelets never adequately typify the lithic assemblages. Other modified bladelets depict some variability that needs to be better described, both technologically and functionally. But one striking element that characterizes Robberg assemblages is the absence of ‘microliths’/geometric tools, namely of bladelets or flakes that were intentionally shaped into geometric forms such as triangles, trapezes or crescents and segments. The other Robberg tools, such as denticulates, notches and scrapers, are more ubiquitous and they display little consistency within and between assemblages (see Mitchell 1995). In addition, we may remember the presence of macro-tools within Robberg assemblages, as mentioned at Sehonghong (Mitchell 1995), Rose Cottage Cave (Wadley 1996) as well as in the lower Robberg of EBC.

Albeit limited, some typological variety occurs from site to site. One of the rare examples is provided by the site of Sehonghong where truncated tools have been found in the lower Robberg units (Mitchell 1995). These pieces have been manufactured on bladelets and on flakes. So far, such tools have not been described elsewhere and might typify a phase or a regional expression/adaptation within the Robberg.

Some variations occur from site to site regarding the proportion of bladelets and/or of the types of cores discarded at the site. These variations reflect different mechanisms that relate to site functions, regional adaptations and temporal changes. The differences we noticed at EBC between the quartz and the silcrete (in terms of core types, dimensions and proportions of modified pieces) provide one illustration of the technological variability that might occur within and between Robberg sites.

So far, only a few studies have been able to define temporal trends within the Robberg, partly because of the discontinuous nature of the archaeological record and possibly because of the analytical tools. Regarding the earlier phase of the Robberg, Mitchell’s study of the Sehonghong lithic sequence led him to hypothesize a chronological change between the LGM and the LG, though considerable technological continuity throughout the sequence is emphasized (Mitchell 1995). These differences between a LGM and

a LG phase are based on the patterns of core reduction and on potential functional changes in the way bladelets were used. Few other authors have discussed the earliest phases of the Robberg. Kaplan (1989), for example, proposes the distinction between an 'early' and a 'late' Robberg at Umhlatuzana on the basis of the frequencies of *outils écaillés* and bladelets that are higher in the lower phase. It is also worth noticing the recent work at Putslaagte 8 where the 25–22 000 BP lithic group is said to have some Robberg-like characteristics although there are differences with the 21–18 000 BP group classified as more typical Robberg (Mackay et al. 2015). Additionally, Pargeter and Redondo (2016) recently recognized that bladelets from Sehonghong changed in morphology after 18 000 cal. BP.

In the EBC sequence, there is a clear trend at the end of the Robberg toward a larger selection of coarse-grained rocks and the production of flakes (Parkington 1990; Orton 2006). A similar trend has been noticed at Sehonghong (Mitchell 1995), when Robberg inhabitants start to exploit dolerite and hornfels more frequently than opalines, as well as at Nelson Bay Cave (Deacon 1978) where quartzite becomes dominant over quartz. This change in raw material selection and blank production suggests a contemporaneous and potentially gradual technological transformation toward the end of MIS2.

While there are some regional variations and uncertainties regarding the chronology, the present set of data may support the existence of three main stages within the Robberg, though their significance and nature remain to be further evaluated. These stages would be composed of an early phase from 23 000 until 18 000 BP (LGM), an LG phase that would last until 13 000 BP, and a terminal phase that will last until the 'transition' to Holocene technologies sets in. The understanding of these phases might bring new information on how groups adapted and what the details of the Robberg technology imply within the panel of microlithic industries.

TO CONCLUDE

The technological identity of the Robberg is based on an exclusive production of bladelets that were bracketed within a narrow dimensional range (max. of 22–25 mm long, max of 8–10 mm breadth). These bladelets were obtained from various reduction strategies associated with both free hand and anvil percussion. Different morphologies of bladelets were produced but those with parallel laterals were the main component. Modifications of the blanks were limited, in terms of frequency and intensity, and often took the form of irregular and shallow retouch. All these blanks appear to be part of a composite technology and hafted in different positions: laterally, obliquely and axially. These characteristics, together with the 'absence' of blades and geometric tools, contribute to defining the Robberg as a non-geometric microlithic technology and add further variability to the known corpus of Late Pleistocene technologies.

The Robberg is somewhat coherent in technology but is also characterized by a complex system of territorial networks and symbolic communication (Mitchell 2002). Robberg occupations have been found in different contexts, from the coast to high altitudes, from caves to open-air sites, depicting a system adapted to all sorts of different environments. More detailed studies (in terms of technology and subsistence) will help clarify the discussion of the existence and significance of spatial and temporal trends within the Robberg.

The Robberg is characterized by several innovations, one of which is the use of heat treatment applied to silcrete. This technological innovation was only recently discovered in the South African MSA and the question of its precise time frame, its spatial and temporal evolution and the associated procedures is still a matter of debate (Schmidt et al. 2013; Schmidt et al. 2015; Wadley & Prinsloo 2014). The evidences from EBC extends the chronology and known contexts of heat treatment on South Africa's West Coast, with evidence from the Robberg but also from the late MSA and ELSA (Porráz et al. 2016 this issue). Furthermore, if heat treatment was mainly applied to improve the suitability of silcrete for knapping, we observe a side-effect: pyrofracturation of the blocks used to pre-segment blocks before knapping. Although no tempering residues on silcrete artefacts have so far been found on Robberg lithics, the recurrent presence of HINC fracture surfaces indicates that heat treatment was performed without a specific set up of the fires (see Schmidt et al. 2015).

The main innovation associated with the Robberg relates to its microlithic nature. This technology was the solution adopted by Robberg groups to cope with new needs, of internal and/or external origin. One way to understand the spark behind this innovation is to regard the benefits and the implications that might be associated with such an innovation, and to question its context of appearance as well as its variability in space and development in time. We might also refer to other microlithic industries that developed independently and that might give new clues of interpreting the Robberg.

One of the main current questions regards the origin of the Robberg. There are uncertainties regarding the nature and form of the technological succession from the ELSA to the Robberg. And it is presently an assumption to consider the ELSA as one homogeneous tradition. The current set of data shows continuity regarding the production of small products and the use of bipolar percussion. But the ELSA and the Robberg differ regarding the nature of their reduction sequences, the control and regularity of the products as well as their sets of formal tools. More techno-typological studies as well as new controlled excavation and new ¹⁴C dating are yet required to clarify this succession. As currently seen, the Robberg seems to appear at ca. 23 000 cal. BP from Limpopo to the West Coast, suggesting a 'rapid' diffusion of groups and/or adoption of ideas throughout the sub-continent.

The appearance of the LGM and the rise of Robberg industries represent an improbable coincidence. However, if the LGM offers a context of appearance, it does not give any direct explanation of what the main changes were that populations had to face. What we observe is that the Robberg technology marks a new stage in local microlithic technology, characterized by a composite technology that durably impacted the sizes and morphologies of the inserts.

The miniaturization of tools changes the way populations had to plan and adapt to available geological resources, giving access to a wider range of raw materials. In the meantime, it presumably represents an easily transportable technology as well as a maintainable and reliable technology with inserts that were quickly and easily replaced (see Mitchell 1988b). These observations (and assumptions) characterize a system that was optimizing time, from procurement to manufacture, and that surely impacted the way populations were territorially organized. Based on the study from EBC, the nature of the raw material provisioning strategies supports the hypothesis that the shelter was occupied by small groups for rather short-term occupations.

The Robberg differs from other sub-contemporaneous industries from Eurasia (e.g. Clarkson et al. 2009; Langlais et al. 2012; Tomasso 2014) or from other industries classified as microlithic (e.g. the Howiesons Poort). One main difference relates to the larger blades that still represent a primary component in these industries while they have ‘disappeared’ in the Robberg system. Moreover, unlike the Robberg, other composite technologies are associated with geometric forms, which are often interpreted as a change related to the adoption of new hunting weapons.

The understanding of the Robberg, that is, the reasons behind its appearance, has to be integrated within a regional perspective, in other word with regard to the ELSA technologies, environment and symbolisms. But this question should also be addressed with regard to other microlithic industries that might help deciphering what manifestations relate to the historical processes and what manifestations relate to the trend (or ‘*tendance*’, after Leroi-Gourhan 1945). In a technical perspective, the disappearance of the blade (its obsolescence) has been interpreted as one stage of development of composite technologies (Boëda 2013). The Robberg is presently a unique manifestation. While it shares for example strong similarities with the European Mesolithic regarding its miniaturization, the lack of geometrics illustrates a different functional path. The Robberg signs an original technical trajectory and challenges the way we approach and understand broader technical processes such as those of microlithization and geometrization.

NOTE

¹ The limit we established between blades and bladelets follows Tixier (1965).

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