southern african

Field archaeology

2025 Vol. 20
https://doi.org/10.36615/safa.20.2025

ISSN 2789-1844 Online
ISSN 1019-5785 Print

ALBANY MUSEUM

PASt. ALL FROM ONE

UNIVERSITY OF JOHANNESBURG

Southern African Field Archaeology
2025 Vol. 20: Article 3561
Research report (peer-reviewed): Received October 2024; Revised January 2025; Published April 2025
DOI: https://doi.org/10.36615/safa.20.3561.2025

ISSN 1019-5785
ISSN 2789-1844

Morphological and functional variability of the geometric microlithic backed tools from the late Holocene at Pomongwe Cave (Matobo, western Zimbabwe)

Precious Chiwara-Maenzanise [a, b, c, *], Ancila Nhamo [c, d] & Guillaume Porraz [e]

[a]Human Evolution Research Institute (HERI), University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa
[b]Department of Geological Sciences, University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa
[c]Department of History, Heritage and Knowledge Systems, University of Zimbabwe, P.O. Box MP 167, Mount Pleasant, Zimbabwe
[d]Research Innovation and Industrialisation Directorate, University of Zimbabwe, P.O. Box MP 167, Mount Pleasant, Zimbabwe
[e]CNRS, Aix-Marseille Université, UMR 7269, Laboratoire Méditerranéen de Préhistoire Europe Afrique (LAMPEA), 13094 Aix-en-Provence, France
**Corresponding author email: precious.maenzanise@uct.ac.za*

ABSTRACT
Microlithic backed tools are a key feature of the Later Stone Age late Holocene period in southern Africa. These tools were widely distributed and produced in various geometric shapes and sizes. Despite extensive study and classification, questions remain regarding whether their morphological variability was driven by functional, technological, or stylistic factors. This study investigates the variability of microlithic backed tools from Pomongwe Cave in Matobo, western Zimbabwe, during the Amadzimba phase (ca. 5800 to 2300 BP). We classified the microlithic backed tools into three main morpho-functional categories, which we interpret as reflecting different hafting designs and tool functions. We propose that microlithic backed tools were part of a composite system and likely served as projectile weapons. The creation of specialised tools for specific tasks demonstrates a high level of innovation and provides insight into hunter-gatherer hunting strategies during the late Holocene in Matobo.

Keywords: Later Stone Age, Matobo, morpho-functional, composite technology, hunting weapon

1. Introduction

The Later Stone Age (LSA) late Holocene represents an important period of economic and social transformation in southern Africa, beginning around 4000 bp (Mitchell 2005, 2024; Lombard et al. 2012, 2022; Sadr 2015, 2019; Forssman 2017; Stewart & Mitchell 2018; Kinahan 2019; Guillemard 2020a). This period is generally categorised into two industries: the final LSA, spanning approximately 4000-100 bp, and the ceramic final LSA, which emerged after 2000 bp (Lombard et al. 2012). Around 4000 bp, some hunter-gatherer groups produced diverse lithic technologies, reflecting shifts in subsistence strategies and social organisation. By 2000 bp, the emergence of domesticated sheep and the use of ceramics further transformed these societies, marking a significant economic and social transition (Guillemard 2020b, 2024). One way to investigate how LSA late Holocene hunter-gatherers were structured and organised on a sub-continental scale is to examine the artefacts they created and used (Parkington et al. 1980; Parkington 1987; Barham 1992; Guillemard 2020a, 2024). Stone tools, in particular, offer valuable information on subsistence strategies and technological adaptations. Lithic studies play a crucial role in characterising the history and development of late Holocene human societies (Parkington et al. 1980; Mazel 1989; Guillemard 2020a, 2024).

Microlithic backed tools are one of the hallmarks of the late Holocene in southern Africa (Deacon 1984; Mazel 1989; Walker 1995; Close & Sampson 1998a; Ambrose 2002; Hiscock et al. 2011). These miniaturised tools, characterised by steep blunting retouch on one edge, appear in a wide range of geometric shapes and sizes, prompting discussions on how to interpret their variability (Parkington et al. 1980; Close & Sampson 1998b; Lewis 2015; Pargeter 2016). They are often seen as components of composite tools, glued into shafts and used for cynegetic activities (Yaroshevich et al. 2013; Fullagar 2016; Goldstein & Shaffer 2017; Tomasso et al. 2018; Taipale et al. 2022). However, alternative interpretations suggest their use in cutting activities (Wadley & Binneman 1995; Charrié-Duhautet et al. 2016). Some researchers further argue that stylistic factors may help explain variations in shape and size during manufacture (Wiessner 1983). Additionally, their presence across various sites has sparked debate, with some arguing that they indicate social connectedness (Way et al. 2022), while others propose mere convergence (Clarkson et al. 2018).

The late Holocene in southern Africa is characterised by a diversity of stone tool knapping methods and techniques employed by various hunter-gatherer groups, continuing until the gradual disappearance of stone tools and LSA sites (Guillemard 2020a). During this period, hunting techniques varied widely across regions, with evidence of bow-and-arrow use and various trapping methods, including pit traps found at ≠Gi in Botswana and others as seen at the Keimoes desert kite sites in South Africa (e.g., Brooks & Yellen 1977; van der Walt & Lombard 2018; Lombard & Badenhorst 2019; Lombard et al. 2020, 2021; Lotter et al. 2023). In coastal sites in South Africa, there is evidence of marine resource exploitation, with extensive middens highlighting the importance of marine life in the diet (Miller et al. 1995; Sealy 2006). Similarly, in the Thukela Basin, the widespread presence of marine shell during the late Holocene suggests shifting social strategies among hunter-gatherer communities (Mazel 1989). In more arid regions such as the Kalahari Basin, hunter-gatherers exploited resources from freshwater habitats and seasonal wetlands, as evidenced by sites near the Boteti River (Denbow 1986). In the Eastern Cape, Hall (1990) highlights an intensification in the exploitation of freshwater mussels, crabs, fish, and tortoises, alongside the creation of storage facilities to prolong availability of seasonally scarce, nutrient-rich seeds. This intensification of resource exploitation may have contributed to the development of more sedentary lifestyles, particularly in the Kalahari and Eastern Cape regions (Denbow 1986; Hall 1990). Together, these examples underscore the profound social and economic changes that occurred across southern Africa during the late Holocene. Diversity in subsistence strategies, technological adaptations, and settlement patterns reveals that these changes were shaped by distinct local conditions and resources.

In this study, we focus on the Zimbabwean late Holocene period referred to as the Amadzimba phase (ca. 5800 to 2300 BP; Walker 1995), named after the type site of Amadzimba and located in Matobo (Fig. 1). It is regarded as the final stage of hunter-gatherer communities, before the onset of herders and farmers in the region. Evidence of this phase has been identified at key sites, including Pomongwe and Bambata Caves in Matobo, as well as at sites outside Matobo, such as Duncombe Farm, Diana's Vow, and Nyazongo. While knowledge on the Amadzimba remains limited, this study aims to investigate its distinctive characteristics within the Matobo region. By examining microlithic backed tools, a defining feature of the Amadzimba, we seek to explore how this phase in Matobo may relate to other late Holocene cultural and social expressions in southern Africa and beyond. However, we acknowledge that a comprehensive understanding of the late Holocene in Matobo requires a complete analysis of multiple assemblages and all their components, an endeavour for the future when additional data are available.

In Matobo, the Amadzimba phase is associated with large game hunting and the use of poisonous plants (Walker 1995). Storage pits, believed to have been used for storing marula fruits and caterpillars also occur during this phase, and based on the analysis of their botanical remains (primarily the marula fruits), Walker (1995) proposed that occupations occurred from spring to autumn. The high amount of marula fruit remains during this period is linked to population growth in the region, indicating increased consumption to sustain larger groups and expanding settlement sites (Walker 1995).

The Amadzimba phase coincided with a warm and wet climate, enhancing environmental productivity and providing abundant food and resources (Walker 1995). This climatic amelioration supported population growth and the sustenance of larger groups in Matobo (Walker 1995). Elsewhere during the late Holocene, population expansion is observed in the Thukela Basin where Mazel (1989) noted changes in subsistence strategies, the development of new lithic tools, and the emergence of three distinct social regions. Walker (1995) further highlights the significance of the back of the Matobo Caves during the later stages of forager history. These areas were used for storing valuable items, such as protein-rich caterpillars, and they functioned as central spaces for family activities like cooking, eating, and sleeping. In contrast, the front and central sections of the caves served more communal purposes.

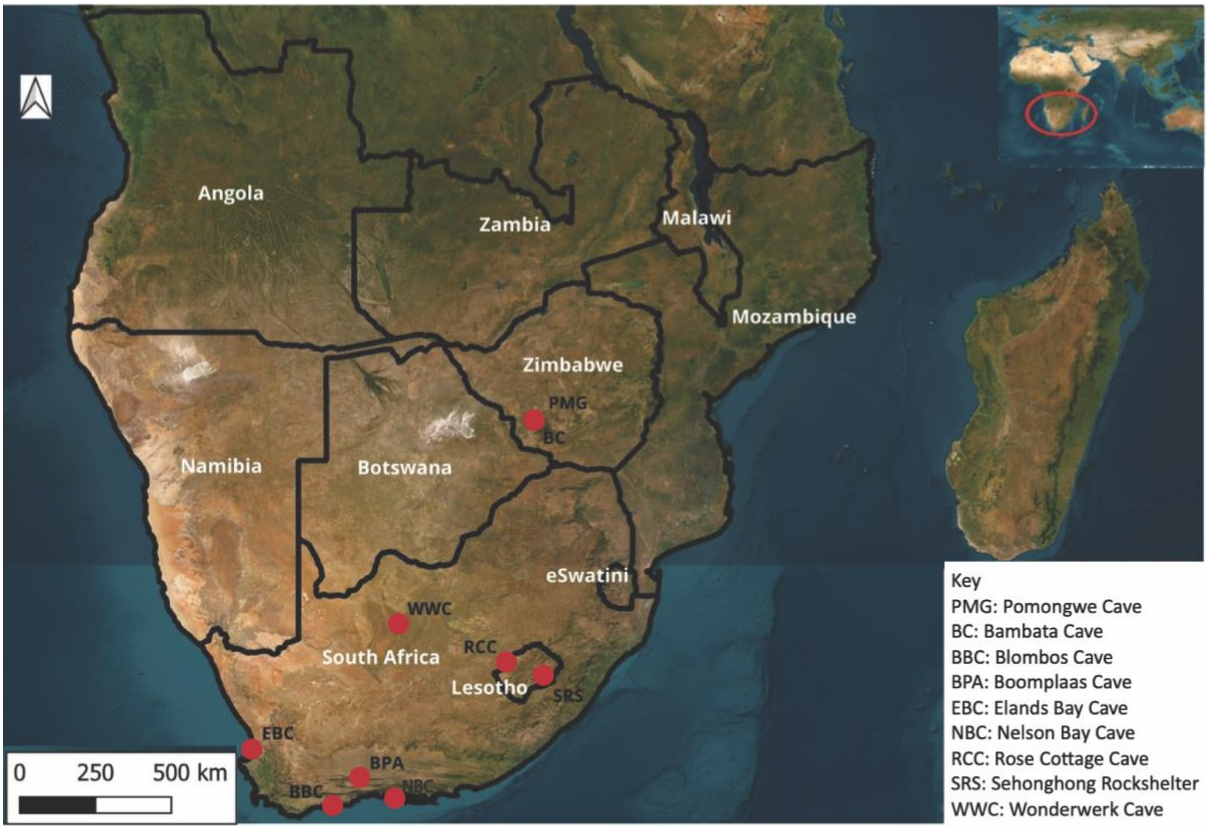


Figure 1. Location of Pomongwe Cave in relation to Later Stone Age sites in southern Africa.

The late Holocene Amadzimba phase at Pomongwe Cave is characterised by the proliferation of bone technology, as evidenced by numerous bone tools comprising points, arrows, rods, and shafts (Walker 1995). This period is also notable for an increase in ornamental artefacts, such as shell pendants, cylindrical, disc and oblate bone beads, along with numerous ostrich eggshell beads (Fig. 2). Rock art was likely an integral part of the daily lives of these populations as well (Bourdier et al. 2020; Dudognon et al. 2021). Regarding the technological tradition, the Amadzimba is known for its production of small blanks and bladelets, as well as prevalent microlithic backed tools (Walker 1995). These geometric backed tools are found in various forms including points, segments, trapezoids, triangles, and truncates.

In this study, we build upon previous research by Walker (1995) and investigate the morphological variability of the microlithic backed tools at Pomongwe Cave. Our analysis prompts a broader inquiry into the mechanisms driving the observed variability, questioning whether it is the result of functional objectives and designs (i.e., form follows function), technological adaptations (i.e., form reflects production stages), or stylistic preferences (i.e., form reflects individual and collective choices). Consequently, this paper seeks to clarify how societies in southern Africa were technologically and socio-economically organised during the late Holocene.

Pomongwe Cave

Pomongwe Cave (20°32'46" S, 28°30'54" E) is located within the Matobo World Heritage Site in Matabeleland Province, western Zimbabwe. Matobo is a hilly area characterised by natural rock shelters formed beneath large boulders. Since the 1930s, it has been a focal point for Stone Age studies, resulting in the discovery of several Middle Stone Age (MSA) and LSA sites, including Amadzimba, Cave of Bees, Bambata, Nswatugi, and Pomongwe Caves (Armstrong 1931; Cooke & Robinson 1954; Cooke 1963; Walker 1995; Walker & Thorp 1997; Jones 2013).

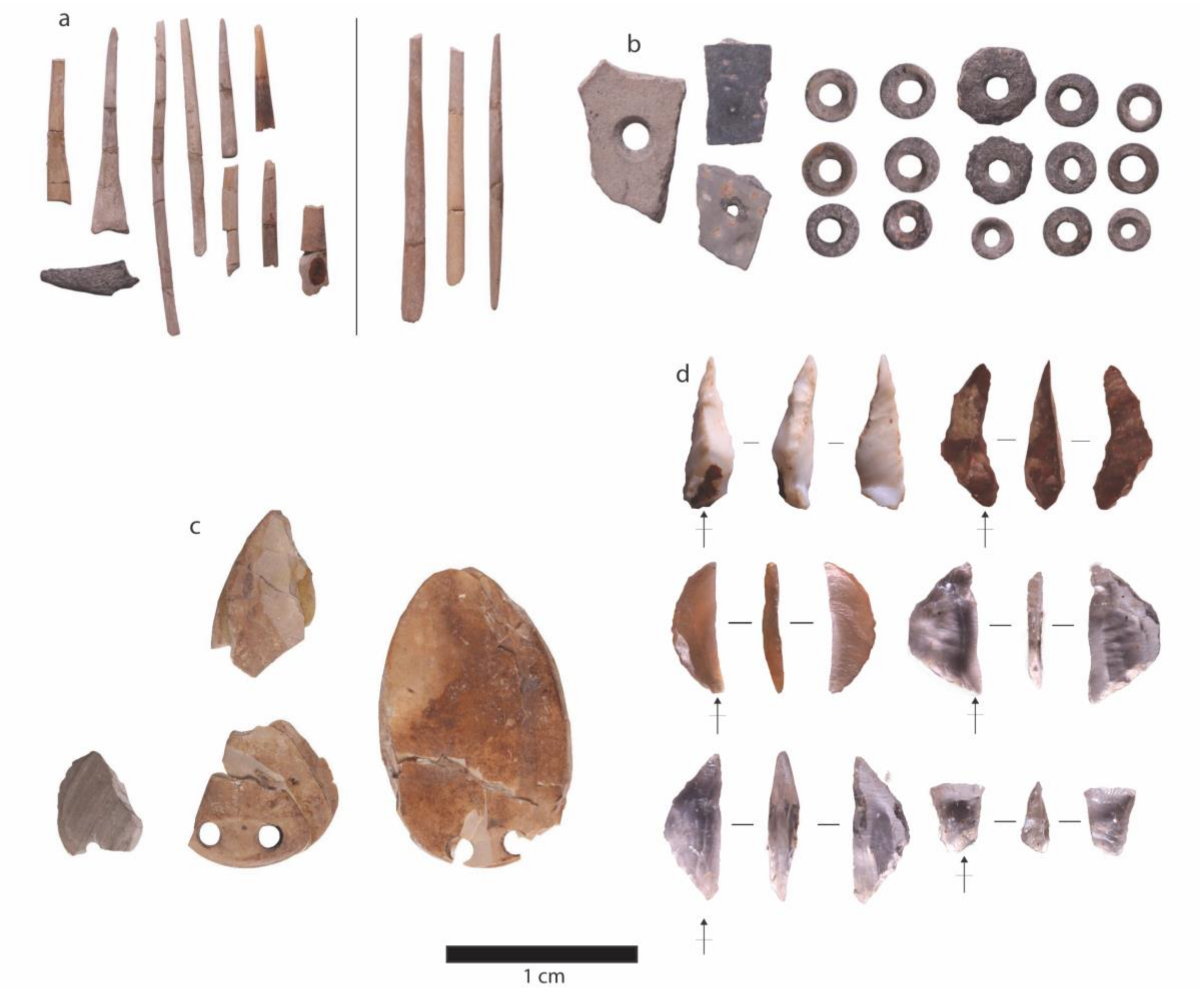


Figure 2. Artefacts from the Amadzimba phase at Pomongwe Cave, Matobo, Zimbabwe: (a) bone tools, (b) ostrich eggshell beads, (c) shell pendants, and (d) geometric backed tools.

The cave is a 20-metre-long by 20-metre-wide apsidal formation, created through negative exfoliation, a characteristic feature of areas comprising granite. Archaeological research at Pomongwe Cave began with Cooke's (1963) excavation, during which he uncovered three trenches, labelled Trench I-III, revealing well-stratified MSA and LSA occupations extending to a depth of four metres. Cooke's (1963) work laid the foundation for defining Zimbabwe's MSA and LSA chrono-cultural phases, including what has been termed the Bembesi or Proto-Stillbay, Magosian, Pomongwe, and Nswatugi (Cooke 1963; Walker 1995). However, some terminology, such as Proto-Stillbay and Magosian, was revised by Walker (1995) and is no longer used in contemporary Stone Age studies in Zimbabwe.

Pomongwe Cave was later excavated by Walker (1995), who dug two trenches labelled Trench IV and Trench V, exposing 1.4 metres of stratigraphy with well-stratified LSA occupations (Walker 1995; Fig. 3). Organic materials, including faunal and botanical remains, are well-preserved throughout the sequence. Walker (1995) organised the sedimentary sequences into members (A to C), which were further subdivided into stratigraphic units and subunits. Trench V contains 12 LSA units, which have been dated and classified into four industries from top to bottom: Amadzimba, Nswatugi, Pomongwe, and Maleme (Table 1; see also Walker 1995). Walker's (1995) work forms the basis for the chrono-cultural sequences used in the study of the Zimbabwean LSA today.

In 2017, the Matobart project was initiated at Pomongwe Cave, aiming to deepen our knowledge of the region's population prehistory (see Bourdier 2019; Porraz et al. 2023). This project integrates the analysis of excavated finds with the study of Pomongwe's rock art (Bourdier 2019; Porraz et al. 2020, 2023). An essential aspect involves recording the art, a crucial initial phase for any artistic study (Bourdier et al. 2020; Dudognon et al. 2021). This documentation was complemented by the reopening of previous excavations to better understand the context of the collections, re-examine site formation processes, and establish absolute dates (Porraz et al. 2023). Additionally, the project includes studying existing Pomongwe Cave collections housed in museums, such as fauna, lithic artefacts, ochre, and painted spalls (see Chiwara-Maenzanise 2018; Matembo 2019; Mnkandla 2019; Nhunzvi 2019; Nhunzvi et al. 2020).

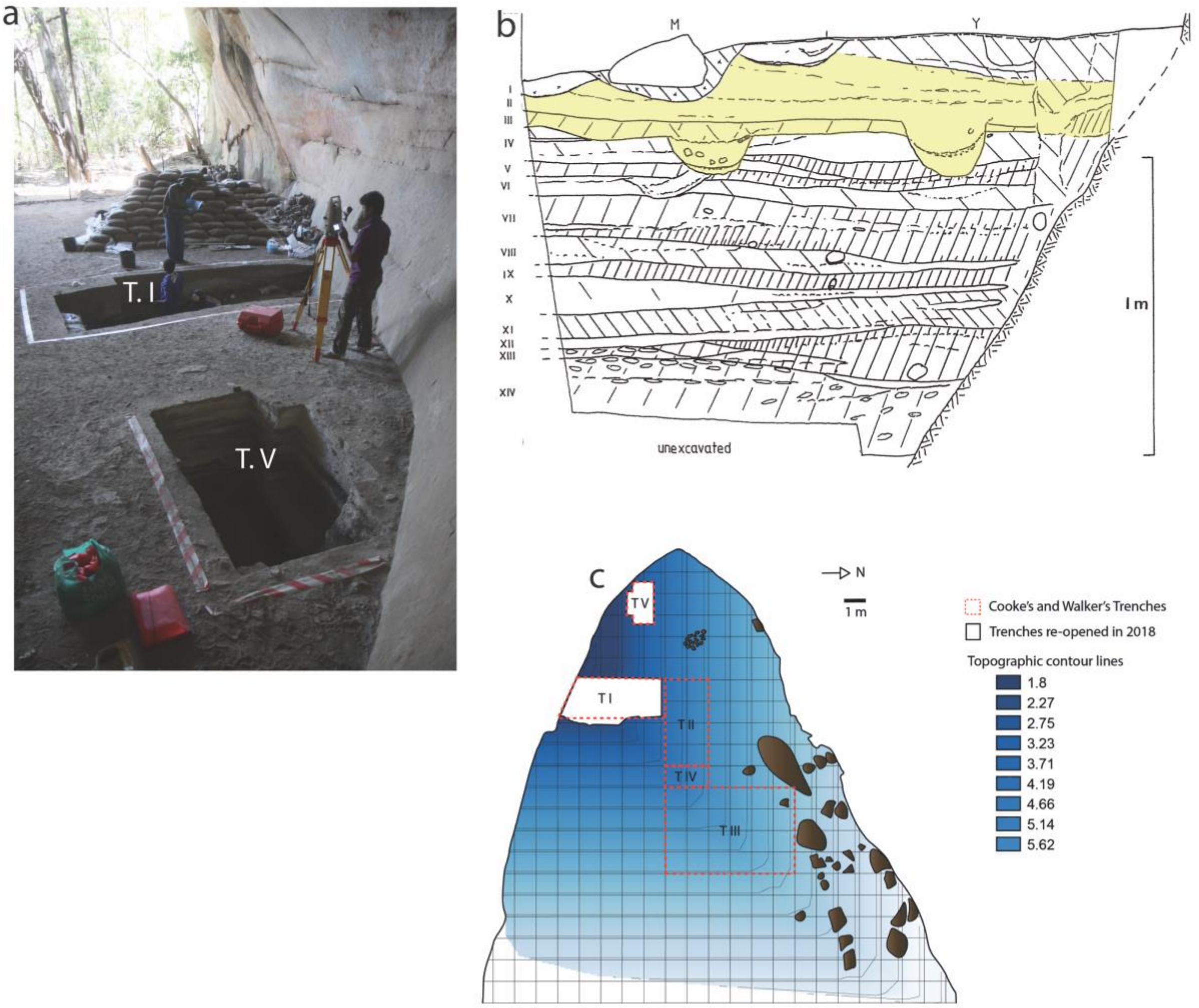


Figure 3. (a) Photograph of Pomongwe Cave during the 2017 excavations, showing the locations of Trench I (T.I) and Trench V (T.V); (b) reproduction of the Trench V profile drawn by Walker (1995) with Amadzimba units II and III highlighted in yellow; and (c) locations of Trench I and Trench V on the new grid (Computer-Aided Design by M. Thomas).

This study analyses the existing Amadzimba collections from Pomongwe Cave, focusing specifically on the microlithic backed tools associated with units II (comprising eight subunits) and III (comprising three subunits) of Trench V, as excavated by Walker (1995). Trench V contains well-stratified sediments with very good organic preservation. Walker (1995) noted the presence of numerous pits closely associated with Units II and III, as illustrated in the drawing of his main profile (Fig. 3). Notably, in Unit II, a piece of cordage was discovered in a pit alongside grass and marula stones (Walker 1995). Unit II, composed of white ash soil, was directly dated to 4825-4300 BP (Pta-3085); Unit III, consisting of brown ash soil, was directly dated to 5644-5317 BP (Pta-3083; Table 1).

During Walker's (1995) excavations, sediments were sieved through a 2 mm mesh, ensuring the recovery of most artefacts. These artefacts were meticulously curated, preserving their context more effectively than the finds from Cooke's (1963) excavations. According to Walker's (1995) publication, a total of 64 409 artefacts were recovered throughout the Trench V sequence, including 17 144 artefacts from the Amadzimba phase. Of those from the Amadzimba phase, 66% (n=11 322) are from Unit II, and 34% (n=5822) are from Unit III. Lithic pieces constitute the largest portion of the Amadzimba assemblage (93%, n=15 908), followed by faunal remains (6%, n=1066) and bone tools (1%, n=170).

Table 1. Radiocarbon dates and chrono-cultural attribution of the LSA sequence at Pomongwe Cave, based on Walker (1995: table 30). Calibration: OxCal v4.3 (Bronk Ramsey 2017), SHCal13 atmospheric curve (Hogg et al. 2013). The radiocarbon date indicated with * was rejected by Walker (1995). Uncal=uncalibrated and cal=calibrated.

Member	Unit	Chrono-cultural attribution (Walker 1995)	Radiocarbon dating (subunit). uncal (bp)	Radiocarbon dating (subunit). cal (BP) 95.4%	Radiocarbon lab & reference number
A	I	Modern			
B	II	Amadzimba	4090±70 bp	4825-4300 BP	Pta-3085
	III	Amadzimba	4810±80 bp	5644-5317 BP	Pta-3083
	IV	Nswatugi	-	-	-
	V	Nswatugi	-	-	-
	VI	Nswatugi	-	-	-
	VII	Nswatugi	8420±80 bp	9531-9138 BP	Pta-3470
	VIII	Nswatugi	-	-	-
	IX	Pomongwe	-	-	-
	X	Pomongwe	-	-	-
	XI	Pomongwe	9500±120 bp	11 170-10 411 BP	Pta-3117
	XII	Maleme	-	-	-
	XIII	Maleme	12 300±100 bp	14 740-13 836 BP	Pta-3118
C	XIV	MSA	13 000±120 bp*	15 879-15 144 BP	Pta-3119

2. Materials and methods

Walker (1995) documented a total of 57 799 lithics from the Trench V sequence, with 98% (n=56 557) classified as flakes, blades, cores, chunks, and chips, and the remaining 2% (n=1242) categorised as formal tools. Within the Amadzimba phase, 15 908 lithics were recorded, including 2913 flakes, 477 blades, and 147 cores. Furthermore, 11 897 lithics were classified as chunks and chips. Formal tools comprised 474 specimens, of which 72% (n=342) were recovered from Unit II and 28% (n=132) from Unit III (Table 2). The data outlined in Table 2 indicate a significant disparity in artefact sample sizes between the two units. Unit II yielded a notably larger assemblage of lithics compared to Unit III, suggesting an expansion in lithic production during the late Holocene phase. Quartz, particularly filonian and crystal quartz, emerges as the predominant raw material across both units.

Table 2. Summary of lithic artefacts recorded by Walker (1995) from the Amadzimba phase.

Category	Unit II	Unit III	Total
Flakes	1936	977	2913
Blades	355	122	477
Cores	108	39	147
Chunks and chips	7908	3989	11 897
Formal tools	342	132	474
Total	**10 649**	**5259**	**15 908**

Interestingly, the proportional percentages of formal tools relative to the total number of artefacts in both Unit II and Unit III remain consistent at 3% (Unit II: n=342/10 649; Unit III: n=132/5259). Of the formal tools, 32% (n=150) are backed pieces, 19% (n=90) are small convex scrapers, and 49% (n=234) are other types of tools, such as anvils, grindstones, rubbing stones, and polishing stones.

The microlithic backed tools analysed in this study were sourced from squares PM, PY, and PZ, within the aforementioned units. Following a thorough review of the boxes from these squares, we identified 138 pieces, slightly fewer than the 150 recorded by Walker (1995). Of the 138 that we identified and examined, 80% (n=110) originated from Unit II, while 20% (n=28) came from Unit III. The backed pieces include 100 complete tools, with segments (28%, n=38) comprising the largest portion, followed by points (22%, n=31), triangles (18%, n=26), trapezoids (3%, n=4), and tranchets (1%, n=1), based on Walker's (1995) classification. Additionally, 38 pieces (28%) were categorised as broken or miscellaneous.

For the purposes of this study, a segment is defined as a tool with a convex or semi-circular retouched back and a straight or convex edge ending in one or more points. A point features two straight edges, with one or both being retouched, making it single or double-backed. A triangle has an angular back formed by abrupt retouch and a straight edge terminating in points, and symmetry was used to subdivide these pieces into scalene (with sides of different lengths) and isosceles (with two equal sides) shapes. A trapezoid is characterised by two distinct angles at the back, with the distal and proximal parts retouched while the mesial part remains unretouched; it also has a straight edge ending in points. Lastly, a tranchet is a small axe head with a short edge and two points.

Morpho-functional classification
We adopted a morpho-functional classification to analyse the microlithic backed tools, as developed by Chesnaux (2013, 2014). This method classifies lithic tools based on their functional attributes, aiming to overcome the limitations of traditional typologies (Chesnaux 2013, 2014). The advantage of the morpho-functional approach lies in its ability to distinguish between a tool's intended purpose or function and its operational mechanism. While the intended purpose answers the question, "What was it designed to do?", the operational mechanism explores, "How does it perform its task?" (Chesnaux 2013, 2014; Guillemard & Porraz 2019).

To achieve this, the morpho-functional analysis involves distinguishing the three main functional parts of a backed tool: the point(s), the edge, and the back (Fig. 4). The point and edge are considered the putative active parts as they play a direct role in the tool's function (e.g., when tools are used as projectiles, or in drilling or cutting-related activities; Chesnaux 2013, 2014). The point is the sharp or rounded end of the backed tool, where the edge and back converge to form an angle of less than 90°. The edge is the sharp side of the backed tool, typically characterised by an angle ranging from 20° to 50°. The back, on the other hand, is the passive component, characterised by a surface that is intentionally blurred by backing. The back is usually the gripping part of the tool, typically hafted into a handle (Chesnaux 2013, 2014). This approach has also been applied in southern Africa, at Balerno Main Shelter for the study of Wilton scrapers, which will facilitate future inter-site comparisons (see Guillemard & Porraz 2019).

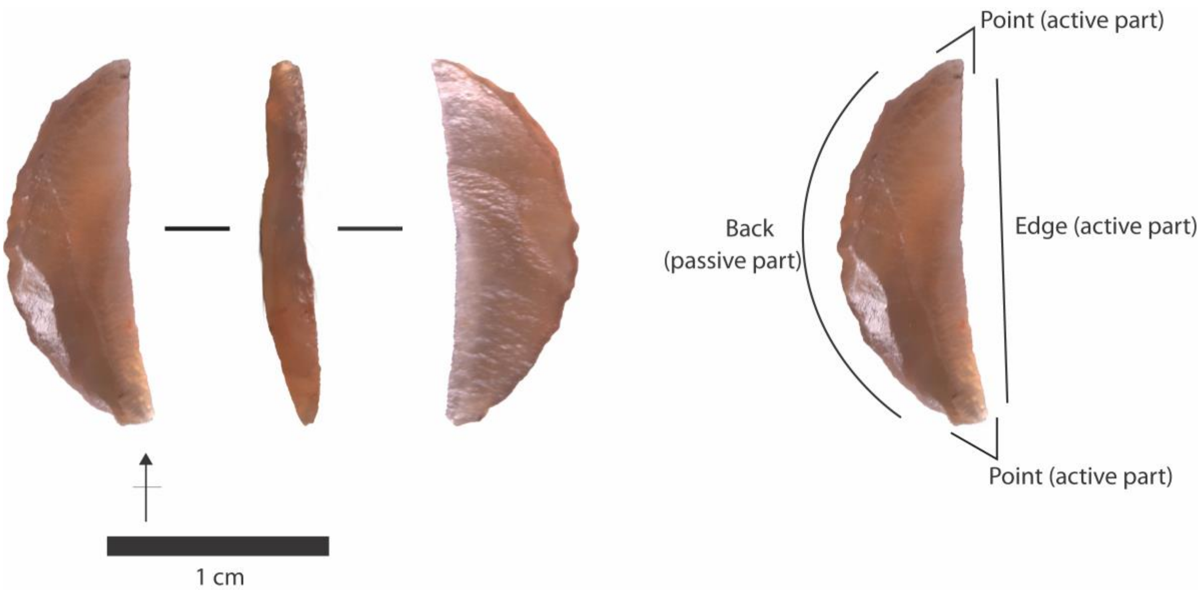


Figure 4. Three main morpho-functional attributes (point, back, edge) of a microlithic backed tool as defined in this study.

Using the morpho-functional classification described here, we differentiated geometric backed pieces based on the number of pointed parts: double points (those with two opposing pointed parts) and mono-points (those with a single pointed part). Mono-points were further classified by symmetry, which refers to the proportional distribution of a tool's morphology, resulting in mono-point centred (a single point along the longitudinal axis) and mono-point off centred (a single point oblique to the longitudinal axis). Broken microlithic backed pieces with no identifiable active parts were classified as indeterminate.

General attributes

Additional data were recorded for each backed piece, including the type of raw material, the type of blank modified into the backed piece (flake, blade, or bladelet), profile shape (flat, curved, or twisted), and retouch type (direct or crossed). Crossed removals originate from both faces of the piece, while direct removals are made from the lower face (see Inizan et al. 1999). We also examined the distribution of retouch, considering whether it was partial, total, continuous, or discontinuous. Continuous retouch refers to a series of uninterrupted removals along an edge, whereas discontinuous retouch involves one or more interruptions along the same edge. The term partial retouch applies when the retouch does not extend across the entire length of an edge, while total retouch denotes retouching that spans the full length of the edge (Inizan et al. 1999). Metric measurements were recorded using a vernier calliper and included maximum length from the percussion point (or platform centre, if not visible) to the distal end along the flaking axis, width perpendicular to the length, and maximum thickness. For broken pieces, length measurements were taken for left and right lateral backed pieces only. Width and thickness measurements were only taken for pieces with mesial and proximal parts, or mesial and distal parts. No measurements were recorded for indeterminate backed pieces. The angles of the points were measured using a goniometer, specifically the angle between the two edges that converge to form the pointed part of the piece. Finally, we noted the geometric form of each piece (point, segment, triangle, trapezoid, or tranchet) as classified by Walker (1995) to facilitate future data comparisons with earlier works, such as those by Deacon (1984).

Functional analysis

Macro-fracture, residue, rounding, and scar analyses were conducted on the microlithic backed tools to explore tool function. Macro-fractures, defined as wear traces visible to the naked eye or under a low-powered microscope, were identified using the methods outlined by Fischer et al. (1984), Sano (2009), Chesnaux (2013, 2014), and Coppe and Rots (2017). Two main classes of macro-fractures were recorded: cone and bending fractures (Chesnaux 2013, 2014). Cone fractures, including spin-off fractures, result from concentrated force applied to a small area and are typically found near the contact area. Bending fractures, which include impact burinations, transverse fractures with step terminations, as well as snap, feather, and hinge-terminating fractures, occur when force is distributed over a larger surface, with the fracture not necessarily beginning near the contact area (Fischer et al. 1984; Sano 2009; Chesnaux 2013, 2014; Pargeter 2011; Coppe & Rots 2017).

Spin-offs exceeding 2 mm (Chesnaux 2013), impact burinations, and step-terminating fractures, along with other functional traces, are considered diagnostic impact fractures (Fischer et al. 1984; Sano 2009; Chesnaux 2014; Coppe & Rots 2017). In contrast, spin-offs smaller than 2 mm (Chesnaux 2013), as well as snap terminating, feather, and hinge fractures, are classified as non-diagnostic fractures (Fischer et al. 1984; Sano 2009). In this study, spin-offs exceeding 2 mm were identified as being diagnostic of impact damage, following Chesnaux's (2013) experimental framework, which was specifically designed for microliths. We did not adopt the criteria of Fischer et al. (1984) and Sano (2009), which classify spin-offs exceeding 6 mm as diagnostic of impact damage as their experiments were based on larger artefacts, whereas microliths from LSA assemblages are often only slightly larger than 6 mm in maximum length. Diagnostic impact fractures are typically associated with the use of tools as projectile weapons, whereas non-diagnostic fractures are not necessarily related to hunting and may result from a range of other processes, including post-depositional factors.

We also observed rounding on the pointed parts of the microlithic backed tools. These rounded surfaces, characterised by their smoothness and fine polish, may indicate the contact material and the manner in which force was applied (Rots 2005). Additionally, micro-scar analysis on tool edges was conducted following Claud (2008). The recorded attributes, as presented in Figure 5, include (a) morphology, (b) distribution, (c) direction, (d) depth, and (e) dimension.

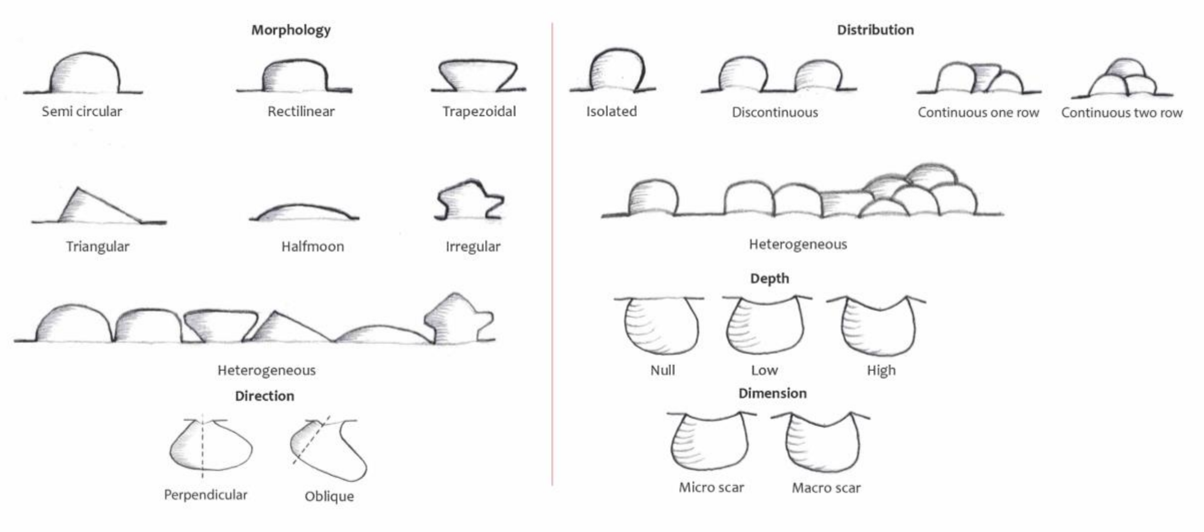


Figure 5. Drawing of the variables used to describe micro-scars on microlithic backed tools (modified from Claud 2008).

Macro-residues were identified on the backs of the backed pieces. The analysis involved identifying both organic and inorganic residues, such as adhesives, using the naked eye or a low-powered microscope (Marreiros et al. 2015). Such analysis is essential for detecting traces of glue related to hafting on backed pieces, particularly given the excellent organic preservation at Pomongwe Cave. To examine fractures, residues, rounding, and scars, we utilised a Madell MC binocular microscope with magnifications ranging from 7X to 45X. Micrographs were captured using an Olympus microscope with magnifications from 5X to 50X.

3. Results

Raw material exploitation

Three raw materials were used in the production of microlithic backed tools at Pomongwe Cave, with a noticeable preference for translucent quartz that accounts for 83% (n=115) of the assemblage. This is significantly higher than the use of milky quartz (12%, n=16) and chalcedony (5%, n=7; Fig. 6). The preference for quartz can be attributed to its local availability, as noted by Walker (1995; also see Matembo 2019). Chalcedony, on the other hand, is not naturally found in Matobo, and Walker (1995) suggested that it was imported from outside the area.

Classifying microlithic backed tools

Combining the major morpho-functional attributes (point, edge, and back) resulted in the individualisation of three morpho-technical classes:

- Type 1 Mono-point centred: this includes backed tools with a single point aligned with the longitudinal axis, formed by abrupt rectilinear retouch that converges to create a sharp distal point.
- Type 2 Mono-point off centred: this consists of backed tools with a single point not aligned with the longitudinal axis, where the back is shaped by abrupt rectilinear retouch, also leading to a sharp distal point.
- Type 3 Double point: this comprises backed tools with two opposed points, with the back of the tool formed by abrupt, rectilinear, or convex retouch (Fig. 7).

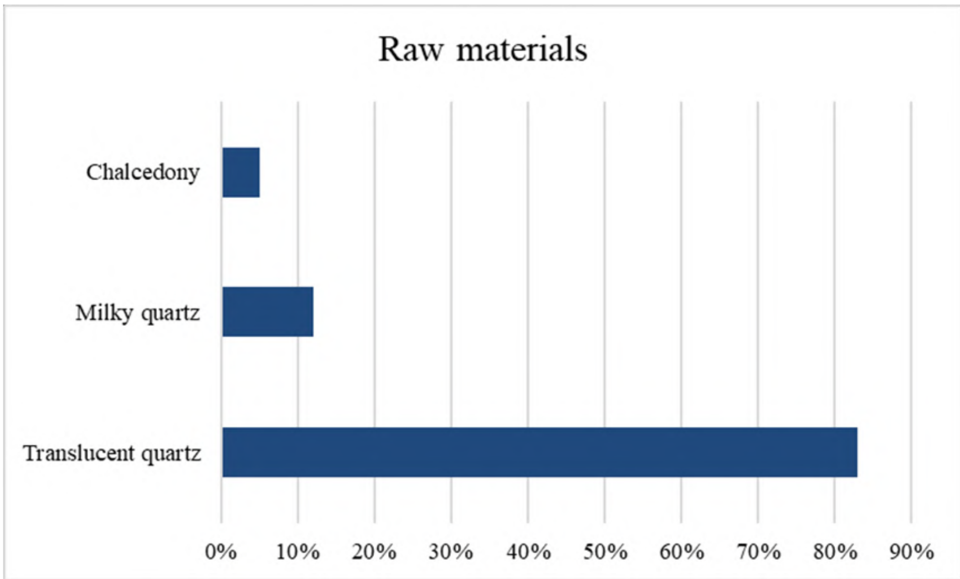


Figure 6. Raw material distribution for the Pomongwe Cave microlithic backed tools (n=138).

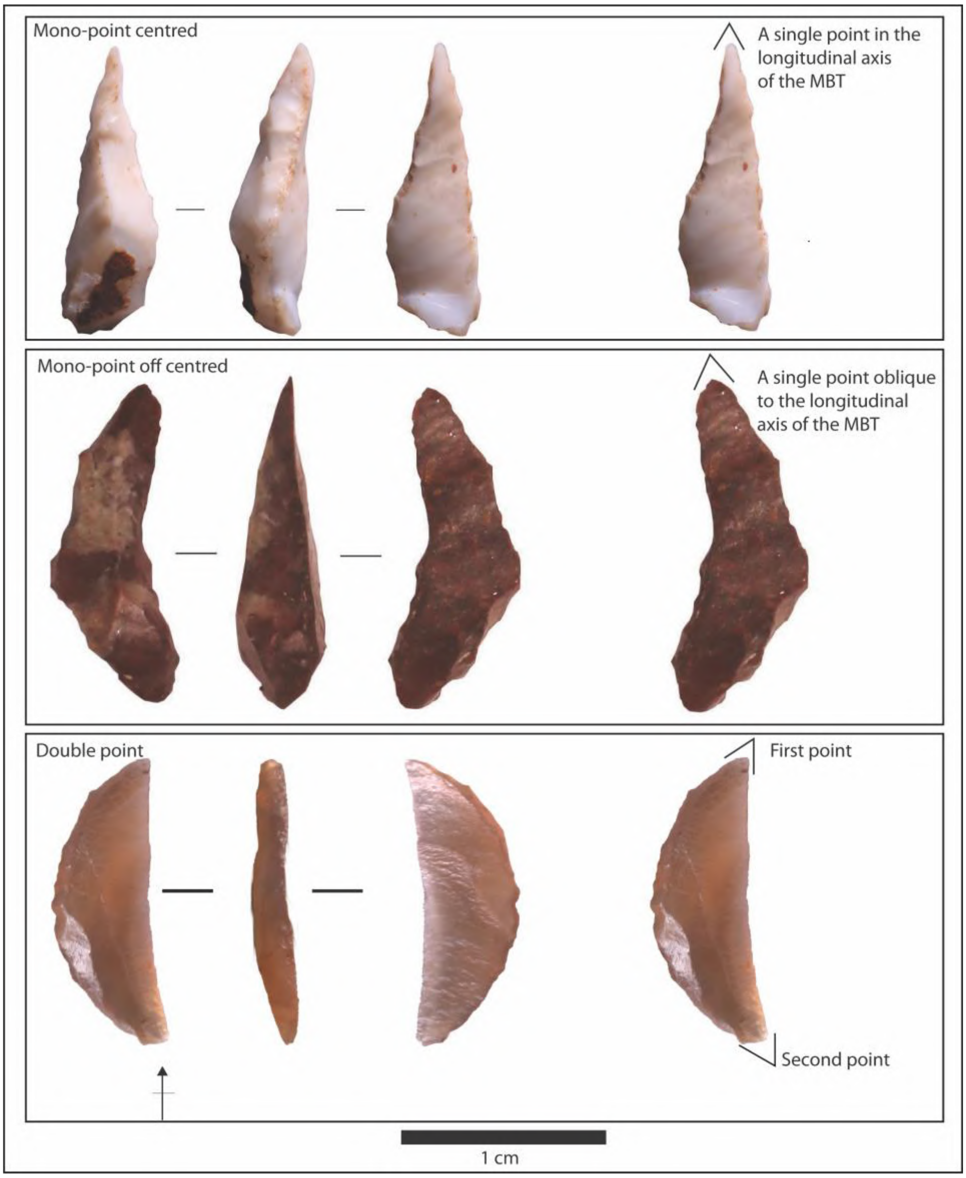


Figure 7. Microlithic backed tool morpho-functional classification (MBT=microlithic backed tool).

The morpho-functional classification of the backed tools from Pomongwe Cave indicates that double point backed pieces represent the majority of the assemblage at 50% (n=69), followed by mono-point off centred microliths, which make up 14% (n=19). Mono-point centred backed tools constitute 8% (n=12). Additionally, 28% (n=38) are indeterminate (broken) pieces that could not be classified into any of the categories.

Table 3 shows that, when classifying the backed tools based on their active and passive parts (point, edge, and back), the mono-point centred category includes some of the backed tools from Walker's (1995) point class, while the mono-point off centred class combines backed tools that Walker (1995) classified as both points and segments. Lastly, the double point category encompasses backed tools that Walker (1995) classified as segments, triangles, trapezoids, and tranchets (Figs 8-10).

Table 3. Morpho-functional types of microlithic backed tools from Pomongwe Cave and subsequent typological forms (points, segments, triangles, trapezoids, tranchets).

Morpho-functional type	Unit II	Unit III	n	%
Mono-point centred			12	8
Points	11	1		
Mono-point off centred			19	14
Points	7	2		
Segments	9	1		
Double point			69	50
Segments	28	10		
Scalene triangles	8	3		
Isosceles triangles	14	1		
Trapezoids	3	1		
Tranchet	1	-		
Undetermined fragments	29	9	38	28
Total	**110**	**28**	**138**	**100**

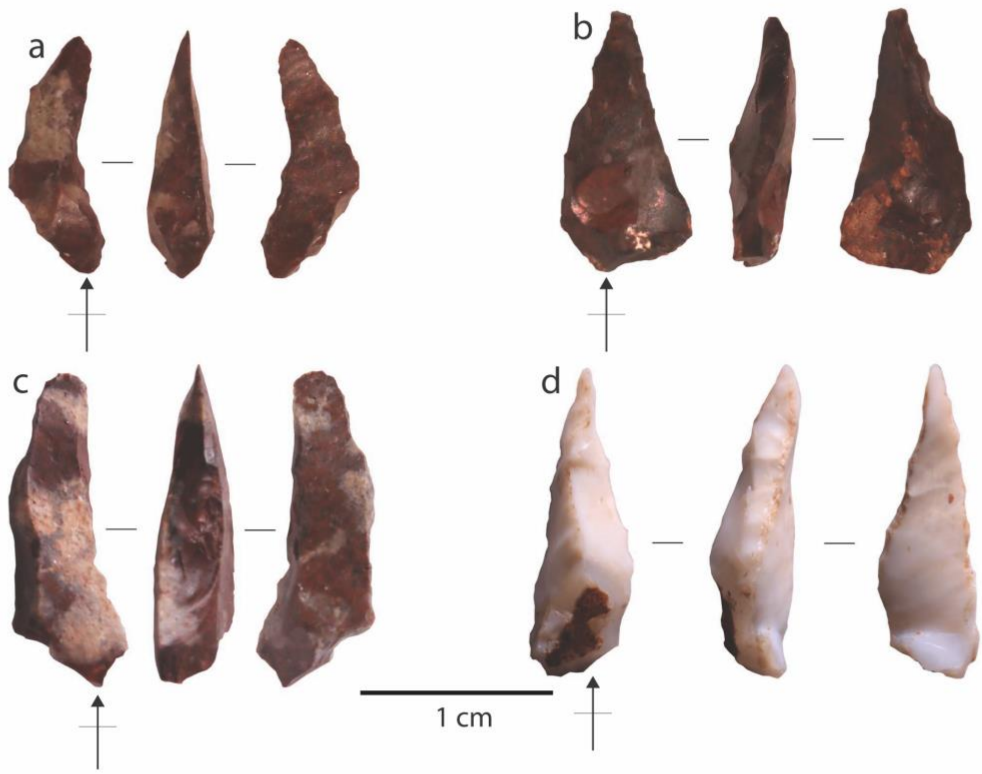


Figure 8. Mono-point backed pieces from the Amadzimba phase. (a) mono-point off centred point (#392); (b) mono-point centred point (#425); (c) mono-point off centred point (#404); and (d) mono-point centred point (#330). All pieces are from Unit II and raw materials include chalcedony (a-c) and milky quartz (d).

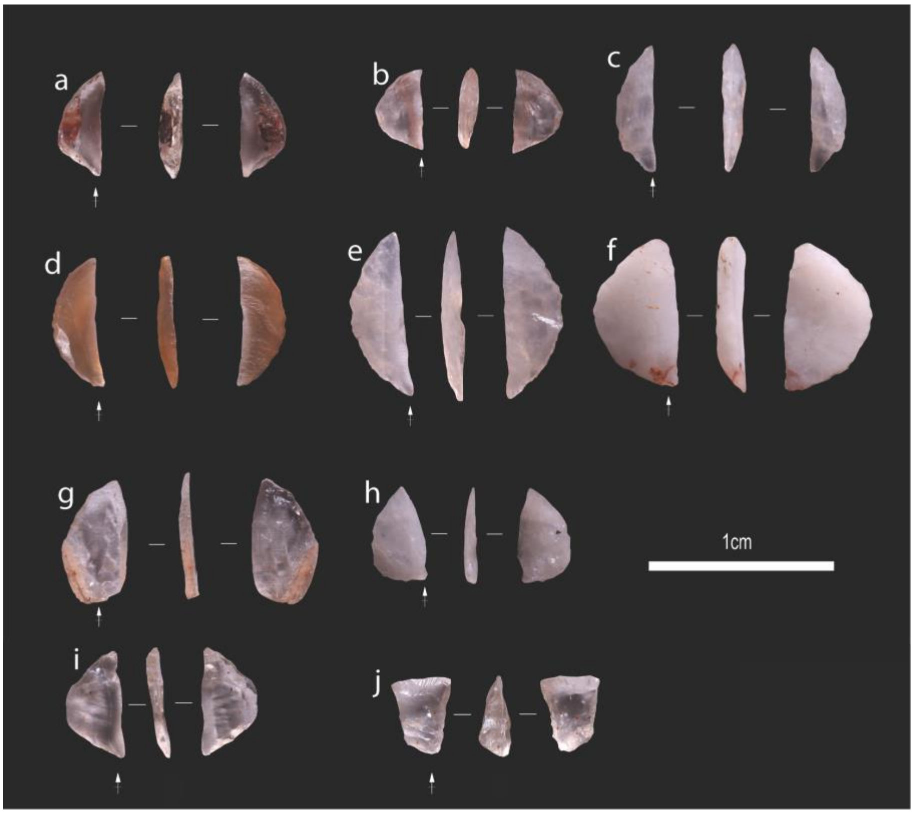


Figure 9. Double point backed pieces from the Amadzimba phase. (a-f) double point segments (#219, 211, 16, 332, 380, and 52, respectively; b-e are from Unit II, a and f are from Unit III); (g and h) mono-point off centred segments (#341 and 34, respectively, both from Unit II); (i) double point trapezoid from Unit II; (j) double point tranchet from Unit II. All pieces are translucent quartz, except for d, which is chalcedony, and f and h, which are milky quartz.

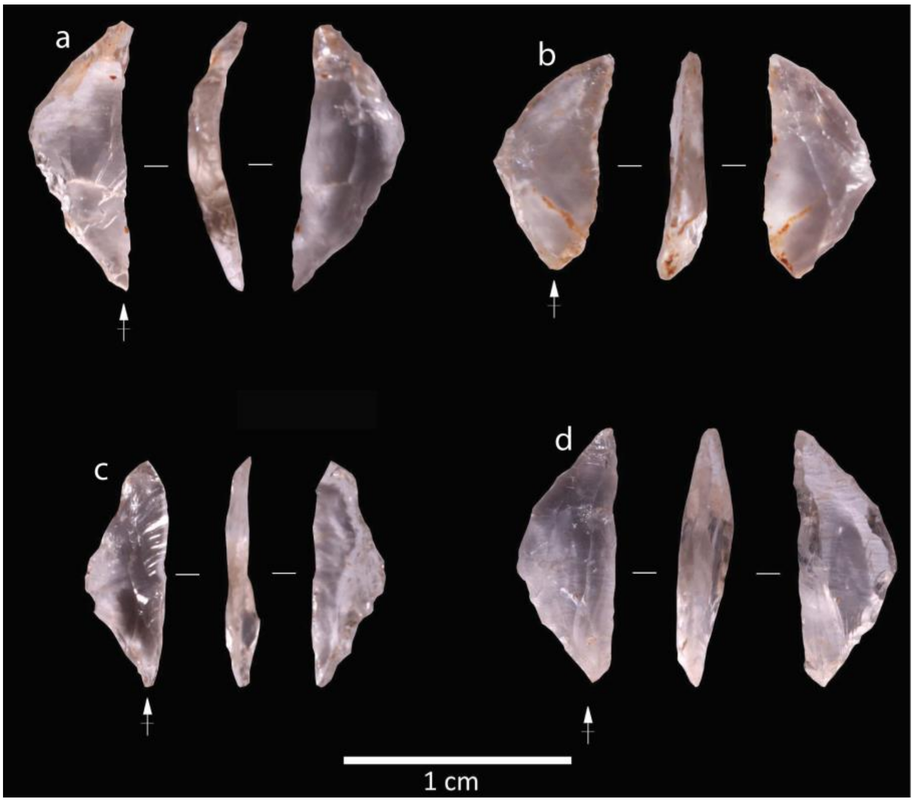


Figure 10. Double point backed pieces from the Amadzimba phase. (a and b) double point scalene triangles (#344 and 31); (c and d) double point isosceles triangles (#415 and 340). All are translucent quartz from Unit II.

General attributes per morpho-functional category

In terms of measurements, mono-point centred pieces have a mean length of 15 mm (SD=2.1), a width of 5 mm (SD=0.8), and a thickness of 3.3 mm (SD=1). Mono-point off centred pieces have mean dimensions of 8.7 mm (length, SD=1.2), 4.9 mm (width, SD=0.7), and 2.4 mm (thickness, SD=1.1). Double point pieces average 11.3 mm (length, SD=2.2), 5.2 mm (width, SD=1.5), and 1.7 mm (thickness, SD=0.6).

The boxplot (Fig. 11) shows that mono-point centred pieces differ from the other two categories of backed pieces in that they are longer. The box plot also shows that length varies the most, with mono-point centred having the highest mean and mono-point off centred the smallest. The length of the double point category comprises a broader range of data values when compared with the other two. Width is relatively consistent across all categories, while thickness is similar but slightly greater (based on larger mean values) in the mono-point centred pieces.

The microliths were made from non-cortical bladelets. The backing is total and continuous and predominantly features crossed retouch (91%; n=126), while 9% (n=12) exhibit direct retouch. The profile shapes of mono-point centred pieces are mostly flat, while mono-point off centred pieces are primarily twisted. Double points typically have flat profiles, with few exhibiting curved shapes. The pointed angles of the backed pieces range between 40° and 60°, with a mean of 50°.

Functional analyses

The macro-fracture analysis of the backed tools indicates diagnostic impact fractures on 27% (n=37) of the pieces, while non-diagnostic damage was recorded on 41% (n=57). The remaining 32% (n=44) showed no fractures. Among those with diagnostic impact damage, 60% (n=22) are double points, 35% (n=13) are mono-point off centred, and 5% (n=2) are mono-point centred backed pieces. The majority (86%, n=19) of double points with diagnostic impact fractures exhibited impact burinations, whereas only 14% (n=3) displayed transverse fractures with step terminations. All 13 mono-point off centred pieces displayed evidence of impact burinations, while the two mono-point centred microliths exhibited impact burinations as well. Rounding was observed on six mono-point centred pieces (Table 4, Fig. 12).

As previously highlighted, non-diagnostic damage was recorded on 57 backed pieces. Of these, a small proportion (7%, n=4) of mono-point centred backed pieces exhibited snap terminating fractures. In the mono-point off centred category, 9% (n=5) displayed snap terminating fractures, while 4% (n=2) showed hinge fractures. Within the double point category, 14% (n=8) exhibited snap terminating fractures, and 23% (n=13) displayed spin-offs smaller than 2 mm. In the category of broken or indeterminate pieces, 31% (n=18) exhibited snap terminating fractures, followed by 7% (n=4) with spin-off fractures smaller than 2 mm, and 5% (n=3) with hinge fractures (Table 5).

Micro-scar analysis revealed that 56% (n=77) of the analysed backed tools showed no scar traces. Among those with scars, 92% (n=56) were isolated and discontinuous, while only 8% (n=5) exhibited continuous micro-scars. These scars have a semi-circular morphology, are mostly perpendicular in direction, and vary in depth (Fig. 13).

Results from the macro-residue analysis showed that the majority (90%, n=124) of the pieces did not retain any residues, while a smaller percentage (10%, n=14) exhibited black residues (possibly adhesives) on the mesial and proximal parts of the back. The residues were observed on 2 mono-point centred pieces (14%), 3 mono-point off centred pieces (21%), and 9 double point pieces (65%).

4. Discussion

Function of geometric backed tools at Pomongwe Cave

We begin by discussing the mono-point centred pieces, which are distinct within our sample of microlithic backed tools. Of the eight mono-point centred tools exhibiting visible damage, six display rounding on their tips, indicating that they may have been used in rotational activities such as drilling. This distinction is further reflected in their dimensional variability, as they are longer than the other backed tool types. Moreover, these tools show a clear preference for chalcedony (believed to have been sourced from outside the Matobo) and milky quartz, in stark contrast to the other two categories that were made from translucent quartz. Based on these observations, we hypothesise that the backing of the mono-point centred pieces was likely intended to shape and align the tip along the longitudinal axis of the tool. Furthermore, two additional mono-point pieces exhibited impact burination fractures, but it is difficult to confirm whether mono-point centred pieces were used as hunting tips because of the low incidence of diagnostic damage.

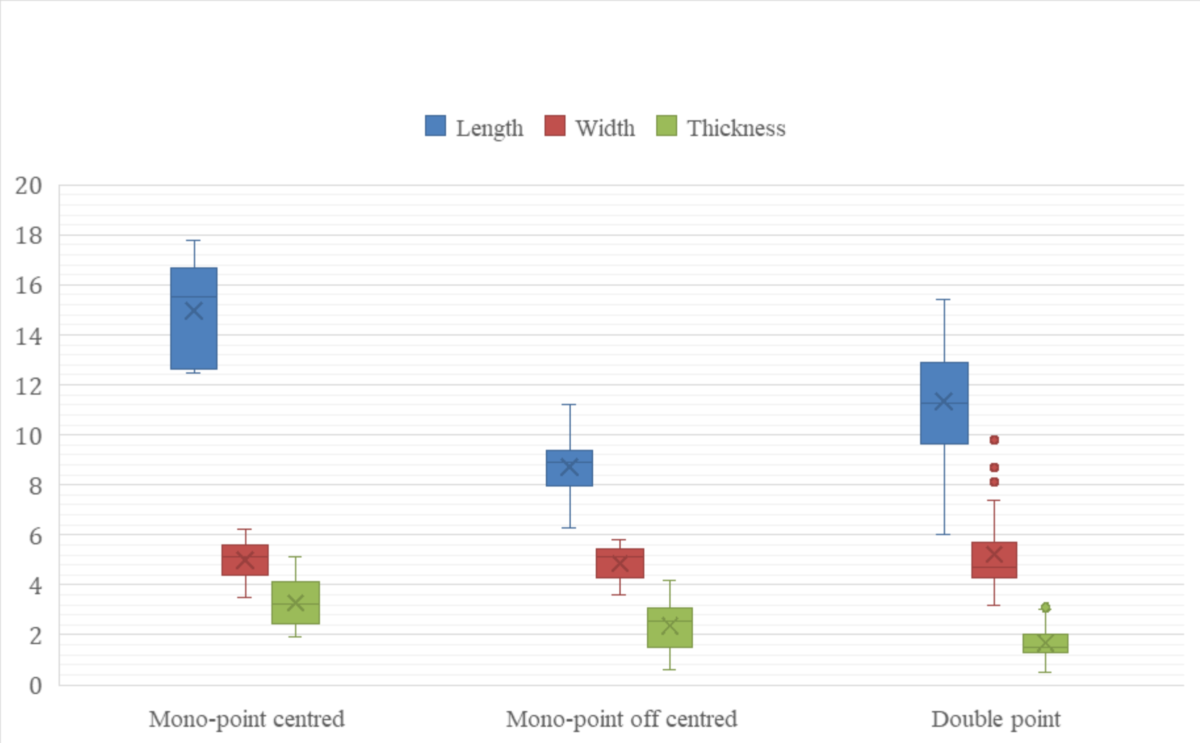


Figure 11. Dimensional variations (mm) for the Pomongwe Cave microlithic backed pieces (n=100; mono-point centred: n=12; mono-point off centred: n=19; double point: n=69). Broken pieces are excluded.

Table 4. Diagnostic impact fractures (DIFs) observed on microlithic backed tools.

DIFs	Mono-point centred	Mono-point off centred	Double points
Transversal fractures	-	-	3
Burination fractures	2	13	19
Rounding	6	-	-
Micro-scars	3	5	13
Total	**11**	**18**	**35**

We therefore cautiously propose that these mono-point centred points were likely employed to perforate materials, for example, when drilling small, circular holes into shells and ostrich eggshells to create beads and pendants, which are abundant in the Amadzimba levels at Pomongwe Cave. Walker (1995) documented 537 ostrich eggshell beads, 3 pendants, 2 bone disc beads, and 1 bone cylinder bead from the Amadzimba units, some of which are illustrated earlier in this paper (Fig. 2). Similarly, at Little Muck Shelter in Limpopo, South Africa, experimental work and use-wear analysis suggests that early foragers likely employed microliths to drill beads (Sherwood & Forssman 2024).

Mono-point off centred backed pieces exhibit residues and impact burinations, with no transverse fractures. Given the sporadic diagnostic impact damage, and drawing on Chesnaux's (2013, 2014) experimental model, we tentatively suggest that the combination of impact burinations, the absence of transverse fractures, and the offset single point along the longitudinal axis of these backed pieces, likely indicates that they were laterally hafted as barbs on an arrow shaft. Lateral hafting would enhance the tool's potential for laceration, thereby improving its stability during hunting (Chesnaux 2013, 2014).

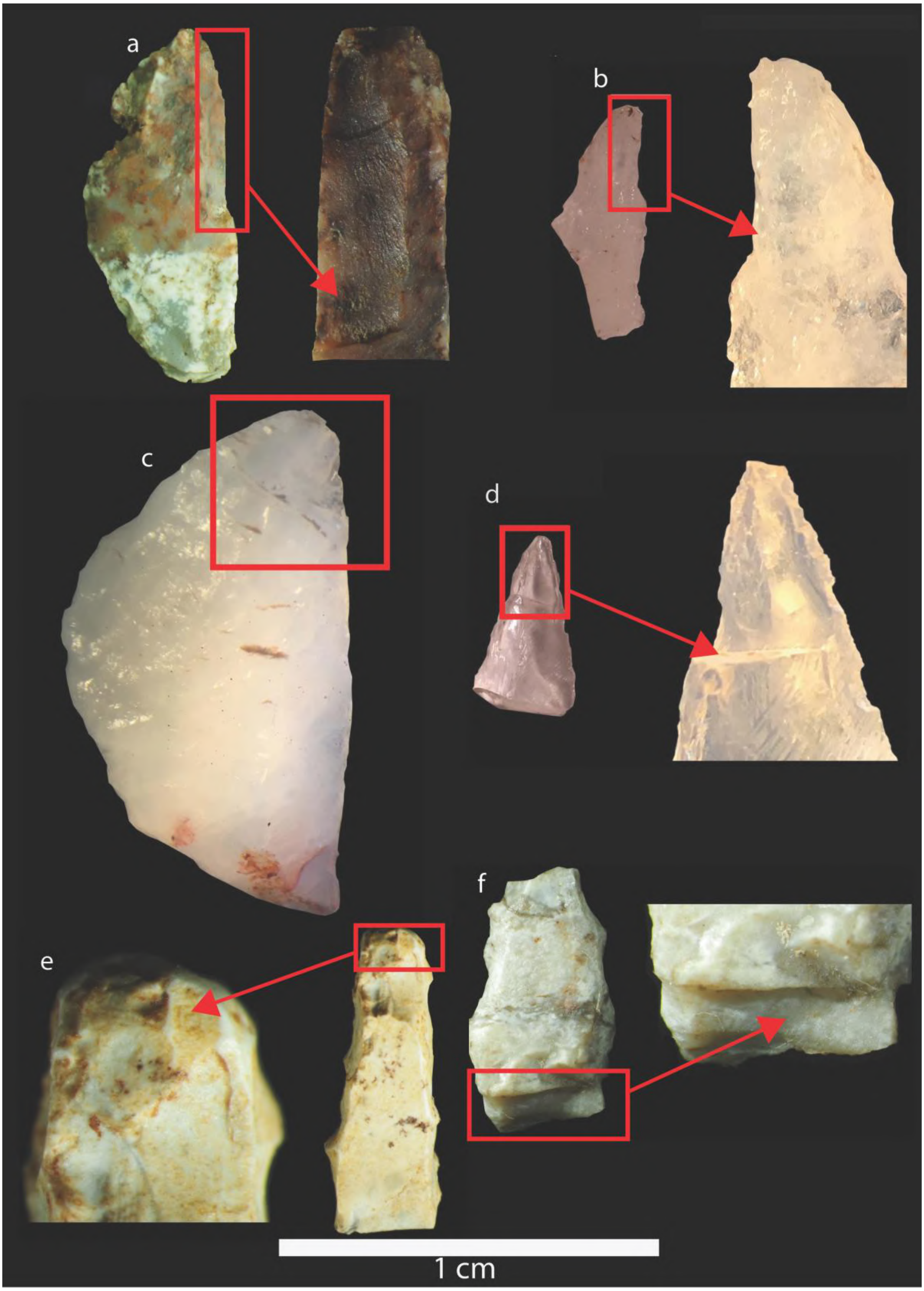


Figure 12. Micrographs of microlithic backed tools showing damage: (a) impact burination on a double point piece, (b) impact burination on a double point fragment, (c) transverse fracture with step termination on a double point piece, (d) transverse fracture with step termination on a tip fragment, (e) rounding on a mono-point centred piece, and (f) hinge fracture on an indeterminate fragment.

Table 5. Non-diagnostic damage observed on microlithic backed tools.

Non-diagnostic damage	Mono-point centred	Mono-point off centred	Double points	Indeterminates
Snap terminating fractures	4	5	8	18
Spin-off <2mm	-	-	13	4
Hinge fractures	-	2	-	3
Total	**4**	**7**	**21**	**25**

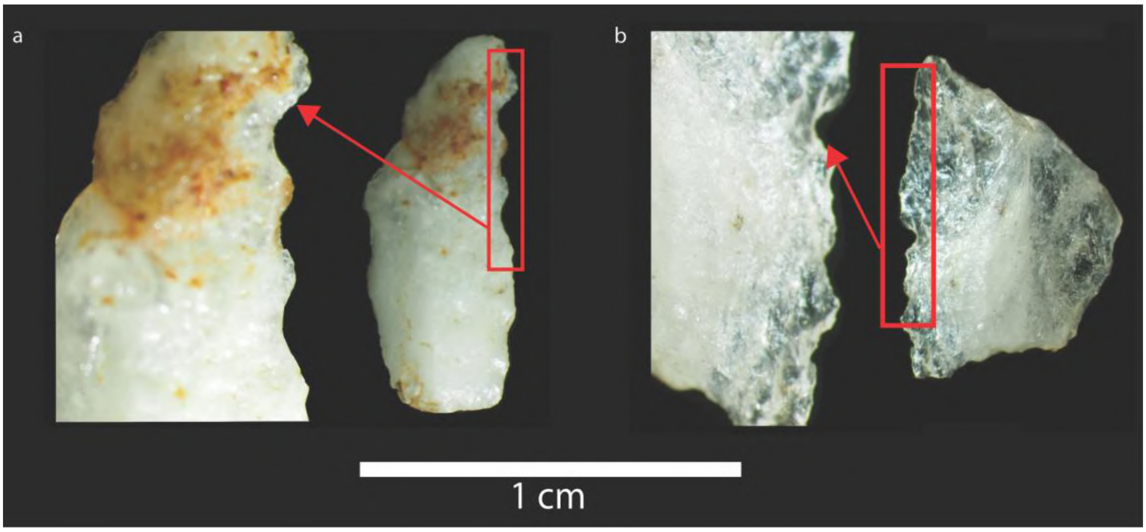


Figure 13. Micrographs of microlithic backed tools with (a) continuous and (b) isolated micro-scars.

Moreover, double point microlithic backed tools display evidence of residues, impact burinations, and transverse fractures with step terminations. Based on Chesnaux's (2013, 2014) experimental model, we propose two possible hafting methods for these tools. First, the prevalence of burin-like fractures over transverse fractures in double points from Pomongwe Cave suggests they may have been hafted laterally on the shaft as barbs. Second, the presence of transverse fractures with step terminations indicates that some double points may have been hafted disto-laterally, meaning they were attached near the tip of the shaft but along the side (see Fig. 14). Similar to mono-point off centred tools, double points hafted laterally would likely enhance laceration and retention during hunting, while those hafted disto-laterally would have provided additional penetration, laceration, and retention.

We propose that mono-point off centred and double point backed tools from Pomongwe Cave were integral components of a hafting system that employed lateral and disto-lateral hafting techniques. These tools likely functioned as barbs, affixed to a shaft with adhesives in a composite system. This system aligned multiple interchangeable components in sequence, allowing damaged parts to be replaced. The need for such interchangeability likely drove the consistent production of repetitive forms and similar dimensions, resulting in reliable and effective hunting weapons.

The moderate variation in forms and sizes suggests that these tools were designed to fit similar weapon systems. Variations in the shapes of double points, such as segments, triangles, and trapezoids, may reflect stylistic choices. However, the creation of composite tools appears to have encouraged standardised production, ensuring functional consistency. This does not preclude the variability that existed but highlights the balance between functionality and stylistic expression.

While this study clarifies the mode of insertion, other functional parameters remain unexplored and warrant further analysis. Once the functional decision-making processes are fully understood, cultural and stylistic interpretations can be more effectively addressed. Additionally, aspects such as the form, size, and shape of the shaft, its materials, and methods of construction have not been examined in detail. Additionally, details concerning the hunting context, including prey size and behaviour, are not thoroughly explored in this study. These unexamined aspects highlight significant avenues for future research to deepen our understanding of the design and use of composite tools within broader ecological and cultural frameworks.

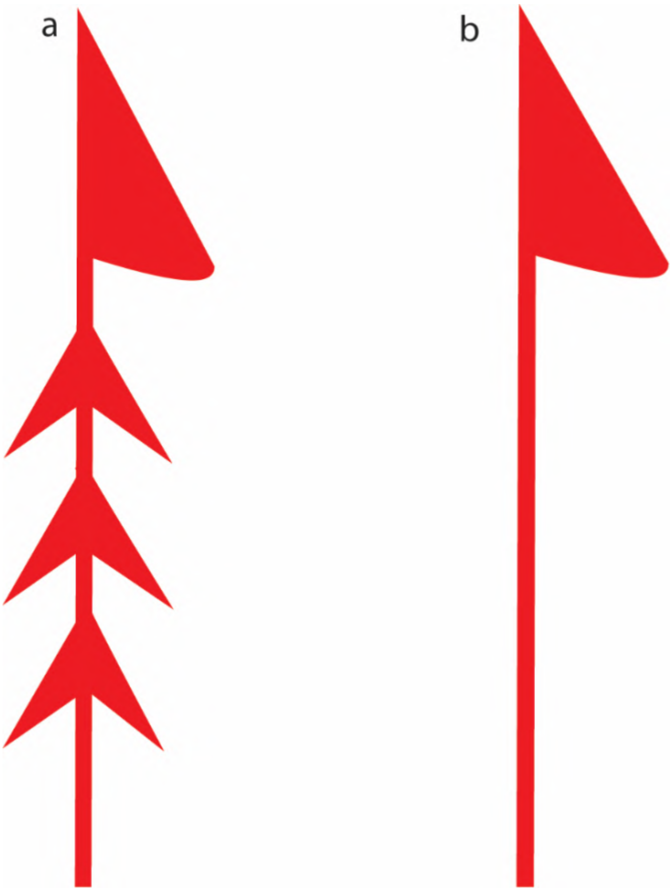


Figure 14. Illustration of (a) disto-lateral and lateral hafting, depicting a composite tool with pieces aligned in sequence to form an effective hunting implement, and (b) disto-lateral hafting.

We propose that the composite tools from Pomongwe Cave were likely used to hunt the animals represented in the Trench V faunal assemblage. With excellent organic preservation in Walker's (1995) Trench V, faunal remains constitute the largest portion of the Amadzimba artefact assemblage and include bovids such as the common eland (*Taurotragus oryx*), impala (*Aepyceros melampus*), tsessebe (*Damaliscus lunatus*), sable antelope (*Hippotragus niger*), and black wildebeest (*Connochaetes gnou*; Walker 1995).

The discussion above suggests that tools with similar active and passive components were likely hafted in the same position and manner, supporting their classification through a morpho-functional approach. For instance, tools with a single point aligned along the longitudinal axis were likely used for drilling, as their shape and hafting configuration allowed for effective rotational force and penetration into various materials. In contrast, backed pieces with double points, such as triangles, segments, and trapezoids appear to have served comparable roles on an arrow shaft. Their symmetrical design and dual points may have enhanced aerodynamic efficiency, penetration, and incision capabilities upon impact. This suggests that backed tools were likely strategically hafted to maximise efficiency in hunting or combat, whereas mono-point centred backed tools were likely optimised for tasks requiring precision and controlled force application. Thus, classifying them as double points or mono-points based on function is entirely appropriate, as it reflects the intentional design choices made by past toolmakers. The potential use of these backed tools as cutting implements, as suggested by Walker (1995), is not entirely dismissed in this study, as our analysis of the scars was preliminary. The observed scars are mostly isolated, discontinuous, and shallow, making it difficult to interpret cutting motions based on these initial results. Therefore, a more comprehensive microwear analysis is needed in the future.

Non-diagnostic impact fractures are typically difficult to interpret due to their ambiguous characteristics, as they can result from multiple processes beyond intentional use. However, a portion of the microlithic backed tools from Pomongwe Cave, exhibiting snap terminating fractures, spin-offs smaller than 2 mm, and hinge fractures, are likely to have resulted either from stone tool manufacture or post-depositional processes, such as trampling. These types of fractures often occur when tools are subjected to mechanical stress, either during their initial production, where forceful blows may cause unintended breakage, or through natural taphonomic processes that alter artefacts over time. We base this interpretation on several experimental studies (Fischer et al. 1984; Sano 2009; Chesnaux 2013) that have explored these processes in greater detail. These studies have demonstrated that similar breakage patterns can emerge from both human activities, such as knapping and tool maintenance, and natural disturbances, making it essential to consider multiple lines of evidence when assessing non-diagnostic impact damage.

When comparing the Pomongwe Cave Amadzimba assemblage with other late Holocene examples in southern Africa, such as the Wilton technocomplex at Balerno Main Shelter in Limpopo, South Africa, a shared characteristic among these toolkits is the predominance of scrapers and backed pieces within the formal tool categories (e.g., Guillemard & Porraz 2019). The morpho-functional characteristics of the Balerno Main Shelter scrapers suggest they were often hafted and employed in tasks like scraping, which was integral to various economic and social contexts (Guillemard & Porraz 2019; Guillemard 2020a). Guillemard (2020a) suggests that the presence of microlithic industries across southern Africa during the late Holocene can be attributed to a combination of vertical and horizontal cultural transmission, as well as possible independent innovations.

Despite these similarities, a notable distinction between the Amadzimba assemblage and other southern African collections is the higher frequency of backed pieces relative to scrapers. This discrepancy may reflect unique subsistence strategies and social transformations, suggesting that the Amadzimba assemblage represents a distinct regional expression. For instance, scrapers predominate the typological composition of assemblages from sites such as Balerno Main Shelter, Rose Cottage Cave, Boomplaas, and Jubilee Shelter during the late Holocene (Deacon 1984; Wadley 1996, 2000; Guillemard & Porraz 2019; Guillemard 2020a).

Beyond the African context, the European Upper Palaeolithic provides compelling evidence of microlithic backed pieces integrated into composite tools. Analyses of use-wear and residues, supported by experimental studies, demonstrate that these composite barbed points were meticulously crafted from multiple microlithic components. Their design was tailored to target particular prey and align with seasonal hunting strategies, highlighting the advanced planning, adaptability, and ingenuity of these human populations (see Pétillon et al. 2011; Tomasso et al. 2018; Taipale et al. 2022).

In Australia the situation is similar, where the emergence of microlithic backed tools during the mid-to-late Holocene are interpreted as barbs that were hafted into composite systems (Hiscock 1994). Their development is thought to reflect strategies aimed at minimising the risks associated with environmental changes, increased mobility, and the colonisation of previously uninhabited areas (Hiscock 1994, 2006). A notable example comes from southeastern Australia, at Mussel Shelter in the Sydney Basin, where a significant rise in the use of backed tools is observed between 4000 and 3500 BP. These tools, integrated into composite systems, served a variety of functions such as cutting, drilling, and potentially as projectiles (Attenbrow et al. 2009). This increase in the use of backed tools is closely associated with elevated foraging risks and societal restructuring, both driven by a transition to cooler and drier climatic conditions (Attenbrow et al. 2009). In contrast, the increase in backed tools during the late Holocene in Matobo is linked to warmer and wetter conditions, which are argued to have contributed to population growth (Walker 1995). Consequently, the need to sustain this population increase likely led to the development of new hunting strategies, resulting in the production of numerous backed pieces during this period. This suggests both shared technological innovations and distinct regional adaptations during the late Holocene.

Despite the limitations outlined in this study, our findings provide some clarity on potential hunting weaponry in the Matobo region. There is a general lack of evidence and interpretations regarding the use of backed pieces in a composite arrangement within Zimbabwe, despite the well-established record of composite, multi-component tool technologies in southern Africa, spanning from the MSA to the LSA (see Veall 2022). Therefore, our findings have the potential to stimulate future discussions on related topics in Zimbabwe, serving as a foundation for understanding late Holocene hunting strategies in Matobo. Our study may also contribute to comparative studies of late Holocene innovations across southern Africa.

While our study has the potential to stimulate discussions on hunting weaponry in Zimbabwe, future research should explore the role of processes such as trampling in combination with appropriate experimental studies. Experiments should also use local raw materials, such as translucent and milky quartz. This study relied heavily on Chesnaux's (2013, 2014) macro-fracture experiments, which were based on flint, to interpret the diagnostic impact fractures. Therefore, future studies should incorporate use-wear experiments, particularly with the most preferred translucent quartz. Additionally, experimentation should explore tool designs, hafting strategies, and hunting systems. While we have proposed that microlithic backed tools were likely used as projectiles, the broad variability in hunting weapons warrants further examination through experimentation.

We recommend analysing other formal tools in the Pomongwe Cave assemblage, such as scrapers, to better understand their technology and function. This would provide a more comprehensive view of hunter-gatherer life during the final phases of the LSA at the site and in Matobo. Furthermore, we suggest examining the full *chaîne opératoire* of the blanks and cores from the Amadzimba phase to better understand the technological mechanisms behind the production of these tools. Additionally, we recommend investigating the abundant Amadzimba bone tools to complement this research and supplement the data on Amadzimba cultural expressions. Future research could also expand to other sites in Matobo, such as Bambata, where Walker (1995) recorded a significant number of geometric backed pieces and other material culture. Conducting use-wear analysis on Bambata's backed tools would facilitate comparisons between the Matobo sites and provide a more complete picture of the regional Amadzimba. Collectively, these future studies would contribute to a more thorough understanding of the Amadzimba in the Matobo and across Zimbabwe.

5. Conclusion

Microlithic backed tools are characteristic formal tools that occur in most late Holocene lithic assemblages in southern Africa. In Zimbabwe, the late Holocene Amadzimba, dated between ca. 5800 and 2300 BP, is marked by a proliferation of these tools of various shapes and sizes. They are found at sites such as Bambata and Pomongwe Caves and they predominate formal tool samples, which suggests they were commonly used by populations in the Matobo during this period.

The present study focused on the microlithic backed tools from Pomongwe Cave, and a sample of 138 specimens were analysed from units II and III, which correspond to the late Holocene phase. We moved away from the previously used typological system that classified these tools based on geometric shapes and instead, adopted a morpho-functional approach, classifying the tools based on morphometric criteria and summarising the observed variations in their structure (active versus passive parts).

Our findings demonstrate that mono-point centred backed tools were likely used for drilling, while mono-point off centred and double points were laterally and disto-laterally hafted as barbs on an arrow shaft. We further propose the existence of composite tool technology at Pomongwe Cave, where backed pieces were hafted in sequence to form hunting weapons designed to maximise penetration, laceration, and retention, and where hafting components could be substituted when damaged to ensure a successful hunt.

These results fill a gap in understanding late Holocene hunting weaponry at Pomongwe Cave, where evidence has been limited. The study also opens avenues for future discussions on hunting weaponry in the Matobo. Compared to other regions, the Amadzimba at Pomongwe Cave may represent a unique expression, with the proliferation of backed tools possibly linked to changes in subsistence strategies, population growth, and improved climate. Our study thus contributes knowledge about the intricate behaviours and complex cultures of hunter-gatherers during the final phases of the LSA. Further investigation into microlithic backed tools and lithic assemblages from other late Holocene sites in Matobo is essential for deepening our understanding of the social and cultural transformations occurring during this period on a broader regional scale.

Acknowledgements
We acknowledge that this paper is based on research from Precious Chiwara-Maenzanise's Master's dissertation, completed at the University of Zimbabwe in 2018. We extend our gratitude to the University of Zimbabwe for providing a tuition waiver to Precious Chiwara-Maenzanise. The analysis of microlithic backed tools in France was funded by the Matobart project, led by Camille Bourdier, for which we are thankful. Additional financial support was provided by the French Ministry of Foreign Affairs and the *Agence Nationale de la Recherche* (project ANR-21-CE27-0030-01). Special thanks to Lorene Chesnaux for her guidance and support during the use-wear analysis in France and to Alexandra Legrand Pineau for allowing us to take photographs using their microscopes at Nanterre University in Paris. We also thank Humphrey Nyambiya for the map, and the reviewers and editors of Southern African Field Archaeology for their insightful comments that have improved the manuscript.

References
Ambrose, S.H. 2002. Small things remembered: Origins of early microlithic industries in sub-Saharan Africa. Archaeological Papers of the American Anthropological Association, 12(1): 9-29.
Armstrong, A.L. 1931. Rhodesian archaeological expedition 1929: Excavations in Bambata Cave and research on prehistoric sites in Southern Rhodesia. Journal of the Royal Anthropological Institute, 61: 239-276.
Attenbrow, V., Robertson, G. & Hiscock, P. 2009. The changing abundance of backed artefacts in south-eastern Australia: A response to Holocene climate change? Journal of Archaeological Science, 36(12): 2765-2770.
Barham, L.S. 1992. Let's walk before we run: An appraisal of historical materialist approaches to the Later Stone Age. South African Archaeological Bulletin, 47: 44-51.
Bourdier, C. 2019. Peintures rupestres et environnements culturels des Matobo, Zimbabwe. Lesedi, 23: 25-29.
Bourdier, C., Dudognon, C., Frouin, M., et al. 2020. Approche interdisciplinaire de la paroi ornée: Pomongwe Cave et le program Matobart. Lesedi, 23: 13-18.
Bronk Ramsey, C. 2017. Methods for summarising radiocarbon datasets. Radiocarbon, 59: 1809-1833.
Brooks, A.S. & Yellen, J.E. 1977. Archaeological excavations at ≠Gi: A preliminary report on the first two field seasons. Botswana Notes and Records, 9: 21-30.
Charrié-Duhaut, A., Porraz, G., Igreja, M., et al. 2016. Holocene hunter-gatherers and adhesive manufacture in the West Coast of South Africa. Southern African Humanities, 29(1): 283-306.
Chesnaux, L. 2013. Microliths from 62 rue Henry-Farman, Paris (15th arrondissement): Specific arrows for different types of game hunted in particular places. In: Valentin, B., Souffi, B., Ducrocq, T., et al. (eds) Mesolithic palethnography research on open-air sites between Loire and Neckar, proceedings of the international round-table meeting, Paris, November 26-27, 2010: 119-132. Paris: Société préhistorique française.
Chesnaux, L. 2014. Variability in the manufacturing of triangular geometric microliths during the early Mesolithic: Toward a simplification of barb manufacturing? A comparative techno-functional analysis of microlithic assemblages from Saint-Lizier at Creysse (24) and La Grande Rivoire at Sassenage (38). Palethnologie. Archéologie et Sciences Humaines, 6: 55-63.
Chiwara-Maenzanise, P. 2018. Morpho-functional variability of the late Holocene microlithic backed tools from Pomongwe Cave, Matobo, Western Zimbabwe. Masters Dissertation. Harare: University of Zimbabwe.
Clarkson, C., Hiscock, P., Mackay, A., et al., 2018. Small, sharp, and standardised: Global convergence in backed microlith technology. In: O'Brien, M., Buchanan, B. & Eren, M. (eds) Convergent Evolution in Stone-tool Technology: 175-200. Cambridge: MIT Press.
Claud, E. 2008. Le statut fonctionnel des bifaces au Paléolithique moyen récent dans le Sud-Ouest de la France. Étude tracéologique intégrée des outillages des sites de La Graulet, La Conne de Bergerac, Combe Brune 2, Fonseigner et Chez-Pinaud / Jonzac. Doctoral Thesis. Bordeaux: University of Bordeaux.
Close, A.E. & Sampson, C.G. 1998a. Backed microlith clusters in late Holocene rock shelters of the Upper Karoo. South African Archaeological Bulletin, 53: 63-72.
Close, A.E. & Sampson, C.G. 1998b. Recent backed microlith production in central South Africa. Lithic Technology, 23(1): 5-19.
Cooke, C.K. 1963. Report on excavations at Pomongwe and Tshangula Caves, Matopo Hills, Southern Rhodesia. South African Archaeological Bulletin, 18 (7): 73-151.
Cooke, C.K. & Robinson, K.R. 1954. Excavations at Amadzimba Cave, Matopo Hills, Southern Rhodesia. Occasional Papers of the National Museum of Southern Rhodesia, 2(19): 699-728.

Coppe, J. & Rots, V. 2017. Focus on the target. The importance of a transparent fracture terminology for understanding projectile points and projecting modes. Journal of Archaeological Science: Reports, 12: 109-123.

Deacon, J. 1984. The Later Stone Age of Southernmost Africa. Oxford: British Archaeological Reports Publishing.

Denbow, J. 1986. A new look at the later Prehistory of the Kalahari. Journal of African History, 27(1): 3-28.

Dudognon, C., Frouin, M., Touron, S., et al. 2021. Recherche, conservation et valorisation d'un patrimoine mondial: Des défis multiples dans les Matobo, Zimbabwe. In: Favel, B., Gaultier-Kurhan, C. & Heimlich, G. (eds) Art Rupestre et Patrimoine Mondial en Afrique Subsaharienne: 67-90. Paris: Hemispheres Editions.

Fischer, A., Hansen, P.V. & Rasmussen, P. 1984. Macro and micro wear traces on lithic projectile points: Experimental results and prehistoric examples. Journal of Danish Archaeology, 3(1): 19-46.

Forssman, T. 2017. Foragers and trade in the middle Limpopo Valley, c. 1200 BC to AD 1300. Azania: Archaeological Research in Africa, 52: 49-70.

Fullagar, R. 2016. Uncertain evidence for weapons and craft tools: Functional investigations of Australian microliths. In: Iovita, R. & Sano, K. (eds) Multidisciplinary Approaches to the Study of Stone Age Weaponry. Vertebrate Paleobiology and Paleoanthropology: 159-166. Dordrecht: Springer.

Goldstein, S.T. & Shaffer, C.M. 2017. Experimental and archaeological investigations of backed microlith function among mid-to-late Holocene herders in southwestern Kenya. Archaeological and Anthropological Sciences, 9: 1767-1788.

Guillemard, I. 2020a. Change and continuity in the lithic technologies from final to ceramic final Later Stone Age, Limpopo Basin, South Africa. Doctoral Thesis. Johannesburg: University of the Witwatersrand.

Guillemard, I. 2020b. Equating language, genes and subsistence? The appearance of herding in southern Africa. Azania: Archaeological Research in Africa, 55(1): 97-120.

Guillemard, I. 2024. Exploring Wilton microlithic technologies: New analyses from Rose Cottage Cave, South Africa. Quaternary Science Reviews, 333: 108679.

Guillemard, I. & Porraz, G.E. 2019. What is a Wilton scraper? Perspectives from the late Holocene assemblage of Balerno Main Shelter, Limpopo Province, South Africa. Southern African Humanities, 32: 135-162.

Hall, S.L. 1990. Hunter-gatherer-fishers of the Fish River Basin: A contribution to the Holocene prehistory of the Eastern Cape. Doctoral Thesis. Stellenbosch: Stellenbosch University.

Hiscock, P. 1994. Technological responses to risk in Holocene Australia. Journal of World Prehistory, 8: 267-292.

Hiscock, P. 2006. Blunt and to the point: Changing technological strategies in Holocene Australia. In: Lilley, I. (ed.) Archaeology in Oceania: Australia and the Pacific Islands: 69-95. Oxford: Blackwell Publishing.

Hiscock, P., Clarkson, C. & Mackay, A. 2011. Big debates over little tools: Ongoing disputes over microliths on three continents. World Archaeology, 43(4): 653-664.

Hogg, A.G., Hua, Q., Blackwell, P.G., et al. 2013. SHCal13 southern hemisphere calibration, 0-50,000 years cal BP. Radiocarbon, 55(4): 1889-1903.

Inizan, M.L., Reduron-Ballinger, M., Roche, H., et al. 1999. Technology and Terminology of Knapped Stone. Nanterre: CREP.

Jones, N. 2013. The Prehistory of Southern Rhodesia. Second Edition. Cambridge: Cambridge University Press.

Kinahan, J. 2019. The origins and spread of pastoralism in southern Africa. Oxford Research Encyclopedia of African History. Available from: https://doi.org/10.1093/acrefore/9780190277734.013.678 (Accessed: 2025).

Lewis, L. 2015. Early microlithic technologies and behavioural variability in southern Africa and South Asia. Doctoral Thesis. Oxford: University of Oxford.

Lombard, M. & Badenhorst, S. 2019. A case for springbok hunting with kite-like structures in the northwest Nama Karoo bioregion of South Africa. African Archaeological Review, 36(3): 383-396.

Lombard, M., Wadley, L., Deacon, J., et al. 2012. South African and Lesotho Stone Age sequence updated (I). South African Archaeological Bulletin, 67(195): 123-144.

Lombard, M., Caruana, M.V., van der Walt, J., et al. 2020. The Keimoes 3 desert kite site, South Africa: An aerial lidar and micro-topographic exploration. Antiquity, 94 (373): 197-211.

Lombard, M., Lotter, M.G., van der Walt, J., et al. 2021. The Keimoes Kite Landscape of the trans-Gariep, South Africa. Archaeological and Anthropological Sciences, 13: 1-22.

Lombard, M., Bradfield, J., Caruana, M.V., et al. 2022. The Southern African Stone Age sequence updated (II). South African Archaeological Bulletin, 77(217): 172-212.

Lotter, M.G., Forssman, T., Bielderman, S., et al. 2023. Using aerial survey to record new sites in the Keimoes kite landscape of South Africa. Southern African Field Archaeology 18: 2421.

Marreiros, J., Mazzucco, N., Gibaja, J., et al. 2015. Macro and micro evidences from the past: The state of the art of archaeological use-wear studies. In: Marreiros, J., Gibaja Bao, J. & Ferreira Bicho, N. (eds) Manuals

in Archaeological Method, Theory and Technique: Use-Wear and Residue Analysis in Archaeology: 5-26. New York: Springer.
Matembo, J. 2019. The Middle and Later Stone Age crystal quartz technologies of Pomongwe Cave, Matopos (Zimbabwe). Masters Dissertation. Johannesburg: University of the Witwatersrand.
Mazel, A.D. 1989. People making history: The last ten thousand years of hunter-gatherer communities in the Thukela Basin. Southern African Humanities, 1: 1-168.
Miller, D., Yates, R.J., Jerardino, A., et al. 1995. Late Holocene coastal change in the southwestern Cape, South Africa. Quaternary International, 29/30: 3-10.
Mitchell, P. 2005. Modelling Later Stone Age societies in southern Africa. In: Stahl, A.B. (ed.) African Archaeology: A Critical Introduction: 150-117. Oxford: Blackwell Publishing.
Mitchell, P. 2024. The Archaeology of Southern Africa. Cambridge: Cambridge University Press.
Mnkandla, T. 2019. A reconstruction of palaeoenvironmental conditions in Matobo World Heritage landscape: A geoarchaeological perspective. Masters Dissertation. Harare: University of Zimbabwe.
Nhunzvi, J. 2019. Diversity in Late Stone Age Art in Zimbabwe. An elemental and mineralogical study of pigments (ochre) from Pomongwe Cave, Matobo Hills, Western Zimbabwe. Masters Dissertation. Harare: University of Zimbabwe.
Nhunzvi, J., Nhamo, A., Dayet, L., et al. 2020. Diversity in Late Stone Age Art in Zimbabwe. Lesedi, 23: 23-26.
Pargeter, J. 2011. Assessing the macrofracture method for identifying Stone Age hunting weaponry. Journal of Archaeological Science, 38(11): 2882-2888.
Pargeter, J. 2016. Lithic miniaturisation in late Pleistocene southern Africa. Journal of Archaeological Science: Reports, 10: 221-236.
Parkington, J.E. 1987. Changing views of prehistoric settlement in the western Cape. In: Parkington, J.E. & Hall, M. (eds) Papers in the Prehistory of the Western Cape, South Africa: 4-23. Oxford: British Archaeological Reports.
Parkington, J.E, Cable, C., Carter, P.L., et al. 1980. Time and place: Some observations on spatial and temporal patterning in the Later Stone Age sequence in southern Africa [with comments and reply]. South African Archaeological Bulletin, 132: 73-112.
Pétillon, J.M., Bignon, O., Bodu, P., et al. 2011. Hard core and cutting edge: Experimental manufacture and use of Magdalenian composite projectile tips. Journal of Archaeological Science, 38(6): 1266-1283.
Porraz, G.E., Chiwara-Maenzanise P., Haaland, M., et al. 2020. Les sous-sols de l'art rupestre à l'abri Pomongwe (Matobo, Zimbabwe). Lesedi, 23: 18-22.
Porraz, G., Nhamo, A. & Bourdier, C. 2023. Pomongwe Cave, Zimbabwe. In: Beyin, A., Wright, D.K., Wilkins J., et al. (eds) Handbook of Pleistocene Archaeology of Africa: Hominin Behaviour, Geography, and Chronology: 1225-1237. Springer: Cham.
Rots, V. 2005. Wear traces and the interpretation of stone tools. Journal of Field Archaeology, 30(1): 61-73.
Sadr, K. 2015. Livestock first reached southern Africa in two separate events. PLoS ONE, 10(8): e0134215.
Sadr, K. 2019. Atop Kasteelberg: Social complexity in the Later Stone Age of South Africa. African Archaeological Review, 36: 89-103.
Sano, K. 2009. Hunting evidence from stone artefacts from the Magdalenian Cave site Bois Laiterie, Belgium: A fracture analysis. Quartär, 56: 67-86.
Sealy, J. 2006. Diet, mobility and settlement pattern among Holocene hunter-gatherers in southernmost Africa. Current Anthropology, 47(4): 569-595.
Sherwood, N.L. & Forssman, T. 2024. Ostrich eggshell beads: Hole drilling technology at Little Muck Shelter, South Africa. Journal of Archaeological Science, 172: 106091.
Stewart, B.A. & Mitchell, P.J. 2018. Late Quaternary paleoclimates and human-environment dynamics of the Maloti-Drakensberg region, southern Africa. Quaternary Science Reviews, 196: 1-20.
Taipale, N., Chiotti, L. & Rots, V. 2022. Why did hunting weapon design change at Abri Pataud? Lithic use-wear data on armature use and hafting around 24,000-22,000 BP. PLoS ONE, 17(1): e0262185.
Tomasso, A., Rots, V., Purdue, L., et al. 2018. Gravettian weaponry: 23,500-year-old evidence of a composite barbed point from Les Prés de Laure (France). Journal of Archaeological Science, 100: 158-175.
van der Walt, J. & Lombard, M. 2018. Kite-like structures in the Nama Karoo of South Africa. Antiquity, 92(363): 1-6.
Veall, M.A. 2022. Hafting technology in the Stone Age of southern Africa. Oxford Research Encyclopedia of Anthropology. Available from: https://doi.org/10.1093/acrefore/9780190854584.013.60. (Accessed: 2025).
Wadley, L. 1996. Changes in the social relations of precolonial hunter-gatherers after agropastoralist contact: An example from the Magaliesberg, South Africa. Journal of Anthropological Archaeology, 15: 207-217.
Wadley, L. 2000. The Wilton and pre-ceramic post-classic Wilton Industries at Rose Cottage Cave and their context in the South African sequence. South African Archaeological Bulletin, 55(172): 90-106.
Wadley, L. & Binneman, J. 1995. Arrowheads or pen knives? A microwear analysis of mid-Holocene stone

segments from Jubilee Shelter, Transvaal. South African Journal of Science, 91(3):153-155.

Walker, N.J. 1995. Late Pleistocene and Holocene Hunter-gatherers of the Matopos: An Archaeological Study of Change and Continuity in Zimbabwe. Uppsala: Societas Archaeologica.

Walker, N.J. & Thorp, C. 1997. Stone Age archaeology in Zimbabwe. In: Pwiti, G. (ed.) Caves, Monuments and Texts. Zimbabwean Archaeology Today: 9-32. Uppsala: Societas Archaeologica.

Way, A.M., de la Peña, P., de la Peña, E., et al. 2022. Howiesons Poort backed artefacts provide evidence for social connectivity across southern Africa during the Final Pleistocene. Scientific Reports, 12(1): 9227.

Wiessner, P. 1983. Style and social information in Kalahari San projectile points. American Antiquity, 48(2): 253-276.

Yaroshevich, A., Nadel, D. & Tsatskin, A. 2013. Composite projectiles and hafting technologies at Ohalo II (23 ka, Israel): Analyses of impact fractures, morphometric characteristics and adhesive remains on microlithic tools. Journal of Archaeological Science, 40(11): 4009-4023.

Southern African Field Archaeology
2025 Vol. 20: Article 3540
Research report (peer-reviewed): Received October 2024; Revised February 2025; Published May 2025
DOI: https://doi.org/10.36615/safa.20.3540.2025

ISSN 1019-5785
ISSN 2789-1844

Archaeological survey of the Modder River dongas, Free State, South Africa

Felipe Cuartero Monteagudo [a, b, *], Maïlys Richard [c, d], Lloyd Rossouw [e, f] & Michael B. Toffolo [a, c, e, *]

[a]Geochronology and Geology Programme, National Research Centre for Human Evolution (CENIEH), Paseo Sierra de Atapuerca 3, 09002 Burgos, Spain
[b]Department of History and Philosophy, University of Alcalá, Calle Colegios 2, 28801 Alcalá de Henares, Spain
[c]Archéosciences Bordeaux, UMR 6034 CNRS-Bordeaux Montaigne University, Esplanade des Antilles, 33607 Pessac, France
[d]Department of Early Prehistory and Quaternary Ecology, University of Tübingen, Burgsteige 11, 72070 Tübingen, Germany
[e]Department of Plant Sciences, University of the Free State, Zastron Street, 9301 Bloemfontein, South Africa
[f]Florisbad Quaternary Research Department, National Museum Bloemfontein, 9301 Bloemfontein, South Africa
Corresponding author email: felipe.cuartero@uah.es, michael.toffolo@u-bordeaux-montaigne.fr

ABSTRACT
The semi-arid grasslands of the Free State Province of South Africa have produced the earliest evidence of the presence of *Homo sapiens* in the subcontinent, together with an extensive Pleistocene palaeoenvironmental record based on fossil assemblages. However, the known Middle Stone Age (MSA) archaeological sites in the Free State are limited to a few major localities that cannot be integrated into a unitary narrative, thus hindering our understanding of human cultural evolution in the central interior of South Africa. Here we report the results of a survey of the dongas of the Modder River aimed at documenting new localities embedded within its alluvial terraces. We identified 43 previously unknown archaeological areas spanning the Late Pleistocene to Holocene based on the regional chronology, of which the majority are MSA sites. Four of the latter include artefacts *in situ* and thus hold potential for excavation and absolute dating by trapped-charge methods. The occurrence of a specific lithic type at six sites along the course of the river highlights a pattern in the occupation of the region during Marine Isotope Stage 5, which confirms the importance of the grasslands of the central interior for the characterisation of the spatiotemporal distribution of human groups in the open landscape during the MSA.

Keywords: Pleistocene; South Africa; Modder River; Middle Stone Age; Later Stone Age

1. Introduction

Homo sapiens emerged in Africa in the late Middle Pleistocene, around 300 000 years ago, and their appearance broadly overlaps with the onset of the Middle Stone Age (MSA) (Deino et al. 2018; Bergström et al. 2021). This archaeological period is characterised by increased evidence of symbolism (e.g., Bouzouggar et al. 2007; Watts et al. 2016; d'Errico et al. 2020), social networking (e.g., Lombard 2012; Brooks et al. 2018; Stewart et al. 2020), technological advancements in tool manufacture (e.g., Wadley et al. 2009; Mourre et al. 2010), and use of fire (e.g., Schmidt et al. 2020; Wadley et al. 2020a, b). In addition, the MSA saw a persistent population expansion into a wide range of ecosystems, including deserts, rainforests, and high mountains, which were only marginally occupied in earlier periods (Jones & Stewart 2016; Roberts & Stewart 2018).

In southern Africa, the earliest *H. sapiens* fossil is from the interior of the subcontinent, where the Florisbad spring site in the Free State Province of South Africa (henceforth Free State) produced the partial cranium of a basal *H. sapiens* (Dreyer 1935; Clarke 1985; Grün et al. 1996; Grün & Stringer 2023). The site also yielded one of the few dated assemblages of early MSA lithic artefacts in South Africa (Kuman et al. 1999) and a palaeoenvironmental sequence based on pollen and sedimentary analyses (Rubidge & Brink 1985; Kuman et al. 1999; Toffolo et al. 2015, 2017; Scott et al. 2019), and it is the type locality of the Florisian Land Mammal Age (Brink 1987, 1988, 1994; Brink & Lee-Thorp 1992; Brink & Henderson 2001; Codron et al. 2008; Manegold & Brink 2011). The latter indicates the existence of an extensive system of palaeolakes and wetlands in this region during the Middle and Late Pleistocene, which supported large animal populations in an open grassland ecosystem (Brink 2016).

Recent research in the Kalahari Basin has produced palaeoenvironmental evidence that confirms the importance of the arid and semi-arid interior of southern Africa in the evolution of early *H. sapiens* (Wilkins 2021; Wilkins et al. 2021; Burrough et al. 2022; Lukich & Ecker 2022; Ecker et al. 2023). However, despite this renewed interest and the growing number of studies focused on the interior of southern Africa, only a few archaeological sites offer accurate and long chronologies, and as a result vast swathes of land remain archaeologically blank with regard to the Pleistocene record, especially in the case of the grasslands of the Free State (Toffolo 2024). This hinders a proper assessment of human settlement dynamics in the region and our ability to establish causal links between climate change and human adaptive strategies (e.g., Faith et al. 2021).

In this paper, we report the results of an archaeological survey of the Modder River in the western Free State, which was carried out with the aim of documenting the occurrence of artefacts and fossils within dongas. Dongas are a common geomorphological feature in the South African landscape, comprising extensive erosional gullies and crests produced by surface runoff of water during thunderstorms in areas characterised by poor plant cover. These features are found mainly in river terraces and less frequently in lunette dunes around pans, and are especially important for archaeologists because they offer a comprehensive view of Pleistocene stratigraphy and often contain stratified sites (e.g., Brink et al. 1999; de la Peña & Witelson 2020; Will et al. 2024). This aspect is particularly crucial because the presence of a sedimentary matrix allows the application of trapped-charge dating methods, which is not possible when artefacts and fossils are found in surface scatters.

Portions of the Modder have been the object of surveys since at least the 1920s (e.g., Goodwin & van Riet Lowe 1929), although they were rarely published (Churchill et al. 2000; Rossouw 2006) and usually confined to archaeological impact assessments (e.g., by the National Museum Bloemfontein) and dissertations (Tsokeli 2005; Trower 2010). Excavations, on the other hand, have been focused on only a handful of sites, such as Kranskraal (van Hoepen 1932), Erfkroon (Bousman et al. 2023), Lovedale (Wroth et al. 2022), and Damvlei (Toffolo et al. 2023). In 2022, we initiated a new survey programme of all the dongas along the major rivers in the western Free State as part of the project 'PalaeoEcology and OPen-LandscapE adaptations of Pleistocene humans in South Africa' (PEOPLE), which aims to understand the role that freshwater availability had in the evolution of *H. sapiens* in the semi-arid grasslands of the Free State. Therefore, this study presents the first comprehensive survey of the Modder dongas between Rustfontein Dam and the Rademansval locality and a description of all the archaeological areas that were encountered. The sites are discussed within the chronological and archaeological context of the Free State and help build an archaeological map of the Modder catchment.

2. Regional setting

The Modder is a meandering river that flows ~370 km through the western Free State in a south-north direction from its headwaters near Dewetsdorp to Maselspoort, and then in an east-west direction until its confluence into the Riet River at Modderrivier, immediately to the west of the border with the Northern Cape (Barker 2011) (Fig. 1). Together with the Riet and the Vet-Sand, the Modder is one of the few rivers flowing in the semi-arid western Free State, which is mainly part of the Grassland Biome (Dry Highveld Grassland Bioregion) but includes also the Savanna Biome (Eastern Kalahari Bushveld Bioregion) at the border with the North West and Northern Cape and the Nama-Karoo Biome (Upper Karoo Bioregion) at the border with the Northern Cape (Mucina & Rutherford 2006).

The catchment of the Modder River (17 360 km^2) is characterised by a narrow valley bordered by dolerite hills and sills in its eastern portion (east of Bloemfontein), whereas the western portion features a wide valley with a deeply incised riverbed and local gradient ≤1°, which exposed a series of alluvial terraces (Myburgh 1997; Barker 2011; Tooth et al. 2013). The latter are in many places further incised by dongas, which produced archaeological sites such as Erfkroon, Lovedale, Damvlei, Mitasrust, Kranskraal, and Waterval. Other known sites within the Modder catchment include Florisbad, Vlakkraal (Wells et al. 1942), and Baden-Baden (van Aardt et al. 2016) (Fig. 2).

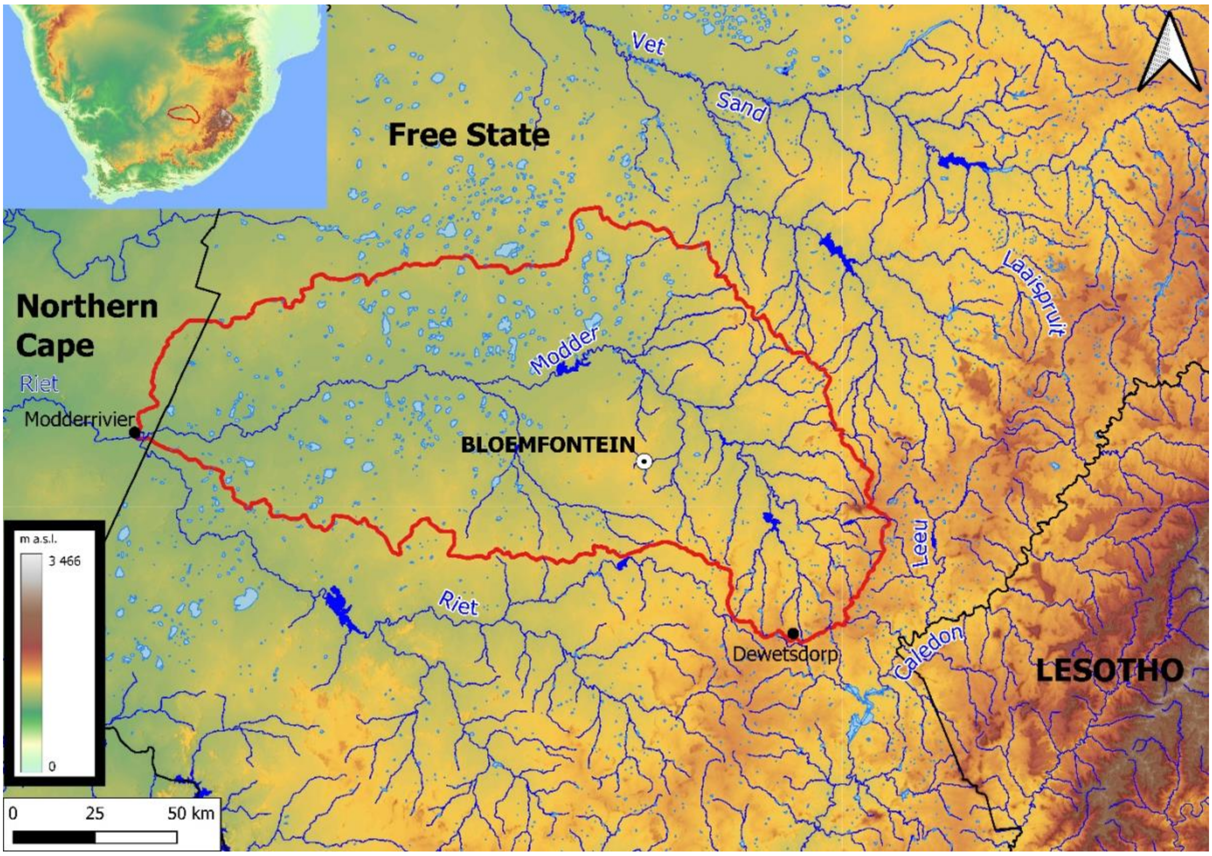


Figure 1. Map of the western Free State showing the location of the Modder River catchment (red line). The inset shows the location of the catchment within southern Africa. Digital elevation model (DEM): Shuttle Radar Topography Mission (SRTM) 1-arc second Global, National Geospatial-Intelligence Agency (NGA), USGS Earth Resources Observation and Science (EROS), retrieved from NASA Earthdata; Hydrography and borders: Department of Water and Sanitation (DWS), South Africa, and Mucina & Rutherford (2006); Topography: Esri Topographic (basemap) and World Topographic Map (available from: https://www.arcgis.com/home/item.html?id=7dc6cea0b1764a1f9af2e679f642f0f5).

At least three alluvial terraces are known to exist between five and 33 m above the Modder riverbed, although in discontinuous portions along its course (Myburgh 1997). Detailed sedimentological, chronological, and archaeological research at Erfkroon, a donga located on the right bank of the Modder 67 km northwest of Bloemfontein, produced a chronostratigraphic sequence of four alluvial terraces (Churchill et al. 2000; Tooth et al. 2013; Lyons et al. 2014; Palmison 2014; Brink et al. 2016; Morris 2019; Bousman et al. 2023). These terraces are called, from oldest to youngest, Wolwespruit, Erfkroon, Orangia, and Soetdoring (Fig. 3). Only the Orangia terrace bears artefacts and fossils, which punctuate a sedimentary sequence representing the Late Pleistocene and Holocene divided into four major allostratigraphic units and comprising two palaeosols and five lithostratigraphic beds (Bousman et al. 2023). More specifically, the Lower Grey Bed includes MSA occupations dated by luminescence between ~99 and ~55 ka; the van den Berg (Red) Palaeosol comprises late MSA occupations dated between ~55 and ~28 ka; the rubified silt at the base of the Upper Grey Bed produced an early Later Stone Age (LSA) occupation dated to ~21 ka; the upper portion of the Upper Grey Bed yielded an undated Robberg occupation; and the Neethling (Brown) Palaeosol is characterised by Lockshoek (Oakhurst) occupations, which in South Africa are dated to the first half of the Holocene (Lombard et al. 2022). Remarkably, a similar stratigraphic sequence comprising a Lower Grey Bed with MSA artefacts, a Red Palaeosol with late MSA artefacts, an Upper Grey Bed with LSA artefacts, and a brown sediment with LSA artefacts, was identified at Waterval, a donga located on the right bank of the Modder near Sannaspos, 32 km east of Bloemfontein and 94 km southeast of Erfkroon as the crow flies, suggesting that the chronostratigraphic sequence established at Erfkroon may be applicable all along the course of the river (Trower 2010). This stratigraphic framework was used as reference during the survey to help contextualise different MSA clusters within the same donga and to facilitate comparisons between dongas. Not all surveyed dongas exhibit the complete Orangia sequence, presumably because of advanced erosion, and thus assigning artefacts to one bed or another remains difficult in some cases due to the absence of absolute ages. In addition, one should keep in mind that the Red Palaeosol developed on pre-existing sediments, and therefore its age may vary to some extent along the river. Nevertheless, the Erfkroon stratigraphy is a good starting point to propose a relative chronological sequence for the findings of the survey.

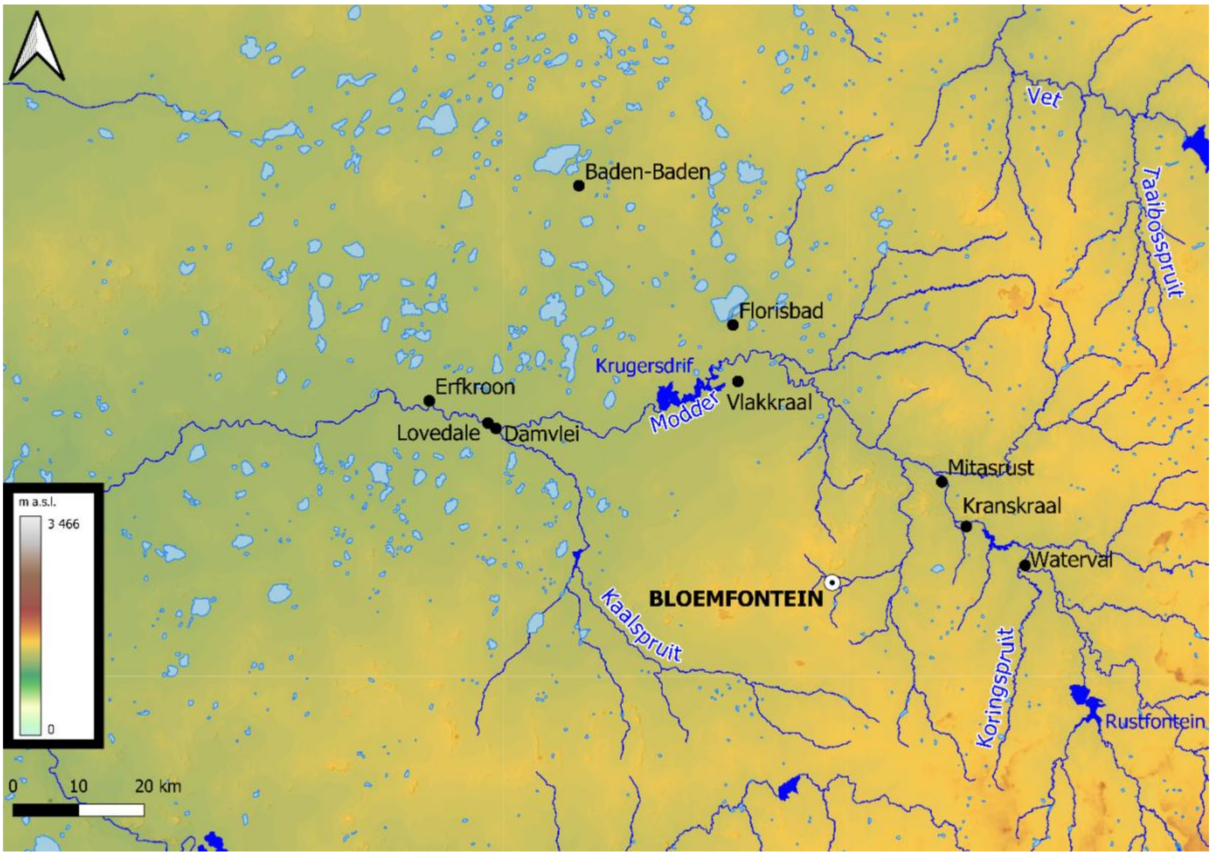


Figure 2. Map of the Modder River basin showing the location of known archaeological sites. The pale blue patches represent saltpans, whereas the dark blue patches represent dams. DEM: SRTM 1-arc second Global, NGA, USGS EROS, retrieved from NASA Earthdata; Hydrography and borders: DWS, South Africa, and Mucina & Rutherford (2006); Topography: Esri Topographic (basemap) and World Topographic Map (available from: https://www.arcgis.com/home/item.html?id=7dc6cea0b1764a1f9af2e679f642f0f5).

3. Methods

Our survey of the Modder dongas spanned the portion of the river between Rustfontein Dam, 50 km to the southeast of Bloemfontein, and the locality of Rademansval, 90 km to the west of Bloemfontein, covering almost 160 km of its course. Dongas were identified using Google Earth, where they appear as light-coloured patches of land next to the riverbed that stand out compared to the surrounding vegetated areas. The historical imagery function allowed us to visualise dongas in different seasons (dry vs. wet) and under different light conditions, which is particularly useful to determine the presence of deeply incised gullies (based on the size of shaded areas) and to assess their potential for the preservation of Pleistocene deposits. We also used the imagery provided by the

CDNGI Portal of the Department of Rural Development and Land Reform of South Africa (http://www.cdngiportal.co.za/CDNGIPortal/) and the topographic map of South Africa (https://htonl.dev.openstreetmap.org/ngi-tiles/#6/-28.621/24.625). The selected dongas were surveyed on foot after locating the landowners and obtaining their permission to access the properties. No significant dongas exist between Rademansval and Modderrivier and for this reason that portion of the river was not surveyed.

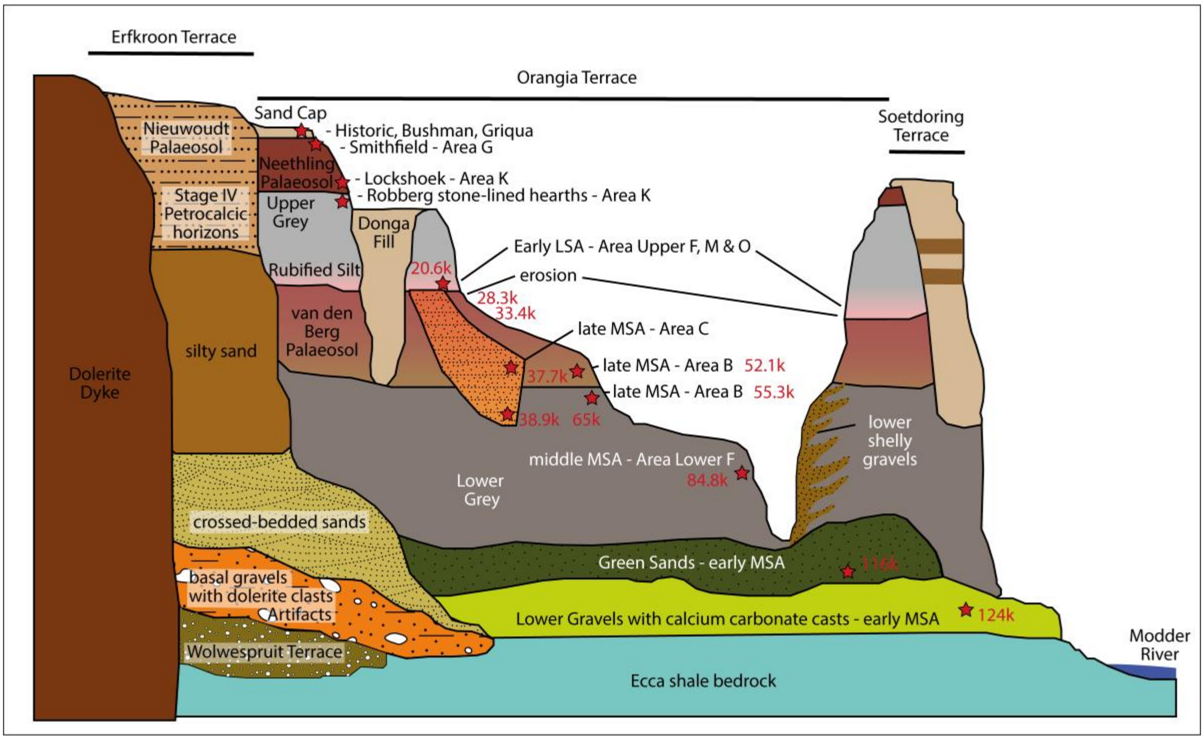


Figure 3. Stratigraphic cross-section of the Modder River terraces at Erfkroon (reproduced from Bousman et al. 2023 with permission from Springer Nature).

The survey comprised the visual inspection of exposed donga surfaces to identify clusters or concentrations of artefacts as well as single spots or occurrences of pieces in sections, and/or any associations between faunal remains and lithic artefacts. The dongas were first surveyed following their perimeters and main drainage channels to establish the local stratigraphic sequence and to locate artefact concentrations. Then, each donga was systematically surveyed in the areas that showed significant concentrations of knapped artefacts and/or fossils, counting first these archaeo-palaeontological remains with overall counts by area. After, we determined (by visual assessment) the centroid of each area based on it having a higher artefact/fossil density. We identified archaeological areas when clusters of 10 or more artefacts occurred within a surface area of 10 000 m^2 (density ratio=0.001 artefacts per m^2); lower densities were considered as isolated findings. The boundary between archaeological areas was arbitrarily set when there was a distance of at least 100 m from the centroid (cluster) of an archaeological area and the next. In addition, the stratigraphic framework established by Bousman et al. (2023) at Erfkroon and Trower (2010) at Waterval was used as reference to distinguish archaeological areas of different age. Artefacts and faunal remains were recorded by GPS, documented with photographs and analysed in 1 m square grids. This grid was placed at the centroid and counts were recorded of all recognisable knapped artefacts including chips under 2 cm, but excluding chunks or angular fragments where intentional knapping could not be identified. After each count the grid was moved to neighbouring parts of the cluster/concentration, as many times as necessary, until reaching artefact densities of $<1/m^2$. No artefacts or fossils were collected during survey; after study, they were placed in the same position where they were found.

The counts of stone tools have been compiled indicating their technological categories, the raw materials, the degree of preservation, and the sedimentary context where the artefacts were found. The technological categories are divided into cores, debitage, and retouched pieces. Retouched pieces follow some conventional terms such as sidescraper, endscraper, denticulate, notch, borer, burin, backed blade or bladelet, *pièce esquillée*, knife, unifacial point, adze, and geometric. We also include the counts of Lovedale points, "(…) a narrow tool made on a blade with trimmed tips and bifacially trimmed bases, which removes the striking platforms and most of the bulbs of percussion", due to their restricted geographical and chronological range in the Free State, which allows comparisons with dated sites in the region (Wroth et al. 2022: 11). Unknapped blocks or cobbles are classified into cobble, block, hammerstone, and grindstone categories. Debitage is classified as non-diagnostic flake, flake fragment, blade, blade fragment, small flakes and chips (<2 cm), *Levallois* point, and *Levallois* flake categories. The size of the artefacts is classified into large (>8 cm), medium (4 to 8 cm), small (<4 to 2 cm), and microlithic (<2 cm) categories. The classification of cores follows Conard et al. (2004) and includes parallel (*Levallois*), platform, inclined (discoidal), initial, bipolar, and multidirectional types. When further details are considered in platform cores, the most abundant type in our surveys, we follow the classification system of Porraz et al. (2016), which considers the following sub-types: high-backed, narrow-sided, frontal, conic, bipolar, and bipolar reduced. Furthermore, when some additional details are described for retouched tools, we define the invasiveness of the retouch according to Bader et al. (2016), which essentially simplify the criteria of Clarkson (2002). All the artefacts that we found are made on hornfels unless otherwise specified, as hornfels is the only locally available raw material used during the MSA.

The depositional context of the artefacts was recorded according to their primary or secondary positions, indicating the landform where the artefacts were found. Primary contexts include artefacts identified in vertical sections that are naturally exposed by the erosional processes at work in dongas, usually within convex slopes or ridges. Artefacts found on the surface were considered to be in secondary contexts. Similarly, artefacts located on concave slopes, flat steps (eroded high surfaces) or gullies belong to the category of secondary contexts. We also distinguished palaeochannels in exposed sections, where erosion and transport took place in the past and thus redeposited older material. Based on the stratigraphic position of our findings, we specified the main sedimentary features of the layer containing them (visible or preserved thickness of the deposit, matrix and clast composition, colour) and their relative position compared to other layers.

4. Results

We identified 34 dongas with potential for preserving deep (>2 m) stratigraphic sequences, of which 25 were surveyed on foot; the remainder could not be accessed because we could not locate the owners or they did not want to provide access for different reasons (e.g., presence of large game) (Table 1). During the survey, we recorded 755 lithic artefacts and 28 faunal remains (whole or fragmented). The Supplementary Online Material (SOM) reports artefact counts by technological category (SOM 1 Tables 1-17) and by raw material (SOM 1 Tables 18-27) and provides descriptions of the main finds (SOM 1 Figs 1-50). The dongas and the archaeological areas they contain are described following the course of the river, downstream from Rustfontein Dam to the Rademansval locality, and are divided into eastern and western catchments. The former goes from Rustfontein Dam to Maselspoort, whereas the latter spans from Krugersdrif Dam to Rademansval. This arbitrary division is proposed because only one donga of interest exists between Maselspoort and Krugersdrif Dam, but it could not be accessed (Molhoek). The eastern catchment includes 10 dongas, six of which were surveyed: Palmietfontein 1 and 2, Watervalsdrift, Waterval, Kranskraal, and Mitasrust (Fig. 4). Kranskraal, which was excavated by van Hoepen (1932) and produced an MSA occupation, is not reported here as it will be the subject of a dedicated study. The western catchment includes 23 dongas, 19 of which were surveyed: Uitvlug-Wes, Georgina 1 and 2, Lovedale 2, Abrahamskraal 1-3, 4 and 5, Nielsview 1, 2, 3, and 4, Thorndale, Erfkroon 2, 3, and 4, Penhoek, Winterdraai/Fairview, Slagkraal, and Loogkop (Fig. 5).

Eastern catchment

Palmietfontein: Palmietfontein 1 and 2 have a relatively wide surface but shallow reliefs because of advanced erosion. Palmietfontein 1 features a single archaeological area (A1) characterised by grey sediments comprising sandy clay (in places exhibiting a more reddish to brown colour) covered with small calcium carbonate nodules. One locale is characterised by a great number of rounded clasts of dolerite, shale, and hornfels, which are interpreted as a palaeochannel deposit. Only a few artefacts have been identified in this donga, including an isolated proximal *Levallois* point fragment and non-diagnostic rounded flakes and flake fragments in the palaeochannel gravels. The occurrence of the *Levallois* point fragment in the grey sediment may be interpreted as a parallel with the Lower Grey Bed at Erfkroon. Palmietfontein 2 exhibits a red horizon probably equivalent to the Red Palaeosol, which is almost completely eroded and features a single area with ridges up to 0.5-0.7 m in height in the central portion of the donga. Grey sandy clay, with calcium carbonate nodules, was observed underneath the red horizon, which may facilitate correlation with the Lower Grey Bed at Erfkroon. A total of eight non-diagnostic flakes of hornfels and sandstone were found on the slopes of the eroded Red Palaeosol, at the contact with the underlying grey sediment (SOM 1 Table 1; Figs 1-3).

Table 1. List of the selected dongas and their coordinates, following the course of the river, with stratigraphy indicated from top to bottom.

Donga	Catchment	Coordinates	Surface area (m^2)	Stratigraphy	Reference	SOM 1
Palmietfontein 1	Eastern	29°15'28.34" S 26°37'7.41" E	90 000	Lower Grey Bed	This study	Table 1 Figures 1-2
Palmietfontein 2	Eastern	29°15'8.94" S 26°36'56.40" E	26 000	Red Palaeosol Lower Grey Bed	This study	Table 1 Figure 3
Likatlong	Eastern	29° 9'5.93" S 26°35'7.44" E	-	-	Trower (2010)	-
Farm 1345	Eastern	29° 8'54.74" S 26°34'7.35" E	-	-	Trower (2010)	-
Rampaii	Eastern	29° 7'50.31" S 26°34'6.11" E	-	-	Trower (2010)	-
Jonkersdrift	Eastern	29° 6'50.58" S 26°32'33.24" E	-	-	Trower (2010)	-
Watervalsdrift	Eastern	29° 6'49.06" S 26°31'40.64" E	50 000	Upper Grey Bed	This study and Trower (2010)	Table 2 Figure 4
Waterval	Eastern	29° 6'12.40" S 26°31'26.69" E	153 000	Brown Palaeosol Upper Grey Bed Red Palaeosol Lower Grey Bed	This study and Trower (2010)	Tables 3, 18 Figures 5-10
Kranskraal	Eastern	29° 2'56.71" S 26°25'56.50" E	-	-	van Hoepen (1932)	-
Mitasrust	Eastern	28°59'14.24" S 26°23'40.17" E	112 000	Red Palaeosol Lower Grey Bed (with light grey-bluish clay)	This study and Rossouw (2006)	Tables 4, 19 Figures 11-18
Molhoek	Eastern	28°50'40.60" S 26° 9'47.76" E	-	-	Not surveyed	-
Uitvlug-Wes	Western	28°52'39.67" S 25°56'6.35" E	705 000	Upper Grey Bed Red Palaeosol Lower Grey Bed	This study	Table 5 Figures 19-20
Georgina 1	Western	28°54'43.95" S 25°53'12.83" E	80 000	Red Palaeosol Lower Grey Bed	This study	Table 6
Georgina 2	Western	28°55'3.72" S 25°52'36.63" E	180 000	-	This study	-
Wonderkop	Western	28°55'21.93" S 25°51'24.65" E	-	-	Not surveyed	-
Hoekpan	Western	28°53'59.00" S 25°49'46.05" E	-	-	Not surveyed	-
Stryd	Western	28°54'22.79" S 25°45'56.79" E	-	-	Not surveyed	-
Paardekraal	Western	28°54'31.83" S 25°44'46.68" E	-	-	Not surveyed	-
Lovedale 2	Western	28°54'3.07" S 25°40'28.39" E	8000	Upper Grey Bed Red Palaeosol Lower Grey Bed	This study	Tables 7, 20 Figure 21
Abrahamskraal 1,2,3	Western	28°53'28.66" S 25°39'44.48" E	70 000	Brown soil Light grey-bluish clay (Lovedale 1 sequence)	This study	Table 8
Abrahamskraal 4	Western	28°54'3.53" S 25°40'18.13" E	34 000	Upper Grey Bed Red Palaeosol Lower Grey Bed	This study	Table 9
Abrahamskraal 5	Western	28°53'56.79" S 25°37'29.43" E	117 000	Lower Grey Bed (with light grey-bluish clay)	This study	Tables 10, 21 Figures 22-28

Donga	Catchment	Coordinates	Surface area (m²)	Stratigraphy	Reference	SOM 1
Nielsview 1	Western	28°53'37.66" S 25°40'9.45" E	4000	Brown Palaeosol Upper Grey Bed	This study	Tables 11, 22
Nielsview 2	Western	28°53'42.50" S 25°40'14.07" E	6500	Brown Palaeosol Upper Grey Bed	This study	Tables 11, 22
Nielsview 3	Western	28°53'20.31" S 25°40'0.93" E	177 000	Brown Palaeosol Upper Grey Bed	This study	Tables 11, 22
Nielsview 4	Western	28°53'36.22" S 25°40'40.54" E	74 000	Brown Palaeosol Upper Grey Bed Red Palaeosol Lower Grey Bed	This study	Tables 11, 22 Figures 29-30
Thorndale	Western	28°53'15.87" S 25°39'12.40" E	57 000	Red Palaeosol Lower Grey Bed	This study	Tables 12, 23
Erfkroon 2	Western	28°53'0.86" S 25°36'58.93" E	109 000	Brown Palaeosol Upper Grey Bed Red Palaeosol Lower Grey Bed	This study	Tables 13, 24 Figures 31-33
Erfkroon 3	Western	28°52'37.86" S 25°36'9.75" E	181 000	Red Palaeosol Lower Grey Bed	This study	Tables 14, 25 Figures 34-42
Erfkroon 4	Western	28°53'20.32" S 25°37'7.78" E	112 000	Brown Palaeosol Upper Grey Bed Red Palaeosol Lower Grey Bed	This study	-
Penhoek	Western	28°51'27.13" S 25°31'19.27" E	52 000	Red Palaeosol Lower Grey Bed	This study	Tables 15, 26 Figures 43-45
Winterdraai Fairview	Western	28°52'51.40" S 25°28'28.81" E 28°52'39.49" S 25°28'46.70" E	330 000	Upper Grey Bed Red Palaeosol Lower Grey Bed	This study	Tables 16, 27 Figures 46-50
Slagkraal	Western	28°54'48.85" S 25°24'4.53" E	18 000	Red Palaeosol Lower Grey Bed	This study	Table 17
Loogkop	Western	28°53'34.50" S 25°20'21.26" E	82 000	Upper Grey Bed	This study	Table 17

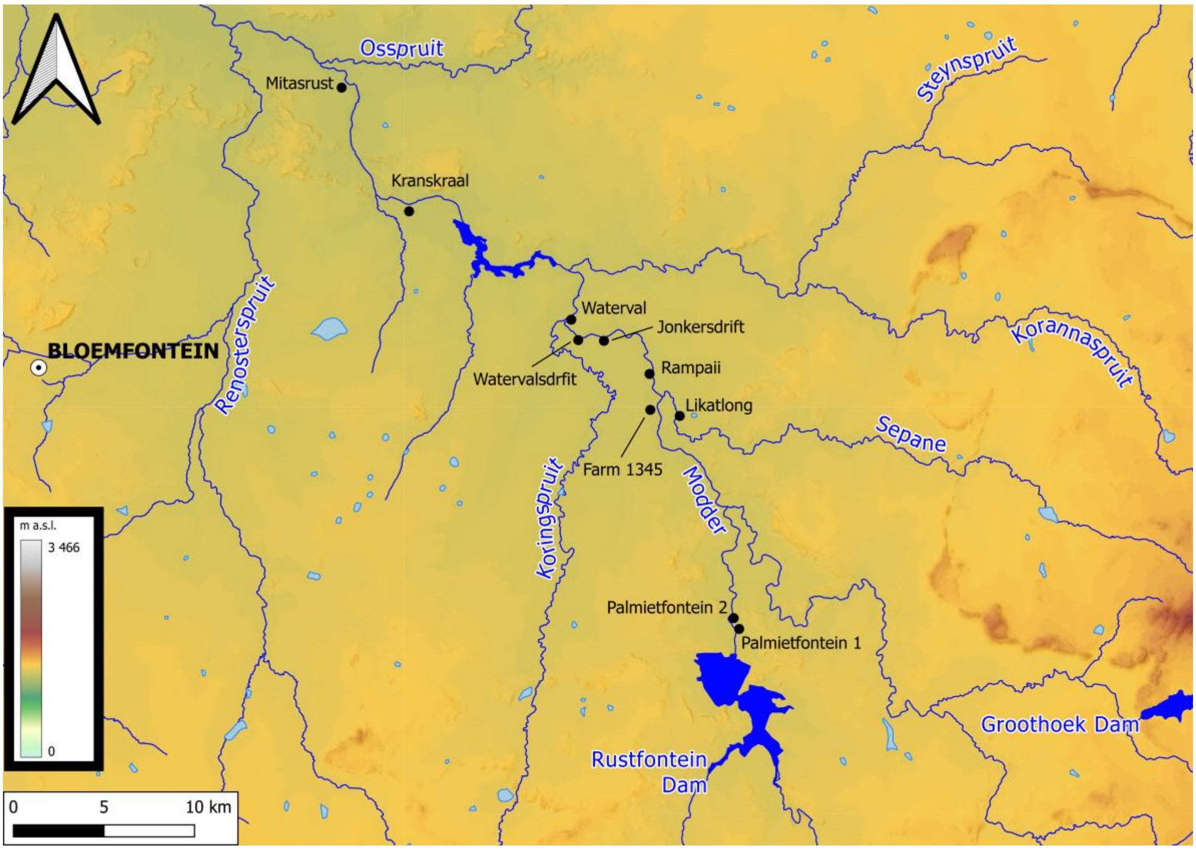


Figure 4. Map of the eastern catchment of the Modder River, showing the location of the selected dongas. The pale blue patches represent saltpans, whereas the dark blue patches represent dams. DEM: SRTM 1-arc second Global, NGA, USGS EROS, retrieved from NASA Earthdata; Hydrography and borders: DWS, South Africa, and Mucina & Rutherford (2006); Topography: Esri Topographic (basemap) and World Topographic Map (available from: https://www.arcgis.com/home/item.html?id=7dc6cea0b1764a1f9af2e679f642f0f5).

Watervalsdrift: Watervalsdrift falls within the western portion of ‘Area B’ in Trower (2010), which also includes to the east the Jonkersdrift donga that we could not survey. Watervalsdrift is a small, shallow donga that is characterised by extensive erosion that left shallow dome-shaped ridges. The sediment is mostly composed of grey sandy clay with calcium carbonate nodules in places at the surface, which could be linked to the Upper Grey Bed at Erfkroon since it is covered by a brown soil. The density of artefacts is very low (0.00014/m^2) compared to other areas in the survey, with only four artefacts documented: a polyhedral or multidirectional core, two flakes and a small *Levallois* core of MSA technology (SOM 1 Table 2; Fig. 4). Contrary to Trower (2010), we could not identify any clear LSA or historic artefacts.

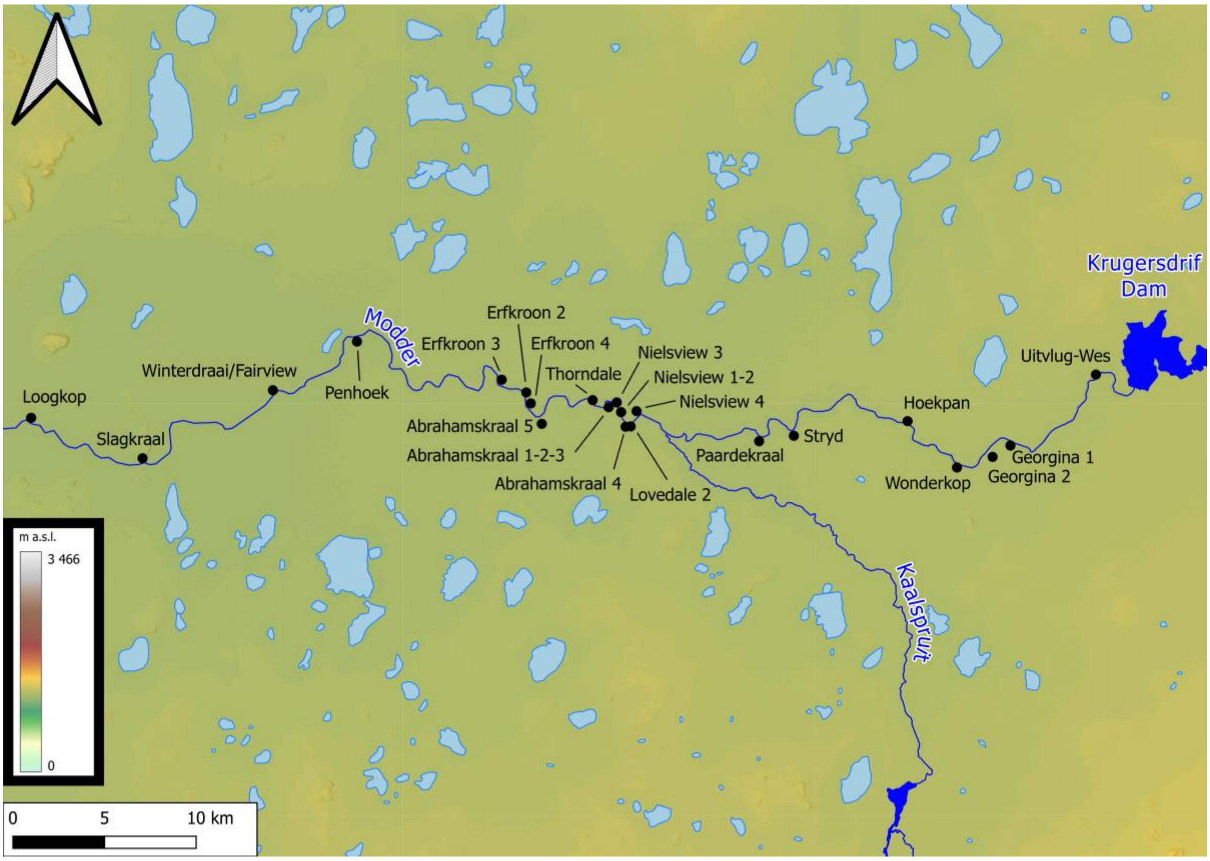


Figure 5. Map of the western catchment of the Modder River, showing the location of the selected dongas. The pale blue patches represent saltpans, whereas the dark blue patches represent dams. DEM: SRTM 1-arc second Global, NGA, USGS EROS, retrieved from NASA Earthdata; Hydrography and borders: DWS, South Africa, and Mucina & Rutherford (2006); Topography: Esri Topographic (basemap) and World Topographic Map (available from: https://www.arcgis.com/home/item.html?id=7dc6cea0b1764a1f9af2e679f642f0f5).

Waterval: Waterval is a wide and deep (8 m between its top and the riverbed) donga that corresponds to ‘Area A’ in Trower (2010). The stratigraphy of the sediments cut by the donga matches the Lower Grey Bed-Red Palaeosol-Upper Grey Bed succession at Erfkroon, with the Red Palaeosol being less visible close to the river and clearer at the edge of the donga. We differentiate three archaeological areas according to the density of finds. Area 1, the westernmost, is located between the river and a high crest, which allows for stratigraphic control. The majority of the artefacts found here occur in the Lower Grey Bed, a thick layer (2.5 to 3 m) of grey sandy clay with calcium carbonate nodules underlying the Red Palaeosol (0.8 to 1 m thickness), the Upper Grey Bed (2.6 to 2.8 m), and the Brown Palaeosol (0.5 to 0.7 m) at the top. Finds appear at the surface of concave and convex slopes of a less eroded zone with dome-shaped ridges, and include: seven flakes, an inclined core, and a dolerite cobble. Other artefacts were found on the highest part of the eroded ridges of the Upper Grey Bed (a grindstone) or the bottom of gullies filled with sand (a unifacial point and a *Levallois* point, both highly weathered) (SOM 1 Figs 5-6). Area 2 produced sparse faunal remains, with shaft fragments of long bones of large mammals and a cluster of MSA tools that includes a Lovedale point (Fig. 6), a unifacial point and several elongated flakes in hornfels and sandstone with faceted platforms. These items were found at the surface of an eroded zone with convex ridges within the Lower Grey Bed (SOM 1 Figs 7-9). Area 3, finally, contains numerous LSA artefacts including many small narrow-sided platform cores in hornfels and fine-grained siliceous rocks, some convex scrapers and a microlithic artefact (a trapeze) in chert or a similar rock (SOM 1 Tables 3, 18). This area is located at the surface of long, convex and extensively eroded ridges within the Upper Grey Bed. Some MSA-like artefacts located in this area suggest a displacement of pieces from this period in the floodplain or, as proposed earlier by Trower (2010), a possible re-use of older artefacts by LSA groups inhabiting the area (SOM 1 Fig. 10). We estimate similar densities for Areas 1, 2, and 3, at around 0.01 artefacts per m^2. When comparing our work with the results of Trower (2010), we find that we have documented very few artefacts both in Watervalsdrift and Waterval, but the type of information we recorded is consistent with his data in terms of lithic technology, especially for Waterval. Our finds were significantly less numerous and the fauna was less preserved, probably as a result of the collection of artefacts and fauna during the previous survey.

Figure 6. Lovedale points from Waterval (top row), Mitasrust (middle row), and Abrahamskraal 1 (bottom row).

Mitasrust: Mitasrust was surveyed by Rossouw (2006), who collected Florisian fauna and observed MSA artefacts. The surface, exposed by erosion, covers a large area with a main donga channel that goes from the west to the east. The main donga exhibits several tall profiles (up to 5 m in height) where the uppermost levels are characterised by silts and sands presumably deposited during the Holocene that cover thick layers of small, cemented gravels at the base of sections (SOM 1 Figs 11-12). The tributary dongas to the south exposed a large area, the western portion of which exhibits a Red Palaeosol-Lower Grey Bed sequence, whereas the eastern portion is characterised by light grey-bluish sandy clay deposits with calcium carbonate nodules consistent with the Lower Grey Bed. The zone located to the south of the main drainage channel shows two separated archaeological areas with high densities of artefacts. Area 1, to the east, has 16 artefacts in a surface of 752 m^2 (density=0.021), whereas Area 2, to the west, has 32 pieces in 1218 m^2 (density=0.026). Both areas show MSA artefacts associated with faunal remains and some isolated LSA artefacts covered with brown patina (mostly endscrapers and one adze) that most likely come from the overlying Red Palaeosol, which is almost completely eroded away in these areas (SOM 1 Tables 4, 19).

Area 1 was identified following the bottom of the main donga drainage channel from the river to its inception, after locating many artefacts embedded in the channel fill that include a big platform core used to produce blades and *Levallois* points. This area is connected with the main donga through a short and deep tributary gully that erodes a surface with high gradient slopes. Two clusters were identified in this area, both deep into the Lower Grey Bed (2.5 to 3 m): one (C1) within a gravel bed, and a second cluster (C2) embedded within finer sediments. C1 exhibits some diagnostic MSA artefacts (two *Levallois* cores, a unifacial point, and flakes with faceted platforms) (Fig. 7). C2 includes an MSA unifacial point associated with some vertebrae of a medium-sized mammal at the base of a recent erosional channel (SOM 1 Figs 13-14).

Area 2 is located 110 m to the west of Area 1 and includes three clusters in the Lower Grey Bed. The first two clusters (C1 & C2) are eroded domes with ridges, whereas C3 is a flat step with an accumulation of clasts laterally sectioned by a gully. C1 shows an accumulation of flakes linked to a platform core with no clear diagnostic features. The presence of quartzite is remarkable in this cluster, as it is not a rock found in the geology of the region (Holmes & Barker 2006). C2 includes some non-diagnostic flakes, two unifacial points, a *Levallois* core and some blades of clear MSA technology, as well as a tool on a blade with alternating retouch, and a borer-like tool with denticulated edges, similar to artefacts found at Erfkroon and Waterval (Trower 2010; Bousman et al. 2023). An equid molar was the only faunal remain in the cluster. Some of the flakes in C2 were found stuck into the sections of the side channels that erode the large dome of Lower Grey sediment. Finally, C3 includes several diagnostic MSA artefacts, such as two Lovedale points (Fig. 6), a sidescraper (on core), and blade/bladelet fragments (SOM 1 Figs 15-18).

Western catchment

Uitvlug-Wes: Uitvlug-Wes features a large donga system where most of the eroded surface is covered by vegetation and only one fifth is exposed terrain. We identified four drainages, of which the two to the east appear to be barely active in terms of erosion as they are covered by thick vegetation, and the two to the west are clearly active during the rainy season due to the absence of vegetation. In this second portion, the westernmost drainage features a high profile (up to 5 m in places) characterised by the Lower Grey Bed-Red Palaeosol-Upper Grey Bed sequence on top of Ecca shale bedrock, including water-worn hornfels nodules at the surface. In this area we found non-diagnostic flakes on the surface of the section slopes that are difficult to correlate with any sediment bed. The second drainage coming from the west shows greater maturity in its erosion, as indicated by massive sand deposits that fill the gullies. Except for two examples of weathered *Levallois* points associated with the base of the Lower Grey Bed and calcium carbonate nodules (1.2 to 1.4 m of visible thickness), only non-diagnostic artefacts were found in this area (A1) (SOM 1 Fig. 19). The easternmost donga features a small barren area (A2) next to the river where a single dolerite flake was found on the surface of a convex slope of the Lower Grey Bed with calcium carbonate nodules, underlying a remnant of the Red Palaeosol (SOM 1 Table 5, Fig. 20).

Georgina: Georgina 1 is small and includes two areas with artefacts (SOM 1 Table 6). Area 1 is located in the eastern portion of the drainage and produced non-diagnostic artefacts on a convex slope at the contact between a Lower Grey Bed and overlying Red Palaeosol. This small cluster includes seven non-diagnostic flakes with unidirectional scars, a small blade, and an inclined core. In the drainage to the west, close to the edge of the donga, we found an artefact (A2) stuck into a Lower Grey Bed with calcium carbonate nodules, on top of which a Red Palaeosol is visible on the opposite side of the donga. Between these areas and closer to the riverbed, we found an accumulation of fossil bones within a brown alluvium including many anatomical parts of different vertebrates, probably related to a carnivore den. Georgina 2 is a shallow gully almost completely covered by vegetation and with a yellow sand infill devoid of artefacts.

Figure 7. Unifacial points from Mitasrust (top row), Erfkroon 3 (middle row), and Penhoek (bottom row).

Lovedale: The Damvlei and Lovedale dongas have produced LSA and MSA occupations, respectively (Richard et al. 2022, 2023; Wroth et al. 2022; Toffolo et al. 2023). The Lovedale 2 donga, 1 km downstream of Lovedale 1 on the same side of the river, is a small erosional feature characterised by high crests and ridges that match the Lower Grey Bed-Red Palaeosol-Upper Grey Bed sequence at Erfkroon. The donga features isolated MSA artefacts and faunal remains throughout its extension, one cluster of ungulate faunal fragments including several teeth, one cluster of MSA artefacts with blades and fragments of unifacial points and two clusters of LSA artefacts and vertebrate fauna, including ungulate teeth (density=0.041) (SOM 1 Tables 7, 20). The LSA clusters are located in the Upper Grey Bed although in a secondary context and can be assigned to the Lockshoek industry based on the occurrence of large endscrapers (Fig. 8; SOM 1 Fig. 21). These clusters, separated by only a few metres, may be part of the same occupation.

Figure 8. Lockshoek scraper from Lovedale 2.

Abrahamskraal: To the west of Lovedale 2, the same donga system falls within the neighbouring farm Abrahamskraal and is hereby called Abrahamskraal 4. This larger drainage features a small yet diagnostic assemblage of MSA artefacts divided in two areas. Area 1, with two flakes and a *Levallois* point, is located in a deep gully running perpendicular to the river. The pieces were found at the surface of a dome in the Lower Grey Bed with calcium carbonate nodules, stratigraphically beneath a Red Palaeosol and Upper Grey Bed. Area 2 presents two *Levallois* cores and one flake at the base of a high bluff next to the river (SOM 1 Table 9). The sedimentary context is consistent with the Lower Grey Bed. Further to the west, on the same side of the Modder, three smaller drainages that are part of the same donga were surveyed near the Abrahamskraal homestead. Abrahamskraal 1, 2, and 3 exhibit a relatively small surface area that does not match the stratigraphic succession of Erfkroon, but rather the one observed at Lovedale 1 in which the MSA occupation occurs in a bed of light grey-bluish sandy clay under a Holocene brown silty sand (Wroth et al. 2022). We observed only a few lithic artefacts of both MSA and LSA technology and faunal remains (including fragments of ungulate teeth) (SOM 1 Table 8). However, one of the MSA artefacts is a broken and weathered Lovedale point characterised by the typical bifacial trimming of the base (Fig. 6).

To the west of Abrahamskraal 4, Abrahamskraal 5 includes three drainages of which we could survey only the easternmost, since the other two are part of a game enclosure. The donga we surveyed features two archaeological areas. Area 1 is a small occurrence of only two artefacts in primary depositional context that include an MSA unifacial point and a blade or flake stuck into the section (SOM 1 Fig. 22). The exiguous cluster is nevertheless important if we consider its primary position and diagnostic character of the tools. Area 2 is placed 140 m to the southeast of Area 1. This area is one of the richest MSA areas discovered in our survey with up to 40 artefacts including many diagnostic MSA tools and cores. We divided this area into two clusters due to its richness. C1 includes a *Levallois* recurrent centripetal core on flake, a '*déjeté*' sidescraper, a *Levallois* flake, and three *Levallois* points (Fig. 9; SOM 1 Figs 23-25). C2 includes a unipolar *Levallois* or high-backed platform core, two blades with faceted butts, two *Levallois* flakes, a small *Levallois* point and several sets of flakes that could possibly come from some knapping episodes (SOM 1 Tables 10, 21 & Figs 26-28). We did not find faunal remains, but the scatters of flintknapping waste and formal tools suggests the possibility of ephemeral occupations. The artefacts were found in a light grey-bluish sandy clay with calcium carbonate and iron oxide nodules, not capped by any later sediment, which could be consistent with the stratigraphic sequence at Lovedale 1.

Nielsview: The Nielsview farm includes four dongas featuring the Lower Grey Bed-Red Palaeosol-Upper Grey Bed-Brown Palaeosol succession. Nielsview 1, 2, and 3 produced only a handful of non-diagnostic artefacts, except for a Lockshoek scraper at the boundary between the Upper Grey Bed and Brown Palaeosol. Nielsview 4 is the most developed of the dongas in this property in terms of erosional incision, and the richest in artefacts, although mainly comprising isolated and non-diagnostic finds sometimes accompanied by bone fragments and ungulate teeth (SOM 1 Figs 29-30). One cluster, found in the upper portion of the Lower Grey Bed close to the boundary with the overlying Red Palaeosol, included a *Levallois* point (Fig. 9) and a platform core of clear MSA technology (SOM 1 Tables 11, 22).

Thorndale: Thorndale exhibits a large zone to the north covered by the Red Palaeosol, whereas to the south it only preserves the Lower Grey Bed. Next to the northern drainage there is a small archaeological area (A1) with two large dolerite cobbles stuck into the Red Palaeosol and some flakes and a sidescraper located on the surface of the nearby dome-shaped ridges. Another area (A2) is found to the south of the previous and shows several low, well-rounded mounds or domes of the Lower Grey Bed with rounded dolerite pebbles and calcium carbonate nodules, including a large number of poorly preserved MSA artefacts. The latter were found on the surface of mounds and into the reworked sediments at the bottom of the drainage gully. The cluster nevertheless includes some large blades, flakes and a *Levallois* point that clearly indicate an MSA site, although of secondary context (SOM 1 Tables 12, 23).

Erfkroon: Erfkroon 1 and 3 belong to the eponym farm, and the former has produced several MSA and LSA occupations, including some of the very few early LSA and Robberg assemblages in the Free State (Bousman et al. 2023), whereas Erfkroon 2 and 4 belong to the Edelweiss farm.

Erfkroon 2 features a complete stratigraphic sequence that matches that of Erfkroon 1. From top to bottom, one can easily discern an aeolian sand cap, the Brown Palaeosol (0.5 to 0.6 m), the Upper Grey Bed (1.7 to 1.9 m), the Red (van den Berg) Palaeosol (0.4 to 0.6 m), and a thick Lower Grey Bed (>5 m). The portion of the sequence down to the Red Palaeosol is mainly confined to the edges of the donga, whereas its central portion has exposed deep incisions into the Lower Grey Bed. The main drainage channel runs east-west creating deep sections, with bluffs up to 5 m in height. The northern side of the donga bottom (A1) exhibits isolated MSA artefacts (density 0.018) that include blades and a *Levallois* point characterised by rounded edges indicative of some degree of transportation.

Figure 9. *Levallois* points from Abrahamskraal 5 (top row), Nielsview 4 (middle row), and Winterdraai/Fairview (bottom row; point on *Levallois* blade).

The main archaeological area is located to the south of the drainage channel and exhibits a greater density of artefacts and assemblages of faunal remains (A2). The latter are mainly ungulate teeth of Florisian species, such as *Megalotragus priscus* (Brink et al. 2016). A2.1 comprises 12 artefacts on a surface of around 140 m^2 (density=0.08) and includes several diagnostic MSA artefacts with weathered and rounded surfaces embedded in the Lower Grey Bed (SOM 1 Fig. 31). A2.2 is located to the south of A2.1 at the boundary between Lower Grey Bed and Red Palaeosol. This cluster contains numerous artefacts (74) spread onto a relatively small surface area of around 150 m^2 (density=0.49). Flakes and flake fragments with unipolar directions in their scars and flat single platforms represent the largest component of the assemblage. There are also some blades, a *Levallois*-like core with a single platform and a wide final scar, and a small *Levallois*-like point with flat platform and some dolerite cobbles. Along this accumulation of knapping scatter, we also identified a scaled piece that could be related to an early LSA industry (SOM 1 Fig. 32). A2.3, located at the top of dome-shaped ridges in the Lower Grey Bed, is characterised by only a few artefacts and several faunal remains in primary depositional context. In this case, the accumulation of artefacts has a low density (0.037) but noteworthy is the association of fauna and lithics related to the final steps of the *chaine opératoire* (SOM 1 Tables 13, 24). The artefacts include a unifacial point with regular to invasive retouch, two thin and curved blades, and a core exploited in several directions with a final wide scar worked in the way of a *Levallois* core, which could also be classified as a platform, high-backed core or inclined core (SOM 1 Fig. 33).

Erfkroon 4 is another large and deeply incised donga featuring the same stratigraphic sequence as Erfkroon 1, which however produced only a few and isolated LSA artefacts, possibly related to the Lockshoek industry.

Erfkroon 3 comprises three drainages where we identified a poorly preserved archaeological area in the central one (A1), three areas in the northern one (A2, A3, and A4) and three areas in the southern one (A5, A6, and A7) (SOM 1 Tables 14, 25). A1, in the middle part of the central drainage, presents the Lower Grey Bed underlying the Red Palaeosol, the latter visible only near the edge of the donga, ~400 m from the riverbed. This area includes isolated and rolled MSA artefacts embedded in a palaeodonga channel facies with small gravels.

The northern drainage features a spring at the edge of the donga near to which we identified numerous artefacts (A2) grouped in three clusters. C1 includes flakes and flake fragments at the base of a bluff laterally eroded by a channel fed by the nearby spring (SOM 1 Fig. 34). C2 is located on top of a flat step between C1 and C3 and includes nine artefacts associated with many cobbles of different rock types (SOM 1 Fig. 35). C3 also contains cobbles, as well as MSA artefacts: blades (with regular retouch in one case), a unifacial point and a bipolar core. This cluster occurs on the top of a flat, inclined surface (SOM 1 Fig. 36). All clusters occur in the Lower Grey Bed, which is capped by the Red Palaeosol visible at the spring. Area 3 is located 30 m to the west of Area 2 in a similar sedimentary context. However, we decided to separate this small accumulation of artefacts (13) due to the presence of a gully that interrupts the stratigraphic continuity (SOM 1 Fig. 37). Only a unifacial point with regular retouch seems diagnostic of an MSA occupation (Fig. 7). A4 is located a few metres to the north of A3 from which it is separated by a gully, and it occurs on the surface of a low ridge in the upper portion of the Lower Grey Bed. The lithic assemblage of this area features the use of some dolerite cobbles, and it comprises a group of flakes and flake fragments similar in technology and size (unipolar, single platforms, medium to small sized) that suggest a single or short episode of knapping (SOM 1 Fig. 38).

A5, in the southern drainage, is a cluster of microlithic artefacts found at the surface of the Upper Grey Bed, next to an eroded bluff of brown sands. The assemblage is characterised by many bladelets and endscrapers, with a clear attribution to an LSA occupation. The standardised aspect of some bladelets suggests high levels of control of the reduction process: single (flat) platforms, parallel edges and ridges, thin sections, and slightly curved profiles (Fig. 10). This regularity could be linked to knapping techniques such as indirect percussion, proposed for some Robberg industries, although freehand percussion has also been proposed for bladelet production during this period (Porraz et al.

2016). Only two small endscrapers are documented as formal tools at this area (SOM 1 Fig. 39). A6 is located 100 m to the north of A5, at the contact between the Red Palaeosol and Upper Grey Bed. We identified two clusters at the top of eroded ridges, with the first (C1=26 pieces) probably linked to a single knapping episode of a high-backed (or semi-conical) platform core, which occurs with associated unipolar elongated flakes (SOM 1 Fig. 40). The second cluster (C2=22 pieces) shows a greater diversity in the technology and the weathering of the artefacts found there. Several patina colours occur on a variety of artefacts that include a *Levallois* point, many non-diagnostic flakes, dolerite cobbles, and a scaled piece formally attributable to an early LSA industry (SOM 1 Fig. 41). Area 7 is located 70 m to the north of Area 6 and includes only three lithic artefacts and the vertebra of a medium-sized ungulate at the contact zone between the Upper Grey Bed and Brown Palaeosol (SOM 1 Fig. 42).

Figure 10. Bladelet from Erfkroon 3.

Penhoek: Penhoek comprises a main drainage of southeast-northwest direction and two minor drainages of southwest-northeast direction. We identified one archaeological area in each drainage. The stratigraphic sequence exposed by the donga includes the Red Palaeosol, visible at its edge, and the Lower Grey Bed underneath, in which all the artefacts were found (SOM 1 Tables 15, 26).

Penhoek A1 presents two separate clusters. The artefacts (45) are spread onto the surface of convex, eroded ridges of the Lower Grey Bed with calcium carbonate nodules. C1 includes dolerite cobbles, non-diagnostic flakes and flake fragments, some blades and two denticulates made on *Levallois* flakes. The blades (two of them crested) in some cases exhibit thin and curved profiles (SOM 1 Fig. 43). C2 contains flakes and flake fragments, three blades, and a narrow-sided platform core (SOM 1 Fig. 44). Based on the lithics, the entire area likely comprises one or more MSA occupations. The denticulates and the blades with curved and thin profile also suggest a possible association to a pre-Still Bay technocomplex (i.e., before the Still Bay and after the early MSA), even if the nearby site of Florisbad shows a slightly different composition of its pre-Still Bay assemblage, with less formal tools compared with other contemporary sites (Kuman et al. 1999; Brink & Henderson 2001; Henderson 2001).

A2 is in the middle drainage, where extensive erosion has produced dome-shaped ridges and high crests. The sediment exposed in this area comprises a thick (>3 m) layer of the Lower Grey Bed with calcium carbonate nodules capped in places by brown sand. Artefacts occur on the sides of a large sediment dome laterally cut by two gullies. The upper part of this dome features MSA artefacts (two blades, two unifacial points, a sidescraper; Fig. 7) in association with faunal remains including several cranial fragments, some molars, and some epiphysis and diaphysis fragments probably related to mid-sized ungulates. The bluffs created by the gullies are also characterised by many bones and bone fragments (including ribs and vertebrae) and a few lithic artefacts such as flakes and blades (SOM 1

Fig. 45). The final stages in the *chaine opératoire* of the artefacts, linked to the varied representation of anatomical parts of the fauna, suggest temporary occupations related to hunting or carcass processing.

A3 is a wide and deeply eroded portion of the westernmost drainage. As in Area 2, the slopes created by the erosion of the Lower Grey Bed exhibit high gradients. In this case, the sedimentary facies related to palaeodonga channels are more frequent and include rolled artefacts and bone fragments embedded in sandy sediment with calcium carbonate nodules characterised by horizontal fabric. The few, poorly preserved artefacts nevertheless include some clearly attributable MSA artefacts such as flakes with faceted butts, a *Levallois* point, and one elongated overshot flake with centripetal removals.

Winterdraai/Fairview: Winterdraai/Fairview is divided into two portions because it belongs to two different farms, with Fairview to the east and Winterdraai to the west. We identified three archaeological areas spanning the Lower Grey Bed-Red Palaeosol-Upper Grey Bed sequence, clearly visible in high profiles (SOM 1 Tables 16, 27). Isolated MSA artefacts, such as *Levallois* and unifacial points were found at different locales at the bottom of these sections, where the Lower Grey Bed is visible, although it is not possible to determine the occurrence of an actual site (SOM 1 Fig. 46). A1 is an LSA site located at the edge of the donga, at the base of an eroded bluff of the Upper Grey Bed. A3 is located at the southernmost part of the eroded surface of this donga, within the Lower Grey Bed. Despite the presence of some MSA artefacts, their poor preservation as well as the sediment composition, mostly yellow sands, indicate a secondary context formed in recent times (SOM 1 Fig. 47).

A2 is located on the left side of the main drainage channel of the donga and features an accumulation of artefacts and dolerite cobbles associated with a shallow and eroded crest of Red Palaeosol. Some of the artefacts were found on the surface of the ridges of this crest, whereas many others were found at the base of the ridges and at the contact with the underlying ridges of the Lower Grey Bed. We identified three clusters to facilitate artefact counts, although the presence of isolated artefacts between clusters suggests the possibility of a single assemblage. C1 and C2 include many flakes and flake fragments with unidirectional scars associated with two high-backed platform cores, which seem to be the result of one or two separate knapping episodes (SOM 1 Figs 48-49). The platforms are mostly produced by a single facet and one of the cores suggests the removal of *Levallois*-like end products (triangular flakes). C3 includes a large blade, a large unifacial point on a *Levallois* blade (Fig. 9), and some *Levallois* flakes linked to a dolerite cobble. Compared to the artefacts found in C1 and C2, probably related to short episodes of occupation and linked to the Red Palaeosol, the C3 artefacts have clearer MSA technological features, and its spatial association with the other clusters could be only circumstantial (SOM 1 Fig. 50). Its position, on an eroded surface of the Lower Grey Bed next to the base of the erosional crests of the Red Palaeosol, would seem to corroborate this interpretation.

Slagkraal: Slagkraal is a small and shallow donga that features the Red Palaeosol, close to the edge of the donga with low bluffs of 0.5 to 0.7 metres, and the Lower Grey Bed outcropping at the bottom of the drainage. Lithic artefacts were found on this surface, more precisely an assemblage of three short and thick flakes presumably obtained from the exploitation of inclined cores, which suggest a possible MSA chronology.

Loogkop: Loogkop features only one significant locale. This single cluster comprised an accumulation of seven endscrapers, a sidescraper, some flakes, and an inclined core produced by recycling an older core with brown patina. The entire assemblage could be related to an LSA occupation, probably Lockshoek. The stratigraphy, in this case, does not allow placing the cluster in a relative chronology since the sedimentary context, composed of grey sediments possibly consistent with the Upper Grey Bed, is capped by a thin layer of brown sands. An abandoned quarry next to the road bordering the property contains large hornfels cobbles that could have been an attracting factor for the occupation of this area. Other hornfels outcrops are known at Erfkroon 1 and Damvlei, but none of these feature artefacts. Based on the polished cortex of some cores found at Lovedale 1, hornfels cobbles were probably sourced from the riverbed (Wroth et al. 2022).

5. Discussion

The surveyed dongas include 43 areas of archaeological interest along the Modder River, thereby multiplying threefold our knowledge of the human occupation of the area during the late Quaternary. Three main results become immediately apparent: 1) MSA and LSA technocomplexes are represented throughout the catchment, although actual sites characterised by large assemblages occur only at specific localities, which are Waterval, Kranskraal, and Mitasrust in the eastern catchment and Lovedale, Abrahamskraal, Erfkroon, Penhoek, and Winterdraai/Fairview in the western catchment; 2) the lithic assemblages that we found are confined to the Late Pleistocene and Holocene, thus confirming previous observations that the terraces of the Modder do not preserve Early and Middle Pleistocene sediments (Toffolo 2024 and references therein); 3) except for Abrahamskraal, all of the sedimentary contexts bearing artefacts are consistent with the allostratigraphic succession established at Erfkroon, which highlights the relevance of the Orangia terrace for the entire catchment. In the following sections, we discuss the results of the survey based on the Upper Grey Bed-Red Palaeosol-Lower Grey Bed framework.

Upper Grey Bed

The Upper Grey Bed yielded several LSA assemblages all along the Modder. The main LSA occurrences that we identified are Waterval A3, Lovedale 2, Erfkroon 3 A5, Winterdraai/Fairview A1 and Loogkop, although isolated artefacts belonging to the Lockshoek industry were observed in almost all dongas, such as concavo-convex scrapers with scaled retouch, large endscrapers, and adzes, highlighting the importance of this early Holocene technocomplex in the region. These tools were found in the clusters at Lovedale 2 and Loogkop. Waterval A3 produced many pieces in opaline, fossilised wood, agate, chert, and other cryptocrystalline silicates (sourced from the riverbed; e.g., Sampson 1968, 1970) including small flakes and some microliths associated with hornfels artefacts such as scrapers and bladelet cores, which appear to be part of the Wilton technocomplex. Only a few bladelets were found there, although Trower (2010) found them with more frequency during his survey. At Erfkroon 3 A5, on the contrary, we found many bladelets but no bladelet core and also some scrapers and non-diagnostic flakes in varied raw materials but with a clear predominance of hornfels. The presence of the bladelets, with unfaceted single platforms and parallel ridges and edges suggests a possible association with the Robberg technocomplex, which would be consistent with results from Area K at Erfkroon 1 (Palmison 2014; Bousman et al. 2023). If confirmed by absolute dating, which is currently not available, the existence of this Robberg assemblage would require a reconsideration of human presence in the grasslands of the western Free State during Marine Isotope Stage (MIS) 2 (Mitchell 2017).

Red Palaeosol

The archaeological areas associated with the Red Palaeosol are Palmietfontein 2, Georgina A1, Thorndale A1, Erfkroon 2 A2.2, Erfkroon 3 A4 and A6, Winterdraai/Fairview A2, and Slagkraal A1. This is a significant group of sites if we consider that the average thickness of this deposit and its chronological range are considerably less than those proposed for the Upper Grey and Lower Grey Beds. However, only half of these occurrences (Erfkroon 2 A2.2, Erfkroon 3 A4 and A6, and Winterdraai/Fairview A2) deserve a deeper analysis, since the others comprise small clusters of artefacts, and only Winterdraai/Fairview showed potential for *in situ* artefact recovery. Nevertheless, taking into consideration all the assemblages that we found, we can identify repetitive technological traits across these occupations. Besides a few formal tools that include scrapers and two scaled pieces (Erfkroon 2 A2.2 and Erfkroon 3 A6), most of the artefacts are sets of flakes with unidirectional scars and high-backed platform cores exploited using hard hammerstones – perhaps the small dolerite ‘balls’ that usually appear in association with these cores and flakes. Some of the cores show a final triangular scar and *Levallois*-like products but plain, unfaceted platforms were also observed, for instance short and thick blades or points, found in some archaeological areas such as Erfkroon 2 A2.2.

The overall impression with the scatters of flakes and cores is that many of the artefacts could refit and be the result of place provisioning (*sensu* Mackay et al. 2014) rather than individual provisioning. It is difficult to assign the assemblages in the Red Palaeosol to specific technocomplexes due to their different features (e.g., appearance of *Levallois*-like products but predominance of unfaceted platforms), although they could be consistent with either the post-Howiesons Poort or final MSA (*sensu* Lombard et al. 2022), or perhaps with the early LSA. The early LSA assemblages at Erfkroon 1 are characterised by bipolar pieces made on large flakes (Bousman et al. 2023). These pieces are scarce in our survey, but we found at least two similar examples, one at Erfkroon 2 A2.2 and one at Erfkroon 3 A6, which appear to derive from the Red Palaeosol. This deposit seems to hold potential to further explore the MSA/LSA transition in South Africa, which currently is poorly understood (Bousman & Brink 2018; Bader et al. 2022).

Lower Grey Bed

Most of the archaeological areas identified during our survey derived from, or were found embedded in, the Lower Grey Bed. Several of these (Palmietfontein 1 A1, Uitvlug-Wes A1, Thorndale A2, Erfkroon 2 A1 and A2.1, Erfkroon 3 A1, and Penhoek A3) were deposited in high-energy water environments such as channels, and as a result the artefacts are rolled or weathered. These assemblages are unfortunately less significant given the possibility of long-distance transport, even though they include diagnostic MSA artefacts and sometimes also fauna as at Penhoek A3. Other areas, on the contrary, produced well-preserved artefacts but in very small quantities: Watervalsdrift, Uitvlug-Wes A2, Abrahamskraal 4 A1 and A2, Lovedale 2 A1, Nielsview 4, and Erfkroon 3 A3 and A7. The most informative areas for the study of the MSA, which can be considered as sites based on their high density of artefacts, include Waterval A1 and A2, Mitasrust A1 and A2, Abrahamskraal 5 A1 and A2, Erfkroon 2 A2.3, and Penhoek A1 and A2. All of them contain abundant MSA artefacts, except for Erfkroon 2 A2.3 and Penhoek A2 that show lower densities of stone tools, and all of them contain associated fauna and lithics with the exception of Waterval A1 and Abrahamskraal 5, where only artefacts were found. Furthermore, Mitasrust A2, Abrahamskraal 5 A1, and Erfkroon 2 A2.3 exhibit artefacts stuck in sections created by gully erosion, and thus hold potential for the excavation of artefacts *in situ.*

With regard to lithic technocomplexes, we are somewhat limited in our interpretation by the lack of common diagnostic features defining pre-Still Bay assemblages in the South African interior (Wurz 2013; Porraz et al. 2018; Pazan et al. 2022), given that later technocomplexes such as the Still Bay and Howiesons Poort are absent in the western Free State and in our sample. Similarly, we can exclude on typological grounds the early MSA technocomplex (~300-120 ka), based on the local example of Florisbad (Kuman et al. 1999). Therefore, we are left with assemblages that probably span MIS 5 (~130-71 ka) (Lisiecki & Raymo 2005). The occurrence of Lovedale points at Waterval, Mitasrust, and Abrahamskraal lends support to this interpretation, as this type of point was dated to ~77-69 ka at Lovedale (Wroth et al. 2022) and to ~96-64 ka at Rose Cottage Cave (Harper 1997; Valladas et al. 2005; Pienaar et al. 2008), and it was also found at Kranskraal (van Hoepen 1932) and Vlakkraal (Wells et al. 1942). The presence of *Levallois* cores (recurrent centripetal and unidirectional convergent), large *Levallois* flakes, *Levallois* and unifacial points, and Lovedale points at Waterval, Mitasrust, and Abrahamskraal 5 supports the contemporaneity of the assemblages. In addition, the light grey-bluish colour of the sedimentary context in which these assemblages are embedded appears similar to Sedimentary Unit 4 at Lovedale, which marks the beginning of the MSA occupation at the site (Richard et al. 2022; Wroth et al. 2022). Considering the quantity and variety of artefacts stuck in bluffs (primary depositional context) together with faunal remains, and the occurrence of Lovedale points, we conclude that Mitasrust is the most promising site for the characterisation of the Lower Grey Bed in the eastern portion of the Modder catchment, which remains undated (Rossouw 2006). Absolute dating of the nearby Kranskraal donga would further contribute to the refinement of the MSA chronology of the region.

Surveys in southern Africa

Other surveys conducted in South Africa or in nearby countries such as Botswana have shown a positive correlation between artefact densities and access to raw materials and proximity to water (Shaw et al. 2019; Ecker et al. 2023; Staurset et al. 2023; Will et al. 2024). Both resources seem to be extremely important for the occupation of the Karoo during the Earlier Stone Age, whereas the MSA occupations show more flexibility in the use of local raw materials or transport of knapped items up to 50 km from the outcrops (Hallinan 2022).

The dominant fine-grained sediments of the Grassland Biome differ completely from the Karoo landscape, where the rocky surface shows high amounts of hornfels exposed by erosion with a near-continuous presence of knapped artefacts (Sampson 1985; Hallinan 2022). Perhaps for this reason it is more difficult to determine the origin of the raw materials knapped at the MSA sites. Even if hornfels outcrops have been found at Loogkop, Damvlei, and Erfkroon, we see many macroscopic differences in the quality of their fracture compared with the hornfels used in most artefacts from these MSA sites. Other surveys in the area have found hornfels outcrops more than 25 km away from the Modder (e.g., Orton 2021), which could be related to the raw materials exploited at the MSA sites of the Orangia terrace, but further petrological or geo-chemical analyses are needed to confirm the provenance of the latter. The density of artefacts and faunal remains is relatively low at all surveyed sites when compared to other areas such as the Jojosi dongas (Will et al. 2024), the Tankwa Karoo (Hallinan 2022), or the Doring River (Shaw et al. 2019), where concentrations of hundreds of artefacts were counted over a few square metres. As we have stated, some of these areas are directly related to outcrops or to rocky and arid surfaces exposed by deflation and they are not easily comparable with our case study. Other examples like the pan fields in the Tsabong area (Ecker et al. 2023) and the Makgadikgadi Basin (Staurset et al. 2023), or the Virginia-Theunissen area (de Ruiter et al. 2011) seem to provide better parallels. The latter example, with donga systems incising the alluvial terraces of the Vet and Sand Rivers offers a direct comparison with the Modder, although no artefact counts are available.

The majority of MSA sites documented in the Lower Grey Bed show high rates of formal tools (including unifacially retouched or unretouched *Levallois* points, blades, and scrapers) compared to the lower rates of cores and informal non-diagnostic flakes. This feature fits well with an individual provisioning pattern (Mackay et al. 2018) whereby human groups in the area would take with them a kit of largely utilitarian tools that would be subjected to occasional trimming as seen at Lovedale (Wroth et al. 2022) or Erfkroon (Bousman et al. 2023). Both residential mobility strategy camps and logistical mobility strategy extraction camps could produce similar accumulations of high amounts of formal tools, but they are hardly discernible (Barton & Riel-Salvatore 2014). On the contrary, occupations in the Red Palaeosol, with higher proportions of unretouched flakes and cores and with higher amounts of cortex and possible refits, seem more likely to be the result of place provisioning, with on-site knapping actions. A similar change from individual to place provisioning has been determined for the Winter Rainfall Zone, from the MIS 5 Still Bay industries to the post-Howiesons Poort (Mackay et al. 2018). The allostratigraphy of the Modder River could be a valuable context to determine a shift in the occupation patterns during the late MSA.

6. Conclusions

The Modder River has been the subject of prehistoric research since the 1920s, showing its potential for understanding the MSA and LSA records of the central interior of South Africa. What was lacking until recently was a stratigraphic and chronological reference framework to provide context to archaeological occurrences. Our survey, carried out based on such a framework, has facilitated a deeper chronological understanding of the numerous archaeological areas that we found, now organised for the entire Modder catchment. While additional absolute dating is necessary in the eastern portion of the catchment in order to confirm stratigraphic correlations with its western portion, the presence of a time-constrained lithic type like the Lovedale point throughout the basin, and in the highlands of the eastern Free State, seems to indicate the existence of a local cultural tradition during MIS 5. This may contribute to the definition of technocomplexes in the interior of South Africa during this time period, and lead to a better understanding of human presence in these open interior landscapes.

Acknowledgements

The research leading to this article was conducted under the auspices of the National Museum

Bloemfontein. It was funded by the European Union. Views and opinions expressed are however those of the authors only and do not necessarily reflect those of the European Union or the European Research Council Executive Agency. Neither the European Union nor the granting authority can be held responsible for them. This work is supported by a European Research Council grant (PEOPLE, n. 101039711, DOI: 10.3030/101039711). Michael Toffolo was also supported by the grant RYC2021-030917-I funded by the MCIN/AEI/10.13039/501100011033 and by the "European Union NextGenerationEU/PRTR". The 2022 fieldwork expenses were covered by a grant from the French Institute in South Africa (IFAS) to Maïlys Richard, titled "Exploring potential Middle Stone Age occupations in the interior of South Africa". The authors wish to thank Jacob 'Japie' Maine for his assistance during fieldwork and the farm owners for their permission to access properties. We thank also C. Britt Bousman for the shapefile of the Modder catchment.

Supplementary online material

Cuartero Monteagudo et al. Supplementary Online Material File 1

References

Bader, G.D., Cable, C., Lentfer, C., et al. 2016. Umbeli Belli Rock Shelter, a forgotten piece from the puzzle of the Middle Stone Age in KwaZulu-Natal, South Africa. Journal of Archaeological Science: Reports, 9: 608-622. https://doi.org/10.1016/j.jasrep.2016.08.038

Bader, G.D., Mabuza, A., Price Williams, D., et al. 2022. Rethinking the Middle to Later Stone Age transition in southern Africa – A perspective from the highveld of Eswatini. Quaternary Science Reviews, 286: 107540. https://doi.org/10.1016/j.quascirev.2022.107540

Barker, C.H. 2011. Utilising published data for DTM construction and drainage basin delineation in the Modder River catchment, Free State, South Africa. South African Geographical Journal, 93: 89-103. https://doi.org/10.1080/03736245.2011.565150

Barton, C.M. & Riel-Salvatore, J. 2014. The formation of lithic assemblages. Journal of Archaeological Science, 46: 334-352. https://doi.org/10.1016/j.jas.2014.03.031

Bergström, A., Stringer, C., Hajdinjak, M., et al. 2021. Origins of modern human ancestry. Nature, 590: 229-237. https://doi.org/10.1038/s41586-021-03244-5

Bousman, B., Brink, J., Rossouw, L., et al. 2023. Erfkroon, South Africa. In: Beyin, A., Wright, D.K., Wilkins, J. & Olszewski, D.I. (eds) Handbook of Pleistocene Archaeology of Africa: Hominin Behavior, Geography, and Chronology: 1431-1450. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-031-20290-2_92

Bousman, C.B. & Brink, J.S. 2018. The emergence, spread and termination of the Early Later Stone Age event in South Africa and southern Namibia. Quaternary International, 495: 116-135. https://doi.org/10.1016/j.quaint.2017.11.033

Bouzouggar, A., Barton, N., Vanhaeren, M., et al. 2007. 82,000-year-old shell beads from North Africa and implications for the origins of modern human behavior. Proceedings of the National Academy of Sciences, 104: 9964-9969. https://doi.org/10.1073/pnas.0703877104

Brink, J.S. 1987. The archaeozoology of Florisbad, Orange Free State. Memoirs van die Nasionale Museum, Bloemfontein, 24: 1-151.

Brink, J.S. 1988. The taphonomy and palaeoecology of the Florisbad spring fauna. Palaeoecology of Africa and the Surrounding Islands, 19: 169-179.

Brink, J.S. 1994. An ass, *Equus* (*Asinus*) sp., from the late Quaternary mammalian assemblages of Florisbad and Vlakkraal, central southern Africa. South African Journal of Science, 90: 497-500. https://hdl.handle.net/10520/AJA00382353_7812

Brink, J.S. 2016. Faunal evidence for a mid- and late Quaternary environmental change in southern Africa. In: Knight, J. & Grab, S.W. (eds) Quaternary Environmental Change in Southern Africa: Physical and Human Dimensions: 284-305. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9781107295483.018

Brink, J.S. & Lee-Thorp, J.A. 1992. The feeding niche of an extinct springbok, *Antidorcas bondi* (Antelopini, Bovidae), and its palaeoenvironmental meaning. South African Journal of Science, 88: 227-229. https://hdl.handle.net/10520/AJA00382353_9466

Brink, J.S. & Henderson, Z.L. 2001. A high-resolution Last Interglacial MSA horizon at Florisbad in the context of other open-air occurrences in the central interior of southern Africa: An interim statement. In: Conard, N.J. (ed.) Settlement Dynamics of the Middle Paleolithic and Middle Stone Age: 1-20. Tübingen: Kerns Verlag.

Brink, J.S., Berger, L.R. & Churchill, S.E. 1999. Mammalian fossils from erosional gullies (dongas) in the Doring River drainage, central Free State, South Africa. In: Berger, C., Manhart, H., Peters, J., et al.

(eds) Historia Animalium ex Ossibus: Beiträge zur Paläoanatomie, Archäologie, Ägyptologie, Ethnologie und Geschichte der Tiermedizin: Festschrift für Angela von den Driesch: 79-90. Rahden/Westfalen: Verlag Marie Leidorf.

Brink, J.S., Bousman, C.B. & Grün, R. 2016. A reconstruction of the skull of *Megalotragus priscus* (Broom, 1909), based on a find from Erfkroon, Modder River, South Africa, with notes on the chronology and biogeography of the species. Palaeoecology of Africa, 33: 71-94. https://doi.org/10.1201/b19410

Brooks, A.S., Yellen, J.E., Potts, R., et al. 2018. Long-distance stone transport and pigment use in the earliest Middle Stone Age. Science, 360: 90-94. https://doi.org/10.1126/science.aao2646

Burrough, S.L., Thomas, D.S.G., Allin, J.R., et al. 2022. Lessons from a lakebed: Unpicking hydrological change and early human landscape use in the Makgadikgadi Basin, Botswana. Quaternary Science Reviews, 291: 107662. https://doi.org/10.1016/j.quascirev.2022.107662

Churchill, S.E., Brink, J.S., Berger, L.R., et al. 2000. Erfkroon: A new Florisian fossil locality from fluvial contexts in the western Free State, South Africa. South African Journal of Science, 96: 161-163. https://hdl.handle.net/10520/AJA00382353_8897

Clarke, R.J. 1985. A new reconstruction of the Florisbad cranium, with notes on the site. In: Delson, E. (ed) Ancestors: The Hard Evidence: 301-305. New York: Alan R. Liss.

Clarkson, C. 2002. An index of invasiveness for the measurement of unifacial and bifacial retouch: A theoretical, experimental and archaeological verification. Journal of Archaeological Science, 29: 65-75. https://doi.org/10.1006/jasc.2001.0702

Codron, D., Brink, J.S., Rossouw, L., et al. 2008. The evolution of ecological specialization in southern African ungulates: Competition- or physical environmental turnover? Oikos, 117: 344-353. https://doi.org/10.1111/j.2007.0030-1299.16387.x

Conard, N.J., Soressi, M., Parkington, J.E., et al. 2004. A unified lithic taxonomy based on patterns of core reduction. South African Archaeological Bulletin, 59: 12-16. https://doi.org/10.2307/3889318

d'Errico, F., Pitarch Martí, A., Shipton, C., et al. 2020. Trajectories of cultural innovation from the Middle to Later Stone Age in Eastern Africa: Personal ornaments, bone artifacts, and ocher from Panga ya Saidi, Kenya. Journal of Human Evolution, 141: 102737. https://doi.org/10.1016/j.jhevol.2019.102737

de la Peña, P. & Witelson, D.M. 2020. 'Project Piedemonte': Between the Maloti-Drakensberg and the Great Escarpment in the Eastern Cape Province, South Africa. Antiquity, 94: e20. https://doi.org/10.15184/aqy.2020.101

de Ruiter, D.J., Churchill, S.E., Brophy, J.K., et al. 2011. Regional survey of Middle Stone Age fossil vertebrate deposits in the Virginia-Theunissen area of the Free State, South Africa. Navorsinge van die Nasionale Museum Bloemfontein, 27(1): 1-20. https://nationalmuseumpublications.co.za/wp-content/uploads/2020/08/VOLUME-27-PART-1.pdf

Deino, A.L., Behrensmeyer, A.K., Brooks, A.S., et al. 2018. Chronology of the Acheulean to Middle Stone Age transition in eastern Africa. Science, 360: 95-98. https://doi.org/10.1126/science.aao2216

Dreyer, T.F. 1935. A human skull from Florisbad, Orange Free State, with a note on the endocranial cast by C.U. Ariens Kappers. Proceedings of the Academy of Sciences of Amsterdam, 38: 119-128.

Ecker, M., Green, C., Henderson, A., et al. 2023. Archaeological survey near Tsabong, Kgalagadi District, southwestern Botswana. Azania: Archaeological Research in Africa, 58: 517-535. https://doi.org/10.1080/0067270X.2023.2260150

Faith, J.T., Du, A., Behrensmeyer, A.K., et al. 2021. Rethinking the ecological drivers of hominin evolution. Trends in Ecology & Evolution, 36: 797-807. https://doi.org/10.1016/j.tree.2021.04.011

Goodwin, A.J.H. & van Riet Lowe, C. 1929. The Stone Age Cultures of South Africa. Edinburgh: Neil & Co. https://www.biodiversitylibrary.org/item/127022#page/13/mode/1up

Grün, R. & Stringer, C. 2023. Direct dating of human fossils and the ever-changing story of human evolution. Quaternary Science Reviews, 322: 108379. https://doi.org/10.1016/j.quascirev.2023.108379

Grün, R., Brink, J.S., Spooner, N.A., et al. 1996. Direct dating of Florisbad hominid. Nature, 382: 500-501. https://doi.org/10.1038/382500a0

Hallinan, E. 2022. "A survey of surveys" revisited: Current approaches to landscape and surface archaeology in southern Africa. African Archaeological Review, 39(1): 79-111. https://doi.org/10.1007/s10437-021-09469-z

Harper, P.T.N. 1997. The Middle Stone Age sequences at Rose Cottage Cave: A search for continuity and discontinuity. South African Journal of Science, 93: 470-475. https://hdl.handle.net/10520/AJA00382353_89

Henderson, Z. 2001. The integrity of the Middle Stone Age horizon at Florisbad, South Africa. Navorsinge van die Nasionale Museum Bloemfontein, 17: 25-52. https://hdl.handle.net/10520/AJA00679208_1374

Holmes, P. & Barker, C.H. 2006. Geological and geomorphological controls on the physical landscape of the Free State. South African Geographical Journal, 88: 3-10. https://doi.org/10.1080/03736245.2006.9713841

Jones, S.C. & Stewart, B.A. 2016. Africa from MIS 6-2. Dordrecht: Springer. https://doi.org/10.1007/978-94-017-7520-5
Kuman, K., Inbar, M. & Clarke, R.J. 1999. Palaeoenvironments and cultural sequence of the Florisbad Middle Stone Age hominid site, South Africa. Journal of Archaeological Science, 26: 1409-1425. https://doi.org/10.1006/jasc.1999.0439
Lisiecki, L.E. & Raymo, M.E. 2005. A Pliocene-Pleistocene stack of 57 globally distributed benthic $\delta^{18}O$ records. Paleoceanography, 20: PA1003. https://doi.org/10.1029/2004PA001071
Lombard, M. 2012. Thinking through the Middle Stone Age of sub-Saharan Africa. Quaternary International, 270: 140-155. https://doi.org/10.1016/j.quaint.2012.02.033
Lombard, M., Bradfield, J., Caruana, M.V., et al. 2022. The southern African Stone Age sequence updated (II). South African Archaeological Bulletin, 77: 172-212. https://www.jstor.org/stable/27200587
Lukich, V. & Ecker, M. 2022. Pleistocene environments in the southern Kalahari of South Africa. Quaternary International, 614: 50-58. https://doi.org/10.1016/j.quaint.2021.03.008
Lyons, R., Tooth, S. & Duller, G.A.T. 2014. Late Quaternary climatic changes revealed by luminescence dating, mineral magnetism and diffuse reflectance spectroscopy of river terrace palaeosols: A new form of geoproxy data for the southern African interior. Quaternary Science Reviews, 95: 43-59. https://doi.org/10.1016/j.quascirev.2014.04.021
Mackay, A., Hallinan, E. & Steele, T.E. 2018. Provisioning responses to environmental change in South Africa's winter rainfall zone: MIS 5-2. In: Robinson, E. & Sellet, F. (eds) Lithic Technological Organization and Paleoenvironmental Change: 13-36. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-64407-3_2
Mackay, A., Stewart, B.A. & Chase, B.M. 2014. Coalescence and fragmentation in the late Pleistocene archaeology of southernmost Africa. Journal of Human Evolution, 72: 26-51. https://doi.org/10.1016/j.jhevol.2014.03.003
Manegold, A. & Brink, J.S. 2011. Descriptions and palaeoecological implications of bird remains from the Middle Pleistocene of Florisbad, South Africa. Paläontologische Zeitschrift, 85: 19-32. https://doi.org/10.1007/s12542-010-0069-6
Mitchell, P.J. 2017. Discontinuities in hunter-gatherer prehistory in southern African drylands. Journal of Anthropological Archaeology, 46: 40-52. https://doi.org/10.1016/j.jaa.2016.07.001
Morris, S.E. 2019. Paleolandscape reconstruction using geoproxy evidence at Erfkroon, South Africa. Masters Dissertation. San Marcos: Texas State University. https://digital.library.txstate.edu/bitstream/10877/8980/1/MORRIS-THESIS-2019.pdf
Mourre, V., Villa, P. & Henshilwood, C.S. 2010. Early use of pressure flaking on lithic artifacts at Blombos Cave, South Africa. Science, 330: 659-662. https://doi.org/10.1126/science.1195550
Mucina, L. & Rutherford, M.C. 2006. The Vegetation of South Africa, Lesotho and Swaziland. Pretoria: South African National Biodiversity Institute.
Myburgh, A. 1997. The geomorphological evolution of the northwestern Free State since the Mesozoic. Doctoral Thesis. Bloemfontein: University of the Free State.
Orton, J. 2021. Heritage Impact Assessment: Proposed 132kV/400kV on-site Main Transmission Substation (MTS) and associated infrastructure near Dealesville. Boshof Magisterial District, Free State. Unpublished report compiled for SLR Consulting (South Africa) (Pty) Ltd, Reg. no.: 2013/220482/07.: 1-40. Available from: https://sahris.sahra.org.za/sites/default/files/heritagereports/Mainstream%20Kentani%20MTS%20HIA%20report%20Final%2017-11-21.pdf
Palmison, M.E. 2014. Excavation, analysis, and intersite comparison of the Robberg industry components at the open-air site of Erfkroon, South Africa. Masters Dissertation. San Marcos: Texas State University. https://digital.library.txstate.edu/bitstream/10877/5282/1/PALMISON-THESIS-2014.pdf
Pazan, K.R., Dewar, G. & Stewart, B.A. 2022. The MIS 5a (~80 ka) Middle Stone Age lithic assemblages from Melikane Rockshelter, Lesotho: Highland adaptation and social fragmentation. Quaternary International, 611-612: 115-133. https://doi.org/10.1016/j.quaint.2020.11.046
Pienaar, M., Woodborne, S. & Wadley, L. 2008. Optically stimulated luminescence dating at Rose Cottage Cave. South African Journal of Science, 104: 65-70. https://hdl.handle.net/10520/EJC96762
Porraz, G., Igreja, M., Schmidt, P., et al. 2016. A shape to the microlithic Robberg from Elands Bay Cave (South Africa). Southern African Humanities, 29: 203-247. https://doi.org/10.10520/EJC-55c098b90
Porraz, G., Val, A., Tribolo, C., et al. 2018. The MIS5 Pietersburg at '28' Bushman Rock Shelter, Limpopo Province, South Africa. PLOS One, 13: e0202853. https://doi.org/10.1371/journal.pone.0202853
Richard, M., Kaplan-Ashiri, I., Alonso, M.-J., et al. 2023. New ESR dates from Lovedale, Free State, South Africa: Implications for the study of tooth diagenesis. South African Archaeological Bulletin, 78: 95-103. https://www.jstor.org/stable/27303676
Richard, M., Pons-Branchu, E., Carmieli, R., et al. 2022. Investigating the effect of diagenesis on ESR dating of

Middle Stone Age tooth samples from the open-air site of Lovedale, Free State, South Africa. Quaternary Geochronology, 69: 101269. https://doi.org/10.1016/j.quageo.2022.101269

Roberts, P. & Stewart, B.A. 2018. Defining the 'generalist specialist' niche for Pleistocene *Homo sapiens*. Nature Human Behaviour, 2: 542-550. https://doi.org/10.1038/s41562-018-0394-4

Rossouw, L. 2006. Florisian mammal fossils from erosional gullies along the Modder River at Mitasrust farm, central Free State, South Africa. Navorsinge van die Nasionale Museum Bloemfontein, 22: 145-161. https://hdl.handle.net/10520/AJA00679208_1811

Rubidge, B.S. & Brink, J.S. 1985. Preliminary survey of the extent and nature of the Pleistocene sedimentary deposits at Florisbad, South Africa. Navorsinge van die Nasionale Museum Bloemfontein, 5: 69-76. https://journals.co.za/doi/pdf/10.10520/AJA00679208_395

Sampson, C.G. 1968. The Middle Stone Age Industries of the Orange River Scheme Area. Bloemfontein: National Museum.

Sampson, C.G. 1970. The Smithfield Industrial Complex: Further Field Results. Bloemfontein: National Museum.

Sampson, C.G. 1985. Atlas of Stone Age Settlement in the Central and Upper Seacow Valley. Bloemfontein: National Museum.

Schmidt, P., Stynder, D., Conard, N.J., et al. 2020. When was silcrete heat treatment invented in South Africa? Palgrave Communications, 6: 73. https://doi.org/10.1057/s41599-020-0454-z

Scott, L., van Aardt, A.C., Brink, J.S., et al. 2019. Palynology of Middle Stone Age spring deposits in grassland at the Florisbad hominin site, South Africa. Review of Palaeobotany and Palynology, 265: 13-26. https://doi.org/10.1016/j.revpalbo.2019.02.009

Shaw, M., Will, M., Watson, S., et al. 2019. The Doring River Archaeological Project: Approaching the evolution of human land use patterns in the Western Cape, South Africa. PaleoAnthropology, 2019: 400-422. https://doi.org/10.4207/PA.2019.ART138

Staurset, S., Coulson, S.D., Mothulatshipi, S., et al. 2023. Making points: The Middle Stone Age lithic industry of the Makgadikgadi Basin, Botswana. Quaternary Science Reviews, 301: 107823. https://doi.org/10.1016/j.quascirev.2022.107823

Stewart, B.A., Zhao, Y., Mitchell, P.J., et al. 2020. Ostrich eggshell bead strontium isotopes reveal persistent macroscale social networking across late Quaternary southern Africa. Proceedings of the National Academy of Sciences. https://doi.org/10.1073/pnas.1921037117

Toffolo, M.B. 2024. Pleistocene archaeology and environments of the Free State, South Africa. Azania: Archaeological Research in Africa, 59: 317-351. https://doi.org/10.1080/0067270X.2024.2379724

Toffolo, M.B., Brink, J.S. & Berna, F. 2015. Bone diagenesis at the Florisbad spring site, Free State Province (South Africa): Implications for the taphonomy of the Middle and Late Pleistocene faunal assemblages. Journal of Archaeological Science: Reports, 4: 152-163. https://doi.org/10.1016/j.jasrep.2015.09.001

Toffolo, M.B., Brink, J.S., van Huyssteen, C., et al. 2017. A microstratigraphic reevaluation of the Florisbad spring site, Free State Province, South Africa: Formation processes and paleoenvironment. Geoarchaeology, 32: 456-478. https://doi.org/10.1002/gea.21616

Toffolo, M.B., Tribolo, C., Horwitz, L.K., et al. 2023. Palaeoenvironments and chronology of the Damvlei Later Stone Age site, Free State, South Africa. South African Archaeological Bulletin, 78: 57-74. https://www.jstor.org/stable/27303673

Tooth, S., Hancox, J.P., Brandt, D., et al. 2013. Controls on the genesis, sedimentary architecture, and preservation potential of the dryland alluvial successions in stable continental interiors: Insights from the incising Modder River, South Africa. Journal of Sedimentary Research, 83: 541-561. https://doi.org/10.2110/jsr.2013.46

Trower, G. 2010. An investigation into the archaeological, palaeontological and stratigraphic continuity between two sections of the Free State's Modder River, observed within selected erosional gullies (dongas). Masters Dissertation. Bloemfontein: University of the Free State.

Tsokeli, R.D. 2005. An evaluation of the spatial variability of sediment sources along the banks of the Modder River, Free State Province, South Africa. Masters Dissertation. Bloemfontein: University of the Free State. https://scholar.ufs.ac.za/bitstreams/529fd55b-f204-4cb6-8d9f-8281b4c5a86d/download

Valladas, H., Wadley, L., Mercier, N., et al. 2005. Thermoluminescence dating of burnt lithics from Middle Stone Age layers at Rose Cottage Cave. South African Journal of Science, 101: 169-174. https://hdl.handle.net/10520/EJC96375

van Aardt, A.C., Bousman, C.B., Brink, J.S., et al. 2016. First chronological, palaeoenvironmental, and archaeological data from the Baden-Baden fossil spring complex in the western Free State, South Africa. Palaeoecology of Africa, 33: 117-152. https://doi.org/10.1201/b19410

van Hoepen, E.C.N. 1932. Die Mosselbaaise Kultuur. Argeologiese Navorsing van die Nasionale Museum Bloemfontein, 1: 27-54.

Wadley, L., Hodgskiss, T. & Grant, M. 2009. Implications for complex cognition from the hafting of tools with compound adhesives in the Middle Stone Age, South Africa. Proceedings of the National Academy of Sciences, 106: 9590-9594. https://doi.org/10.1073/pnas.0900957106

Wadley, L., Backwell, L., d'Errico, F., et al. 2020a. Cooked starchy rhizomes in Africa 170 thousand years ago. Science, 367: 87-91. https://doi.org/10.1126/science.aaz5926

Wadley, L., Esteban, I., de la Peña, P., et al. 2020b. Fire and grass-bedding construction 200 thousand years ago at Border Cave, South Africa. Science, 369: 863-866. https://doi.org/10.1126/science.abc7239

Watts, I., Chazan, M. & Wilkins, J. 2016. Early evidence for brilliant ritualized display: Specularite use in the Northern Cape (South Africa) between ∼500 and ∼300 Ka. Current Anthropology, 57: 287-310. https://doi.org/10.1086/686484

Wells, L.H., Cooke, H.B.S. & Malan, B.D. 1942. The associated fauna and culture of the Vlakkraal Thermal Springs, O.F.S. Transactions of the Royal Society of South Africa, 29: 203-233. https://doi.org/10.1080/00359194209519813

Wilkins, J. 2021. *Homo sapiens* origins and evolution in the Kalahari Basin, southern Africa. Evolutionary Anthropology: Issues, News, and Reviews, 30: 327-344. https://doi.org/10.1002/evan.21914

Wilkins, J., Schoville, B.J., Pickering, R., et al. 2021. Innovative *Homo sapiens* behaviours 105,000 years ago in a wetter Kalahari. Nature, 592: 248-252. https://doi.org/10.1038/s41586-021-03419-0

Will, M., Blessing, M., Möller, G.H.D., et al. 2024. The Jojosi Dongas: An interdisciplinary project to study the evolution of human behaviour and landscapes in open-air contexts. Southern African Field Archaeology, 19: 3010. https://doi.org/10.36615/safa.19.3010.2024

Wroth, K., Tribolo, C., Bousman, C.B., et al. 2022. Human occupation of the semi-arid grasslands of South Africa during MIS 4: New archaeological and paleoecological evidence from Lovedale, Free State. Quaternary Science Reviews, 283: 107455. https://doi.org/10.1016/j.quascirev.2022.107455

Wurz, S. 2013. Technological trends in the Middle Stone Age of South Africa between MIS 7 and MIS 3. Current Anthropology, 54: S305-S319. https://doi.org/10.1086/673283

Southern African Field Archaeology
2025 Vol. 20: Article 3408
Research report (peer-reviewed): Received September 2024; Revised January 2025; Published July 2025
DOI: https://doi.org/10.36615/safa.20.3408.2025

ISSN 1019-5785
ISSN 2789-1844

Dune, outcrop, and pan sediments from the southern Kalahari Basin: A geoarchaeological case study from the Kgalagadi district, Botswana

Inèz Faul [a, *], Taylor Grandfield [b], Stefan Dreibrodt [c], Sarah Mothulatshipi [d], Phillip Segadika [e], Christopher Green [a], Marine Frouin [b] & Michaela Ecker [a]

[a]Institute of Pre- and Protohistoric Archaeology, Kiel University, Johanna-Mestorf-Str. 2-6, 24118, Kiel, Germany
[b]Department of Geosciences, Stony Brook University, 255 Earth and Space Sciences Building, Stony Brook, NY 11794-2100, USA
[c]State Office for Monument Preservation Baden-Württemberg, Fischersteig 9, 78343 Gaienhofen-Hemmenhofen, Germany
[d]Department of History, University of Botswana, Private Bag UB 0022, Gaborone, Botswana
[e]Department of National Museum and Monuments, Khama Crescent, Gaborone, 9999, Botswana
**Corresponding author email: ifaul@ufg.uni-kiel.de*

ABSTRACT
Research from the southern Kalahari Basin (previously considered to be of limited Pleistocene archaeological significance) has provided evidence of human occupation. Surveys and excavations conducted in the Kgalagadi District near Tsabong in south-western Botswana have revealed a plethora of archaeological evidence. The region includes geomorphological features, including dunes, low quartzite hills, and pans. Duricrust formations are visible inside the pans. Previous research suggests that the pans form in topographical low points and likely already existed during the Pleistocene, while lunette dunes accumulated from deflated pan sediment during recent drying periods. However, in this region, these features have not been analysed in a geoarchaeological context, which can provide insight into the formation of archaeological sites. We investigated the mechanisms involved in the deposition of pan, dune, and sandy outcrop sediment by applying a multi-method analysis to thirty sediment samples. Analysis of pan samples reveals the presence of mostly intergrade duricrusts, with some calcretes present. Pan sediment containing fragmented ostracod valves in juvenile instars indicates post-mortem transport (taphocoenosis), and along with the diatoms (*Campylodiscus* sp.), are indicative of a brackish to saline water body. Inner dune samples share more similarities with pan sediments than with the red sand samples, as they contain higher concentrations of calcium oxide and some contain calcite and sepiolite. Particle size distributions change from unimodal in the outcrops and red dunes, to polymodal in the pans, suggesting that runoff during the wet season contributes to site formation. Sediment deflation by wind contributed to artefacts being exposed on the surfaces of the outcrops. This study therefore identifies three main site formation processes, namely deflation, runoff, and various duricrust formations, which provides insights into the environmental and climatic conditions that influenced human habitation in the Kalahari.

Keywords: Kalahari, duricrusts, sedimentology, geoarchaeology

1. Introduction

Most evidence for human evolution and associated cognitive milestones during the Pleistocene in southern Africa comes from cave sites on the southern Cape Coast (such as Blombos Cave [Henshilwood et al. 2018], Pinnacle Point [Marean 2010], and Klasies River [Wurz 2008]), as well as a few inland cave sites like Wonderwerk Cave (Berna et al. 2012) and Border Cave (Sievers et al. 2022). The focus on cave sites often overlooks the potential contributions of open-air archaeological sites to interpret the archaeological record. Notable open-air sites, such as Florisbad (Grün et al. 1996; Toffolo et al. 2017) in the Free State and Kathu Pan (Wilkins 2017; Lukich et al. 2020), Ga-Mohana (Wilkins 2023), and Canteen Kopje (e.g., Kuman et al. 2020) in the Northern Cape, have all assisted in verifying the archaeological importance of the interior. However, many of these sites are located on the southern boundary of the Kalahari in South Africa, with fewer archaeological sites reported in Botswana and other areas of the Kalahari landscape. Recent research in the Makgadikgadi Palaeolake in northern Botswana has inferred the use of the lakebed by early modern humans during dry periods after lake-level high stands in the late Pleistocene (Burrough et al. 2022; Staurset et al. 2023; Thomas et al. 2022). These and similar findings have challenged ideas from the previous century proposing that aridity hindered hominins from settling in the Kalahari (Helgren & Brooks 1983). Despite archaeological research in the Kalahari becoming more prevalent, there is still a lack of focus on the south-western part of the semi-desert in Botswana.

The town of Tsabong (26°1’12” S 22°24’20” E) is the administrative capital of the Kgalagadi district, located approximately 600 km south-west of Gaborone. Despite the area’s uniform and flat landscape, distinctive morphological features are present, including pans (seasonal water bodies), lunette dunes (transverse dunes) on the southern leeward side of most pans, and low quartzite hills (for example, Maleshe Hill) (Fig. 1). These features can be used as proxies for establishing palaeoenvironmental and depositional contexts (Lancaster 1978; Watts 1980; Ringrose et al. 1999; Telfer & Thomas 2006; Telfer et al. 2009; Lukich 2019; Thomas et al. 2022). The archaeological potential of this region has largely been noted in unpublished field reports from Seo Pan by the late Terry Hardaker and Phillip Segadika. A study by Ecker et al. (2023) has confirmed the area is rich in quartzite stone tools belonging primarily to Earlier to Middle Stone Age (ESA and MSA) typologies. These surface scatter sites are often located on raw material outcrops near pans (Ecker et al. 2023). However, a comprehensive geoarchaeological analysis of the pans, outcrops, lunette dunes, and duricrust formations in south-western Botswana, where the lithics are located, has not yet been conducted.

This study employs a multi-method approach to fill this gap. It presents one of the first geoarchaeological studies using particle size analysis (Mastersizer Hydro 2000), loss-on-ignition (LOI), X-ray diffraction (XRD), Energy-Dispersive X-ray Fluorescence (ED-XRF), and the analysis of microfossils in this area. This analysis provides valuable information on the various site formation processes at archaeological sites in the Kgalagadi district. Here, we present the results from the analysis of 30 sediment samples excavated from archaeological sites near the villages of Maleshe and Maralaleng (Fig. 1). The sites near Maleshe village include Maleshe Quarry (MAL Quarry), Maleshe Lunette Dunes 1 (MLD 1) and 2 (MLD 2), Letlakhane Quarry (LET) and Itireleng (ITI). The quarry site samples are from exposed profiles previously used for gravel quarrying. The Maralaleng sites comprise of Maralaleng Quarry (MAR-QCE), Maralaleng Mud Pit (MAR-G1), and Test pits 1 (MAR-T1) and 2 (MAR-T2). Sample abbreviations and contexts are provided in Table 1. These results are compared to existing literature to gain insight into how these archaeological test pits, geotrenches, and exposed profiles relate to the pan and dune sediments in this region, along with insights into the formation of those sediments.

2. Background

The southern Kalahari Basin is host to the Kalahari Group sediments. The most notable of the Kalahari lithologies is the red, wind-blown sand, known as the Kalahari Sands. The Kalahari Sands are characterised as fine to medium sand with sub-rounded to rounded particles (Thomas & Shaw 1991). The visible bedrocks in the study area are quartzites from the Olifantshoek Sequence (Tidi 1994). This area is situated in the Savanna biome of southern Africa (Rutherford et al. 2006). The southern Kalahari Basin experiences highly variable annual mean precipitation (approximately 150-300 mm) (Thomas & Shaw 1991; Byakatonda et al. 2018; Thomas & Wiggs 2022) and is covered by bush and shrub savannah vegetation (Lancaster 1978; Werger 1978), thus classifying it as a semi-desert. Despite this classification, research suggests that the Kalahari was more inhabitable during parts of the Pleistocene, experiencing considerable wet phases (Helgren & Brooks 1983; Wilkins et al. 2021; Lukich & Ecker 2022). The Kalahari drains internally and retains little surface water, even during the rainy season (October-April) (Thomas & Shaw 1991). Moisture fluctuations and deficits (due to high evaporation ratios) contribute to the formation of duricrusts, such as calcretes (Watts 1980; Alonso-Zarza & Wright 2010), over extended periods.

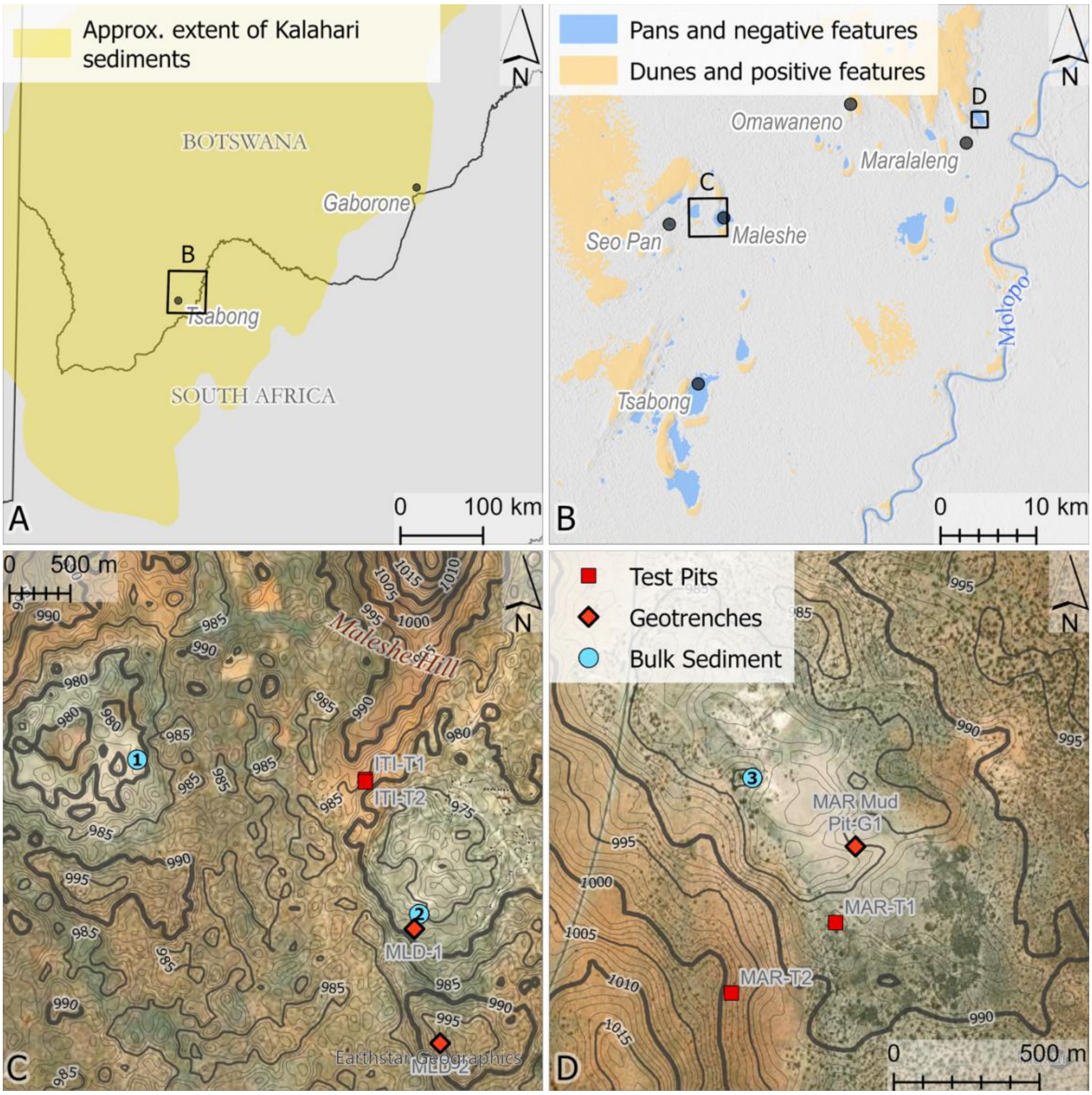


Figure 1. The study area. a) The extent of the Kalahari sediments (after Thomas 1988) in Botswana and South Africa and the geographical location of the town of Tsabong; inset square highlights the study area. b) Map of the Tsabong region; dunes and other elevated (positive) features, and negative features (pans and depressions) are indicated, with the inset squares showing the two areas compared in this study. c) The bulk sediment sampling locations in the Maleshe area within archaeological test pits (ITI-T1 and ITI-T2), depicted as red squares, and exposed profiles (1. LET 2. MAL Quarry) shown as blue dots; geotrenches MLD 1 and MLD 2 are depicted as red diamonds. d) The sampling locations in the Maralaleng area are denoted with red squares depicting archaeological test pits MAR-T1 and MAR-T2 and the exposed profile (3. MAR-QCE) as a blue circle; geotrench MAR-G1 is indicated by a red diamond.

Pans occur in topographical low points (Shaw & Thomas 1997; Schüller et al. 2022). Pans in the southern Kalahari Basin are broadly described as having saline to clayey surfaces (Schüller et al. 2022). Research conducted at Witpan in South Africa (southern Kalahari) suggests that the pans consist of mostly silt and clay, with some aeolian, sand-sized quartz grains that likely settled on the pan floor during a wetter-than-present phase (Telfer et al. 2009). The pans are often accompanied by two lunette dunes (crescent-shaped transverse dunes [Hills 1940]); an outer, larger 'red' dune and a smaller dune with pale-coloured sediment that represent primarily Holocene accumulations caused by sediment deflation, especially from the last 2000 years, according to OSL dating (Telfer & Thomas 2006; Schüller et al. 2022). The lunette dunes are usually located on the south-western side of the pans. The formation of the fringing lunette dunes is argued to be the result of periods of aridity that cause sediment to deflate from the dry pan surface (Lancaster 1978; Thomas & Wiggs 2022; Schüller et al. 2022), but can also occur as a result of sediment moving towards the downward margin by wave action during wet periods (Bowler 1986; Thomas & Wiggs 2022).

Table 1. Table showing the names and abbreviations of test pits, as well as the type of pit.

Name of exposure	Study samples	Type of exposure and context
Iterileng Test Pit 1 (ITI-T1)	ITI-T1	Archaeological test pit on outcrop with Kalahari sand cover.
Maleshe Quarry (MAL Quarry)	MAL Quarry Bed 1 (surface); MAL Quarry Bed 2; MAL Quarry Bed 3; MAL Quarry Bed 4 (Upper); MAL Quarry Bed 4 (Middle); MAL Quarry Bed 4 (Lower); MAL Quarry Bed 5	Exposed profile in quarry.
Maleshe Lunette Dune 1 (MLD 1)	MLD 1.1; MLD 1.2; MLD 1.3; MLD 1.4	Geotrench on inner dune section.
Maleshe Lunette Dune 2 (MLD 2)	MLD 2.1; MLD 2.2; MLD 2.3	Geotrench on outer dune section.
Letlhakane Profile 1 (LET Profile 1)	LET Quarry Profile 1 Bed 1; LET Quarry Profile 1 Bed 2; LET Quarry Profile 1 Bed 3	Geotrench in quarry to extend an already exposed profile.
Letlhakane Profile 2 (LET Profile 2)	LET Quarry Profile 2	Geotrench in quarry to extend an already exposed profile.
Maralaleng Quarry Calcrete Exposure 1 (MAR-QCE1)	MAR QCE 1 Surface; MAR QCE 1 Bed 1; MAR QCE 1 Bed 2	Exposed profile in quarry.
Maralaleng Test Pit 1 (MAR-T1)	MAR-T1 Bed 1 Upper; MAR-T1 Bed 1 Lower; MAR-T1 Bed 2 (Calcrete)	Archaeological test pit on inner dune section.
Maralaleng Test Pit 2 (MAR-T2)	MAR-T2	Archaeological test pit on outcrop with Kalahari sand cover.
Maralaleng Mud Pit Goetrench 1 (MAR-G1)	MAR-G1 Bed 1; MAR-G1 Bed 2 (Upper); MAR-G1 Bed 2 (Lower); MAR-G1 Bed 3	Geotrench inside the pan at MAR.

Duricrust formation is a dominant feature in the Kgalagadi landscape, especially on the pan surfaces, and is characteristic of arid and semi-arid regions (Netterberg 1980; Watts 1980; Warren 1983; Nash et al. 2004). Duricrusts are near-surface crusts that have been chemically precipitated and are classified based on the dominant mineral of cementation (e.g., Nash & Shaw 1998; Kampunzu et al. 2007; Nash 2022). Various types of duricrusts have been identified throughout the Kalahari, such as calcrete (Netterberg 1969; Goudie 1972; Watts 1980; Nash & McLaren 2003), silcrete (Summerfield 1983a; Nash & Shaw 1998; Webb & Nash 2020; Nash et al. 2022), and ferricrete (Munyikwa et al. 2000). The most predominant types of duricrust identified in the southern Kalahari Basin in Botswana are calcretes, silcretes, and intergrade duricrusts (Nash & Shaw 1998; Nash et al. 2004; Nash 2022). Calcretes are cemented by calcium carbonate ($CaCO_3$), whereas silcrete is cemented by silica (SiO_2). Silcrete-calcrete, or cal-silcrete intergrade duricrusts, refers to a duricrust cemented by a mixture of silica and calcium carbonate. Calcrete, silcrete, and intergrade duricrusts are all secondary formations that have precipitated over a host sediment.

Calcretes are terrestrial accumulations of $CaCO_3$ found in semi-arid environments where formation is influenced by factors such as rapid evaporation, groundwater fluctuations, and $CaCO_3$ availability (Netterberg 1969; Watts 1980; Alonso-Zarza & Wright 2010). Watts (1980) conducted a mineralogical analysis on pans north of Gaborone in Botswana and suggested that the clay minerals palygorskite and sepiolite can be linked to the formation of calcrete in this area, but that sepiolite is more common in mature calcrete formations. The calcretes described by Watts (1980) likely developed during periods of increased aridity and are composed of high magnesium calcite. Groundwater calcretes (non-pedogenic) have been described in dry river valleys in central Botswana by Nash and McLaren (2003). These calcretes are described as being more than 4 m-thick, structureless, cemented, and becoming less indurated with depth (Nash & McLaren 2003). Numerous phases of cementation were identified in single profiles, relating to both capillary rise and formation in the vadose zone (Nash & McLaren 2003). Remains of molluscs (*Melanoides tuberculate*) and diatoms (*Campylodiscus* sp.) were found, suggesting an environment with fresh to brackish water conditions when the valleys were active (Nash & McLaren 2003).

A duricrust is considered a silcrete when it has >85% weight SiO_2 (Summerfield 1983b; Nash et al. 1994; Nash 2022). Case studies from the Kalahari Desert in Botswana suggest that silcretes in this region have formed in arid and alkaline environments (Nash et al. 1994). When conducting bulk sediment geochemistry, it is important to note that silcrete geochemistry is affected by the host sediment over which the silcrete formed (Nash et al. 1994). Intergrade duricrusts are widespread in the Kalahari and have been recorded in Namibia and Botswana (Nash & Shaw 1998). The presence of silcrete, calcrete, and intergrade duricrusts indicate the water's pH, as calcretes are more likely to develop at a high pH and silcretes at a lower pH (compared to calcretes) (Nash & Shaw 1998).

3. Site descriptions

Archaeological sites within the villages of Maleshe and Maralaleng were recorded during the 2022 field season. Geoarchaeological samples were collected from three locations in Maleshe (MAL Quarry, ITI, and LET) and from four areas around Maralaleng Pan (MAR-QCE 1; MAR-G1; MAR-T1; MAR-T2) in the village of Maralaleng.

Maleshe

MAL Quarry is a pan with an area of 2.45 km^2 according to the Shuttle Radar Topography Mission (SRTM) elevation model. Observed duricrust profiles within the pan suggest various stages of development. Maleshe Pan is associated with MLD 1 and MLD 2, which are situated southwest of Maleshe village, and artefacts pertaining to the Iron Age have been described on the outer dune (Ecker et al. 2023).

ITI is an open-air site located at the base of Maleshe Hill. The vegetation in the area consists mostly of thorny bushes, some thorny trees, and a few patches of grass. Artefacts relating to ESA and MSA typologies have been previously documented (Ecker et al. 2023). ITI-T1 (Fig. 2) is an archaeological test pit on a quartzite outcrop covered by red sand. ITI-T2 (see supporting online material [SOM] 1 Fig. 1 and Table 1) is a test pit adjacent to ITI-T1. Additional information about all samples is provided in SOM 1 (Table 1) and SOM 2 (Table 1).

LET is a pan site situated between Seo Pan and ITI (Ecker et al. 2023) that has an area of 1.37 km^2 according to the SRTM model. Duricrust profiles are exposed at the surface due to modern quarrying. The profiles at LET, visibly angled on a slope, are located close to an outcrop where lithics have been found (Ecker et al. 2023). LET Pan has an accompanying lunette dune on the southern leeward side, but the lunette dune was not sampled for this study.

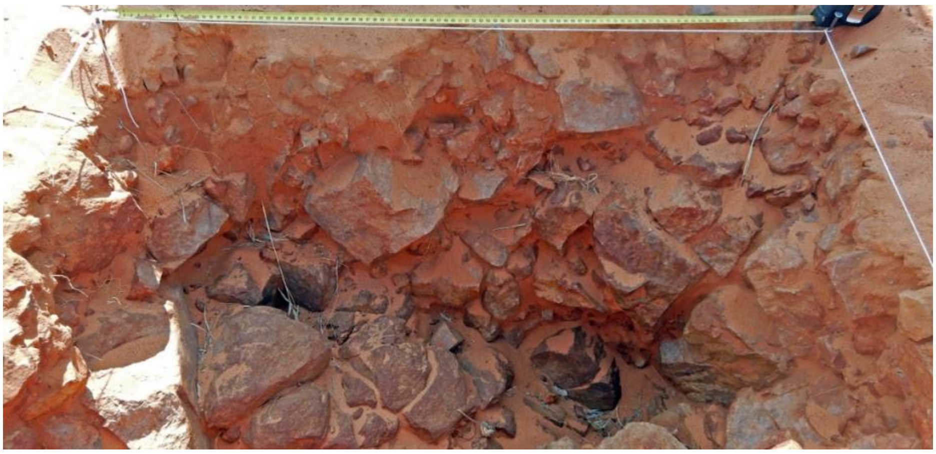


Figure 2. Profile image from archaeological test-pit ITI-T1 (northern profile) located on a quartzite outcrop covered in Kalahari Sand.

Maralaleng
Maralaleng Pan has an area of 1.55 km^2 and it is more vegetated than the other pans mentioned in this study. Various small exposed duricrust profiles are visible near the lowest point of the pan. Maralaleng Pan does not have prominent lunette dunes like the other pans described above, however, an elevated area caused by a quartzite outcrop on the south-western side of the pan is visible (Fig. 1d). MAR-T1 is associated with the white inner dune and MAR-T2 is associated with the outcrop.

4. Materials and methods

Fieldwork method and strategy
Profiles exposed from gravel extraction for road construction were identified at Maleshe Quarry and Maralaleng Pan. These profiles were photographed, drawn, and documented, with samples collected from each identifiable layer. At the dunes and outcrops, archaeological test pits and geotrenches were excavated using trowels and spades. The archaeological test pits, each measuring 1 m^2, were excavated by hand in 10 cm spits using trowels, while geotrenches were dug with a spade without the use of spits. Table 1 lists which sites were exposed profiles, geotrenches, and archaeological test pits. In general, the upper 10 cm of each profile was excluded from sampling to avoid disturbed surface sediment.

Sediment samples were collected in the field during July/August 2022. Each sample was taken from a clearly visible stratigraphic layer, or at regular intervals when stratigraphy was not visible. SOM 1 Table 1 summarises the geoarchaeological field observations made in 2022, detailing the depth of each bulk sediment sample, the profile from which it was excavated, and the GRADISTAT (Blott & Pye 2001) sorting and textural groups.

Study sites
At the Maleshe Pan, the test pits ITI-T1 and ITI-T2 contained a high number of large angular gravels and exhibited no clear stratigraphy (also see SOM 1, Fig. 1, Table 1). Very fine plant roots were visible throughout the profiles. There was little to no void space, with the profiles being clast-supported, where the red sand matrix filled the spaces between clasts. ESA and MSA artefacts made from quartzite have been reported from these test pits (Ecker et al. 2023; Winterhalder 2023).

Two geotrenches (MLD 1 & MLD2) and one exposed profile (MAL Quarry) associated with Maleshe Pan were analysed. Bioturbation, in the form of ant holes, termite holes, and plant material, was present across the profiles studied from Maleshe Pan. The two geotrenches were opened on the inner and outer dunes, respectively. The inner dune (MLD 1) has yellow-white sediment and no visible stratigraphy (Fig. 3). Gastropod shells were excavated from MLD 1 and four bulk sediment samples were taken. The outer red dune (MLD 2; Fig. 4) is the larger lunette dune on the southern side of MAL Quarry (the pan site) and had surface scatters of late ESA, MSA, Later Stone Age (LSA), and Iron Age artefacts. The geotrench was dug downslope and southwest of the village of Maleshe. Although the MLD 2 profile lacked clear stratigraphy, darker patches of sediment were visible, and the presence of roots was visible within the profile. A total of three bulk sediment samples were taken from here. MAL Quarry (Fig. 5) is an exposed profile inside Maleshe Pan where seven bulk sediment samples were collected. At LET two exposed profiles were recorded. Both LET Profile 1 and LET Profile 2 are duricrust profiles (Figs 6 & 7). Three bulk sediment samples were collected from LET Profile 1 and one bulk sediment sample was collected from LET Profile 2.

At Maralaleng Pan, two test pits (MAR-T1 & MAR-T2), one geotrench (MAR-G1) and one exposed profile (MAR-QCE1) were recorded and sampled. Geotrench MAR-G1 is located towards the centre of the pan and reached a depth of 110 cm before a hard duricrust layer was reached (Fig. 8). A total of four bulk sediment samples were collected from this trench. Exposed quarrying profile MAR-QCE1 (Fig. 9) is located north-east of MAR-G1 and is in an area where duricrust extraction was visible. This exposed profile was 150 cm deep and three bulk sediment samples were taken. Archaeological test pit MAR-T1 (Fig. 10) is in the area between the pan and the outcrop and reached a depth of 150 cm. No clear stratigraphy was visible in MAR-T1, except for the transition of upper sandy deposits to lower deposits that contained calcite nodules. Three bulk sediment samples were collected from MAR-T1 in addition to excavated snail shells and fragments of ostrich eggshell. MAR-T2 (Fig. 11) is located on the raw material outcrop where red dune sand is visible on the hill slope outcrop. MAR-T2 reached a depth of 37 cm, and one bulk sediment sample was collected. Although less artefacts were noted in comparison to the ITI test pits, ESA and MSA lithics were recorded during the 2022 survey on the surface of the southern slope and the pan floor (Ecker et al. 2023).

Figure 3. Photograph of geotrench MLD 1 located on the inner dune associated with Maleshe Pan. Bulk sediment sampling locations are marked with circles, while the triangles denote OSL sampling locations. Sample IDs correspond with bed names. Each pole section=25 cm.

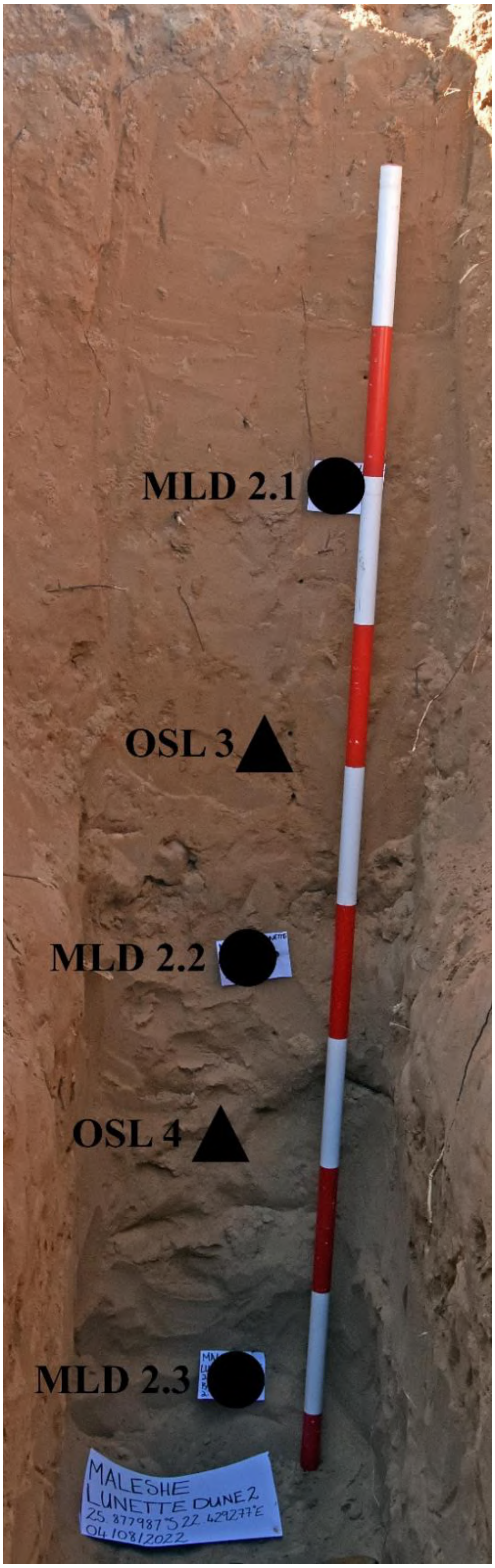


Figure 4. Photograph of geotrench MLD 2 located on the outer dune associated with Maleshe Pan. Bulk sediment sampling locations are marked with circles, while the triangles denote OSL sampling locations. Sample IDs correspond with bed names. Each pole section=25 cm.

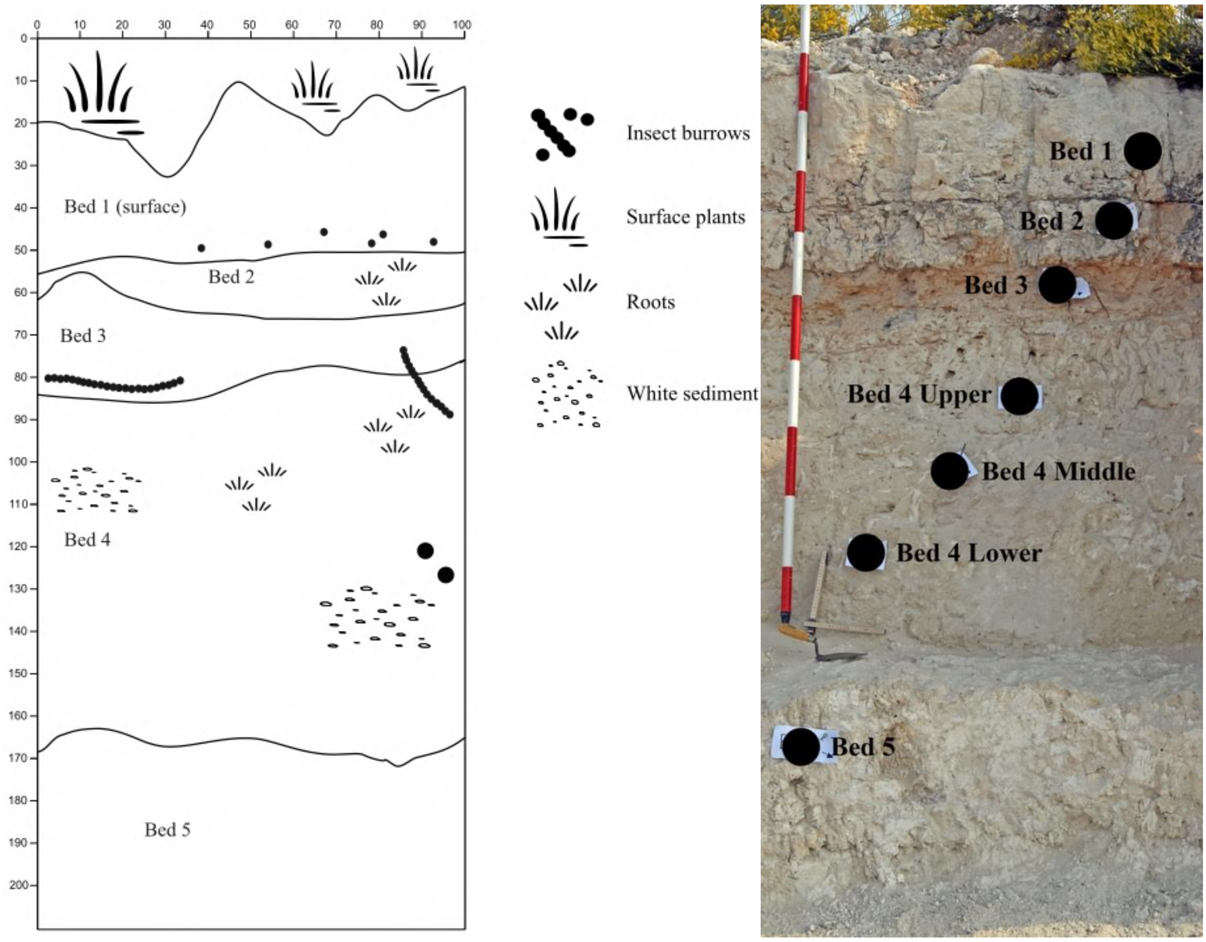


Figure 5. Profile drawing (left, with legend to the right of the drawing) and photograph (right) of exposed duricrust profile MAL Quarry, located inside Maleshe Pan. Black circles represent the locations where bulk sediment samples were collected. Sample IDs correspond with bed names. Each pole section=25 cm.

Analytical methods

Pan and dune geomorphology – GIS: Pan extents were calculated by performing a fill operation in GIS to fill in all self-contained negative features on the elevation model. This technique, typically used in hydrological modelling to ensure that water does not stop when there is no exit from a cell (Tarboton et al. 1991; Planchon & Darboux 2002), was adapted for this study. The original elevation model was subtracted from the filled surface, resulting in a model showing only the extent and depths of all self-contained negative features. A 2 m cut-off depth was then applied to separate these features into individual objects. In this landscape, most of the larger self-contained negative features are pans.

For the dunes, the same operation was applied to an inverted elevation model, resulting in self-contained positive features, which were also separated using the 2 m cut off. Most of these features are hills or ranges of hills, but dunes could be manually extracted based on their form and relative location to pans.

Pan and dune volumes were calculated by isolating a single feature, summing all depths/heights of the cells within the feature, and multiplying by the areal extent of each cell. This method, while an approximation, is relatively straightforward and should be reasonably accurate, as all calculations are derived from the same model and subject to the same constraints. Higher quality elevation models, such as those derived from LiDAR data, would produce more precise results, but such models are not currently available for this area.

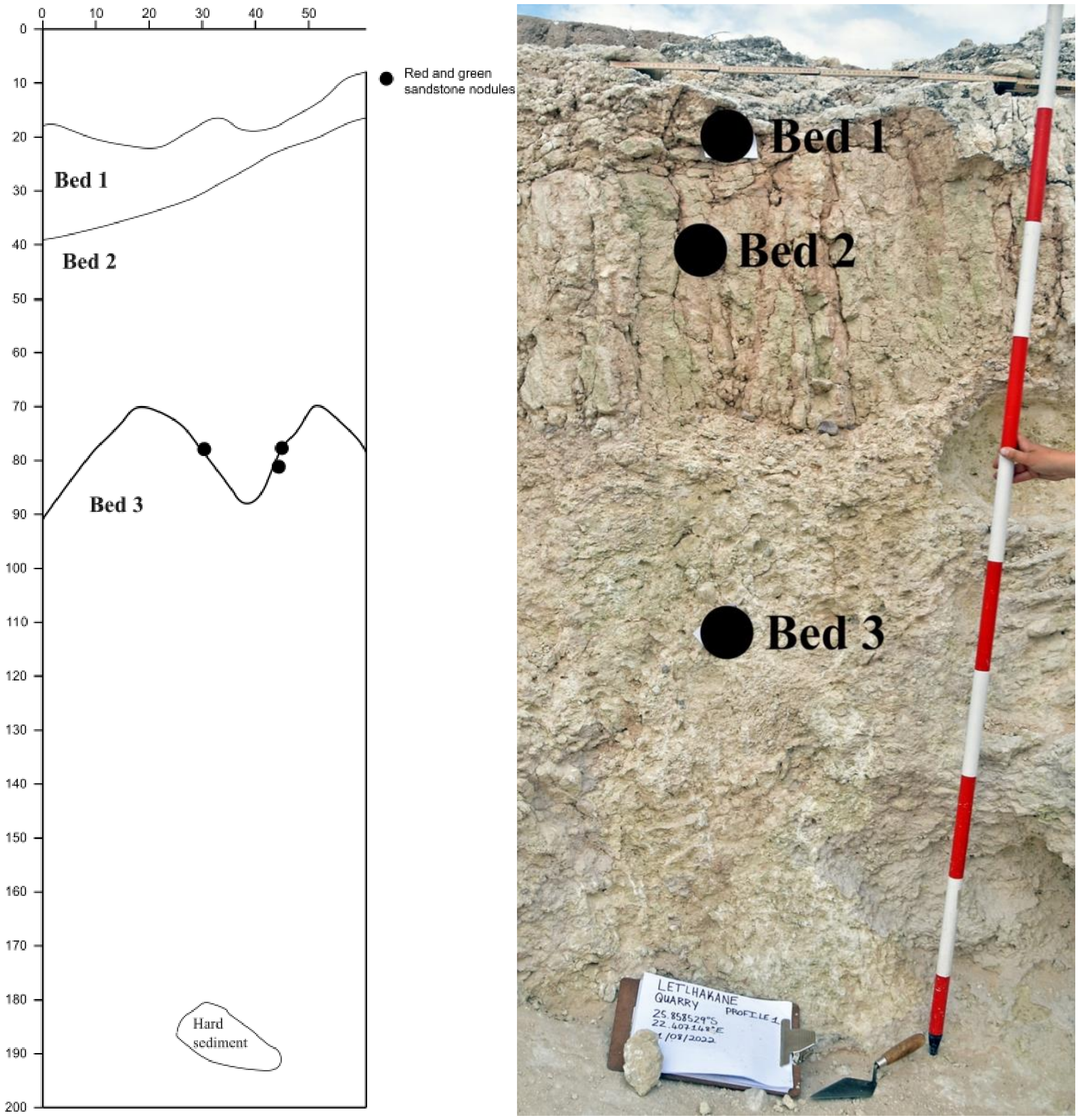


Figure 6. Profile drawing (left, with legend to the right of the drawing) and photograph (right) of the exposed LET Profile 1. Locations of bulk sediment samples are represented by black circles. Sample IDs correspond with bed names. Each pole section=25 cm.

Bulk sediments were collected from exposed profiles at each visible stratigraphic layer using either a trowel or hammer and chisel. Thirty sediment samples are discussed here. The bulk sediment was divided in half in the lab. One half was kept as an archive for microfossil analysis, while the other half was homogenised into fractions larger and smaller than 2 mm. The fraction <2 mm was then used for the LOI, Mastersizer 2000, ED-XRF, and XRD analyses.

LOI was applied using a protocol adapted from Heiri et al. (2001). Approximately 5 g of sediment was dried overnight (>12 hrs) at 105℃ to remove any water content. Samples were then heated at 550℃ in a muffle furnace for 2 hrs to estimate the relative organic matter. Finally, samples were burnt at 940℃ for two hours to approximate inorganic carbonate content.

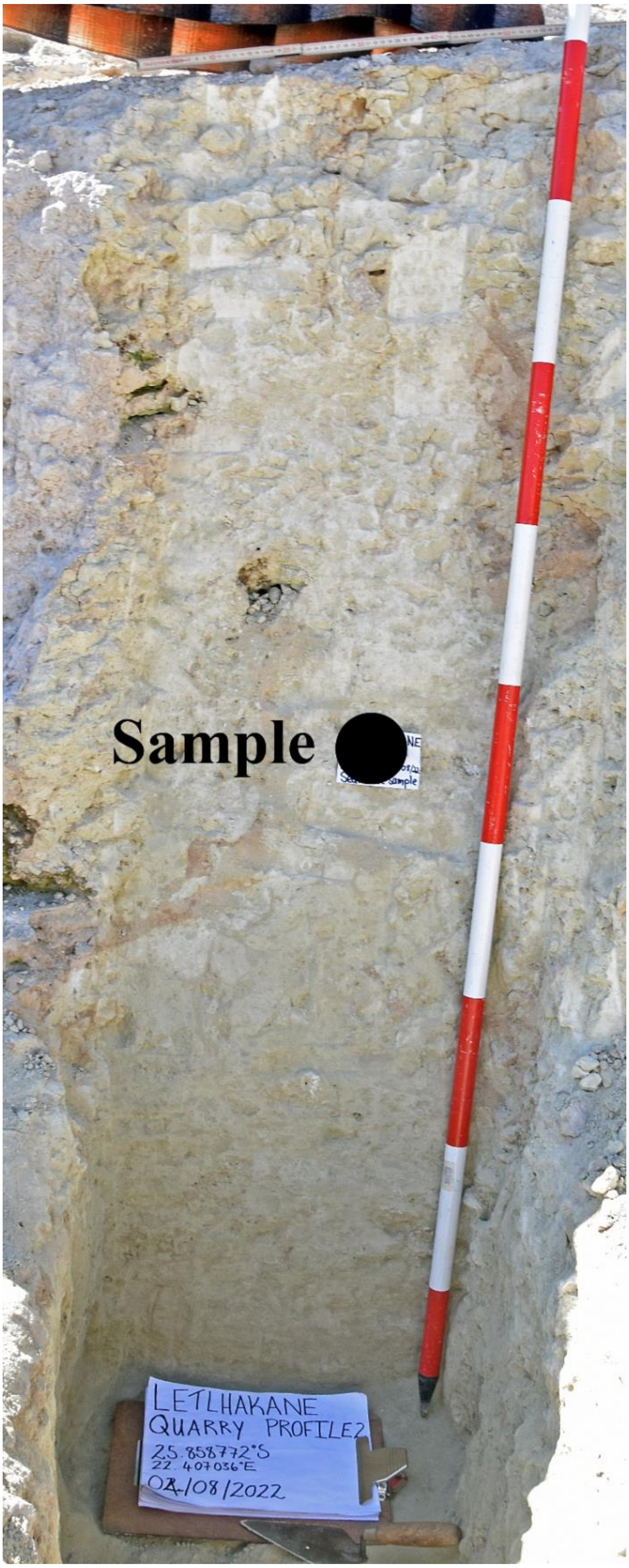


Figure 7. Photograph of exposed profile LET Profile 2 located inside LET Pan. The location of a bulk sediment sample is represented by the black circle. Sample ID is LET Profile 2. Each pole section=25 cm.

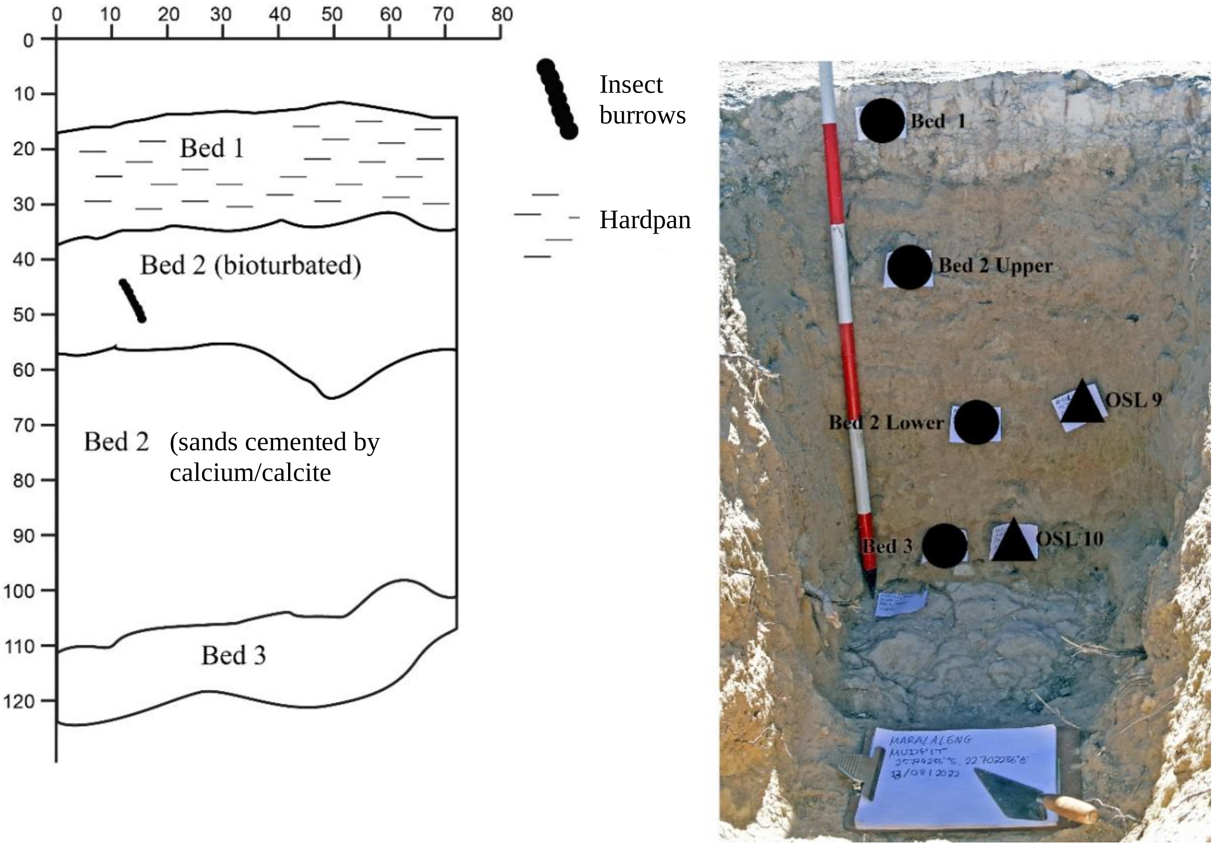


Figure 8. Profile drawing (left, with the legend to the right of the drawing) and photograph (right) of geotrench MAR-G1, located inside Maralaleng Pan. Bulk sediment sampling locations are illustrated with circles, while the triangles indicate OSL sampling locations. Sample IDs correspond with bed names. Each pole section=25 cm.

Between 1.0 and 1.6 g of sediment was used for the Mastersizer particle size analysis. A standard protocol from the Institute for Ecosystem Research (Kiel University) was followed. In this procedure, organic matter was removed by adding 35% hydrogen peroxide (H_2O_2) in 10 ml increments, along with 5-10 ml of distilled water. The samples were then placed in a thermal bath at 60°C until the reaction subsided. One to two additions of 35% H_2O_2 were necessary, as the samples did not contain much organic material. After removing organic matter, two to three rounds of Na-acetate-acetic acid (sodium acetate) buffer were added to the samples to remove the inorganic carbonates. The samples were then placed in a water bath at 60°C again. Following this, the supernatant was removed with a pipette, and 1-3 ml of 1 M magnesium chloride ($MgCl_2$) solution and 10 ml of distilled water was added to the samples. Magnesium chloride was used to speed up the sedimentation process. The supernatant was removed again, 0.5 ml of 0.1 M sodium pyrophosphate ($Na_4P_2O_7$) and 5-10 ml of distilled water was added. Finally, the samples were placed onto a shaker platform overnight. The Mastersizer 2000 (Hydro) was used to establish particle size distributions between 0.02-2000 µm using laser diffraction. GRADISTAT (Microsoft Excel) program version 9.1 (Blott & Pye 2001) was used to gather information on particle size statistics. The size classification of particle sizes was modified by Blott and Pye (2001), from Udden (1914) and Wentworth (1922), to categorise the sediment. The program uses Folk and Ward's (1957) descriptive terms.

To determine the elemental composition of the sediment, an Ametek Spectro Xepos Energy Dispersive XRF machine was used on the samples. Sub-samples of the <2 mm sediment fraction were dried in an oven at 40°C for a minimum of one week. The samples were then homogenised into a <60 µm fraction using an agate mill and covered with a 4 µm plastic film. Each sample was measured for a total of 600 seconds. In this context, when using the ED-XRF, CaO and SiO2 are the main elements used to determine whether a sample is a calcrete, silcrete, or intergrade duricrust. The ED-XRF results assume that all CaO is related to CaCO3 and that all SiO2 is related to either silcrete formation or the original Kalahari host sediment. This approach is used in conjunction with XRD. For selected ground samples (n=9) previously analysed using ED-XRF, an XRD mineral analysis was performed using a D8 Discover by Bruker AXS (Cu K-α radiation with a wavelength of approximately 1.54 Å; step size: 0.037° 2 theta; count time: 2 s/step; measuring range: 2°-70° 2 theta). The XRD device uses theta-theta geometry and has a copper X-Ray source. The homogenised <60 µm fraction was also used for XRD. The samples were selected to further establish the presence of calcification (and CaCO3) and the presence of clay minerals in certain contexts. Minerals from the XRD analysis were identified using the High Score Plus software by PANalytical version 4.8 (4.8.0.255.18) (Degen et al. 2014).

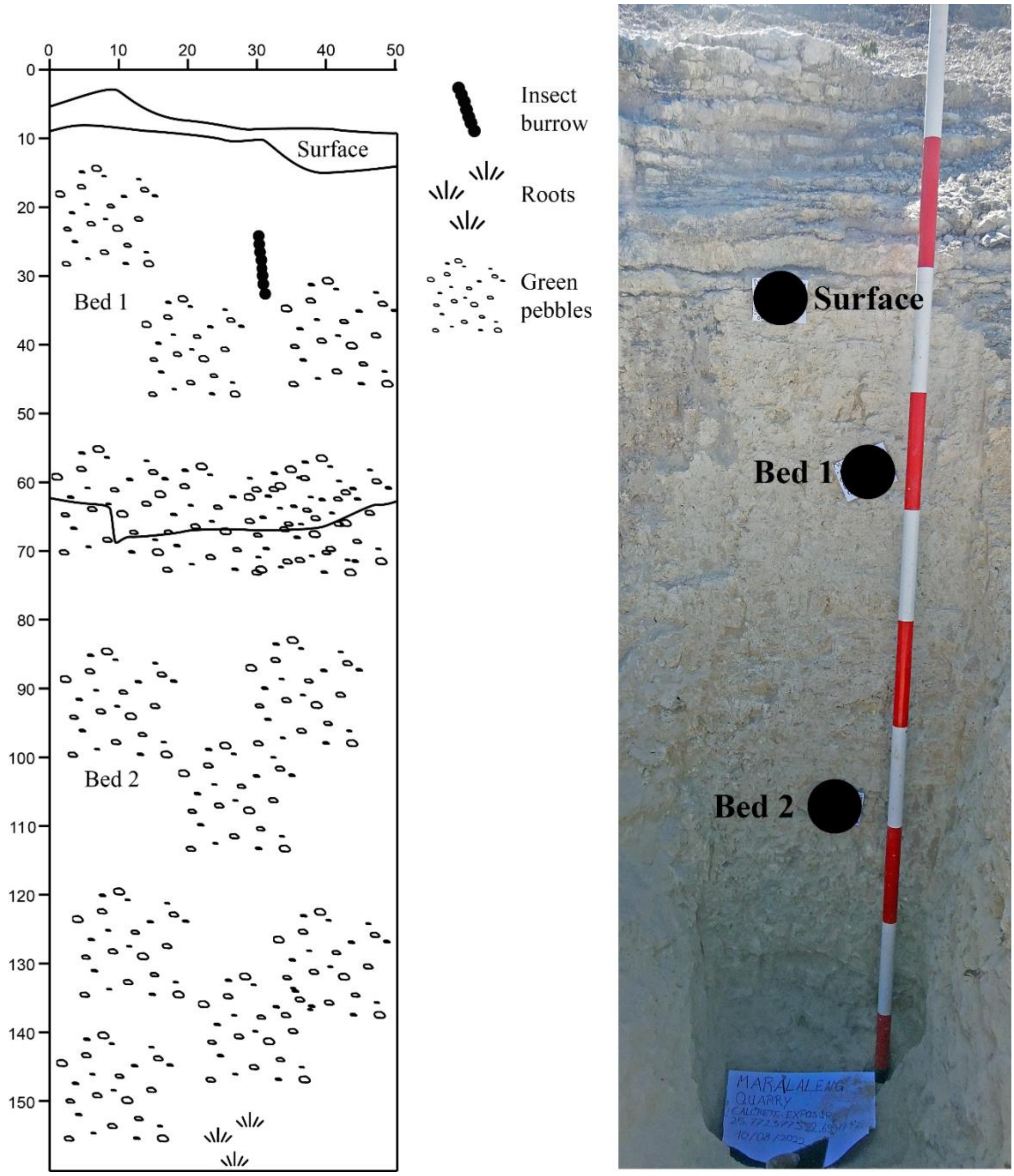


Figure 9. Profile drawing (left, with the legend to the right of the drawing) and photograph (right) of exposed duricrust profile MAR-QCE 1, located inside Maralaleng Pan. Bulk sediment sampling locations are marked with circles. Sample IDs correspond with bed names. Each pole section=25 cm.

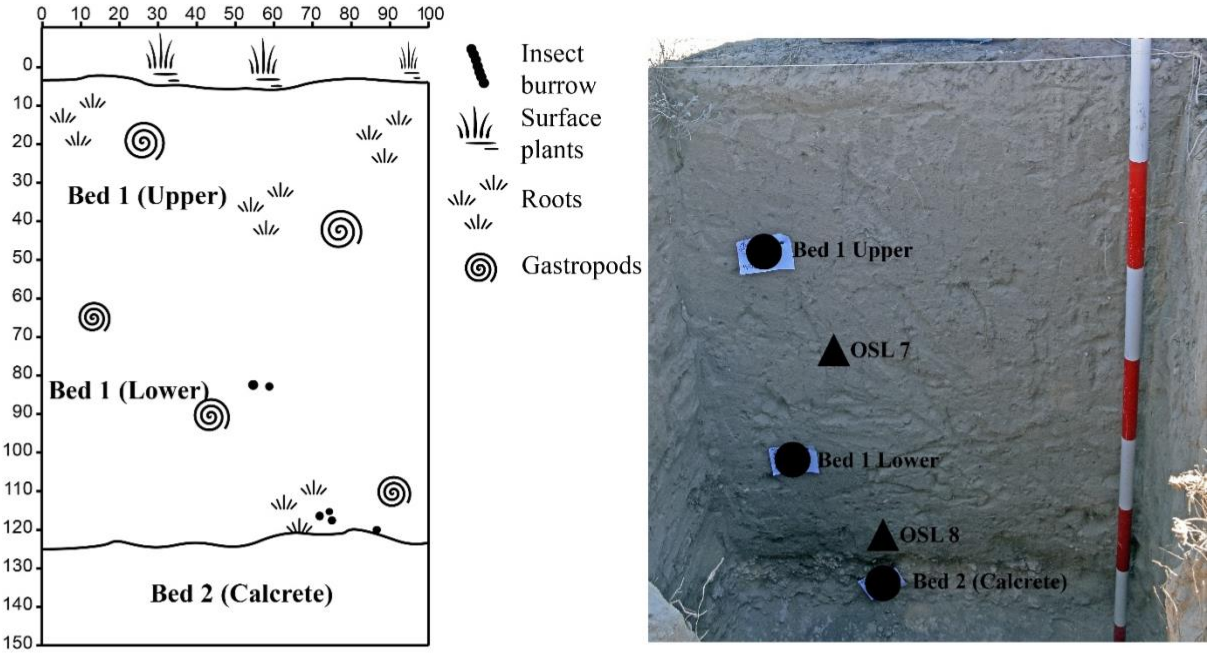


Figure 10. Profile drawing (left, with the legend to the right of the drawing) and photograph (right) of archaeological outcrop test-pit MAR-T1, located in Maralaleng Pan. Bulk sediment sampling locations are marked with circles along with OSL sampling locations (triangles). Sample IDs correspond with bed names. Each pole section=25 cm.

Figure 11. Profile image taken from archaeological test-pit MAR-T2 (southern profile) located on a quartzite outcrop covered in Kalahari Sand.

Sub-samples of approximately ≤50 g from each of the >2 mm un-homogenised bulk sediment samples were washed using deionised water through 63 µm, 125 µm, 250 µm, and 1 mm nest sieves (Horne & Siveter 2016). Samples with larger cemented clasts were first disaggregated in deionised water on a shaker platform overnight before wet sieving. Thereafter, the sieved samples were placed into an oven at 40-60°C until dry. Samples were then analysed on a black picking tray. A fine-picking brush was used to pick out specimens of interest and mounted on a micropalaeontological slide with water-soluble glue. A COXEM EM-30AXN was used to take SEM images of microfossils.

To determine which components are responsible for the main variables between all the samples analysed (Bialik et al. 2021), a Principal Component Analysis (PCA) was conducted using the Paleontological Statistics Software Package version 4.17 (PAST – PAleontological STatistics)

(Hammer & Harper 2001). Before the statistical analysis, all data (ED-XRF, LOI and particle size analysis) were normalised in MS Excel using the logarithmic function (Filzmoser et al. 2009).

5. Results

The outcrop samples, ITI-T1 and MAR-T2 and dune samples from MLD 2 contain very little organic matter and inorganic carbonates, especially compared to inner dune samples MLD 1 and MAR-T1 (Fig. 12). At MLD 1 there is an increase in carbonate content, but a decrease in organic matter with depth. The inorganic carbonate content decreases from MLD 2.1 to MLD 2.2 but increases again in MLD 2.3. The organic content remains fairly consistent, besides a slight decrease, from MLD 2.2 to MLD 2.3 (Fig. 12). The LOI results for MAR-T1 indicate that the inorganic carbonate content increases slightly with depth and is more abundant in the sample than in the organic matter throughout the sequence. At MAR-T2 the organic matter was more abundant in the inorganic carbonate (Fig. 12). The samples with the highest inorganic carbonates were all from the inner dunes, namely MAR-T1 and MLD 1. Red dune and outcrop samples contained more organic matter than inorganic carbonates.

Pan sediments generally had higher concentrations of inorganic carbonates (Fig 13). The inorganic carbonate content decreases with depth at MAL Quarry, but becomes more enriched in the lowermost bed, MAL Quarry Bed 5 (22.3%). Additionally, organic matter content also increases in MAL Quarry Bed 5 (Fig. 13). The percentage of inorganic carbonate content fluctuates at MAR-QCE 1, where Bed 1 has the highest abundance. MAR-QCE 1 Bed 2 has the lowest abundance of inorganic carbonates. The amount of inorganic carbonates decreases with depth at MAR-G1 (Fig. 13).

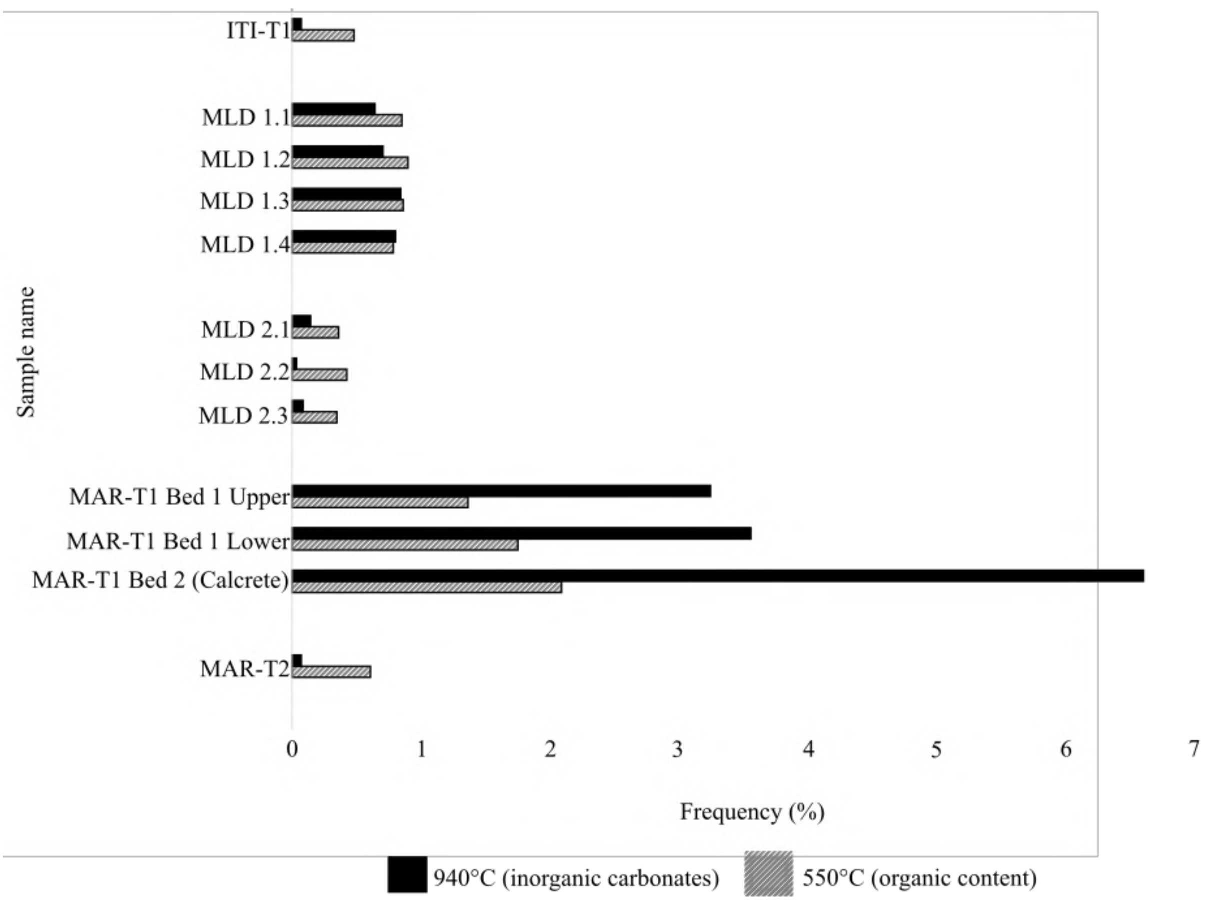


Figure 12. LOI results for organic matter (burnt at 550°C) and inorganic carbonate (burnt at 940 °C) for outcrop and dune samples.

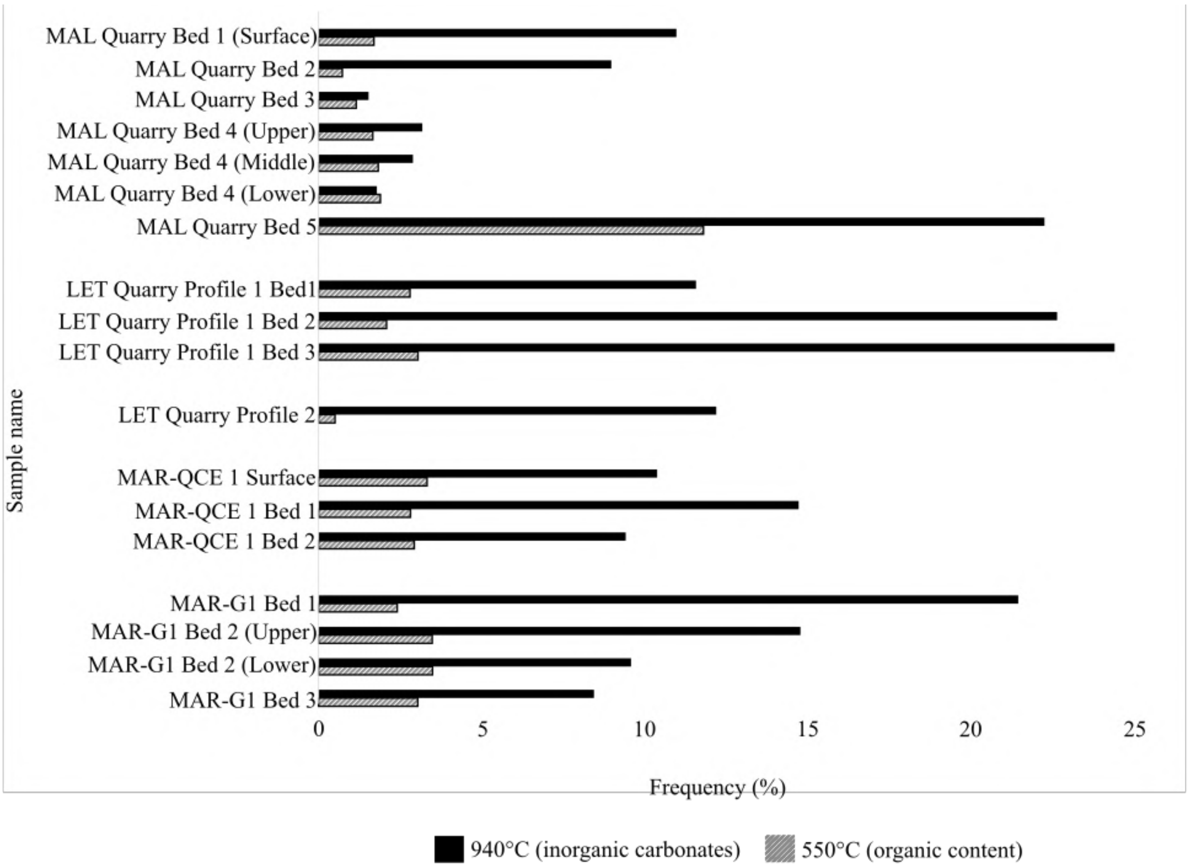


Figure 13. LOI results for organic matter (burnt at 550°C) and inorganic carbonate (burnt at 940 °C) for pan samples.

Particle size distributions from the Maleshe area and Maralaleng Pan ranged from well-sorted to very poorly sorted sediment, depending on the site and the geoproxy analysed (Fig. 14). In general, the red dune and outcrop sediments are well sorted, whereas pan and inner dune samples are more poorly sorted (Fig. 14). The particle size data are provided in SOM 2 Table 1.

The outcrop sample from ITI-T1 consist mostly of medium sand-sized sediment (250-500 μm), but include some silt-sized sediment as well (Fig. 14). ITI-T1 has a unimodal distribution and is moderately sorted. Similarly, MAR-T2 is moderately sorted with a unimodal distribution, having most particles in the medium sand category (250-500 μm). However, MAR-T2 contains 2.7% silt (when all silt classes are counted together) and 0.3% clay. The red outer dune samples from MLD 2 are mostly sand-sized with unimodal distributions that become finer with depth. The inner, white dune, MLD 1, has a unimodal distribution but is comprised of poorly sorted sand. Similarly to MLD 1, the upper two samples from inner dune MAR-T1 (MAR-T1 Upper; MAR-T1 Lower) have unimodal distributions but are also poorly sorted. The lowermost layer in the profile, MAR-T1 Bed 2, was noted as being an unconsolidated sand layer with calcite nodules. The MAR-T1 Bed 2 sediments have a bimodal distribution and are poorly sorted.

At MAL, Quarry Bed 1 (surface) and Quarry Bed 2 have poorly sorted unimodal distributions. Quarry Beds 3 and 4 (upper) are poorly sorted with bimodal distributions. MAL Quarry Bed 4 (middle) sediments are poorly sorted, but with a unimodal distribution. MAL Quarry Bed 4 (lower) exhibits a unimodal, poorly sorted distribution, with 86.6% sand, 13.4% silt and no clay component. MAL Quarry Bed 5 is very poorly sorted and unimodal, consisting of 56.8% sand, 41.7% silt, and 1.5% clay. Samples from LET Profile 1 and 2 are mostly in the medium to fine sand categories. The samples are all unimodal and very poorly sorted, except LET Profile 1 Bed 3, which has a bimodal distribution and is very poorly sorted.

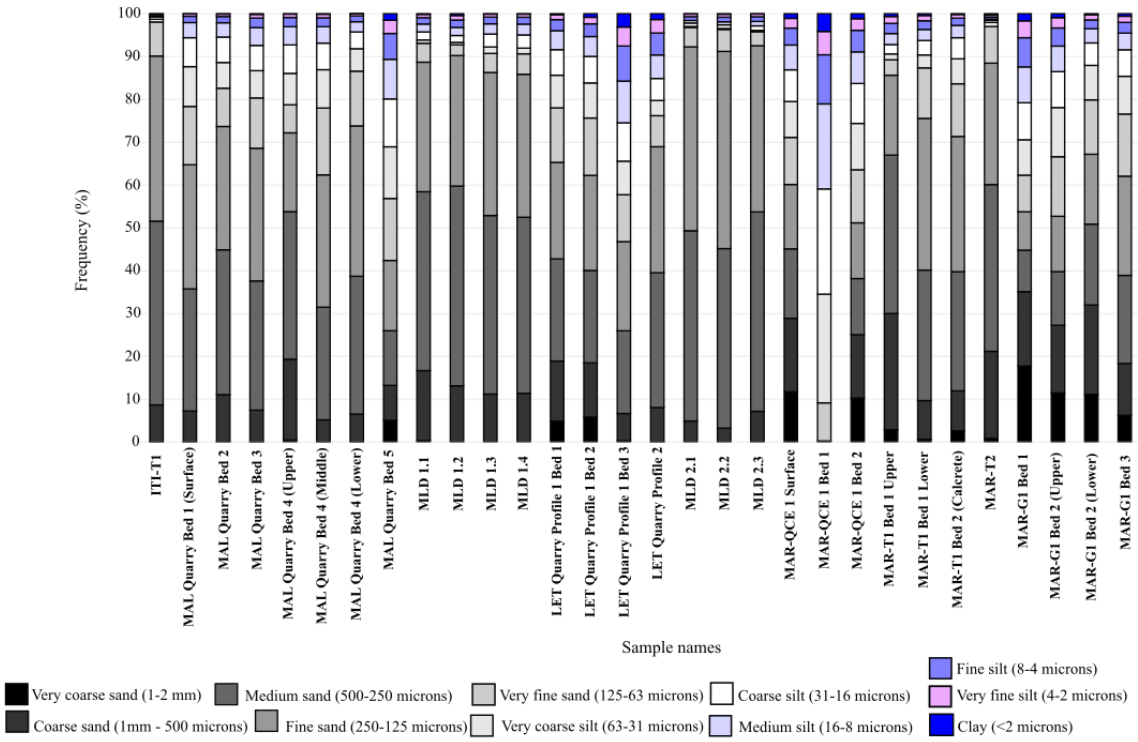


Figure 14. Particle size distribution percentages of all samples calculated using the GRADISTAT program in MS Excel by Blott and Pye (2001).

MAR-QCE 1 surface exhibits a unimodal distribution and is very poorly sorted, with 71.1% sand, 27.8% very coarse to very fine silt, and 1.1% clay. MAR-QCE 1 Bed 1 is also unimodal and poorly sorted. Unlike the previous samples, the main grain size distribution is in the very coarse to very fine silt category (86.7%), with 9.1% sand component, and 4.2% clay. MAR-QCE1 Bed 2 has a bimodal distribution that is very poorly sorted. Sand makes up most of the grain size distribution, whereas very coarse to very fine silt makes up 35.3% and clay makes up 1.2%. Geotrench MAR-G1 Bed 1 is a trimodal distribution that is very poorly sorted and consists of mostly very coarse to very fine sand (62.3%), very coarse silt to very fine silt (36%), and a minor component of clay (1.7%). MAR-G1 Bed 2 Upper has a bimodal distribution that is very poorly sorted. MAR-G1 Bed 2 Lower is a unimodal distribution and the sample is very poorly sorted. Here, the clay fraction only contributes to 0.3% of the total particle sizes, while very coarse to fine sand is at 79.9%. MAR-G1 Bed 3 has a unimodal distribution, but is still very poorly sorted. Sand contributes 76.6% to the total grain size distribution. The silt fraction is 22.8% of the total grain size distribution, and the clay fraction is 0.6%.

The ED-XRF results of the most abundant elements are displayed as percentages in Table 2. Outcrop and outer dune samples are rich in silicon dioxide (SiO_2). Aluminium oxide (Al_2O_3) is the second most abundant element in both the outcrop and outer dune samples. Inner dune samples from MLD 1 are composed mostly of SiO_2, followed by magnesium oxide (MgO) and calcium oxide (CaO). The MLD 1 samples also contain iron oxide (Fe_2O_3) and aluminium oxide (Al_2O_3). At MAR-T1, the CaO content increases with depth (Table 2).

SiO_2 is abundant at MAL Quarry, followed by CaO, MgO, and Al_2O_3, respectively (Table 2). However, the CaO content fluctuates throughout the profile. The MAL Quarry Bed 1 surface is composed of mostly SiO_2 followed by CaO. MAL Quarry Bed 3 has the lowest CaO percentage of the sequence, but it has a high SiO_2 content. The highest concentration of CaO in the MAL Quarry is in the lowermost layer of the sequence (Bed 5). MAL Quarry Bed 5, LET 1 Bed 2, and LET 1 Bed 3 are all pan samples that are cemented mostly by CaO (Table 2). MAL Quarry Bed 5 contains the greatest abundance of CaO and MgO out of all the samples (Table 2). The beds with the highest CaO content in LET are LET 1 Beds 2 and 3 and LET Profile 2. In LET Profile 1 Bed 1 and LET Profile 2, the

SiO_2 content is higher than the CaO content (Table 2). At both MAR-QCE1 and MAR-G1, the SiO_2 content is greater than the CaO content. MAR-G1 has high concentrations of MgO (Table 2).

Table 2. ED-XRF elemental analysis of major elements present throughout all the bulk sediment samples, from July/August 2022, with the results presented in percentages. The context and duricrust classification is also presented.

Site/sample	MgO	Al_2O_3	SiO_2	K_2O	CaO	Fe_2O_3	Classification
ITI-T1	0.1%	1.2%	79.4%	0.1%	0.1%	0.3%	Outcrop (unconsolidated sand)
MAL Quarry Bed 1 (surface)	2.7%	0.4%	36.3%	0.1%	10.2%	0.2%	Near surface calcrete or intergrade duricrust
MAL Quarry Bed 2	2.4%	0.4%	55.2%	0.1%	8.7%	0.2%	Intergrade duricrust
MAL Quarry Bed 3	3.5%	1.1%	82%	0.2%	1.8%	0.4%	Intergrade duricrust (compositionally more similar to silcrete with high SiO_2)
MAL Quarry Bed 4 (upper)	1.4%	0.4%	35.4%	0.1%	1.9%	0.2%	Intergrade duricrust
MAL Quarry Bed 4 (middle)	3.7%	0.7%	51.1%	0.1%	2.4%	0.3%	Intergrade duricrust
MAL Quarry Bed 4 (lower)	5.2%	1.0%	64.7%	0.2%	2.4%	0.3%	Intergrade duricrust
MAL Quarry Bed 5	15.1%	1.3%	19.2%	0.4%	22.4%	0.6%	Calcrete
MLD 1.1	1.7%	0.7%	56.0%	0.1%	0.9%	0.2%	Inner dune
MLD 1.2	1.7%	0.8%	83.7%	0.1%	1.5%	0.2%	Inner dune
MLD 1.3	2.4%	1.1%	89.5%	0.1%	1.9%	0.2%	Inner dune
MLD 1.4	2.4%	0.9%	76.2%	0.1%	1.7%	0.2%	Inner dune
LET Quarry Profile 1 Bed 1	5.6%	0.5%	33.9%	0.2%	9.3%	0.3	Intergrade duricrust or near surface calcrete
LET Quarry Profile 1 Bed 2	4.8%	0.8%	30.2%	0.3%	20.1%	0.4	Near-surface calcrete
LET Quarry Profile 1 Bed 3	7.9%	0.8%	19.2%	0.3%	14%	0.4%	Near-surface calcrete
LET Quarry Profile 2	3.3%	3.1%	58.9%	0.9%	18.7%	0.8%	Intergrade duricrust
MLD 2.1	0.4%	1.4%	78%	0.1%	0%	0.3%	Outer dune (sand)
MLD 2.2	0.5%	1.2%	60.6%	0.1%	0%	0.2%	Outer dune (sand)
MLD 2.3	0.6%	1.1%	68%	0.1%	0.1%	0.3%	Outer dune (sand)
MAR-QCE 1 surface	3.0%	1.0%	40.8%	0.8%	6.9%	0.8%	Intergrade duricrust
MAR-QCE 1 Bed 1	3.5%	3.4%	63.8%	1.5%	16%	1.2%	Intergrade duricrust
MAR-QCE 1 Bed 2	5.4%	5.0%	57.3%	2.2%	10.8%	2.1%	Intergrade duricrust
MAR-T1 Bed 1 upper	4.3%	1.4%	82.7%	0.4%	4.1%	0.5%	Inner dune
MAR-T1 Bed 1 lower	4.8%	1.3%	88.2%	0.3%	4.9%	0.5%	Inner dune
MAR-T1 Bed 2 (calcrete)	4.9%	1.1%	62.8%	0.5%	10.5%	0.5%	Inner dune
MAR-T2	0.1%	1.6%	64.7%	0.1%	0%	0.5%	Outcrop (unconsolidated sand)
MAR-G1 Bed 1	11.9%	2.0%	55.7%	0.6%	24%	0.8%	Intergrade duricrust or near surface calcrete
MAR-G1 Bed 2 (upper)	8.8%	1.9%	30.6%	0.6%	9.8%	1.1%	Calcite cemented sand
MAR-G1 Bed 2 (lower)	8.0%	2.3%	33.0%	0.7%	6.4%	1.9%	Calcite cemented sand
MAR-G1 Bed 3	4.2%	0.9%	28.6%	0.3%	4.7%	0.6%	Calcite cemented sand

Inner dune sediments differ from outer dune and outcrop sediments as they often contain elements present in the duricrusts (e.g., CaO). Outer dune and outcrop samples consist mainly of SiO_2 and do not overlap with the duricrust samples to the extent that the inner dune samples do (Table 2). Field observations (SOM 1 Table 1) and XRD results (SOM 1 Figs 2-10) were also taken into consideration when classifying duricrusts.

The PCA plot (Fig. 15) is based on quantitative data from XRF, LOI, and particle size analysis. Data were normalised in MS Excel using the logarithmic function. Principal component (PC) 1 and PC2 represent 68% of the total variance of the PCA plot. The PCA indicates that the samples form two distinct groups, separating duricrust samples from dune and outcrop samples. However, the inner dune samples from MAR-T1 have been grouped along with duricrust samples in the upper right quadrant. The PCA clusters the inner dune samples from MLD 1 closer to the duricrust samples (such as MAL Quarry Bed 3) rather than with the other dune samples. This suggests some overlap in chemical composition, but differences in particle sizes.

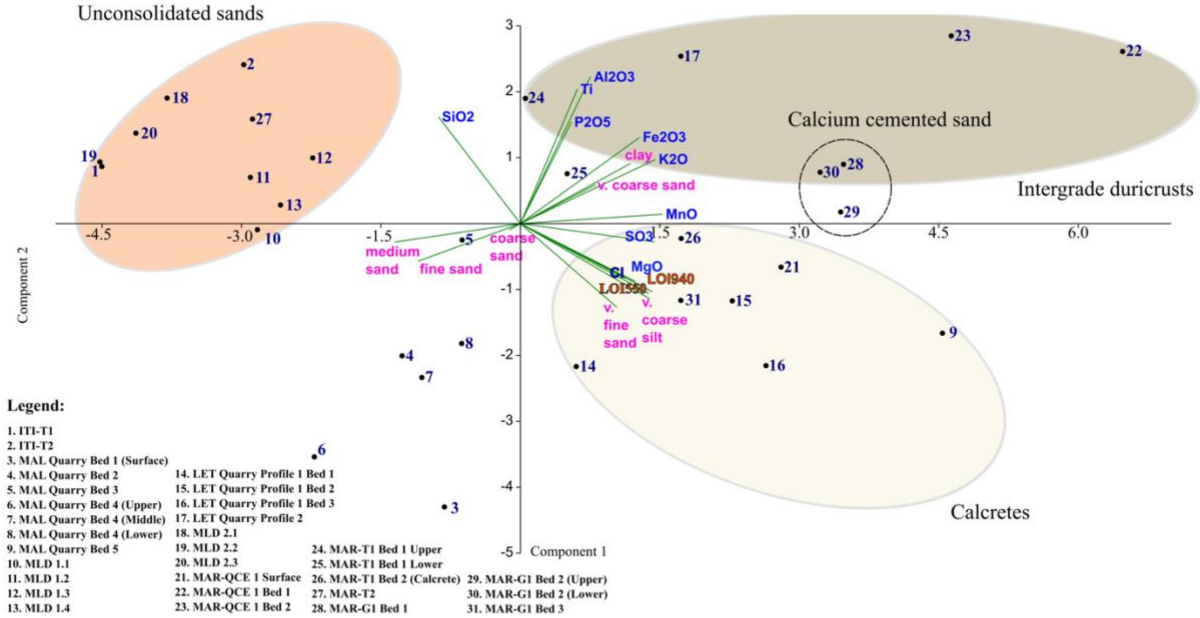


Figure 15. Principal Component Analysis plot based on XRF, LOI, and particle size data.

In the pan (duricrust) samples, calcite and quartz are omnipresent. MAR-G1 contains additional clay minerals, such as sepiolite, which is present in MAR-G1 Bed 2 (lower and upper) and Bed 3. Illite is only present in MAR-G1 Bed 2 (lower). Both calcite and quartz were identified in MAR-QCE 1. Quartz was identified in the dune (and outcrop) samples from MAR, however a difference is noted between inner sand accumulation samples (MAR-T1) and the other red sand (MAR-T2) samples. The clay mineral sepiolite (identified in the pans) is also present in MAR-T1 (Bed 1 lower, and Bed 2 [Calcrete]). The entire MAR-T1 sequence contains calcite. XRD graphs are provided in SOM 1 Figures 2-10.

Only the MAR samples from the pan contained microfossils, most notably the entire MAR-G1 sequence. The genus and species classification of the ostracods is uncertain, due to the ostracods still being in juvenile moulting stages and the valves being badly preserved, thus making taxonomic feature identification (such as ornamentation) difficult. The valves were mostly broken up into smaller, unidentifiable pieces, so taxonomic classifications had to be made using only those few valves with distinguishing morphological features. Despite these uncertainties, the ostracods do bear some morphological similarities to either cf. *Zonocypris* or cf. *Sarscypridopsis* (Fig. 16a). However, this preliminary classification should be approached with caution and adult specimens are necessary to make a definitive taxonomic analysis.

Diatoms were observed in the 63 μm and 125 μm fractions. Note that the samples were cleaned according to an ostracod cleaning protocol and more diatoms could therefore be expected in the sediment if a diatom processing protocol was applied. The diatoms belong to the taxon *Campylodiscus* sp. (Fig. 16b).

6. Discussion

The unconsolidated red sand samples (ITI-T1, MLD 2 & MAR-T2) can be categorised as Kalahari Sands subjected to aeolian processes (e.g., Mokatse et al. 2022). Kalahari sands often exhibit aeolian characteristics, frequently described as fine to medium sands with rounded to sub-rounded grains (Thomas & Shaw 1991; Haddon 2005). These sands may include a weathering component from underlying Karoo sandstones, as suggested by Thomas & Shaw (1991). This weathering component likely contributes to the occurrence of coarser particles in MAR-T2. The classification of ITI-T1, MLD 2 and MAR-T2 as Kalahari Sand is attributed to the relatively well-sorted, unimodal sediment distributions and the predominance of SiO_2 (quartz was also identified by the XRD analysis for MAR-

T2) (akin to descriptions by Thomas & Shaw 1991; Haddon 2005; Haddon & McCarthy 2005). A smaller silt fraction within the Kalahari sand samples can be associated with the input of aeolian dust (Thomas & Wiggs 2022). Lithic surface scatters on the outcrops (ITI-T1 & MAR-T2) are exposed due to aeolian erosion (deflation), causing heavier pieces to remain on the surface while lighter particles are transported away. Stone tools found below the surface in the test pits are not *in situ*, as the covering sediment is a Holocene occurrence. This will, however, require further testing alongside a high-resolution lithic analysis.

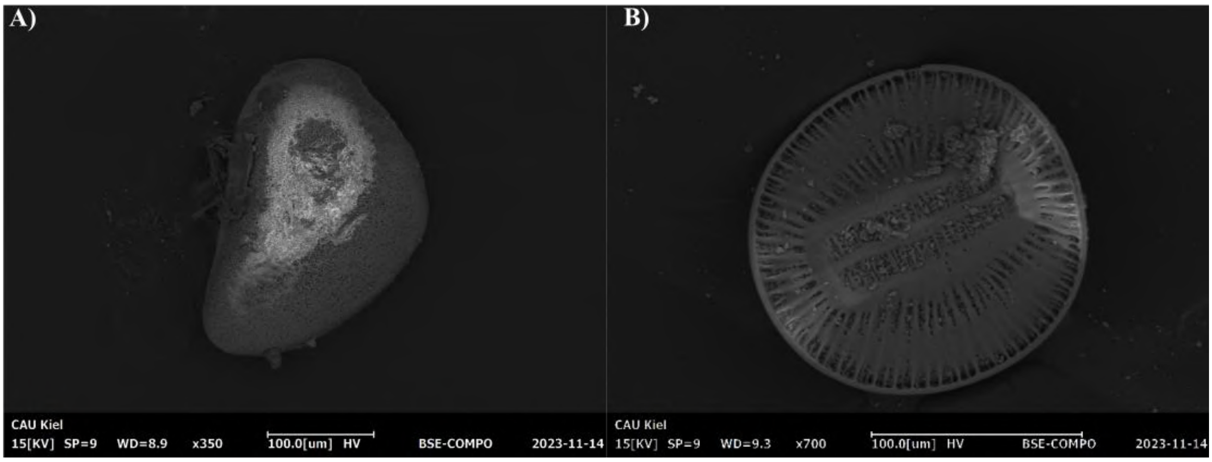


Figure 16. Microfossil taxa from MAR-G1. a) Ostracod from MAR-G1 Bed 2; b) *Campylodiscus* sp. from MAR-G1 Bed 2.

MLD 2 only contains trace amounts of CaO and the sediment is not the same pale colour as observed in the inner dunes and pans. A direct relationship between the outer dunes and pan sediment could not be established. Lancaster (1978) suggests that the red dunes result from Kalahari sand being deflated from the pan site and becoming enriched in red pigment as they age (Norris 1969). This is due to the weathering of iron oxides (Norris 1969; Haddon 2005) and climatic factors, such as periods of increased moisture availability and periodically warmer climates, which cause the dunes to become redder over time (Norris 1969). The sediment from the outer red dune (MLD 2) differs from the inner dunes, which have been deflated from the pans.

The inner dunes (MLD 1; MAR-T1) are poorly sorted, lighter in colour than the outer dunes, and contain CaO and clay minerals (sepiolite and calcite in the case of MAR-T1) likely deflated from the duricrusts in the pans, which is comparable to what Lancaster (1978) has described. The particle sizes of most samples from both MLD 1 and MAR-T1 are unimodal but poorly sorted, with most of the particles in the sand-size category. The lowermost bed of MAR-T1 (Bed 2) is an exception, as it has a bimodal distribution. MAR-T1 Bed 2 contains duricrust nodules, indicating that duricrust formation is a contributing factor to the bimodal particle size distribution and that there is pan sediment underneath the inner dune. The inner dune sediment from both Maleshe Pan (MLD 1) and Maralaleng Pan (MAR-T1) reflects a contribution of deflation and runoff processes during the wet season, as indicated by the poorly sorted sediment. Furthermore, Maralaleng Pan lacks clear dune accumulations, as the outcrop on the southwestern side of the site likely truncated the accumulation of the two ‘typical’ lunette dunes.

The CaO content varies between MLD 1 and MAR-T1. MAR-T1 is more enriched in CaO than MLD 1 samples and contains duricrust nodules in the lowermost bed. Like the outer dunes, the inner dunes are also Holocene accumulations, likely due to short phases of sediment wind transport and sediment runoff from water movement (see Schüller et al. 2022; Thomas & Wiggs 2022). The PCA groups dune and outcrop samples together, except MAR-T1, which is grouped along with duricrust samples, potentially suggesting new duricrust formation. Inner dune samples from MLD 1 are clustered closer to the duricrust sample MAL Quarry Bed 3 rather than the unconsolidated sand samples. The PCA therefore confirms that there are similarities between the inner dunes and the duricrusts. Three distinct clusters are observed in the PCA, namely sandy samples, intergrade duricrusts, and calcretes (Fig. 15). However, despite being grouped with calcretes in the PCA, MAR-G1 Bed 3 has been classified as a calcium cemented sand, as denoted in field observations. However, field observations noted the increased presence of calcite nodules compared to the other samples. Duricrust samples, although more variable than dune samples, tend to be finer-grained (coarse silt and very coarse silt make up a portion of PC2). Inside the pans, sediment sorting is increasingly poor.

Most of the pan duricrusts discussed here are intergrade duricrusts, but where the sediment is more enriched in SiO_2 than CaO. Only a few samples (namely MAL Quarry Bed 5, LET Profile 1 Bed 2 & Bed 3) are calcretes, following the definition described in Watts (1980). Some duricrusts, such as MAL Quarry Bed 1 (surface) and LET Profile 1 Bed 1 may also be calcretes, as they are near the surface and contain CaO as a cementing agent. Without a micromorphological analysis, it is difficult to determine the exact duricrust category, as the silicification of calcretes or the calcification of silcretes is possible and is primarily identified in thin section (Nash & Shaw 1998). Due to the identification of calcite in MAR-G1, MAR-T1, and MAR-QCE 1, by XRD analysis, an inference that the CaO is related to $CaCO_3$ can be made.

The middle beds of MAL Quarry (MAL Quarry Bed 2, Bed 3, & Bed 4 [Upper]), the lower LET Quarry bed (LET Quarry Profile 1 Bed 3) and the MAR-G1 sequence could all be indicative of runoff processes. At MAR-G1 the particle size distributions in the upper samples are polymodal, suggesting multiple sediment inputs, while lower samples are unimodal. In the upper layers, water runoff during the rainy season can cause all particle sizes to be deposited (Schüller et al. 2022). The ostracod specimens in MAR-G1 Bed 1 are poorly preserved and the population structure, mostly juveniles and broken valves, reflects a taphocoenosis (Boomer et al. 2003) with post-depositional movement or diagenesis. A census count of ostracods was therefore not conducted for this contribution. The diatom taxon, *Campylodiscus* sp., has been noted in salt pans in South Africa (Taylor et al. 2007) and across Botswana (Ringrose et al. 2014; Szwarc et al. 2021; Szwarc & Namiotko 2022) indicating a brackish to saline environment (Gasse 2002; Nash & McLaren 2003). A very conservative taxonomic inference would be that the ostracod taxon is either from the genus *Zonocypri*, which indicates fresh to brackish water conditions (Martens et al. 1996, Szwarc & Namiotko 2022) or, that the specimens could belong to the genus *Sarscypridopsis*, which occurs in saline environments, and has been identified at Makgadikgadi (Franchi et al. 2022). Ostracods are often present in lacustrine environments and prefer a pH that is more alkaline rather than acidic. Ostracod valves usually dissolve in highly acidic environments (Griffiths & Holmes 2000). MAR-G1 is more similar to a calcrete than a silcrete, and the presence of the ostracod valves suggest a pH that was not too acidic for ostracods to live in and was also sufficient for valve preservation. The presence of the microfossils and particle sizes in the lower beds of MAR-G1 suggest that this waterbody existed for a long enough period to sustain microfossil populations.

The pan sediments from our region, albeit unimodal in some cases, are generally poorly sorted. Burrough et al. (2009) report that grains at Makgadikgadi became larger and more poorly sorted when cal-silcrete was present, due to the presence of shell, nodules and roots. This could be a possible explanation for larger particle sizes reported in the pans where the intergrade duricrusts are observed. Sepiolite, found in MAR-G1 and MAR-T1, can form in more alkaline conditions than palygorskite under direct precipitation (Watts 1980). Sepiolite and $CaCO_3$ (and by inference, calcite) both precipitate during the dry season (Wang et al. 1994). The presence of sepiolite in both MAR-T1 and MAR-G1 suggest that pan sediment likely deflated from the vicinity of MAR-G1 and was redeposited in MAR-T1. Sepiolite is an authigenic clay mineral often associated with lacustrine environments (such as pans) in semi-arid regions and has been noted in mature calcrete profiles (Watts 1980). The present results suggest various site formation processes across the study region, of which run-off, deflation, and varying pH levels are prominent. These proxies assist in inferring a brackish to saline lacustrine environment when MSA hominins occupied and exploited the landscape.

7. Conclusions

Three main site formation processes have been identified at archaeological sites in the Kgalagadi district, namely runoff, deflation, and duricrust formation. Outcrops and dunes have undergone aeolian deposition or reworking, likely due to sediment deflation. An example that fits descriptions in the literature of this deflation process can be observed at MLD 1 and MAR-T1. Despite the lack of a clear set of lunette dunes at MAR, the role of deflation and aeolian input can still be observed from the particle size data. The outcrop to the south-west of Maralaleng likely stopped sediment from accumulating into a lunette dune, like those found at Maleshe Pan.

These results show that the sediment at each dune and outcrop site is moderately well sorted with unimodal distributions. However, the sediment becomes more poorly sorted, and the occurrence of polymodal distributions increases towards the pans where duricrusts are present. At Maleshe Pan and Maralaleng Pan, surface runoff during the rainy season moves moderately well-sorted sediment from the dunes and outcrops towards the pans, depositing various grain sizes and causing polymodal distributions. The formation of the pans is associated with their locations at low-lying sections of basins, but the role of the water table and other hydrological factors will be analysed in a future micromorphological study.

This research investigated the mechanisms involved in the deposition of the pan, dune, and outcrop sediment, and highlights depositional mechanisms: the deflation of sediment from pans onto the inner dunes, the deflation of sediment on the outcrops leading to the exposure of lithics on the surface, and runoff causing sediment to be taken from the dunes back into the pans, leading to polymodal and/or poorly sorted sediment. The pans were the first to form (suggesting that the occurrence of the lithics in the vicinity is due to the presence of hominins around a body of water) followed by the dunes.

Acknowledgements

This research was conducted under the research permit ENT 8/36/4 L (56), issued on 26 August 2021 by the Botswana Ministry of Environment, Wildlife and Tourism. The project is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under grant number 455851250. The Department of Monuments at the National Museum of Botswana, the University of Botswana, and the McGregor Museum in Kimberley are all appreciated for providing laboratory space, vehicles, equipment, and storage. We value the diligence and hard work put forth by Thuto Isaac Kgannyeng and Boipuso Fox. Our appreciation goes to Keneilwe Petlo, Masa Kedisang, Idah Maniki, Tsephang Dinake, Mariaan de Bruin, Helena Pribliczki and Rowena Winterhalder for their contributions to our 2022 field season. The contributions of the Maleshe, Maralaleng, Maubelo and Tsabong communities were integral to the success of our research and are greatly appreciated. The authors also express their gratitude to Yasmin Dannath for her assistance with the SEM. The authors appreciate the work of Brendan Ledwig, University Kiel, Institute of Geosciences, Mineralogy working group, for his assistance with the processing of the XRD samples and determining mineral presence. The assistance and patience of Prof. David Nash with duricrust related questions is also appreciated. And lastly, the authors would like to thank the reviewers and journal editors for their time and contributions to the article.

Supporting online material

Faul et al. Supporting Online Material File 1
Faul et al. Supporting Online Material File 2

References

Alonso-Zarza, A.M. & Wright, V.P. 2010. Calcretes. Developments in Sedimentology, 61: 225-267. https://doi.org/10.1016/S0070-4571(09)06105-6

Berna, F., Goldberg, P., Horwitz, L.K., et al. 2012. Microstratigraphic evidence of *in situ* fire in the Acheulean strata of Wonderwerk Cave, Northern Cape province, South Africa. Proceedings of the National Academy of Sciences, 109(20): E1215-E1220. https://doi.org/10.1073/pnas.1117620109

Bialik, O.M., Jarochowska, E. & Grossowicz, M. 2021. Ordination analysis in sedimentology, geochemistry and

palaeoenvironment – Background, current trends and recommendations. The Depositional Record, 7(3): 541-563. https://doi.org/10.1002/dep2.161
Blott, S.J. & Pye, K. 2001. GRADISTAT: A grain size distribution and statistics package for the analysis of unconsolidated sediments. Earth Surface Processes and Landforms, 26(11): 1237-1248. https://doi.org/10.1002/esp.261
Boomer, I., Horne, D.J. & Slipper, I.J. 2003. The use of ostracods in palaeoenvironmental studies, or what can you do with an ostracod shell? The Paleontological Society Papers, 9: 153-180. https://doi.org/10.1017/S1089332600002199
Bowler, J.M. 1986. Spatial variability and hydrologic evolution of Australian lake basins: Analogue for Pleistocene hydrologic change and evaporite formation. Palaeogeography, Palaeoclimatology, Palaeoecology, 54(1-4): 21-41. https://doi.org/10.1016/0031-0182(86)90116-1
Burrough, S.L., Thomas, D.S., Allin, J.R., et al. 2022. Lessons from a lakebed: Unpicking hydrological change and early human landscape use in the Makgadikgadi basin, Botswana. Quaternary Science Reviews, 291: 107662. https://doi.org/10.1016/j.quascirev.2022.107662
Burrough, S.L., Thomas, D.S. & Bailey, R.M. 2009. Mega-Lake in the Kalahari: A Late Pleistocene record of the Palaeolake Makgadikgadi system. Quaternary Science Reviews, 28(15-16): 1392-1411. https://doi.org/10.1016/j.quascirev.2009.02.007
Byakatonda, J., Parida, B.P., Kenabatho, P.K., et al. 2018. Influence of climate variability and length of rainy season on crop yields in semiarid Botswana. Agricultural and Forest Meteorology, 248: 130-144. https://doi.org/10.1016/j.agrformet.2017.09.016
Degen, T., Sadki, M., Bron, E., et al. 2014. The HighScore suite. Powder Diffraction, 29(S2): S13-S18. https://doi.org/10.1017/S0885715614000840
Ecker, M., Green, C., Henderson, A., et al. 2023. Archaeological survey near Tsabong, Kgalagadi District, southwestern Botswana. Azania: Archaeological Research in Africa, 58: 1-19. https://doi.org/10.1080/0067270X.2023.2260150
Filzmoser, P., Hron, K. & Reimann, C. 2009. Principal component analysis for compositional data with outliers. Environmetrics, 20: 621-632. https://doi.org/10.1002/env.966
Folk, R.L. & Ward, W.C. 1957. Brazos River bar: A study in the significance of grain size parameters. Journal of Sedimentary Petrology, 27: 3-26.
Franchi, F., Cavalazzi, B., Evans, M., et al. 2022. Late Pleistocene – Holocene palaeoenvironmental evolution of the Makgadikgadi Basin, Central Kalahari, Botswana: New evidence from shallow sediments and ostracod fauna. Frontiers in Ecology and Evolution, 10: 818417. https://doi.org/10.3389/fevo.2022.818417
Gasse, F. 2002. Diatom-inferred salinity and carbonate oxygen isotopes in Holocene waterbodies of the western Sahara and Sahel (Africa). Quaternary Science Reviews, 21: 737-767. https://doi.org/10.1016/S0277-3791(01)00125-1
Goudie, A. 1972. The chemistry of world calcrete deposits. The Journal of Geology, 80(4): 449-463. https://doi.org/10.1086/627766
Griffiths, H.I. & Holmes, J.A. 2000. Non-marine Ostracods and Quaternary Palaeoenvironments: Technical Guide 8. London: Quaternary Research Association.
Grün, R., Brink, J.S., Spooner, N.A., et al. 1996. Direct dating of Florisbad hominid. Nature, 382(6591): 500-501. https://doi.org/10.1038/382500a0
Haddon, I.G. 2005. The sub-Kalahari geology and tectonic evolution of the Kalahari Basin, southern Africa. Doctoral Thesis. Johannesburg: University of the Witwatersrand.
Haddon, I.G. & McCarthy, T.S. 2005. The Mesozoic – Cenozoic interior sag basins of Central Africa: The late-cretaceous – Cenozoic Kalahari and Okavango basins. Journal of African Earth Sciences, 43(1-3): 316-333. https://doi.org/10.1016/j.jafrearsci.2005.07.008
Hammer, Ø. & Harper, D.A. 2001. PAST: Paleontological Statistics Software Package for education and data analysis. Palaeontologia Electronica, 4(1): 1-9. https://palaeo-electronica.org/2001_1/past/past.pdf
Heiri, O., Lotter, A.F. & Lemcke, G. 2001. Loss on ignition as a method for estimating organic and carbonate content in sediments: Reproducibility and comparability of results. Journal of Paleolimnology, 25: 101-110. https://doi.org/10.1023/A:1008119611481
Helgren, D.M. & Brooks, A.S. 1983. Geoarchaeology at Gi, a Middle Stone Age and Later Stone Age site in the northwest Kalahari. Journal of Archaeological Science, 10: 181-197. https://doi.org/10.1016/0305-4403(83)90051-1
Henshilwood, C.S., d'Errico, F., Van Niekerk, K.L., et al. 2018. An abstract drawing from the 73,000-year-old levels at Blombos Cave, South Africa. Nature, 562(7725): 115-118. https://doi.org/10.1038/s41586-018-0514-3
Hills, E.S. 1940. The lunette, a new land form of aeolian origin. Australian Geographer, 3(7): 15-21.

https://doi.org/10.1080/0049184008702196
Horne, D.J. & Siveter, D.J. 2016. Collecting and processing fossil ostracods. Journal of Crustacean Biology, 36(6): 841-848. https://doi.org/10.1163/1937240X-00002487
Kampunzu, A.B., Ringrose, S., Huntsman-Mapila, P., et al. 2007. Origins and palaeo-environments of Kalahari duricrusts in the Moshaweng dry valleys (Botswana) as detected by major and trace element composition. Journal of African Earth Sciences, 48(2-3): 199-221. https://doi.org/10.1016/j.jafrearsci.2006.10.007
Kuman, K., Lotter, M.G. & Leader, G.M. 2020. The Fauresmith of South Africa: A new assemblage from Canteen Kopje and significance of the technology in human and cultural evolution. Journal of Human Evolution, 148: 102884. https://doi.org/10.1016/j.jhevol.2020.102884
Lancaster, I.N. 1978. The pans of the southern Kalahari, Botswana. Geographical Journal, 144: 81-98. https://doi.org/10.2307/634651
Lukich, V. 2019. Palaeoenvironmental reconstruction and geochronology of the archaeological localities at Kathu Pan, South Africa. Doctoral Thesis. Toronto: University of Toronto.
Lukich, V. & Ecker, M. 2022. Pleistocene environments in the southern Kalahari of South Africa. Quaternary International, 614: 50-58. https://doi.org/10.1016/j.quaint.2021.03.008
Lukich, V., Cowling, S. & Chazan, M. 2020. Palaeoenvironmental reconstruction of Kathu Pan, South Africa, based on sedimentological data. Quaternary Science Reviews, 230: 106153. https://doi.org/10.1016/j.quascirev.2019.106153
Marean, C.W. 2010. Pinnacle Point Cave 13B (Western Cape Province, South Africa) in context: The Cape floral kingdom, shellfish, and modern human origins. Journal of Human Evolution, 59(3-4): 425-443. https://doi.org/10.1016/j.jhevol.2010.07.011
Martens, K., Davies, B.R., Baxter, A.J., et al. 1996. A contribution to the taxonomy and ecology of the Ostracoda (Crustacea) from Verlorenvlei (Western Cape, South Africa). African Zoology, 31(1): 22-36. https://www.ajol.info/index.php/az/article/view/154384
Mokatse, T., Diaz, N., Shemang, E., et al. 2022. Landscapes and landforms of the Chobe enclave, northern Botswana. In: Eckardt, F.D. (ed.) Landscapes and Landforms of Botswana. World Geomorphological Landscapes: 91-116. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-86102-5_6
Munyikwa, K., Van Den Haute, P., Vandenberghe, D., et al. 2000. The age and palaeoenvironmental significance of the Kalahari Sands in western Zimbabwe: A thermoluminescence reconnaissance study. Journal of African Earth Sciences, 30(4): 941-956. https://doi.org/10.1016/S0899-5362(00)00062-2
Nash, D.J. 2022. Calcretes, silcretes and intergrade duricrusts. In: Eckardt, F.D. (ed.) Landscapes and Landforms of Botswana. World Geomorphological Landscapes: 223-246. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-86102-5_13
Nash, D.J., Ciborowski, T.J.R., Coulson, S.D., et al. 2022. Mapping Middle Stone Age human mobility in the Makgadikgadi Pans (Botswana) through multi-site geochemical provenancing of silcrete artefacts. Quaternary Science Reviews, 297: 107811. https://doi.org/10.1016/j.quascirev.2022.107811
Nash, D.J. & McLaren, S.J. 2003. Kalahari valley calcretes: Their nature, origins, and environmental significance. Quaternary International, 111(1): 3-22. https://doi.org/10.1016/S1040-6182(03)00011-9
Nash, D.J., McLaren, S.J. & Webb, J.A. 2004. Petrology, geochemistry and environmental significance of silcrete-calcrete intergrade duricrusts at Kang Pan and Tswaane, central Kalahari, Botswana. Earth Surface Processes and Landforms, 29(12):1559-1586. https://doi.org/10.1002/esp.1138
Nash, D.J. & Shaw, P.A. 1998. Silica and carbonate relationships in silcrete-calcrete intergrade duricrusts from the Kalahari of Botswana and Namibia. Journal of African Earth Sciences, 27(1): 11-25. https://doi.org/10.1016/S0899-5362(98)00043-8
Nash, D.J., Shaw, P.A. & Thomas, D.S. 1994. Duricrust development and valley evolution: Process – landform links in the kalahari. Earth Surface Processes and Landforms, 19(4): 299-317. https://doi.org/10.1002/esp.3290190403
Netterberg, F. 1969. Ages of calcretes in southern Africa. South African Archaeological Bulletin, 24: 88-92. https://doi.org/10.2307/3888283
Netterberg, F. 1980. Geology of southern African calcretes. 1: Terminology, description, macrofeatures, and classification. South African Journal of Geology, 83(2): 255-283. https://hdl.handle.net/10520/AJA10120750_1202
Norris, R.M. 1969. Dune reddening and time. Journal of Sedimentary Research, 39(1): 7-11.
Planchon, O. & Darboux, F. 2002. A fast, simple and versatile algorithm to fill the depressions of digital elevation models. Catena, 46(2): 159-176. https://doi.org/10.1016/S0341-8162(01)00164-3
Ringrose, S., Cassidy, L., Diskin, S., et al. 2014. Diagenetic transformations and silcrete-calcrete intergrade duricrust formation in palaeo-estuary sediments. Earth Surface Processes and Landforms, 39(9): 1167-

1187. https://doi.org/10.1002/esp.3516
Ringrose, S., Downey, B., Genecke, D., et al. 1999. Nature of sedimentary deposits in the western Makgadikgadi basin, Botswana. Journal of Arid Environments, 43(4): 375-397. https://doi.org/10.1006/jare.1999.0548
Rutherford, M.C., Mucina, L. & Powrie, L.W. 2006. Biomes and bioregions of southern Africa. In: Rutherford, M.C. & Mucina, L. (eds) The Vegetation of South Africa, Lesotho and Swaziland: 30-51. Pretoria: South African National Biodiversity Institute.
Schüller, I., Belz, L., Wilkes, H., et al. 2022. Kalahari pans: Quaternary evolution and processes of ephemeral lakes. In: Eckardt, F.D. (ed.) Landscapes and Landforms of Botswana. World Geomorphological Landscapes: 167-178. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-86102-5_10
Shaw, P. & Thomas, D.S.G. 1997. Pans, playas and salt lakes. In: Goudie, A. (ed.) Arid Zone Geomorphology: Process, Form and Change in Drylands 2nd Edition: 293-317. John Wiley & Sons Ltd. https://doi.org/10.1002/9780470710777.ch15
Sievers, C., Backwell, L., d'Errico, F., et al. 2022. Plant bedding construction between 60,000 and 40,000 years ago at Border Cave, South Africa. Quaternary Science Reviews, 275: 107280. https://doi.org/10.1016/j.quascirev.2021.107280
Staurset, S., Coulson, S.D., Mothulatshipi, S., et al. 2023. Making points: The Middle Stone Age lithic industry of the Makgadikgadi Basin, Botswana. Quaternary Science Reviews, 301: 107823. https://doi.org/10.1016/j.quascirev.2022.107823
Summerfield, M.A. 1983a. Silcrete as a palaeoclimatic indicator: Evidence from southern Africa. Palaeogeography, Palaeoclimatology, Palaeoecology, 41(1-2): 65-79. https://doi.org/10.1016/0031-0182(83)90076-7
Summerfield, M.A. 1983b. Silcrete. In: Goudie, A.S. & Pye, K. (eds) Chemical Sediments and Geomorphology: 59-93. London: Academic Press.
Szwarc, A., Martens, K. & Namiotko, T. 2021. Two new Cypridopsinae Kaufmann, 1900 (Crustacea, Ostracoda) from southern Africa. ZooKeys, 1076: 83-107. https://doi.org/10.3897/zookeys.1076.76123
Szwarc, A. & Namiotko, T. 2022. Biodiversity of non-marine Ostracoda (Crustacea) of Botswana: An annotated checklist with notes on distribution. Water, 14(9): 1441. https://doi.org/10.3390/w14091441
Tarboton, D. G., Bras, R.L., & Rodriguez-Iturbe, I. 1991. On the extraction of channel networks from digital elevation data. Hydrological Processes, 5: 81-100. https://doi.org/10.1002/hyp.3360050107
Taylor, J.C., Harding, W.R. & Archibald, C.G.M. 2007. An Illustrated Guide to Some Common Diatom Species from South Africa. Pretoria: Water Research Commission.
Telfer, M.W. & Thomas, D.S.G. 2006. Complex Holocene lunette dune development, South Africa: Implications for paleoclimate and models of pan development in arid regions. Geology, 34(10): 853-856. https://doi.org/10.1130/G22791.1
Telfer, M.W., Thomas, D.S.G., Parker, A.G., Walkington, H. and Finch, A.A. 2009. Optically Stimulated Luminescence (OSL) dating and palaeoenvironmental studies of pan (playa) sediment from Witpan, South Africa. Palaeogeography, Palaeoclimatology, Palaeoecology, 273(1-2).50-60.https://doi.org/10.1016/j.palaeo.2008.11.012
Thomas, D.S. 1988. The nature and depositional setting of arid and semi-arid Kalahari sediments, southern Africa. Journal of Arid Environments, 14(1): 17-26. https://doi.org/10.1016/S0140-1963(18)31092-9
Thomas, D. & Shaw, P.A. 1991. The Kalahari Environment. Cambridge: Cambridge University Press.
Thomas, D.S. & Wiggs, G.F. 2022. Dunes of the Southern Kalahari. In: Eckardt, F.D. (ed.) Landscapes and Landforms of Botswana. World Geomorphological Landscapes: 131-154. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-86102-5_8
Thomas, D.S., Burrough, S.L., Coulson, S.D., et al. 2022. Lacustrine geoarchaeology in the central Kalahari: Implications for Middle Stone Age behaviour and adaptation in dryland conditions. Quaternary Science Reviews, 297: 107826. https://doi.org/10.1016/j.quascirev.2022.107826
Tidi, K.J. 1994. A Report on Geological Investigation in the Tsabong Area. Gaborone: Department of Geological Survey.
Toffolo, M.B., Brink, J.S., van Huyssteen, C., et al. 2017. A microstratigraphic reevaluation of the Florisbad spring site, Free State Province, South Africa: Formation processes and paleoenvironment. Geoarchaeology, 32(4): 456-478. https://doi.org/10.1002/gea.21616
Udden, J.A. 1914. Mechanical composition of clastic sediments. Bulletin of the Geological Society of America, 25(1): 655-744. https://doi.org/10.1130/GSAB-25-655
Wang, Y., Nahon, D. & Merino, E. 1994. Dynamic model of the genesis of calcretes replacing silicate rocks in semi-arid regions. Geochimica et Cosmochimica Acta, 58(23): 5131-5145. https://doi.org/10.1016/0016-7037(94)90299-2

Warren, J.K. 1983. Pedogenic calcrete as it occurs in Quaternary calcareous dunes in coastal South Australia. Journal of Sedimentary Research, 53(3): 787-796. https://doi.org/10.1306/212F82BF-2B24-11D7-8648000102C1865D

Watts, N.L. 1980. Quaternary pedogenic calcretes from the Kalahari (southern Africa): Mineralogy, genesis and diagenesis. Sedimentology, 27(6): 661-686. https://doi.org/10.1111/j.1365-3091.1980.tb01654.x

Webb, J.A. & Nash, D.J. 2020. Reassessing southern African silcrete geochemistry: Implications for silcrete origin and sourcing of silcrete artefacts. Earth Surface Processes and Landforms, 45(13): 3396-3413. https://doi.org/10.1002/esp.4976

Wentworth, C.K. 1922. A scale of grade and class terms for clastic sediments. Journal of Geology, 30: 377-392. https://doi.org/10.1086/622910

Werger, M.J.A. 1978. Vegetation structure in the southern Kalahari. The Journal of Ecology, 66(3): 933-941. https://doi.org/10.2307/2259305

Wilkins, J. 2017. Middle Pleistocene lithic raw material foraging strategies at Kathu Pan 1, Northern Cape, South Africa. Journal of Archaeological Science: Reports, 11: 169-188. https://doi.org/10.1016/j.jasrep.2016.11.002

Wilkins, J. 2023. Ga-Mohana Hill North Rockshelter, South Africa. In: Beyin, A., Wright, D.K., Wilkins, J., et al. (eds) Handbook of Pleistocene Archaeology of Africa: Hominin Behavior, Geography, and Chronology: 1469-1480. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-031-20290-2_94

Wilkins, J., Schoville, B.J., Pickering, R., et al. 2021. Innovative *Homo sapiens* behaviours 105,000 years ago in a wetter Kalahari. Nature, 592(7853): 248-252. https://doi.org/10.1038/s41586-021-03419-0

Winterhalder, R. 2023. Treasure between rubble: Lithics from Itireleng and Maralaleng, southern Kalahari, Botswana. Masters Dissertation. Kiel: Kiel University.

Wurz, S. 2008. Modern behaviour at Klasies river. Goodwin Series, 10: 150-156. https://www.jstor.org/stable/40650026

Southern African Field Archaeology
2025 Vol. 20: Article 3028
Research report (peer-reviewed): Received February 2025; Revised May 2025; Published July 2025
DOI: https://doi.org/10.36615/safa.20.3028.2025

ISSN 1019-5785
ISSN 2789-1844

Granite spalling as a proxy of climate change during the late Pleistocene and early Holocene at Pomongwe Cave, Matobo World Heritage Landscape

Thubelihle R. Mnkandla [a, *] & Ancila Nhamo [a, b]

[a]Department of History, Heritage and Knowledge Systems, University of Zimbabwe, P.O. Box MP 167, Mount Pleasant, Zimbabwe
[b]Research Innovation and Industrialisation Directorate, University of Zimbabwe, P.O. Box MP 167, Mount Pleasant, Zimbabwe

**Corresponding author email: tmnkandla@arts.uz.ac.zw*

ABSTRACT
There is limited palaeoenvironmental data on Zimbabwe, primarily because the usual proxies used for climatic reconstructions are rarely preserved in the Zimbabwean archaeological record. Against this background, this research seeks to assess the practicality of using granite spalls that occur in the archaeological record as signatures of past climatic changes. We hypothesise that the size of spalls and the rate of exfoliation are dependent upon climatic conditions such as temperature and precipitation. We apply this principle by analysing the size and concentration of granite spalls within the stratigraphy of Pomongwe Cave, to reconstruct the palaeoclimatic conditions that prevailed during its occupation. Our results indicate that the environmental conditions changed through time, and this is reflected by the occurrence of granite spalls of varying sizes and concentrations. However, the results in this paper present a proof of concept that requires further investigation.

Keywords: Pomongwe, palaeoenvironments, granite spalls, geoarchaeology

1. Introduction

Climatic changes were experienced globally during the shift from the late Pleistocene to the early Holocene, significantly impacting the behaviour of early modern humans. These climatic changes are believed to have played a critical role in human history. Climate changes had implications for the development of modern human behaviour, the expansion of human populations, and their dispersal (Potts 1998; Mellars 2006; Backwell et. al. 2014). Furthermore, the climatic changes that prevailed during the terminal Pleistocene to early Holocene resulted in the development of various tool technocomplexes (Robinson 2023). Unfortunately, in Africa in general and Zimbabwe in particular, limited studies on palaeoenvironmental reconstructions have been conducted to contextualise these dynamics. The limited studies are to some extent a result of a lack of interest and expertise in the area, but the major impediment is the difficulty in finding signatures of climate change in the archaeological record. In other parts of southern Africa, substantial data have been recorded in stalagmites and stalactites from caves, especially limestone caves (Holzkämper et al. 2009; Braun et al. 2019). Unfortunately, these are not commonly found in association with Stone Age sites in Zimbabwe because of the predominance of granite landforms in the country. This dearth in palaeoenvironmental proxies coupled with the abundance of granite has led us to explore whether the use of granite spalls, that are ubiquitous at terminal Pleistocene/early Holocene sites, can be used as proxy data for the reconstruction of palaeoenvironmental conditions. In this regard, we use Pomongwe Cave as the case study in this research.

The site of Pomongwe in the Matobo UNESCO World Heritage Landscape has cultural material that dates from the terminal late Pleistocene to the terminal Holocene (Nhamo-Katsamudanga & Chiwara-Maenzanise 2023). Pomongwe has material that dates to >13 000 BP which falls within the terminal late Pleistocene. It has yielded abundant granite spalls incorporated into the stratigraphic layers. However, this is not a unique case, with extensive occurrences of granite spalls having been recorded at other sites of the same period including but not limited to: Tshangula, Nswatugi, Bambata (in the Matobo), Zombepata (northern Zimbabwe), Ruchera (northeastern Zimbabwe), Redcliff (Midlands), and Diana's vow (southeastern Zimbabwe) (Cooke 1963, 1971; Walker 1995). As such, the use of granite spalls, if found viable, would greatly widen the scope of palaeoenvironmental research in Zimbabwe. It would improve the availability of stable and reliable proxy data that would make temporal and spatial inter-site comparisons easier, currently a major shortfall as identified by Katsamudanga and Nhamo (2016), especially for the Stone Age.

2. Background to palaeoclimatic studies in Zimbabwe

Generally, as compared to other components of the past, palaeoenvironments are not well-researched in Zimbabwe, and in general climate proxies most commonly used in palaeoenvironmental research are lacking (Walker 1995; Katsamudanga & Nhamo 2016). The first attempts to reconstruct palaeoenvironments in Zimbabwe explored the use of geomorphological processes for this purpose. Bond (1949, 1957) was the main proponent of this approach. He made concerted efforts to reconstruct palaeoclimates based on physical evidence of erosional and depositional processes, i.e., based on signatures of pluvial and fluvial processes. The size and distribution of pebbles in riverbeds were used to estimate precipitation levels, with larger pebbles seen to indicate higher river discharge during wet periods (Bond 1964). These pluvial studies enabled Bond (1949, 1957, 1964, 1965) to estimate the changes in temperature and precipitation within particular periods. For example, he studied pebble sizes to estimate that the Earlier Stone Age (ESA) experienced two wet periods: the first was during the transition from the Oldowan to Acheulean, during the early Pleistocene; the second wet period was identified during the late Acheulean, falling within the middle Pleistocene (Bond 1949). In these studies, while pebble size serves as proxy of the amount of water being discharged by rivers, by extension it can also clarify the amount of precipitation falling during a particular period (Dollar 1998). During the wet periods, the rivers have much more carrying capacity than during the dry periods, therefore they can carry larger pebbles further along the rivers. This kind of evidence was derived from sites along the Zambezi River, such as from the Victoria Falls area, and the Lochard and Khami Waterworks near Bulawayo (Summers 1960; Bond 1964, 1965).

However, the use of fluvial and pluvial processes in reconstructing palaeoenvironmental conditions was not without challenges. The chronometric dating of these processes is challenging, which is why researchers such as Bond relied on relative chronologies based on the type of associated stone tools (Acheulean, Sangoan, etc.). Thus, this research was dependent upon the extent of archaeological research at the time. In addition, as Dollar (1998) observes, the evidence used can be a result of other factors besides climate or environmental change. The evidence is also limited in occurrence to the Zambezi and other fairly large rivers in the country.

In addition to fluvial and pluvial processes, dry periods were detected based on chemical processes in the formation of silcrete, calcrete, and ferricrete deposits on stone tools. These deposits occur under conditions of reduced precipitation of less than 450 mm of rainfall (Bond 1964). Some Acheulean and Sangoan tools that occurred in these deposits were argued to derive from such drier periods (Bond & Clark 1954; Bond 1964). Further geomorphological evidence in the form of aeolian sands was used to reconstruct palaeoenvironments in the Hwange National Park and at Victoria Falls. Evidence of aridity comes from the intensification of dune fields, whereas the erosion of the dune surfaces indicates wet periods (Haynes 1996). Haynes (1996) found evidence of extreme fluctuations between dry and wet periods in the Hwange National Park, especially during the early Middle Stone Age (MSA) between 130-120 kya. The occurrence of the wet periods was supported by sedimentological evidence of ancient lakes, and ponded water in both the Hwange National Park and the neighbouring Makgadikgadi Basin in Botswana (Haynes 1996). Although both the aeolian sands and sedimentological evidence constitute good proxies for palaeoenvironmental changes, their occurrence is as limited as that of the other geomorphological data and, therefore, cannot be relied on to provide extensive data for most parts of Zimbabwe.

Other researchers have inferred palaeoenvironmental conditions from faunal remains. For example, a wetter phase of the Bambata period (MSA) was identified using faunal remains by Brain (1969) and Cruz-Uribe (1983) at the site of Redcliff in the Midlands region of Zimbabwe. Here, the presence of the extinct giant Cape horse (*Equus quagga*) was used to infer cooler and wetter conditions during the Bambata period (Cruz-Uribe 1983). Although some faunal assemblages from archaeological sites provide insights into vegetation and climate, the signatures are too specific to have broader applications. For example, Cruz-Uribe (1983) found only one animal that is climate-sensitive.

Researchers who have worked on the terminal late Pleistocene and early Holocene have also tried to reconstruct the palaeoenvironment. Walker (1995) came up with a hypothetical model of past environments in the Matobo based primarily upon palaeoclimatic data from southern Africa. This model is discussed in detail elsewhere in the paper, but what is critical to note here is that it relied heavily on evidence from outside Zimbabwe, i.e., from South Africa and Botswana. This scarcity of local palaeoenvironmental proxies led us to consider the use of granite spalls.

In most cases, the size of granite flakes can reveal important clues about the environmental conditions under which they formed or were altered. Large spalls result from slow and less intense weathering processes, such as from freezing and thawing action. On the other hand, small flakes reflect more intense mechanical weathering, such as through exfoliation associated with thermal stress from dry conditions (Anderson & Anderson 2010). However, smaller flakes can also result from chemical weathering which intensifies during wet periods because of elevated moisture content and organic acids (Boggs 2006). Therefore, by studying granite flake sizes in association with other variables such as cultural indicators, we can infer palaeoenvironmental histories of specific regions.

Granite is an excellent rock type for inferring these palaeoenvironmental conditions because of its durability and resistance to weathering, owing to its composition of quartz, feldspar, and mica, making it a reliable recorder of long-term environmental changes (Plummer et al. 2016). Granite also exhibits distinct and predictable weathering patterns, such as exfoliation, block disintegration, and granular disintegration, which are strongly influenced by environmental factors such as temperature, moisture, and biological activity (Migoń 2006; Marshak 2019). Exfoliation (spheroidal weathering) occurs when the outer layers of granite expand and contract due to repeated heating and cooling in arid and semi-arid regions. Over time, this causes the outer layers to peel away in curved sheets or shells. Block disintegration occurs when granite breaks into smaller, angular blocks as it separates from the parent rock along pre-existing joints or fractures. Environmental forces, such as freeze-thaw cycles, contribute to this process (Migoń 2006; Anderson & Anderson 2010; Marshak 2019). Granular granite disintegration is in most cases a result of chemical weathering, especially in cave environments like those at Pomongwe with heightened humidity and biological activities. In such an environment, minerals such as feldspar and mica react with water through the processes of hydrolysis and oxidation to form clays and iron oxides, leaving quartz behind as loose granules (Ollier 1984; Goudie & Viles 1997). Therefore, all these visible and measurable weathering features can facilitate the analysis and quantification of palaeoenvironmental conditions (Boggs 2006).

Granite is widespread in Zimbabwe (Mugumbate 2013) and much of southern Africa (Twidale 2012). In Zimbabwe, there is an abundance of granite spalls at archaeological sites such as Pomongwe, Bambata, Nswatugi, and Amadzimba (Cooke 1963). Cooke (1971) also found granite spalls at other sites in Zimbabwe, such as at Ruchera and Zombepata in northeast and northwestern Zimbabwe. The potential of finding granite spalls at other Stone Age sites in cave environments elsewhere in Zimbabwe is very high, making the exploration of this ubiquitous material a potentially powerful palaeoenvironmental proxy. Once sufficient methods are established, they can facilitate comparative studies of palaeoenviromental conditions across the country and the region. Therefore, the major aim of this paper is to study the granite spalls found in stratigraphic levels at Pomongwe, and to establish whether they can be used as complimentary proxies of palaeoenvironments in Zimbabwe. Although the use of the spalls in this way has been alluded to by Cooke (1963), there has no systematic study, either in the region or elsewhere globally, that has used spalls to establish past environments. As such, this paper is such an attempt. Sumner et al. (2012) cite several studies that describe the exfoliation of different rock types due to climatic conditions. Although these studies were done mainly in relation to the effects of weathering on rock art, their insights are crucial to our paper.

3. Pomongwe Cave

Pomongwe Cave (Fig. 1) is located approximately 34 km from Bulawayo, Zimbabwe's second-largest city. It is located within the boundaries of the Matobo National Park, facing northeast at the end of a small valley. The cave floor is positioned about three metres above the valley floor (Walker 1995). The cave is about 20 by 20 metres, with a ceiling height above bedrock of about 15 metres (Cooke 1963; Walker 1995; Porraz et al. 2023).

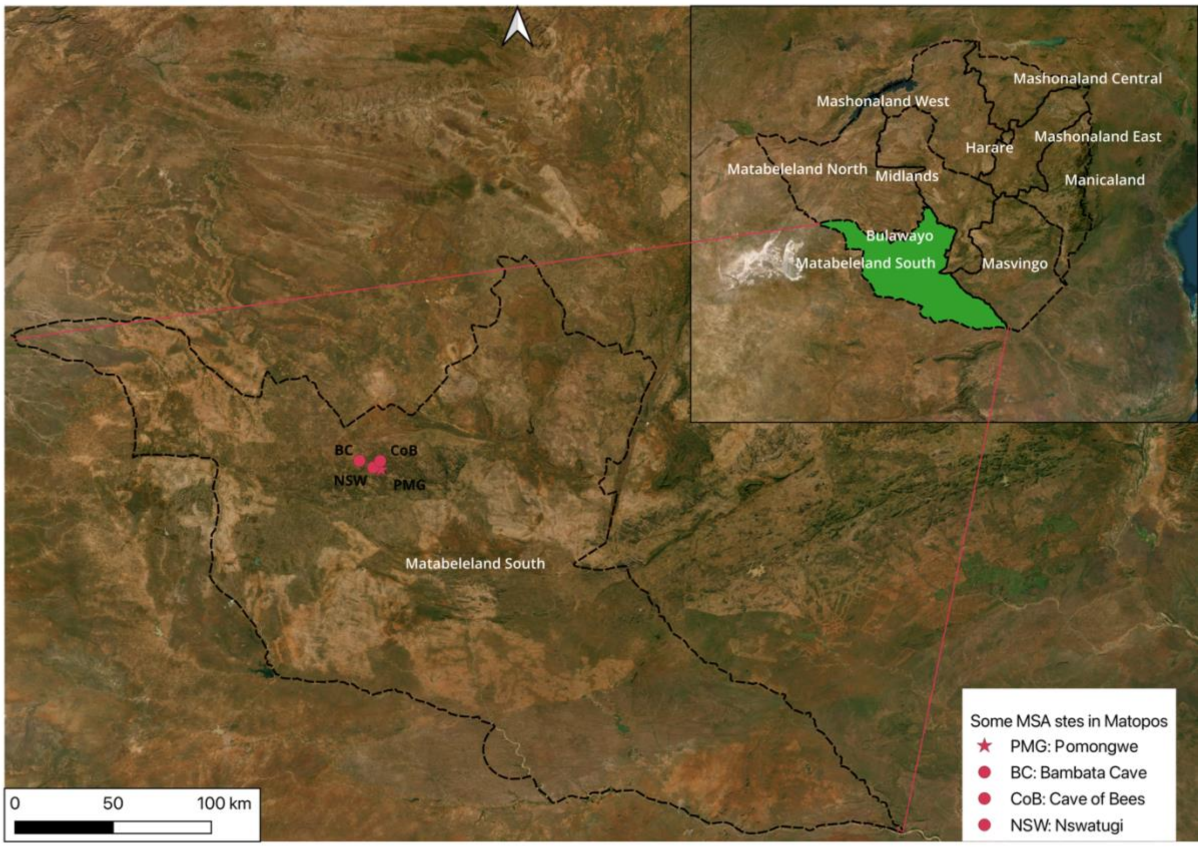


Figure 1. Pomongwe Cave in relation to other Middle Stone Age sites in Matobo such as Bambata, Nswatugi and Cave of Bees (map by Humphrey Nyambiya).

Geologically, the Matobo comprises a granite massif that is brownish-grey in colour and consists of medium sand-sized grains (Grout 1935; Pye et al. 1984). The massif is about 2.65 billion years old and it covers 2050 km^2 (UNESCO 2003). Other rock pockets found in the Matobo include augen gneisses, older granites, and grandiosities, with additional minor intrusions of quartz and dolerite veins (Walker 1995). Smith (1968) noted that there are two types of quartz veins in the Matobo Cultural Landscape. The first type is the result of fracture infilling and the second occurs as single stringers on veins not related to a fault or a fracture zone (Smith 1968).

The deep caves commonly found in the Matobo granite seem to have formed through negative and spheroidal exfoliation, a process where curved layers of rock are peeled away, creating dome-shaped hills. The spheroidal exfoliation occurs in well-jointed rocks when the water penetrates the joints and attacks the blocks from all sides (Basu & Bandyopadhyay 2014). This process is influenced by flow patterns that were created during the formation of the rock, temperature changes that take advantage of fracture planes, and the natural weaknesses of the rock (Smith 1968; Walker 1995; Broderick & Hubbard 2016). This results in the breaking off of a succession of curved layers that eventually form the caves.

Although there are several other archaeological sites in the Matobo Landscape, the focus of this research is on Pomongwe Cave (Fig. 2) because there is an abundance of well-preserved granite spalls within different stratigraphic levels. This allows us to compare their variation in size and concentration over time, and to assess whether it is possible to reconstruct the palaeoenvironmental conditions. Cooke (1963) excavated three trenches, i.e., I, II, and III, at Pomongwe Cave in the 1960s. Trench I has deep stratigraphy down to about 4 metres with MSA and Later Stone Age (LSA) sequences that are separated by a thick layer of spalls, which is devoid of cultural material. The other two trenches were shallower.

Figure 2. Pomongwe Cave exterior view (upper image) and interior view (lower image) (CNRS/Matobart Project).

Following up on this work, Walker (1995) later excavated the site in the 1970s. He excavated two trenches, i.e., IV and V, with the deepest at about 1.4 metres. Walker (1995) focused on the LSA stratigraphy only and for both trenches, he excavated 14 units that were subdivided into different squares and subunits. A square consisted of a large horizontal sub-division of the trench. Trench V had three squares, i.e., squares PM, PY, and PZ (Table 1), and these were then divided into spits on the vertical axis. Spits are the subdivisions of the levels, which followed a fixed thickness of 2 cm (rather than following the natural layers of the sediment). Walker (1995) collected all the granite spalls and chips that he came across during his excavations, allowing us to study the spalls from trench V with precise contextual and temporal control derived from the established stratigraphic levels, and to hypothesise patterns of granite spalling. Pomongwe Cave's trenches I and V were re-opened in 2018 by Guillaume Porraz and his colleagues as part of the Matobart Project. This new project aims to clarify the chrono-cultural sequence and chrono-stylistic variation of rock art at the site (Porraz et. al. 2023).

4. Methods of data collection and analyses

Spalls were sampled from all the levels (I-XIV) of square PM only; squares PY and PZ were not sampled because they did not contain spalls in all the levels. The levels for square PM comprise 107 spits in total. Levels can be referred to as the subdivisions of the stratigraphy on the vertical axis in relation to soil colour and textural changes. These levels are then subdivided into different spits. All the levels had spalls but some spits did not contain any spalls, for example spits 18, 26, 39, 41, 45, and 63. Some of the spits that contained spalls are 1, 19, 27, 36, 42, 44 and 51. We analysed 1650 spalls and excluded those that had a length of <1 cm; these were weighed using a scale. Metric measurements such as length, width, and thickness were recorded using a vernier calliper. A calculation of the arithmetic mean of the length, width, thickness, and weight was generated to explore spall size variation. When trench V was re-opened in 2018, the distribution of spalls across the exposed profile was investigated using high-resolution photographs. This provided a visual impression of the distribution of spalls across the different stratigraphic layers.

Table 1. Walker's trench V archaeological correlations (modified from Walker 1995; Porraz et al. 2023).

Level	Member	Context	PY (square)	PM (square)	PZ (square)	Chrono-cultural	Radiocarbon age	Lab ID
I	A	Loose surface dust	1-4	2-17	None	Modern	-	-
II	B	White ash	5-28	18-25	2-17	Amadzimba	4090±70 BP	Pta-3085
III	B	Brown ash	29-32	26-29	18-19	Amadzimba	4810±80 BP	Pta-3083
IV	B	White ash	33-45	36-40	20	Amadzimba	-	-
V	B	Pale brown	46-48	41-43	21-23	Nswatugi	-	-
VI	B	White ash	49-52	44-50	24-28	Nswatugi	-	-
VII	B	Brown ash	53-60	51-66	29-33	Nswatugi	8420±80 BP	Pta-3470
VIII	B	White ash	61-65	Absent	Absent	Nswatugi	-	-
IX	B	Black ash	66-67	67-75	34-36	Pomongwe	-	-
X	B	White ash	68-69	76-78	-	Pomongwe	-	-
XI	B	Brown ash	71-73	79-91	-	Pomongwe	9500±120 BP	Pta-3117
XII	B	Pale brown ash	Absent	92-93	-	Maleme	-	-
XIII	B	Black ash	74-78	94-97	-	Maleme	12 300±100 BP	Pta-3118
XIV	C	Pale brown ashy loam	80-87	102-107	-	MSA	-	-

5. Results

The metric attributes

The spalls exhibited a wide range of sizes (Figs 3 & 4), varying significantly across the different spits. This substantial disparity in spall sizes provides an opportunity to explore the relationship between size variations and differing environmental conditions, particularly since these variations occur across distinct stratigraphic levels. For instance, the calculated averages of the spalls reveal that level IV contains the largest spalls, with an average length of 3.2 cm, whereas levels VII and XII contain the smallest spalls, with average lengths of 1.9 cm. These differences in spall size across levels may reflect changes in environmental conditions over time, offering valuable insights into the weathering processes at play.

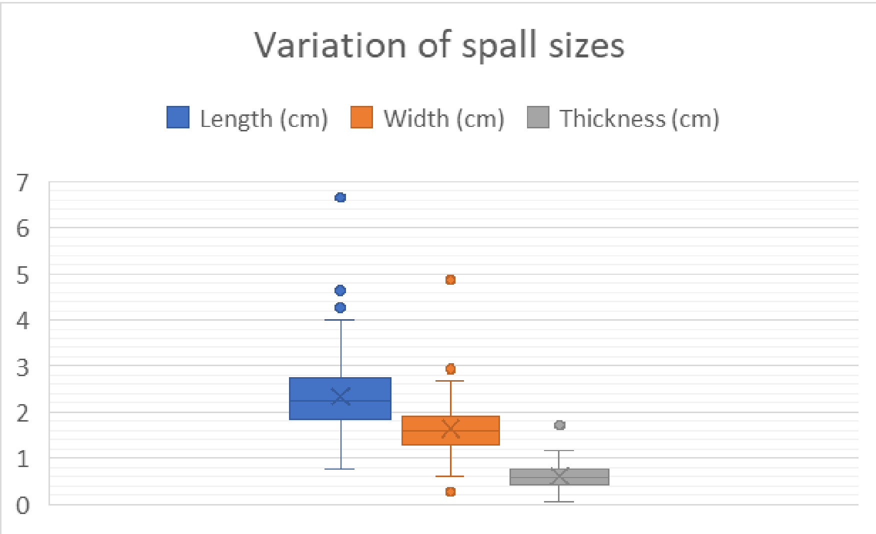


Figure 3. Variation of spall sizes (cm) at Pomongwe Cave.

Figure 4. Examples of spalls from trench V.

However, the distribution of spall sizes varies across different levels. Some levels contain a mix of both small and large spalls, while others are predominated by either large or small spalls. For example, level X, which contains a total of nine spalls, includes both large and small spalls. In contrast, level VII contains only small spalls, with a maximum mean length of 4 cm. These patterns highlight the variability in spall sizes across different levels, which may reflect distinct environmental or depositional conditions.

The spall size variation across the different spits becomes evident when comparing the number of spalls and their respective weights (Fig. 5). For instance, spit 76 contains only three spalls, yet these spalls have a significantly higher average weight of 61.67 g. In contrast, spit 6 in level I contains 24 spalls, but the average weight is much lower at 5.62 g. An even more striking example is spit 105, which contains 115 spalls but has a mean weight of just 3.19 g. These comparisons highlight clear differences in spall size, as the average weight decreases significantly as the number of spalls increases. This trend underscores the relationship between spall size and quantity, with larger spalls being fewer in number and smaller spalls being more abundant.

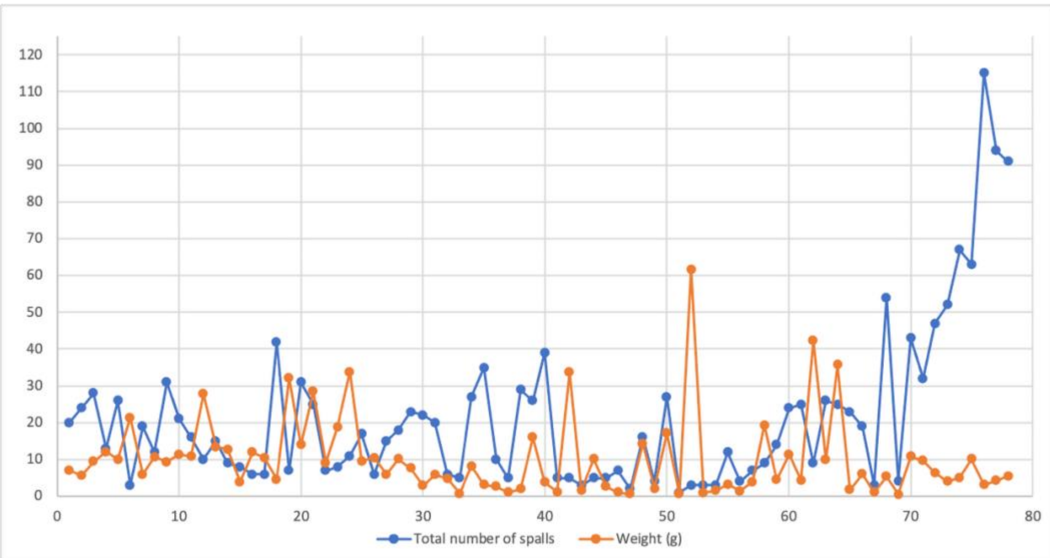


Figure 5. Comparison of spall concentration in relation to their weight.

In addition to the analysis of average length and mean weight, the concentration of spalls across levels also revealed significant disparities. Level XIV contains the largest number of spalls, with 482 spalls accounting for 29.2% of the total assemblage. This is followed by level VII, which contains 210 spalls, representing 12.8% of the analysed pieces. In contrast, level X has the fewest spalls, with only nine spalls, making up just 0.5% of the total assemblage. These findings highlight the uneven distribution of spalls across levels, which likely reflects differences in environmental conditions, potentially due to varying types of weathering and their intensity across the stratigraphic layers.

Overall, the relationship between spall counts, average weight, and average length reveals important patterns in the weathering and depositional processes across different levels (supporting online material [SOM] Table 1). Levels with higher spall counts, such as level XIV with 482 spalls, tend to have smaller average weights and lengths, indicating that these levels experienced more intense weathering or fragmentation, resulting in a greater number of smaller spalls. In contrast, levels with fewer spalls, such as level X with only nine spalls, often exhibit larger average weights and lengths, suggesting less intense weathering processes. Other levels, such as level VII with 210 spalls, show intermediate values, reflecting conditions that promote moderate weathering processes. These trends highlight how spall size and quantity are inversely related, with higher spall counts corresponding to smaller, lighter fragments and lower spall counts associated with larger, heavier pieces (Fig. 5). This relationship provides valuable insights into the varying intensity of weathering processes and environmental conditions across the different stratigraphic layers.

6. Discussion

Palaeoenvironmental reconstructions at Pomongwe Cave

The goal of this paper was to ascertain whether granite spalls found in archaeological levels could serve as proxies for reconstructing palaeoenvironments. A sample of spalls recovered from the site of Pomongwe in the Matobo UNESCO World Heritage Landscape were counted, measured, and weighed according to their stratigraphic levels. The results were then compared across stratigraphic levels to see if they showed varying weathering conditions, possibly resulting from varying environmental conditions.

The analyses have demonstrated significant potential for using granite spalls to reconstruct past environmental conditions at the site of Pomongwe. The examination of spall size, weight, and distribution has provided valuable insights into the weathering processes and possible environmental changes that occurred over time. Variations in these attributes across stratigraphic units may imply distinct periods of intense weathering (high spall counts, small spalls), moderate weathering (intermediate spall counts, mixed sizes), and reduced weathering (low spall counts, large spalls).

Drawing on the principles of granite weathering, periods of intense weathering (high spall counts, small spalls) are linked to intense mechanical and chemical weathering processes. These periods likely correspond to warm and humid conditions, where high rainfall and biological activity accelerated the breakdown of granite into smaller fragments (Sumner et al. 2012). The presence of smaller spalls indicates prolonged exposure to moisture, which promotes chemical weathering processes such as hydrolysis and oxidation (Ollier 1984; Goudie & Viles 1997). Such conditions may align with phases of increased precipitation, during which the climate was conducive to rapid rock disintegration. The presence of both small and large spalls suggests intermittent weathering intensity, where periods of moisture alternated with drier conditions (Anderson & Anderson 2010; Sumner et al. 2012). Limited moisture leads to the predominance of mechanical processes such as freeze-thaw cycles, thermal stress, or salt weathering (Marshak 2019). These conditions may correspond to glacial periods or other phases with reduced rainfall.

The uneven distribution of spalls across levels, with some levels predominated by small spalls and others by larger fragments, highlights oscillations between wet and arid conditions at Pomongwe. These variations were driven by climatic changes over time, particularly during the terminal late Pleistocene and early Holocene. The presence of intermediate levels (e.g., level VII) further supports the idea of transitional climatic conditions. Periods of moderate weathering, characterised by intermediate spall counts and a mix of smaller and larger spalls based on their average weights and lengths (e.g., level VII with 210 spalls), are associated with fluctuating environmental conditions. These periods likely represent transitional phases between humid and arid climates. Periods of reduced weathering, characterised by low spall counts (e.g., level X with nine spalls) and predominated by larger spalls with greater average weights and lengths, likely reflect arid or semi-arid conditions.

The spall data aligns with regional climatic records, suggesting that Pomongwe experienced cyclical environmental changes similar to those experienced at other sites in southern Africa. These changes were likely influenced by global climatic events, such as glacial-interglacial cycles, which affected rainfall patterns and temperature regimes (Partridge et al. 1997). For example, the Last Glacial Maximum (LGM) in southern Africa is associated with arid conditions and reduced weathering, while the early Holocene is characterised by warmer and wetter conditions, consistent with the patterns observed at Pomongwe (Tyson 1986; Thomas & Shaw 2002; Chase & Meadows 2007). Although the levels studied at Pomongwe do not extend to the LGM, Cooke (1963) has reported a level of large spalls in trench I that could date to the same period, further supporting the link between spall size and climatic conditions.

When combining the data from Pomongwe with previous palaeoenvironmental reconstructions done in Zimbabwe, it shows some interesting correlations (Walker 1995; Katsamudanga & Nhamo 2016). Katsamudanga and Nhamo (2016) indicated that at around 20-35 ka, there was a transition from warm, wet conditions to dry, cool conditions. Walker (1995) noted cold, dry conditions from 20 ka to about 15 ka, after which the climate began to ameliorate, becoming cool and wet by 14 ka (Table 2). Walker's (1995) reconstructions also show that around 12 ka, the temperature was warm and rainfall patterns were moderately wet. Katsamudanga and Nhamo (2016) suggest that conditions were cool between 11 and 12 ka, with wet conditions returning by 10 ka. Walker (1995) indicates slightly cooler conditions at 8 ka, while Katsamudanga and Nhamo (2016) describe wet conditions from 9.4 to 4.8 ka. These patterns reveal frequent oscillations in temperature and moisture at the beginning of the Holocene, reflecting the dynamic nature of the region's climate.

Table 2. Postulated environmental conditions at Pomongwe based on granite spall analysis, where the spall details include their sizes and counts.

Level	Spits	Age	Temp/rainfall	Spall details	Archaeological materials	Weathering processes	Environmental conditions
VII	51-62, 64-66	8420±80 BP (Pta-3470)	Cool/wet	Intermediate spall counts, mixed sizes	Large quantity	Intermittent chemical and mechanical weathering; alternating wet and dry conditions	Transitional phases between humid and arid climates; fluctuating moisture levels
XI	79, 81, 83-91	9500±120 BP (Pta-3117)	Cool/wet	Low spall counts, large spalls	Large quantity	Mechanical weathering (freeze-thaw cycles, thermal stress, salt weathering)	Arid or semi-arid conditions; limited moisture
XIII	95-97, 99-101	12 300±100 BP (Pta-3118)	Warm/wet	High spall counts, small spalls	Few	Chemical weathering (hydrolysis, oxidation); mechanical weathering (root wedging)	Warm and humid conditions; high rainfall and biological activity
XIV	102-107	Undated	Very cold/wet	High spall counts, small spalls	Very few	Chemical weathering (hydrolysis, oxidation); mechanical weathering (root wedging)	Warm and humid conditions; high rainfall and biological activity

Similar patterns have been identified at other sites in the Matobo Hills, such as at Bambata and Tshangula. Walker (1985) argued that these sites exhibit intense weathering during humid phases and reduced weathering during arid periods, aligning closely with the spall data from Pomongwe. This suggests that the climatic fluctuations observed at Pomongwe were part of a broader regional trend during the late Pleistocene and Holocene.

In the Kalahari region, Thomas and Shaw (1991) have also documented evidence of arid conditions during glacial periods, characterised by reduced spall counts and larger fragment sizes. These findings are consistent with the patterns observed at Pomongwe, further reinforcing the idea that granite spalls have the potential to serve as a reliable proxy for reconstructing past climatic changes across southern Africa.

Human response to palaeoenvironments at Pomongwe Cave

The weathering patterns observed at Pomongwe provide valuable insight into the relationship between environmental conditions and site occupation. Periods of intense weathering (high spall counts) likely coincided with more favourable conditions for human activity, such as increased water availability and vegetation cover. In contrast, aridity – whether from hot or very cold temperatures (low spall counts) – may have challenged resource availability, influencing human mobility and settlement patterns (Deacon & Deacon 1999; Grove 2009). The spall data, combined with archaeological evidence, allow for the exploration of how humans responded to changing environmental conditions over time.

At Pomongwe, levels with archaeological evidence are indicated in Table 2. Cool, wet conditions are indicated for level VII, dated to 8420±80 BP (Pta-3470), which would have supported abundant vegetation and water resources. The large quantity of archaeological remains in this level suggests substantial human occupation during this time, likely due to the favourable environmental conditions. However, level XI (9500±120 BP, Pta-3117), although also reflecting cool, wet conditions, shows a significantly lower number of spalls compared to level VII. This difference may indicate variation in precipitation, with level XI experiencing less intense rainfall. Despite the lower spall count, the substantial quantity of archaeological materials suggests that human occupation persisted, possibly due to the availability of sufficient resources even under slightly drier conditions.

The warm, wet conditions during level XIII, dated to about 12 300±100 BP (Pta-3118), may have promoted intense weathering, leading to minimal human occupation of the cave. The archaeological materials from this level are relatively few, alluding to this possibility. Despite the warm, wet conditions, other factors such as excessive moisture may have made the cave less habitable. This is especially accentuated in level XIV (~13 ka) with wet conditions and high precipitation that must have led to the accumulation of a large number of granite spalls. Level XIV contains the least archaeological materials of all the levels at Pomongwe, which suggests that the cave may have been abandoned due to high precipitation and intense weathering. This may have rendered the cave unsuitable for human habitation, resulting in only sporadic occupation.

7. Conclusion

This study has demonstrated that granite spalls have the potential to be used as a proxy for reconstructing past environments. Patterns of granite spalling reveal that climatic conditions significantly influence the rate of granite exfoliation. Specifically, this study found that cool, wet conditions resulted in fewer, large spalls, as evidenced by the observed accumulation patterns in the stratigraphy. In contrast, high precipitation plays a pivotal role in accelerating the exfoliation of granite, leading to the accumulation of larger quantities of spalls.

The relationship between environmental conditions and human occupation at Pomongwe Cave further underscores the utility of granite spalls as a palaeoenvironmental proxy. The study shows that humans occupied the cave during cool, wet periods, as indicated by the presence of abundant archaeological remains. However, occupation became sparse or ceased entirely around 13 ka, when conditions shifted to being very cold and wet, likely making the cave less habitable. This highlights the dynamic interplay between climate, weathering processes, and human settlement patterns.

While the results presented in this paper help to provide a proof of concept for using granite spalls as a proxy for palaeoenvironmental reconstruction, further investigation is needed to refine and expand this approach. Areas of future research include enhancing our chronological framework to incorporate additional dating methods, such as Optically Stimulated Luminescence (OSL), that will facilitate stronger inter-site correlation with regional climatic events. Another would be the analysis of granite spalls from other trenches both at Pomongwe, and at all the other sites across Zimbabwe and southern

Africa where granite spalls occur. This would enable the identification of broader trends in their occurrence, further validating their reliability as proxies across different climatic contexts. The development of quantitative models to correlate spall size, weight, and concentration, with specific climatic parameters such as rainfall intensity and temperature fluctuations, would also improve the usefulness of granite spalls as palaeoenvironmental proxies.

In terms of methodology, the employment of macro and micro-scale analyses of the granite spalls, including observations of weathering patterns, abrasions, and surface textures, in addition to measuring their lengths, widths, and thicknesses, would add critical data on spall occurrences that could then facilitate palaeoenvironmental reconstructions. This additional analysis would provide a more comprehensive basis for concluding how the spalls were formed under the prevailing past environmental conditions. Furthermore, the investigation of the material culture found at Pomongwe during warm, wet periods, to determine whether favourable environmental conditions fostered experimentation and innovation in tool making and other technologies, is also important. It is known that environmental conditions led to the development of many technological innovations in the past. Therefore, it would be beneficial to correlate the technological developments with the environmental conditions deduced from analyses of spalling. For example, technological innovations such as the geometric backed artefacts coming from the Amadzimba period at Pomongwe (Chiwara-Maenzanise et al. 2025) may have been environmentally driven.

A closer scrutiny of the occupation history of Pomongwe, particularly during the early Holocene, would also be beneficial. While this study suggests a possible occupation break around 13 ka due to very cold and wet conditions, such conclusions require further investigation to: 1) determine whether there was continuity or discontinuity in occupation during the early Holocene, and 2) explore the factors that led to the reoccupation of the cave. The integration of data from other palaeoenvironmental proxies, such as pollen and stable isotopes, will further help to create a more comprehensive reconstruction of past climates. By addressing these key areas, future research can assess whether granite spalls are a robust and versatile tool for palaeoenvironmental reconstruction, contributing to a deeper understanding of past climatic changes and their impact on human societies. Additionally, exploring the material culture and technological innovations associated with different climatic periods will provide insights into how human populations adapted to and thrived in varying environmental conditions.

Acknowledgements
We acknowledge that this paper is a result of the research carried out by Thubelihle Mnkandla during her Masters studies at the University of Zimbabwe. Our gratitude is extended to the leaders of the Matobart Project, Guillaume Porraz, Camille Bourdier and Ancila Nhamo, for giving Thubelihle the opportunity to be part of this project and for allowing us to use the images from this project in our publication. We also want to thank Humphrey Nyambiya for the map used in this paper. Special thanks also go to the reviewers and editors of the Southern African Field Archaeology Journal for their constructive comments that improved our paper.

Supporting online material

Mnkandla & Nhamo Supporting Online Material File 1

References

Anderson, R.S. & Anderson, S.P. 2010. Geomorphology: The Mechanics and Chemistry of Landscapes. Cambridge: Cambridge University Press.

Backwell, L.R., McCarthy, T.S., Wadley, L., et al. 2014. Multiproxy record of late Quaternary climate change and Middle Stone Age human occupation at Wonderkrater, South Africa. Quaternary Science Reviews, 99: 42-59.

Basu, P. & Bondyopadhyay, M.K. 2014. Some features of weathering in the eastern-north Karanpura basin, Sharkhand, India. International Journal of Geology, Earth and Environmental Sciences, 4(2): 191-207.

Boggs, S. 2006. Principles of Sedimentology and Stratigraphy. California: Pearson Prentice Hall.

Bond, G. 1949. The geology, climates and cultures of the Pleistocene period in Matebeleland, Southern Rhodesia. Doctoral Thesis. Salisbury: University of Rhodesia.

Bond, G. 1957. The geology of the Khami Stone Age sites. Occasional Papers of the National Museums of Southern Rhodesia, 21(A): 115-130.
Bond, G. 1964. Pleistocene environments in southern Africa. In: Howell, F. & Bourliere, F. (eds) African Ecology and Human Evolution: 308-334. Chicago: Aldine.
Bond, G. 1965. Quantitative approaches to rainfall changes in the Quaternary of southern Africa. In: Wright, H. E. & Frey, D.G. (eds) International Studies on the Quaternary: Papers Prepared on the Occasion of the VII Congress of the International Association of Quaternary Research: 323-336. Colorado: Geological Society of America.
Bond, G. & Clark, J.D. 1954. The Quaternary sequence in the middle Zambezi Valley. South African Archaeological Bulletin, 9(36): 115-130.
Brain, C.K. 1969. New evidence for climatic change during Middle and Late Stone Age times in Rhodesia. South African Archaeological Bulletin, 24(95/96): 127-143.
Braun, K., Nehme, C., Pickering, R., et al. 2019. A window into Africa's past hydroclimates: The SISAL_vl Database Contribution. Quaternary, 2(1): 1-33.
Broderick, T. & Hubbard, P. 2016. The Matobo Hills of Zimbabwe: A perfect blend of geology, scenery and human history. In: Anhaeusser, C.R., Viljoen, M.J. & Viljoen, R.P. (eds) Africa's Top Geological Sites: 33-38. Cape Town: Struik Nature.
Chase, B.M. & Meadows, M.E. 2007. Late Quaternary dynamics of southern Africa's winter rainfall zone. Earth Science Reviews, 84(3-4): 103-138.
Chiwara-Maenzanise, P., Nhamo, A. & Porraz, G. 2025. Morphological and functional variability of the geometric microlithic backed tools from the late Holocene at Pomongwe Cave (Matobo, western Zimbabwe). Southern African Field Archaeology, 20: 3561.
Cooke, C.K. 1963. Report on excavations at Pomongwe and Tshangula Cave, Matopo Hills, Southern Rhodesia. South African Archaeological Bulletin, 18(7): 73-151.
Cooke, C.K. 1971. Excavation at Zombepata Cave, Sipolilo District, Mashonaland, Rhodesia. South African Archaeological Bulletin, 26(103): 104-126.
Cruz-Uribe, K. 1983. The mammalian fauna from Redcliff Cave, Zimbabwe. South African Archaeological Bulletin, 38(137): 7-16.
Deacon, H.J. & Deacon, J. 1999. Human Beginnings in South Africa: Uncovering the Secrets of the Stone Age. Walnut Creek: AltaMira Press.
Dollar, S.J.E. 1998. Paleofluvial geomorphology in southern Africa: A review. Progress in Physical Geography, 22(3): 325-349.
Goudie, A.S. & Viles, H.A. 1997. Weathering and the Landscape: Geomorphological Perspectives. New York: Wiley.
Grout, F.F. 1935. The composition of some African granitoid rocks. Journal of Geology, 43(3): 281-296.
Grove, M. 2009. Hunter-gatherer movement patterns: Causes and constraints. Journal of Anthropological Archaeology, 28: 222-233.
Haynes, G. 1996. Quarternary climates and environment in Hwange National Park, Zimbabwe. In: Pwiti, G. & Soper, R. (eds) Aspects of African Archaeology: Papers from the 10th Congress of the Pan-African Association for Prehistory and Related Studies: 71-81. Harare: University of Zimbabwe Publications.
Holzkämper, S., Holmgren, K., Lee-Thorp, K., et al. 2009. Late Pleistocene stalagmite growth in Wolkberg Cave, South Africa. Earth and Planetary Science Letters, 282: 212-221.
Katsamudanga, S. & Nhamo, A. 2016. A review of the reconstructed palaeoenvironmental record of Zimbabwe and call for multidisciplinary research. Palaeogeography, Palaeoclimatology, Palaeoecology, 461: 460-471.
Marshak, S. 2019. Earth: Portrait of a Planet. Sixth Edition. New York: W.W. Norton & Company.
Mellars, P. 2006. Why did modern human populations disperse from Africa ca. 60,000 years ago? A new model. Proceedings of the National Academy of Sciences, 103(25): 9381-9386.
Migoń, P. 2006. Granite weathering. In: Migoń P. (ed.) Granite Landscapes of the World: Geomorphological Landscapes of the World. 24-82. Oxford: Oxford University Press.
Mugumbate, F. 2013. On naturally sculptured granites in Zimbabwe. Address to the Geological Society of Zimbabwe AGM 2013, Harare, Zimbabwe.
Nhamo-Katsamudanga, A. & Chiwara-Manezanise, P. 2023. Pleistocene archaeology of Zimbabwe: An overview. In: Beyin, A., Wright, D.K., Wilkins, J., et al. (eds) Handbook of Pleistocene Archaeology in Africa: Human Behaviour, Geography and Chronology: 1203-1224. Cham: Springer.
Ollier, C. 1984. Weathering. Second Edition. London: Longman.
Partridge, T.C., Scott, L. & Schneider, R.R. 1997. Environmental changes in southern Africa during the Last Glacial Maximum. Quaternary Science Reviews, 16(9): 841-859.
Plummer, C.C., Hammersley, L. & Carlson, D. 2016. Physical Geology. Fifteenth Edition. New York: McGraw-Hill Companies.

Porraz, G., Nhamo, A. & Bourdier, C. 2023. Pomongwe Cave, Zimbabwe. In: Beyin, A., Wright, D.K., Wilkins, J., et al. (eds) Handbook of Pleistocene Archaeology of Africa: Hominin Behavior, Geography, and Chronology: 1225-1237. Cham: Springer.

Potts, R. 1998. Environmental hypotheses of hominin evolution. American Journal of Physical Anthropology, 107(S27): 93-136.

Pye, K. Goudie, A.S. & Thomas, D.S.G. 1984. A test of petrological control in the development of bornhardts and koppies on the Matopos Batholith, Zimbabwe. Earth Surface Processes and Landforms, 9: 455-467.

Robinson, J.R. 2023. A context for connectivity: Insights to environmental heterogeneity in the Late Pleistocene and Holocene of southern Africa through measuring isotope space and overlap. Journal of Palaeolithic Archaeology, 6(34): 1-48.

Smith, C.G. 1968. Some aspects of the geology of the Matopos. Honours Report. Salisbury: University of Rhodesia.

Summers, R. 1960. Environment and culture in southern Africa: A study in the personality of a land-locked country. Proceedings of the American Philosophical Society, 104(3): 266-293.

Sumner, P.D., Hall, K.J., Meiklejohn, K.I., et al. 2012. Weathering. In: Holmes, P. & Meadows, M. (eds) Southern African Geomorphology: Recent Trends and New Directions. 75-93. Bloemfontein: Sun Media Bloemfontein.

Thomas, D.S.G. & Shaw, P.A. 1991. The Kalahari Environment. Cambridge: Cambridge University Press.

Thomas, D.S.G. & Shaw, P.A. 2002. Late Quaternary environmental change in central southern Africa: New data, synthesis, issues and prospects. Quaternary Science Reviews, 71(7): 783-797.

Twidale, C.R. 2012. Granite landscapes. In: Holmes, P. & Meadows, M. (eds) Southern African Geomorphology: Recent Trends and New Directions: 41-72. Bloemfontein: Sun Media Bloemfontein.

Tyson, P.D. 1986. Climate Change in Southern Africa. Oxford: Oxford University Press.

UNESCO. 2003. Advisory Board Evaluation (ICOMOS): Matobo Hills (Zimbabwe) No 306 Rev. Available from: https://whc.unesco.org/en/documents/153151 (Accessed: 2025)

Walker, N.J. 1985. Late Pleistocene and Holocene hunter-gatherers of the Matopos. Quaternary Research, 24(2): 147-161.

Walker, N.J. 1995. Late Pleistocene and Holocene Hunter-Gatherers of the Matopos: An Archaeological Study of Change and Continuity in Zimbabwe. Uppsala: Societas Archaeologica Upsaliensis.

Southern African Field Archaeology
2025 Vol. 20: Article 3964
Research report (peer-reviewed): Received February 2025; Revised June 2025; Published September 2025
DOI: https://doi.org/10.36615/safa.20.3964.2025
ISSN 1019-5785
ISSN 2789-1844

The stratigraphic context, chronology, and cultural sequence at Little Muck Shelter, southern Africa

Tim Forssman [a, b, *], Chante Barnard [a, b], Siphesihle Kuhlase [b], Stephan Woodborne [c] & Sonja van Zyl [b]

[a]Culture and Heritage Studies, School of Social Sciences, University of Mpumalanga, Mbombela 1200, South Africa
[b]Department of Anthropology and Archaeology, University of Pretoria, Private Bag X20, Hatfield 0023, South Africa
[c]iThemba LABS, Private Bag 11, WITS, Johannesburg 2050, South Africa
**Corresponding author email: tim.forssman@ump.ac.za*

ABSTRACT
Hall and Smith's (2000) excavations at Little Muck Shelter in the late 1990s uncovered a Later Stone Age sequence purported to span the last 2000 years. They identified four occupation phases that included what they called workshop phases when resident foragers were crafting vast amounts of goods for the purpose of trade with nearby farmers. In return, foragers obtained domestic items, ceramics, metal and glass beads. Despite the site's distinct occupation horizons, and the potential it offered for understanding forager-farmer relations in the middle Limpopo Valley, no radiocarbon dates were obtained, and its cultural assemblage was not studied in great detail. To address this, a new excavation programme was designed to obtain radiocarbon results for the site's entire occupation and better understand the stratigraphic and cultural sequence inside and outside the shelter. A large suite of radiocarbon dates from two laboratories are stratigraphically inconsistent, contradictory, do not conform with the regionally established cultural chronology, and must be rejected. To circumnavigate this, here we present a detailed chronological sequence for Little Muck based on changes in the cultural material assemblage. We compare this to the previous excavation results and assess stratigraphic relationships across the shelter. Our results make it possible to associate specific changes at the site with forager-farmer interactions in the middle Limpopo Valley, and demonstrate the continued occupation of the shelter into the thirteenth century CE Mapungubwe phase.

Keywords: Later Stone Age, forager archaeology, radiocarbon dating, stratigraphy, middle Limpopo Valley

1. Introduction

The middle Limpopo Valley landscape is well-known for its archaeological sequence because of the local farmer record. It was in this region that socio-political developments led to the eventual establishment of a state-level society at Mapungubwe. Here a chief occupied a palatial hilltop complex, accumulated wealth, developed political authority, controlled the ritual landscape, and centralised long-distance trade (Huffman 2015). These shifts developed over the course of at least three centuries. Long before this began, the valley was occupied by forager communities, also known as hunter-gatherers. Changes in their lifeways were at times muted and in other instances drastic, involving a range of shifts in subsistence, settlements, and craft habits. Of the excavated sites, Little Muck Shelter preserves the most compelling evidence for social developments in forager society, including craft specialisation (Forssman 2020). Understanding the chronology and stratigraphic context of the site is crucial for unlocking insights into local forager histories and their role in the development of complex society.

Presented here is a detailed description of the shelter's context. This includes the site's location on the landscape, but more important, its occupation sequence and stratigraphy. How these relate to the distribution of cultural finds is then appraised. The results from renewed excavations at the site reinvigorates earlier work at the shelter, which lacked absolute dates or rigorous discussion on the stratigraphic profile (Hall & Smith 2000). The findings indicate an occupation sequence that begins shortly before the BCE/CE transition and extends until the late second millennium CE. The shelter was therefore occupied during the course of socio-political developments in the valley and changes in the cultural sequence reflect changing social relations between forager and farmer groups. Little Muck is the only forager occupied site in the region thus far excavated that exhibits intense interactions with farmers that involved the exchange of wealth items from their appearance on the landscape until, and during, the Mapungubwe period. Improved understanding of the stratigraphic and chronological sequence may confidently demonstrate the close social relations taking place at the site. It also allows us to chronologically relate Hall and Smith's (2000) previous work at the site with our own.

2. Context and background

Along the margins of the Limpopo River Mobile Belt, primarily to the south but stretching into Zimbabwe as well, is a sandstone geological exposure. It mostly comprises east-west running ridges with regular gaps and punctuated sandstone koppies (tors) (Fig. 1). Within this belt are numerous Stone Age occupied and painted shelters (Eastwood & Blundell 1999; Forssman 2013, 2014a; Huffman & Woodborne 2021) as well as Iron Age farmer settlements (Huffman & Woodborne 2021). The region also hosts micro-ecological niches within the sandstone hills, and riparian woodland occurs along waterways running through them, of which there are only a few (Hanisch 1981; Gotze et al. 2008). In at least three locations along the Limpopo River, seasonal wetlands (locally known as vleis) occur at the river confluences with the Motloutse, Pitsani and Shashe Rivers (listed from west to east) (Huffman 2009a). These ecological mechanisms all supported a large wildlife population, with a diverse savanna biome speciation (du Toit & Cumming 1999; Rutherford et al. 2006) as well as a variety of floral species, including year-round subsistence options (Acocks 1988).

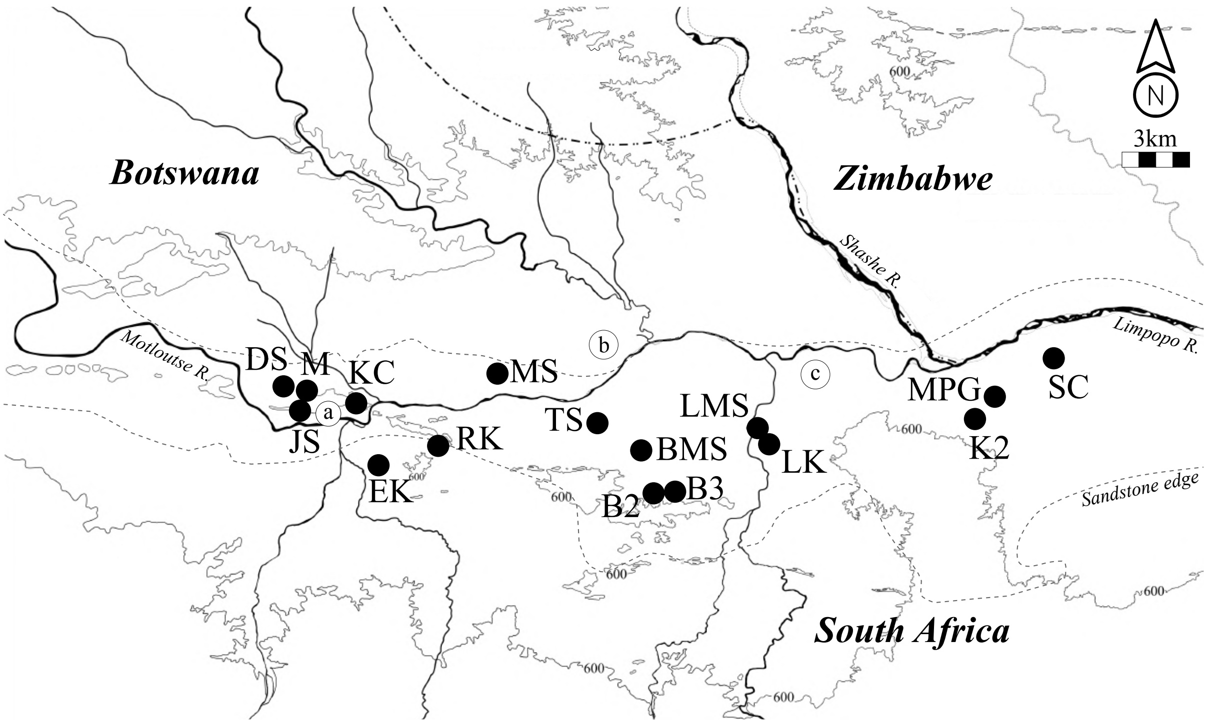


Figure 1. Map of the Little Muck Shelter landscape with the sandstone belt (dashed line) indicated and the seasonal wetlands (a-c). Key sites in the region: B2, Balerno Shelter 2; B3, Balerno Shelter 3; BMS, Balerno Main Shelter; DS, Dzombo Shelter; EK, Euphorbia Kop; JS, João Shelter; K2, Bambandyanalo; KC, Kambaku Camp; LK, Leokwe Hill; LMS, Little Muck Shelter; M, Mmamagwa; MPG, Mapungubwe; MS, Mafunyane Shelter (Tuli Lodge); RK, Ratho Kop; SC, Schroda; and TS, Tshisiku Shelter. Letters marked in circles are vleis at the Limpopo-Motloutse (a), Limpopo-Pitsani (b) and Limpopo-Kolope (c) Rivers' confluences (produced by Tim Forssman).

This region, referred to here as the middle Limpopo Valley, is well known for its Iron Age sequence where southern Africa's first state-level societies appeared. Most research in the area focused on better understanding the associated farmer sequence (e.g., Schoeman 2006; Calabrese 2007; Huffman 2009b, 2015; Chirikure et al. 2014; Antonites & Ashley 2016), but many Stone Age sites have been identified (e.g., Eastwood & Blundell 1999; Kuman et al. 2005; Schoeman 2006; Forssman 2014a) and excavated (e.g., Hall & Smith 2000; van Doornum 2005; Forssman 2014a; Forssman et al. 2022). The result from these works has placed us in a stronger position to interrogate social relations between co-existing foragers and farmers in the valley.

The earliest Later Stone Age evidence in the region is from Balerno Main Shelter (van Doornum 2008). Radiocarbon dates from ostrich eggshell in the basal unit (DAF) produced a date of 11 040±90 bp, which was calibrated to 11 075-10 632 BCE (all dates recalibrated using OxCal 4.1 and the ShCal20 calibration curve; see Forssman 2020). The archaeological assemblage from this depth, however, has not been investigated. Following this, the next earliest date was retrieved from Tshisiku Shelter at 6750±60 bp (from ostrich eggshell) calibrated to 5712-5318 BCE. It was around this time that Balerno Main was abandoned and only reoccupied at ca. 350 BCE. It is from this period onwards that most of the excavated forager sites were occupied for the first time.

Why many more shelters were occupied ca. 2 000 BP fairly suddenly is not clear. In the Matopo Hills, north of the valley, Walker (1995) inferred an increase in the forager population beginning between 6000 and 5000 BP, but elsewhere, such as in the Orange River basin (Parsons 2008) and various regions in Botswana (Walker 1994), this increase only took place after 3000 BP, like in the middle Limpopo Valley. There are various explanations for this increase, such as a bow-wave of forager migrations ahead of farmers moving into the region, a shift in settlement from open-air to shelter sites, or suitable local ecological conditions favouring population growth. Discerning which factor is most likely, or if it was a combination of them, is not possible on present evidence, nor can one with any certainty determine a population increase on present evidence rather than, for example, settlement shifts.

Shelters occupied for the first time in the final centuries BCE include Balerno 2 (van Doornum 2005) and 3 (van Doornum 2014), Dzombo (Forssman 2014b), Mafunyane (Forssman 2016a), Mbere (Kuhlase 2023), and possibly Little Muck (Hall & Smith 2000), while Balerno Main was re-occupied (van Doornum 2008). Most shelters exhibit similar archaeological sequences at this stage, which includes stone assemblages predominated by crypto-crystalline silicates (CCS) and formal categories comprising mostly scrapers and backed tools, the production of ostrich eggshell beads, and a constrained faunal species assemblage. However, Balerno Main is different. It includes a variety of tool types and a large faunal assemblage. Van Doornum (2008) suggested the diversity of finds indicates that the site was an aggregation camp. Aggregation is a settlement mode recorded in the Kalahari Desert when multiple San[1] groups gather at a campsite and feast, perform rituals, hold marriage ceremonies, and exchange gifts (Wadley 1987). This reading of the archaeological sequence conforms to ethnographic findings but it is not certain whether these social systems existed throughout southern Africa (e.g., Mitchell 2003). For example, the middle Limpopo Valley was sufficiently different from the Kalahari environment, such that the same survival strategies, which had social feedbacks, may not have been necessary. It is unclear whether foragers in the valley were as mobile as we tend to assume using Kalahari observations.

In the first centuries CE, notable change began at some forager sites. It is, however, possible that before this herder groups settled or moved through the region, but there is little evidence supporting such a likelihood and none that support any suspected chronology of this movement (Eastwood & Smith 2005). Bambata and Happy Rest ceramics were retrieved from both Little Muck and Mafunyane, which may be the result of contact with farmer groups by the mid-first millennium CE (although the producers of Bambata ware are disputed; Huffman 2005). However, if the result of contact, it may have been with

[1] We use the term 'San' out of respect to the Khoisan community in southern Africa who through the Khoisan Council have indicated a preference for this term or Bushman when not using language names as group designations. When using this term we refer exclusively to historic groups post-dating the arrival of Europeans.

farmers living in the Soutpansberg or outside of the valley since no homesteads have been found locally that pre-date 900 CE (Hall & Smith 2000; Huffman 2007). At Little Muck, at the same time that ceramics make their appearance, stone scraper frequencies increase significantly (Forssman et al. 2018). A recent use-wear analysis has also identified a shift in the use of scrapers at this time; before the arrival of farmers, various materials were worked, but afterwards scrapers were used predominantly to manufacture goods from bone (Sherwood & Forssman 2023). At Dzombo the arrival of farmers stimulated a shift in the forager sequence but here it included an emphasis on backed tools. Fractures on the tools are consistent with damage related to hunting, suggesting their use at the shelter. As with Little Muck, this shift was accompanied by the appearance of farmer technologies in the sequence (Forssman 2015). While these changes were occurring at these sites, other shelters exhibit relative continuity, other than the appearance of low frequencies of farmer items. Balerno Main shows little sign of change and van Doornum (2008) suggested this may be the result of the site's isolation, although this is probably unlikely, since it was only a few kilometres from nearby farmer settlements.

In the succeeding phase, from ca. 900 CE, change was more marked. Almost all sites exhibit a decline in artefact frequencies (van Doornum 2005; Forssman 2014a) whereas continuity persists at Balerno Main (van Doornum 2008). The emphasis on craft at Little Muck and hunting at Dzombo becomes exaggerated compared to the first half of the first millennium CE, suggesting a possible intensification of trade and exchange. Driving these changes, partly at least, was the settlement of the valley by Zhizo ceramic-producing farmer groups. They largely occupied the floodplain periphery and by 1000 CE had established two largescale settlements, Schroda and Leokwe Hill (Calabrese 2007; du Piesanie 2008). Interactions between forager and farmer groups during this period appear to have escalated and resulted in a greater influence on forager lifeways. For example, João Shelter and Euphorbia Kop were occupied from the second millennium CE. Both sites are farmer homesteads but possess forager assemblages inside the village as well as in shelters attached to them. These findings suggest that some foragers began occupying farmer settlements at this time (Forssman 2016b; Forssman et al. 2022). This was predictably accompanied by social and cultural re-organisations as well as shifts in behavioural and subsistence habits.

Leopard's Kopje ceramic-producers arrived in the region around 1000 CE, likely the result of growing farmer interest in the valley precipitated by the arrival of Zhizo producers. Initially these groups are recognised by K2 ware, followed by Mapungubwe ceramics, but a Transitional K2 period overlaps with the end and beginning of each facies, respectively. State-level society formed due to increases in political control and authority, the centralisation of wealth and rituality (namely rain-control and spiritual access to the ancestors), the appearance of divine leadership, and settlement structure reform. The state's capital was at Mapungubwe, occupied from ca. 1220 CE (Huffman 2015). Foragers continued living in the valley during this period but shelter assemblages are elusive. Most of the sites were abandoned, barring only Dzombo (Forssman 2014b) and possibly Little Muck (Forssman et al. 2023), based on available information. During this period, forager lifeways appear to have been heavily disrupted and altered, likely linked to relations with farmers undergoing social transformation but also possibly the result of environmental change. Additional evidence from this period is needed to better understand forager ways of living.

3. Materials and methods

Little Muck is a north-facing shelter situated within the sandstone belt set back approximately 5.8 km south of the Limpopo River. The shelter opening is 12 m wide, and its sheltered area is narrow in the east portion of the site, with a depth of 2 m, but there is a deeper recess of 4 m on the western flank. The ceiling rises steeply along the back wall in the eastern area of the shelter, on which is a large panel of faded rock art, but it is flatter in the western recess where the rock floor extends into the sandstone hill by approximately 4 m with a low ceiling (Fig. 2). Outside the shelter is a large open, sandy area that slopes gently towards the north until it dips into the surrounding bedrock exposure. Along this sandstone base are numerous engravings including grinding hollows, cupules, and gaming boards. The site, therefore, has two primary and viable occupation zones: the internal shelter and the open air in front.

Excavations were carried out in both the sheltered and open areas of the site to determine their chronological and cultural relationships. The excavation programme covered 20 squares, each measuring 1x1 m. Within these, only selected quadrants (50x50 cm) were excavated, resulting in a total of 51 excavated quadrants (Fig. 3). Twenty-two were in the open area and the remainder were either inside the shelter or around the dripline (further details below). Two quadrants from K42 were excavated to connect Hall and Smith's (2000) excavations with the newly excavated squares and to establish stratigraphic relationships. All the excavated squares were dug following the same methods. Stratigraphic units were identified based on colour, compaction, inclusions, and artefact contents. Each unit was excavated separately. In addition, 30 mm spits were maintained throughout the excavations and measured from a datum point. To blend these two methods, stratigraphic changes were recorded within spits. For example, where a stratigraphic unit bisected a single spit, both stratigraphic units within it would be dug and recorded separately (e.g., spit 1, unit GB1 and spit 1, unit GB2). The benefit of this approach is having two interlocking systems of depth control; one based on context and the other based on a systematic and objective measure. Stratigraphy is preferred when discussing the chronology and distribution of cultural finds as much as possible.

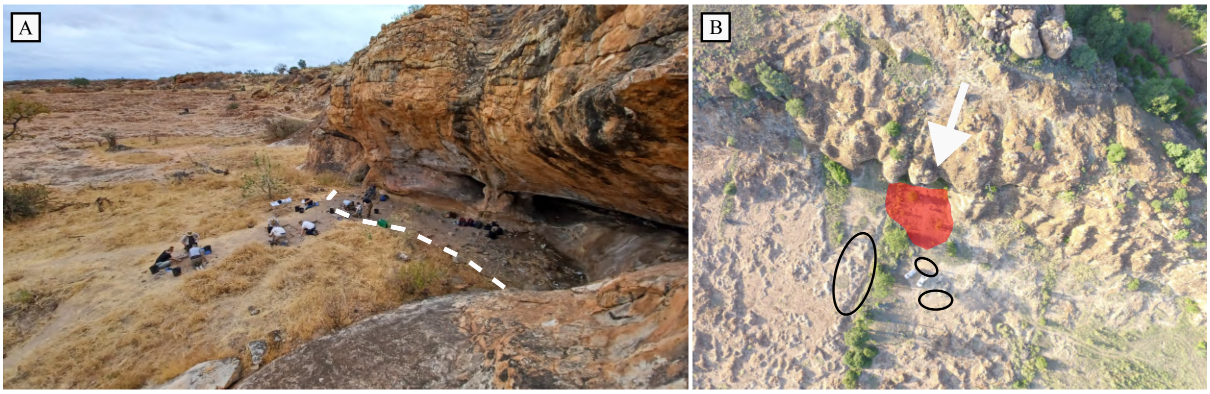


Figure 2. An image showing Little Muck Shelter spatial locations (a) with the dripline indicated by a dashed line, alongside an aerial view of the shelter (b) marked by a white arrow that shows the open area in front of the shelter (red) and the rock markings in black circles.

All contexts were recorded on an adapted Museum of London Archaeological Services context sheet and photographed. Recorded variables for deposit or fill included the dimensions within the square, texture, colour, Munsell value and name (from which an acronym was used to name the context and a number in consecutive order where a duplicated acronym occurred), composition, inclusions and excavation method. Bioturbation, waterlogging, lamination, and suspected rate of accumulation were all noted as well. The distinction between a unit and its overlying/upper unit was also recorded as either distinct, non-distinct, uneven or graded. Finally, a Harris Matrix was completed on the context sheet. Additional information such as date, site name, recorder and photograph numbers were also completed for each context sheet.

The artefacts were all sorted into primary categories (e.g., stone tool, ceramic, etc.) and weighed. While the artefacts have also been analysed, these reports are currently in preparation with some of the results already published (Forssman et al. 2023; Pentz et al. 2024); the specific results are not of relevance here. Instead, we focus on the stratigraphic sequence, chronology and the density and distribution of finds.

4. Results

Stratigraphic context

The stratigraphic sequence was not consistent between the inside and outside areas, as well as within the shelter. A major discontinuity was recorded in J42, for example, where a cut and fill took place. In addition, due to rising bedrock from the deeper portion of the shelter around I42 and J42, it was not possible to confidently connect stratigraphic units between the inside and outside areas. The bedrock rose from the vicinity of J42 in both an easterly and westerly direction, and deposits were shallow outside the shelter. We present all the stratigraphic units with descriptions in Table 1.

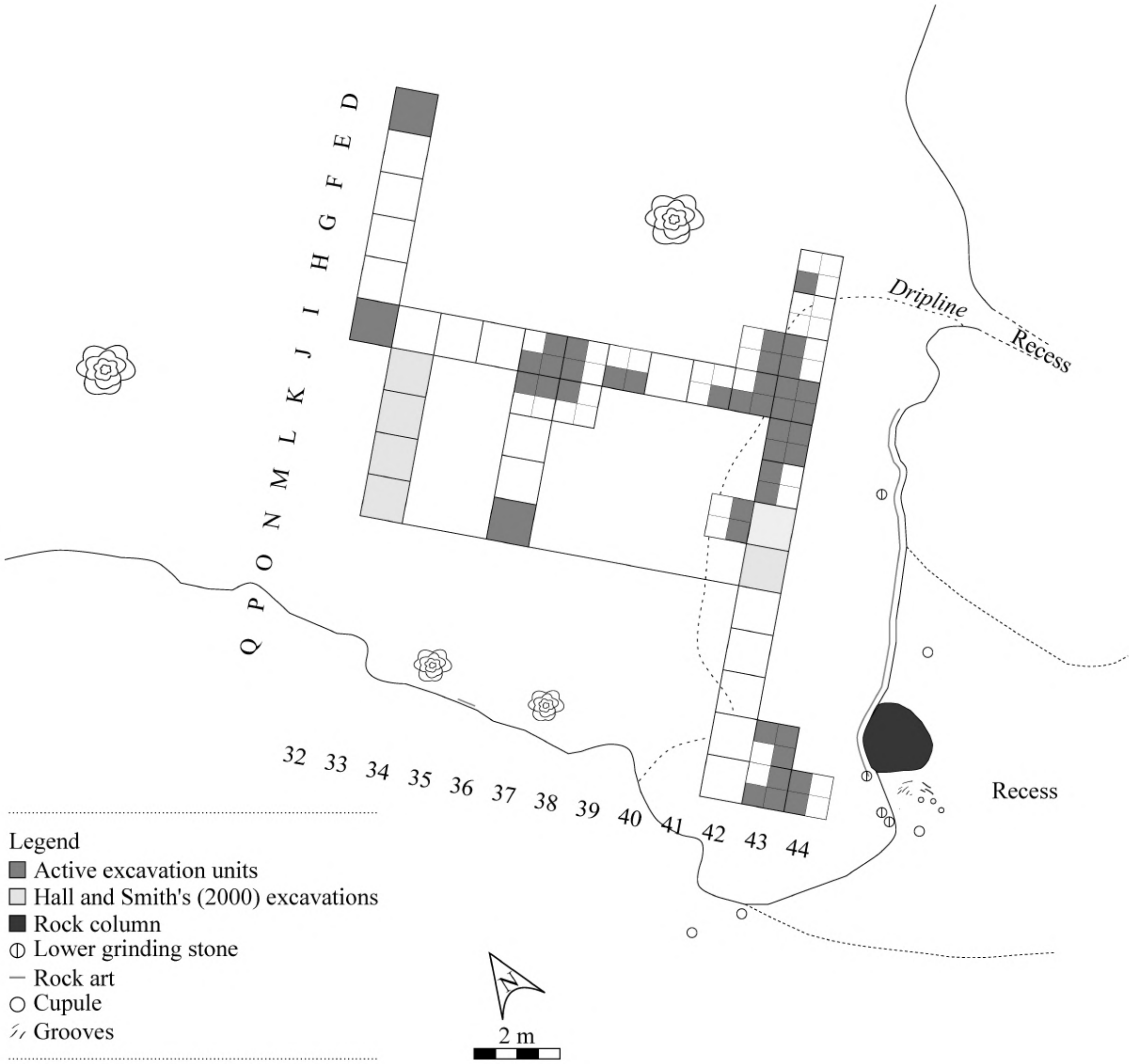


Figure 3. The excavation layout of Little Muck Shelter in dark grey with the Hall and Smith (2000) excavations in light grey (produced by Tim Forssman).

All squares included the same three upper strata. These were semi-distinct from one another but could be confidently separated in almost all cases. The only exception was in square H41 in which a transition into GB3 from GB2 was misidentified and had to be corrected afterwards. This error was amended with no concern of mixing or mislabelling. The three upper strata were GB1, GB2 and GB3. All are grey brown in colour and varied in three specific ways. First, from GB1 to GB3, compaction increased. GB1 was a soft, unconsolidated surface unit that was brushed up onto the compacted, consolidated lower stratum, GB2. GB3 was then highly compacted. Second, inclusions changed. GB3 was clearly marked with an increase of sandstone pebbles, flakes from roof collapse, and rocks. Finally, artefact frequency increased in density from GB1 to GB3, and the artefact character changed as well. This latter change included changes in predominant ceramic decorations as well as the regularity that stone tools appeared, with GB3 possessing the highest density of the three strata. As such, separating the GB strata was possible despite their colour similarities.

Below GB3 was PBG1. This unit represents a clear shift in terms of colour, compaction, grain coarseness, inclusions, and artefacts. The deposit was paler in colour than the above strata and exhibited a notable increase in artefact frequencies. However, from PBG1, there was a split in the stratigraphic sequence. In J42 quadrant B and I42 quadrant A, a different profile was identified compared to elsewhere (Fig. 4). Here PBG1+ followed PBG1. The '+' was used to indicate an increase in artefact densities with no other notable stratigraphic change. As such, PBG1+ appeared the same as PBG1 except for the frequency of artefacts. In this case, the stratum was predominantly composed of artefacts and shell remains. Why such a change took place may relate to different occupation intensities spread throughout the unit (in this case PBG1) with more activities or people at site in the early stages that was followed by less regular visits; a smaller population may also have been present in the shelter; or, it could relate to a shift in activities and activity areas. In any event, it seems to have been affected by highly localised winnowing of the deposit by a drip point along the shelter dripline, since it occurs only in a single quadrant (J42B) over four spits (18-21). The influence water has had on the deposit and assemblage will be elaborated on further when the chronology is discussed since it appears to be significant. As such, and supported by dates presented below, both PBG1 and PBG1+ can be seen as a single occupation phase.

Table 1. Stratigraphic unit descriptions from Little Muck Shelter. Unit titles in italics indicate other names used for the unit until their contiguity could be determined.

Stratigraphic unit	Description of deposit
GB1 *(SB1)*	Fine, greyish brown sand with rock and root inclusions. Evidence for the occurrence of bioturbation and root penetration. This is an unconsolidated surface.
GB2 *(GB4)*	Fine, but compact, greyish-brown sand with root inclusions, most likely a more compact version of GB1. Evidence for bioturbation and root penetration.
DG1	Fine-textured, dark grey fill (500×400 mm and 265×335 mm) situated within unit GB2, with rock inclusions and evidence for root penetration and bioturbation.
GB3 *(LGB1, PG1, GB5, B4, B4C, B5)*	Pale, greyish brown ash that is more textured, and includes a greater amount of rock inclusions than GB2. Root penetration was evident within the unit.
PBG1 *(PBG2, PG1+, GB6)*	Fine textured, ashy sand with rock and pebble inclusions. Evidence for root penetration and bioturbation. Very slight change from the overlying unit.
PBG1+	The only distinct change from the overlying unit is an increase in artefact density.
DRG1 *(DRG2)*	Fine textured, darkish-brown silt/clay; unit was not coarse enough to be identified as sand. Rock and root inclusions.
DRG1+	The only distinct change from the overlying unit is an increase in artefact density.
VDG1 *(PBG3)*	Fine textured, dark-grey ash with sandstone inclusions. Bioturbation was evident within the unit.
VDG1+ *(PBG6+)*	The only distinct change from the overlying unit is an increase in artefact density.
B2 *(B3, B6)*	Richer, more distinct brown sand than in DRG1 (unit above B2 in J42A) with a fine texture. Evidence for root penetration and bioturbation, along with rock and root inclusions. Unit occurs throughout J42A only (Fig. 3).
B2+	The only distinct change from the overlying unit is artefact density. The unit occurs throughout J42A only (unit after B2).
VDB1 *(VDB1-B)*	Medium-textured sand with rock inclusions. Dark brown colour of the deposit appears wet. Evidence for root penetration and bioturbation (J42B). The unit occurs throughout J42B and I42A, and is parallel to unit B2 in J42A (Fig. 3).
VDB1+	The only distinct change from overlying unit is artefact density (J42 B). The unit occurs throughout J42B and I42A, and is parallel to unit B2+ in J42A.
VDB2	Thin, fine-textured, brown layer of sand above bedrock. Evidence of bioturbation and root penetration.
VDB2+	The only distinct change from the overlying unit is artefact density.

Below PBG was VDG1. This unit was finely textured with grey ash making up the matrix. It had a charred appearance and presented as very dark grey and distinct from PBG. The deposit was somewhat compacted but soft enough that it could easily be brushed up. Artefact frequencies declined, notably when VDG1 was below PBG1+, but were nonetheless higher than some of the GB units. This frequency varied across the unit, with some areas composed almost entirely of artefacts and rocks with little deposit in the matrix. A notable change was the amount of *Achatinidae* (land snail) shell. Whereas before it was present in lower frequencies, it increased in VDG1 to very high levels and it was often the most predominant item within the stratum. Most of the shells were broken and some occurred in large pieces, but a large complete shell was recorded with a single perforation in the location of the muscle attachment, likely the result of harvesting.

Following this is VDB1 and then VDB1+. VDB1+ was directly on bedrock in J42B and I42A, but elsewhere it was on top of VDB2, which was followed by bedrock (Fig. 5). It therefore appears that VDB2 was removed in this portion of the site prior to VDB1 being deposited. In J42A, VDB1 is missing indicating a cut and fill here of B2, which is also found throughout the site (these strata are discussed below in more detail). Therefore, there is a varying sequence of cuts and fills with B2/B2+ occurring at the same depths as VDB1/VDB1+ but not together (discussed further below).

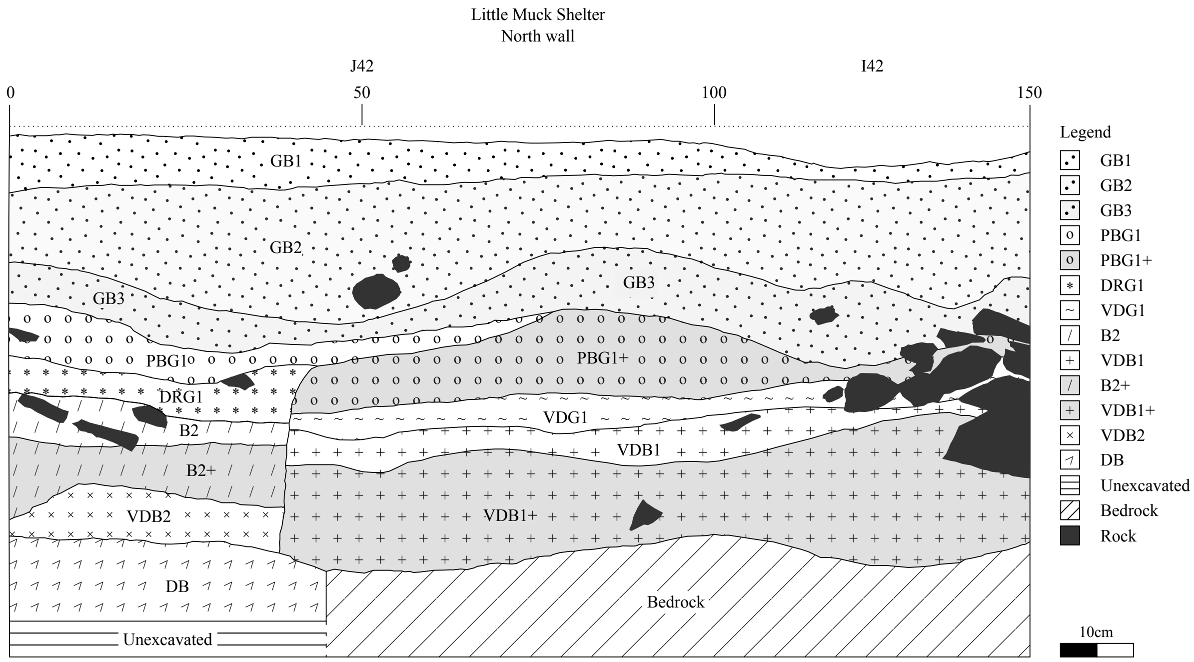


Figure 4. The divided stratigraphic sequence observed in the north wall of J42 (A & B) and I42 (A) (produced by Tim Forssman; from Forssman et al. 2023).

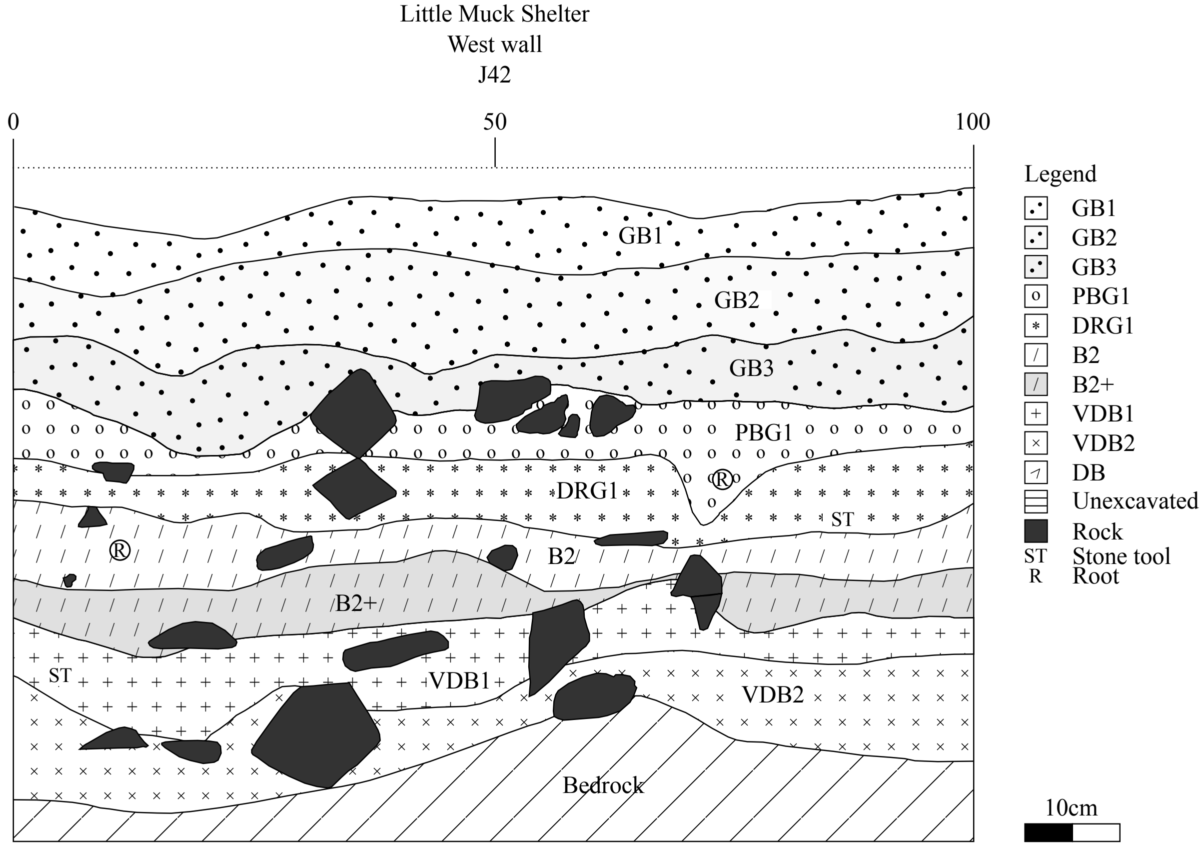


Figure 5. An unbroken sequence along the J42 west wall (C [0-50 cm] and A [50-100 cm]) (produced by Tim Forssman; from Forssman et al. 2023).

More common across the site are the PBG strata followed by DRG1 and DRG1+. DRG1+ has the same relationship as the two PBG stratum, regarding an increase in artefacts. Similarly, it was limited to I41C and I42B, C and D suggesting a drip point or a localised winnowing of the matrix. DRG1 is also horizontally constrained to I42 to K42, but the presence of DRG1+ in I41C and a lack of excavation units next to J and K (i.e., J41 and K41) means that the full extent of these strata cannot yet be established.

Following DRG, is B2; a richer, distinct brown unit with a fine texture. B2 was found in multiple squares and labelled variably (B2 to 4 and B6) until it could be determined that they were all connected. As such, it was found that B2 spanned the full extent of the internal excavated squares, excluding the cut and fill of J42B and I42A. It also included a B2+ unit that was found in a more widespread area than the previously mentioned '+' units; it was found in I42C, J42 and K42A and B. It was thickest in I42C (Fig. 6), between 21 and 24 cm (from spit 23 to 31) but occurred between 60 and 93 cm below datum (spits 20 to 31).

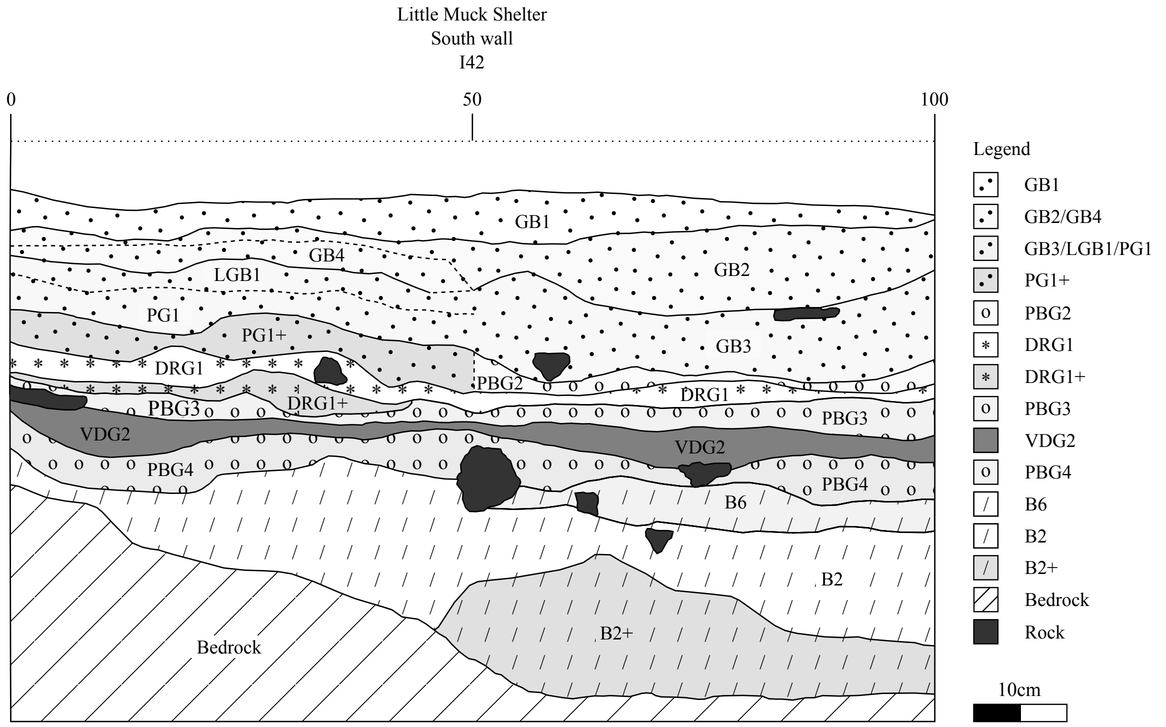


Figure 6. An unbroken sequence along the I42 south wall (D [0-50 cm] and C [50-100 cm]). See Table 1 for stratigraphic units indicated in the profile (produced by Tim Forssman).

The base of the excavated units comprises three strata that are likely related: VDB1, VDB1+ and VDB2. These units are the same in terms of their deposit matrix but were separated based on an increase in artefact density (VDB1+) and moisture (VDB2). In the case of the '+' unit, like B2+, it is spread over a larger area. VDB1+ occurs in H41C and D, H42B, I41A and C, I42A, B and C, and J42B. That it only occurs in J42B, and not the other quadrants in the square which all reached bedrock or any square to the west (in the direction of Hall and Smith's L42), suggests that it is spatially constrained to the eastern portion of the site where it was identified in all the quadrants that reached bedrock. The VDB units appear between 56 and 59 cm below datum and reach the depths of the excavation at 63 cm below datum. In H42B, spit 18, a suspected burrow was identified in an isolated area and was excavated separately (VDB1-B).

In the open the strata were less diverse. All squares contained GB1 to 3 units, which are interpreted as the same as those inside the shelter and connected stratigraphically in the 'I' trench. In D32, the southwestern corner of quadrant C was excavated to bedrock (25x25 cm) to determine its depth, as the deposit had become extremely compacted and contained very few artefacts. This unit was labelled GB7, and bedrock was found a few centimetres below. In I32 and 36, B7 was below GB3 and was sterile, and in M36, B8 was identified, and it was also sterile. Of interest was a circular unit composed of a compacted gritty deposit in I36, I37, J36, and J37. A small square was excavated from the grit layer (25x25 cm) and no artefacts were recovered. It is suspected to be a platform dating to the later use of the shelter by farmers, possibly during the Leopard's Kopje period, as it resembles those excavated by Schoeman (2006) in rain control sites of that age (investigations are ongoing).

Chronology

An initial set of 16 unidentified charred specimens were collected *in situ* and dated at iThemba LABS, Johannesburg. The dates were calibrated using the latest OxCal 4.4 programme (Ramsey 2009) and the Southern Hemisphere Calibration Curve (SHCal20) (Hogg et al. 2020). For the middle Limpopo Valley, the relative chronology of the Iron Age sequence has been well established and the age ranges for ceramic and bead series are fairly constrained (Huffman 2007; Wood 2012). Based on this, an analysis of diagnostic ceramics and glass beads made it possible to relatively date each stratigraphic unit, the results of which are presented in Table 2 (see Barnard 2024 for a complete analysis). This provided a firm, independent cross-reference for the radiocarbon results (Table 3). The dates were inconsistent with the stratigraphic seriation and with the relative chronology. To determine whether this was from a taphonomic process or a sample processing problem, the entire batch, excluding three samples that were depleted in the initial analysis, were re-analysed. The re-analysis involved the selection of different charred material fragments for more aggressive pre-treatment to ensure that contamination issues could be excluded, and each of the analyses is treated as an independent result. The new analyses still did not conform with the cultural chronology and were generally not even statistically similar to the first iteration. In the worst comparison, IT-C-3956 was re-dated to approximately 700 years earlier than in the first analyses. The first date for this sample, however, corresponds to the diagnostic cultural remains. The discrepancies are not related to pre-treatment processes, but the possibility of mixed-age source material will be discussed further.

Table 2. A summary of the strata with their associated relative chronology. Note that phase 4 includes overlying (Zhizo) and underlying (Happy Rest) ceramics suggesting this stratum is a combination of these periods – it is therefore treated separately.

Strata	Phase	Cultural affinities	Relative dates
GB1	8	Historic	18th century
GB2	7	Mapungubwe/transitional K2 (TK2)	1200-1300 CE
GB3	6	K2/Leokwe	1000-1220 CE
PBG1	5	Zhizo	900-1000 CE
PBG1+			
DRG1	4	Zhizo/Happy Rest	450-1000 CE
DRG1+			
VDG1	3	Happy Rest	450-600 CE
VDG1+			
B2	2	Pre-Happy Rest/Bambata	150-600 CE
B2+			
VDB1	1	Pre-ceramic	Pre-150 CE
VDB1+			
VDB2			
VDB2+			

An additional batch of nine unidentified charred specimens collected *in situ*, as well as six bone specimens, were sent to Beta Analytic for radiocarbon dating. Five of the charred materials and four bone samples provided material sufficient for dating. Again, the results did not follow a clear seriation with depth, nor did they align with expectations from the relative cultural chronology. This is surprising because the potential mechanisms that might contaminate the charred material assemblage should not apply to the faunal material. However, bone is notoriously difficult to date as it relies on good collagen preservation. That results could not be obtained from two of the bone samples, and that only one of the four bone collagen results yielded an acceptable elemental C/N ratio (an indication of preservation) suggests very poor preservation. Another batch of five tooth specimens was submitted to Beta Analytic because teeth are typically more robust than bone and preserve better. Still, only one could be dated. The C/N ratio of this sample indicates decent collagen preservation, but the result does not comply with the relative cultural chronology. Of the collagen (bone and tooth) analyses, only one bone sample (that also had an acceptable C/N ratio) yielded a date that meets expectations.

Table 3. Radiocarbon results from charred material and faunal specimens retrieved from Little Muck Shelter. Laboratory codes prefaced with IT-C are from iThemba LABS, and the remainder are from Beta Analytic. The calibration range is the 95.4% probability range. One date that post-dates 1950 CE has elevated ^{14}C levels from nuclear bomb testing and is reported as a percent of modern carbon (pMC).

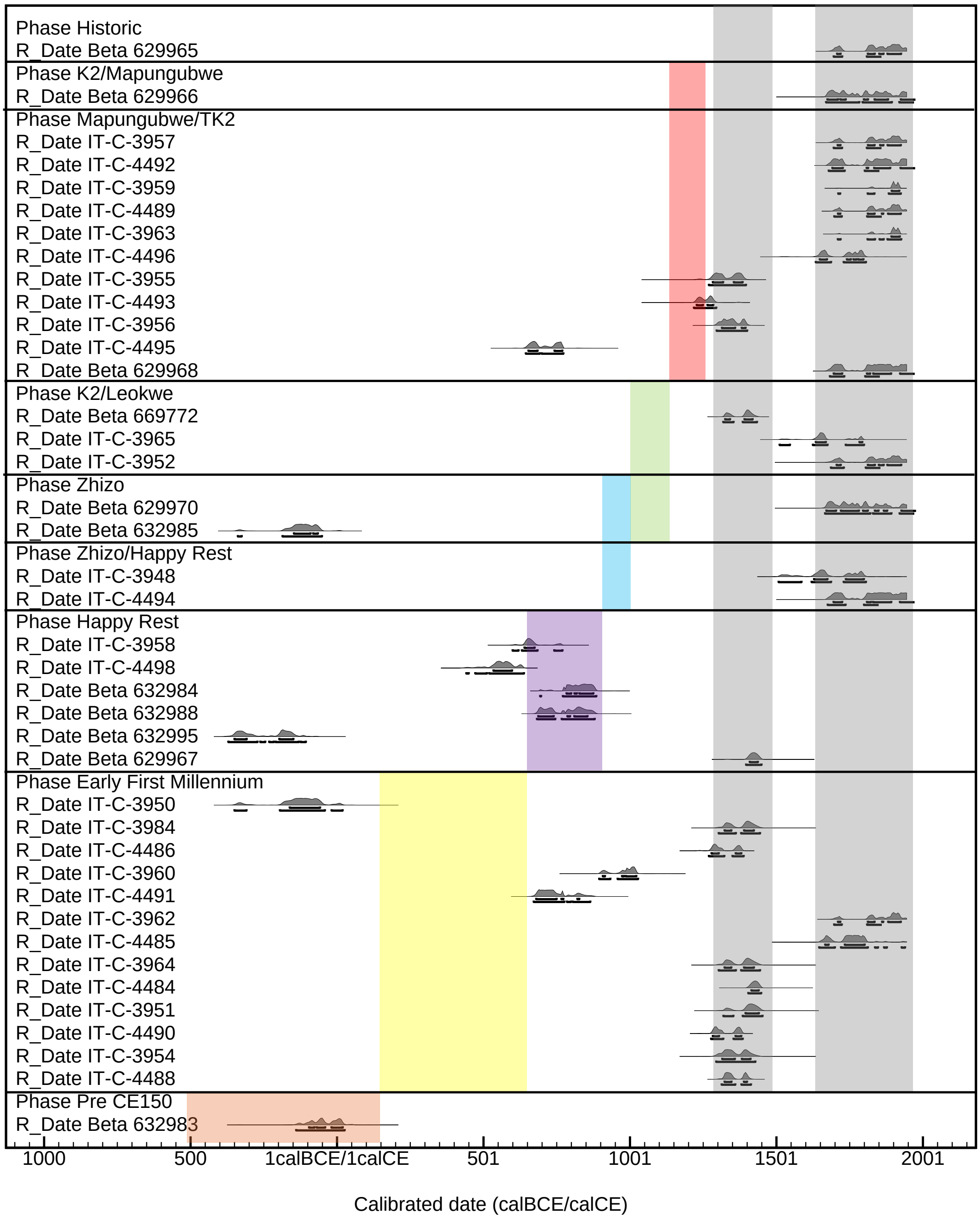
Relative date	Stratum	Material	Code	Date	δ^{13}C	Cal. BCE/CE
Historic	B7	Charred material	629965	120±30	-24.0	1809-1950 CE 1696-1725 CE
K2/Mapungubwe	GB2	Charred material	629966	180±30	-24.8	1920-1950 CE 1795-1895 CE 1670-1784 CE
Mapungubwe/ TK2	GB2	Charred material	IT-C-3957	105±35	-25.2	1809-1950 CE 1696-1725 CE
			IT-C-4492	160±25	-25.7	1802-1950 CE 1679-1734 CE
		Charred material	IT-C-3959	100.6±0.41 pMC	-23.6	post 1950 CE
			IT-C-4489	110±25	-28.0	1810-1950 CE 1698-1724 CE
		Charred material	IT-C-3963	30±30	-23.4	1880-1927 CE 1853-1867 CE 1812-1837 CE 1710-1720 CE
			IT-C-4496	255±30	-24.2	1730-1806 CE 1635-1687 CE
		Charred material	IT-C-3955	720±45	-24.0	1270-1397 CE
			IT-C-4493	795±30	-25.1	1219-1295 CE
		Charred material	IT-C-3956	660±30	-24.4	1297-1401 CE
			IT-C-4495	1380±35	-24.2	699-773 CE 645-693 CE
		Charred material	629968	150±30	-24.3	1804-1950 CE 1683-1732 CE
		Tooth collagen	669772	600±30 (C/N 2.9)	-8.1	1386-1434 CE 1319-1354 CE
K2/Leokwe	GB3	Charred material	IT-C-3965	280±25	-26.1	1737-1800 CE 1625-1675 CE 1512-1547 CE
		Charred material	IT-C-3952	85±50	-23.1	1806-1950 CE 1687-1731 CE
Zhizo	DGB2A (within GB6)	Charred material	629970	190±30	-23.7	1921-1950 CE 1830-1893 CE 1667-1821 CE
	PBG1	Bone collagen	632985	2140±30 (No C/N)	-20.1	187-52 BCE 339-326 BCE
Zhizo/Happy Rest	PBG1/ DRG1	Charred material	IT-C-3948	275±40	-24.4	1730-1806 CE 1621-1687 CE 1508-1586 CE
			IT-C-4494	150±35	-25.1	1800-1951 CE 1676-1735 CE
Happy Rest	DRG1	Charred material	IT-C-3958	1420±30	-25.4	742-770 CE 632-685 CE 600-620 CE
			IT-C-4498	1550±30	-25.8	520-639 CE 473-512 CE 442-450 CE
		Bone collagen	632984	1260±20 (No C/N)	-7.3	772-886 CE 694-697 CE
		Bone collagen	632988	1290±30 (C/N 3.2)	-19.0	768-880 CE 683-746 CE
	DRG1+	Bone collagen	632995	2210±30 (No C/N)	-25.0	125-107 BCE 211-131 BCE 232-216 BCE 263-246 BCE 372-272 BCE
		Bone collagen	629967	550±30 (No C/N)	-23.5	1397-1450 CE
Early first millennium	B6	Charred material	IT-C-3950	2140±35	-25.9	5-12 CE 190-49 CE 344-321 BCE
		Charred material	IT-C-3984	600±45	-24.6	1380-1362 CE 1304-1362 CE
			IT-C-4486	740±30	-25.9	1351-1889 CE 1270-1323 CE
	B2/B6	Charred material	IT-C-3960	1105±30	-23.8	959-1028 CE 896-934 CE

Relative date	Stratum	Material	Code	Date	$\delta^{13}C$	Cal. BCE/CE
			IT-C-4491	1315±30	-24.4	805-865 CE 786-799 CE 672-777 CE
	B2	Charred material	IT-C-3962	80±35	-24.2	1810-1950 CE 1698-1724 CE
			IT-C-4485	225±30	-25.9	1647-1700 CE 1721-1813 CE 1837-1847 CE 1868-1878 CE 1928-1940 CE
		Charred material	IT-C-3964	600±45	-25.0	1380-1445 CE 1304-1362 CE
			IT-C-4484	540±25	-25.8	1405-1449 CE
		Charred material	IT-C-3951	570±45	-24.2	1386-1453 CE 1320-1354 CE
			IT-C-4490	730±25	-25.5	1354-1386 CE 1278-1319 CE
	B2+	Charred material	IT-C-3954	630±50	-24.9	1295-1429 CE
		Charred material	IT-C-4488	630±25	-24.7	1381-1414 CE 1314-1360 CE
Pre-CE150	VDB1+	Bone collagen	632983	2080±30 (C/N unknown)	-14.4	140 BCE-27 CE

Of the 40 radiocarbon dates that we have produced for Little Muck, only five appear to be consistent with expectations based on the relative cultural associations (Fig. 7). This is despite the use of three different materials measured in two different radiocarbon laboratories. Before any credibility can be assigned to the five potentially meaningful dates it is necessary to explore why 35 dates appear to give the wrong results. The first observation is that there are 16 dates that fall into a cluster from 1650 CE to the present, but only one of these might be expected to be relatively modern. There is a suspected Venda-period use of the site (Hall & Smith 2000) and so a late date is expected for the uppermost levels, but the other 15 dates are distributed throughout the sequence. The dates correlate with a notorious part of the calibration curve (Suess Effect) and could conceivably represent the introduction of younger charred material on 15 or 16 different occasions, which would be difficult to explain without disrupting the stratigraphy, but an alternative expedient interpretation is that these are the result of a single taphonomic event. The most likely mechanism that will introduce young, charred material into a clearly well-stratified sequence (i.e., the absence of obvious turbation) as a single event is root infiltration followed by charring. A second cluster of 10 charred material dates have a calibration cluster between 1300 and 1450 CE. These dates are also spread throughout the stratigraphic sequence, and another contamination event by root ingress is likely.

An interesting observation about the bone/teeth dates is that two of the samples, one being a tooth that yielded a reliable C/N ratio, fall into the same 1300 and 1450 CE cluster that was noted in the charred material results. This cannot be considered evidence for a post-Mapungubwe occupation of Little Muck, as these dates are stratified in Mapungubwe and Happy Rest layers and cannot be correct. Despite the two valid C/N ratios on the bone dates, collagen preservation at Little Muck is problematic.

While root penetration and poor collagen preservation may account for the overwhelming underestimation of the Little Muck chronology, there are five dates that appear to be too old based on the stratigraphic relationship to the other dates in comparison with the relative cultural sequence. These include three charred specimens and two bone samples. For the charred material samples, the most expedient explanation for overestimates of age is the problem of old wood (see Wright 2017) – the fact that a hardwood tree in southern Africa can be several hundred years older than the sapwood and the date of the combustion event – but this cannot be the cause for bone collagen age overestimations. Instead, it may be tempting to argue for reworking of deposits, but this is difficult to defend based on the material culture that is well stratified, and on the premise that bone collagen preservation is generally poor.



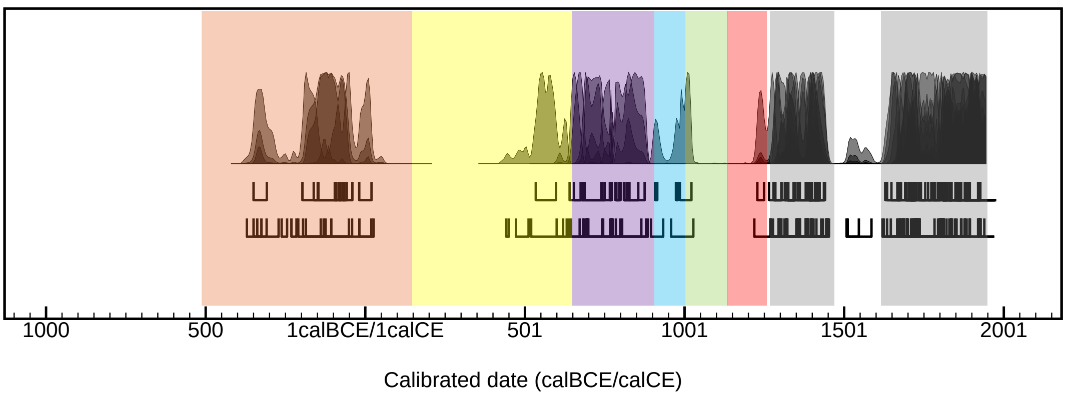


Figure 7. All calibrated dates in order of their stratigraphic appearance and organised following the expected relative chronology established by Forssman et al. (2023).

With 40 radiocarbon dates, Little Muck should be one of the best dated archaeological sequences in the middle Limpopo Valley, but instead it proves to be a very expensive exercise in dating hygiene. It is very likely that waterlogging in the site has directly affected collagen preservation in bone and teeth, while also facilitating root penetration of the sediment after the site was abandoned. The deposit was noticeably moist and some of the squares were located near to the dripline. The criteria to reject dates are, first, the stratigraphic inconsistencies in results from different materials measured in different laboratories across the stratigraphic sequence, and second, the deviation for the established cultural chronology for the region. With only five of the 40 dates meeting expectation, it is important that rejection criteria are balanced against acceptance criteria. For those five dates that appear acceptable, there are no additional criteria that differentiate them from those that are rejected. For this reason, none of the dates are accepted, and the interpretation of the cultural sequence is entirely based on the regional cultural chronology. While this is problematic for establishing a site-specific chronology, the fact that so many dates were generated has demonstrated a systematic problem that may not have been appreciated had only a few dates been acquired. Unfortunately, there is no easy way to circumnavigate this problem and Little Muck is a site that is simply not well suited to radiocarbon dating.

Rejecting the suite of radiocarbon analyses introduces an additional problem. The relative chronology is based on diagnostic ceramics and glass beads that appear in the valley when farmer communities began to settle the region ca. 2000 BP. The Later Stone Age sequence does not have distinct chronological aids that provide a similar, constrained date range as with ceramics. For example, the strata labelled B2/B6 has an unclear relative chronology. Some ceramics and a decline in beads seem to suggest that it is in the ceramic period, possibly Bambata, the earliest ceramic facies (350-550 CE), but these might also have filtered down through the deposit making B2/B6 an early first millennium CE stratum or even from the BCE period. The chronological relationship between B2/B6 and VDB1/VDB1+ is unclear – the one is a fill but how much it post-dates the other is not known. The oldest date, although, as we have argued the dates cannot be accepted, is from VDB1+, one of the lowest units, at 115 BCE-60 CE, which matches both our expectations and the suggestion made by Hall and Smith (2000). Since no datable material was found in this lowermost unit (VDB2/VDB2+), a basal radiocarbon date could not be obtained. Chronological ranges for the past two millennia are reliable, but periods before this cannot be dated solely with the Later Stone Age sequence. We therefore rely on strata to mark possible change.

Cultural sequence

With an established stratigraphic sequence, it is possible to observe the cultural distribution and corresponding densities. We determined density by measuring the mass of artefact categories across the units relative to their volume. This distribution provides a representation of change throughout the sequence, but it cannot be read as a precise reflection of change. Rather, it is a gauge that provides broader context to the site's occupation sequence with reference to increases, decreases, appearances, and disappearances, of key artefact types. It is useful for examining the occupation intensity during different phases. This intensity might relate to longer periods of residency at the site, a larger group occupying the shelter, or more regular tool production or food consumption practices; the data presented below do not help in distinguishing between these possibilities, or others, not listed here, but it is possible that either one conclusion or a combination took place.

The density of stone tools, faunal remains and shell follow a similar trend with a distinct difference in the earliest phase (Fig. 8). Generally, the first millennium CE periods, and earlier, have higher densities than those during the second millennium CE. Stone tools peak in phase 1 (215.01/L) and gradually decline until a small rise in phase 5 (134.58/L) but this is still lower than three of the four preceding phases (refer to Table 2 for phases). In phase 6 there is a considerable decline in stone tool density that continues gradually to phase 8. Fauna peaks later than stone tools, in phase 4 (16.62/L), although the two preceding phases are similar (15.99/L and 14.78/L, respectively). After phase 5 (13.45/L), there is a considerable decline (to 5.8/L) and then a gradual decline to phase 8 (1.63/L). The mismatch between the stone tool and faunal peak is possibly linked to farmer trade. Sherwood and Forssman (2023) correlated shifts in scraper use, processing a range of materials to mostly bone, with the appearance of farmers in the region. The gradual increase in fauna, peaking in or just before the Zhizo period (phase

4 is either Zhizo or Happy Rest), might reflect the increased production of bone implements and how this necessitated a greater density of raw material at the site. Shell data are less clear but resemble the fauna distribution more closely than stone tools.

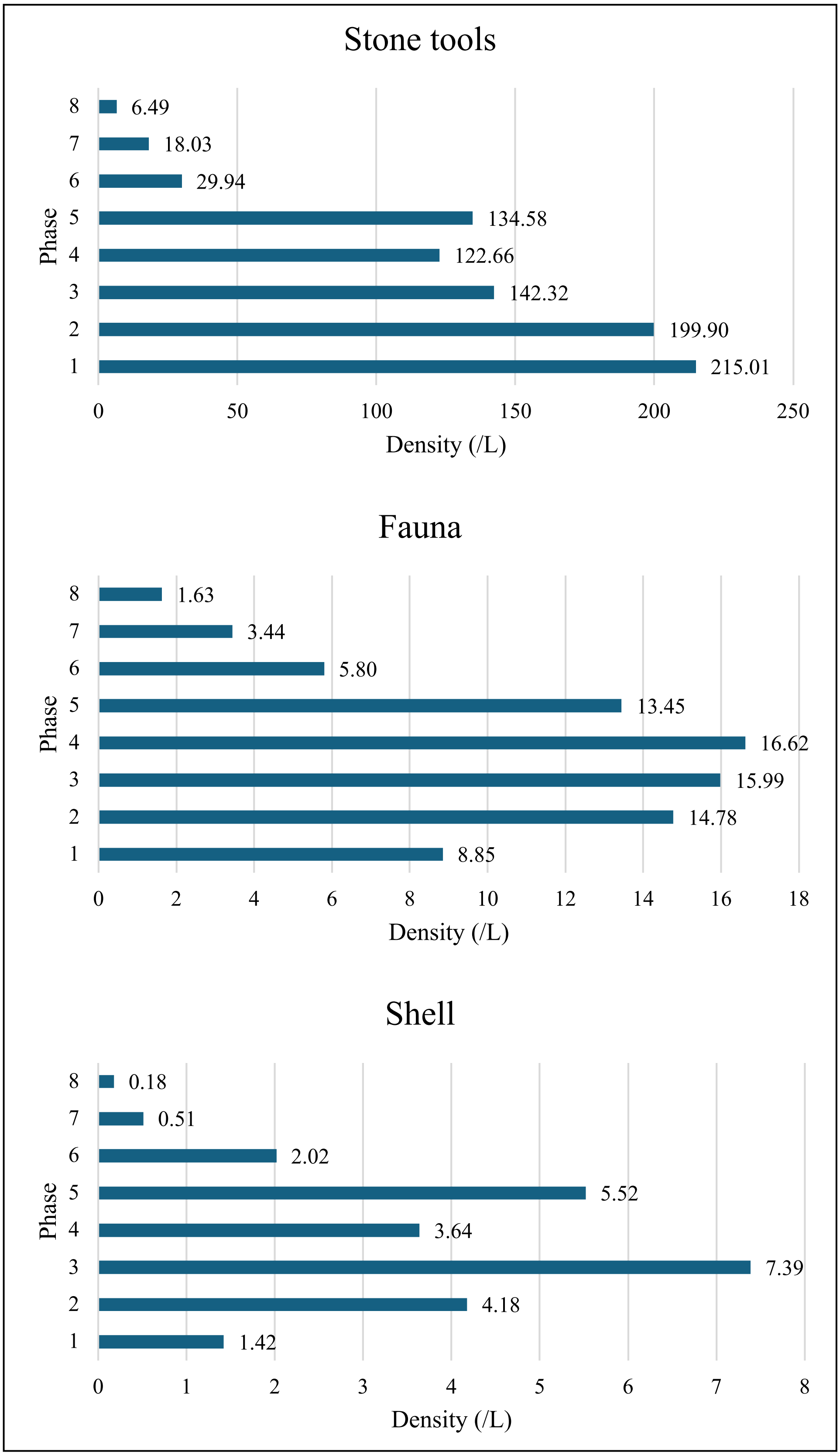


Figure 8. Stone tools (top), faunal remains (middle) and shell (bottom) densities from the pre-ceramic (phase 1) to historic (phase 8) periods.

Ceramic and bead data are useful for tracking forager-farmer exchange or trade. Ceramics and glass beads were produced or acquired, respectively, by farmers, and shell beads are a known forager trade item (Fig. 9). The latter shows a decline in density from the earlier to the later phases, and expectedly ceramics and glass beads show the inverse. The presence of glass beads in the lowermost strata (n=1) is not cause for concern as these artefacts are small and susceptible to movement, but the occurrence of ceramics here is slightly more problematic. Their presence might also be the result of movement, since these were very small sherds and fragments, resulting from burrows or root action, both of which were recorded in areas of the site. Although there is the possibility that mixing has occurred, it is highly unlikely to have reworked the deposit substantially due to the resolved stratigraphic sequence with units being distinct from one another, and it is more likely the result of subsidence that took place in the past as a result of activity in the shelter.

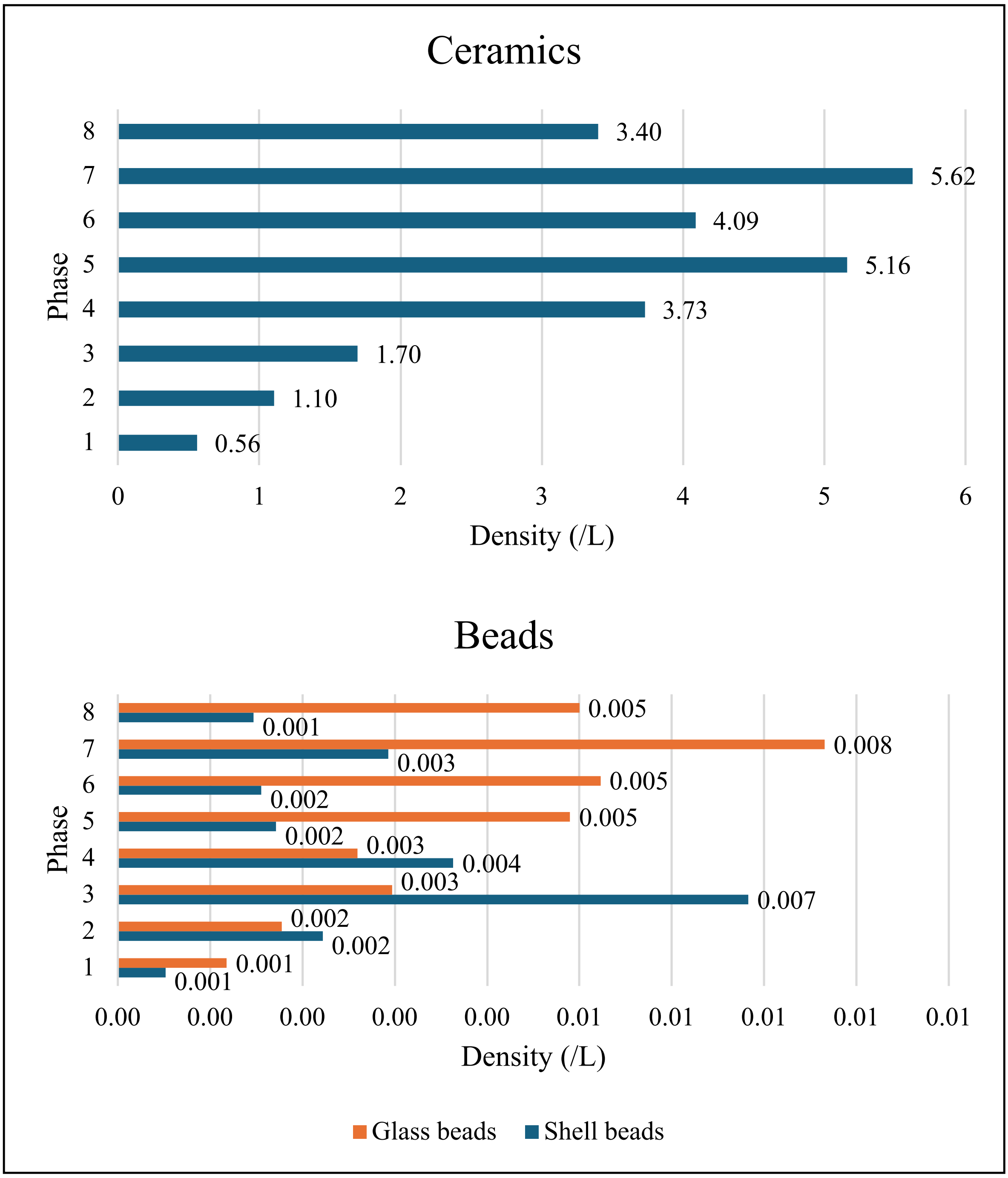


Figure 9. Ceramics (above) and beads (below), showing both glass (orange) and ostrich eggshell (blue) beads, from the pre-ceramic (phase 1) to historic (phase 8) periods.

Collectively, these data indicate that the height of stone tool production took place in the earliest occupation phases and mostly declined until the end of the first millennium CE, with a low peak during the Zhizo period (900-1000 CE). Fauna and shell peak later, in the second half of the first millennium CE, and decline rapidly at 1000 CE. Ostrich eggshell beads peak when shell peaks, in the mid-first millennium CE, and ceramics and glass beads occur at higher frequencies in the later phases. The 1000 CE shift occurs when the farmer settlement of the region intensified, and K2 ceramic-producing farmers appear in the middle Limpopo Valley. Hall and Smith (2000) suggested that this decline was the result of farmers appropriating the space, however, Forssman and colleagues (Forssman 2020; Forssman et al. 2023) argue that foragers continued living at the site in the second millennium CE. They may have done so with farmers, or at times when farmers were not at the site, but the possibility of assimilation cannot be excluded either. Some foragers at this same time began living in farmer settlements, west from Little Muck at João (Forssman 2016b) and Euphorbia Kop (Forssman et al. 2022), and the social landscape was becoming more dynamic. It is entirely conceivable that modalities of assimilation were taking place and are reflected at these sites.

5. Comparison to Hall and Smith's excavations

Although we have mentioned some similarities with Hall and Smith's (2000) earlier work at Little Muck, it is worth considering the stratigraphic relationship between their work and ours in more detail. The only available data are from Square L42, from which their preliminary observations were made. They identified seven stratigraphic units (Hall & Smith 2000) (Fig. 6). Transitions from one to the other were largely non-distinct, except for PGA 3, which was clearly marked from both the upper (PGA 2) and lower (ARB) strata. They argued that each stratum also relates to a specific period, being the Leopard's Kopje Phase (PGA 2, PGA; 1220-1300 CE), Zhizo Phase (PGA 3; 900-1000 CE), Early Iron Age Phase (ARB; 900-150 CE) and Pre-contact (ARB 2; suspected to be pre-150 CE and unlikely by more than a few centuries). Our stratigraphic profile is more complex with more strata as well as some that apply to the same period, as shown above. Despite this, it is possible to connect their work to ours through the excavations in K42.

K42 includes nine primary strata: GB1, GB2, GB3, PBG1, DRG1, DRG2, B2, B2+, and VDB2 (Fig. 10). Except for DRG2, all have been discussed above. DRG2 is similar to DRG1 but was excavated separately as it appeared darker; this was later considered the result of increased moisture rather than an actual stratigraphic change. Several burrows were excavated – DB1, DB3, G1 (located within DB3), and B3 – but these are not included here due to uncertainty regarding their context. Missing is VDB1/VDB1+, which is to be expected since B2/B2+ were present. This finding may support the conclusion that a cut and fill took place, but it is not clear which of VDB1/VDB1+ and B2/B2+ was the cut or fill.

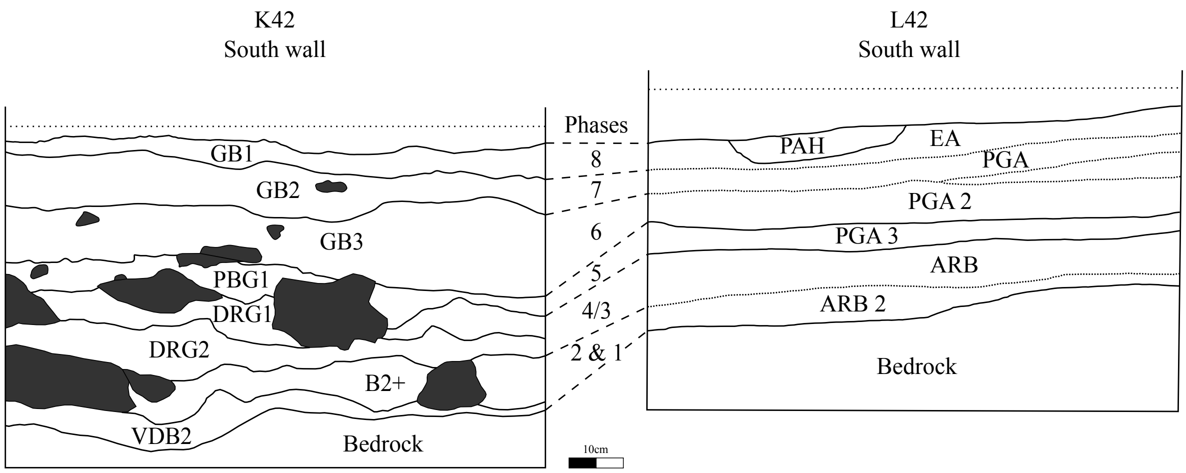


Figure 10. The south walls of K42 (left) and L42 (right) are shown with the suggested phases between them (rocks in K42 marked in dark grey). L42 redrawn from Hall and Smith (2000), which did not include a scale (produced by Tim Forssman).

If we compare these primary units to Hall and Smith (2000), who identified PAH (a limited surface unit), EA, PGA, PGA2, PGA3, ARB, and ARB2, there is a numeric mismatch. Nonetheless, their three upper strata were similar and the change from one to the other not distinct. This is the same as GB1 to GB3. They also all occur at similar depths. It is likely that these are the same (i.e., GB1=EA, GB2=PGA and GB3=PGA2). The following layer of Hall and Smith's (2000) is PGA3, which is distinct from the upper and lower units and contained Zhizo ceramics. PGA3 and our PBG1 are clearly the same. PGA3 also possessed a very high density of finds, which might indicate consistency with PBG1+. Based on the depths of these units, it appears that PGA3 is most likely a combination of PBG1 and PBG1+. Below this, they found ARB and we found DRG1 and 2. Predictably these two are the same; theirs included Happy Rest ceramics, as did ours, and their depth is similar. However, below this, in their ARB2, we identified B2, B2+ and VDB2. They argued ARB2 was a pre-ceramic unit, which we suggest is VDB2 in our excavations, while we suggest B2 and B2+ represent a pre-Happy Rest or possibly a Bambata period. These ceramic facies were combined in their ARB stratum.

The distribution of cultural material, however, does not match their findings. It must be noted that their report includes preliminary data recorded while in the field. As such, it is not based on a thorough analysis and it does not include any density analysis, only numeric. Therefore, we have had to rely on their description of change. Hall and Smith (2000) note fewer artefacts in ARB2 than in the above ARB, followed by an increase in all artefact categories into PGA3, where they were at their highest. From here they decline to the surface but are nonetheless present in low numbers. This pattern is similar to K42 but not in our other squares. Typically, the basal unit has a high density of stone tools and fauna, and this initially declines before increasing in the mid-first millennium CE, followed by a decline and then sudden drop off (Table 4). The peak is not in the Zhizo period, PBG1, as reported by Hall and Smith (2000), possibly reflecting subtle differences in spatial patterns in the shelter. However, their pattern is very much like what was recorded for fauna and shell elsewhere in the site. Therefore, the distribution of most artefact categories follows a similar pattern with a peak in the mid-first millennium CE period, except for stone tools which peak in the final centuries BCE, although it seems that this category may have more variable patterns across the site reflecting production or use strategies.

Table 4. The density of finds (/L) from K42.

Stratum	L	Fauna	Shell	Stone tools	Charred material	Ceramics	Metal	Shell beads	Glass beads
SUR	5.50	0.84	0.22	1.51	0.15	2.25	0	0	0.01
GB1	31.50	0.72	0.03	1.10	0.08	3.26	0	<0.01	<0.01
GB2	49.50	4.77	0.43	13.10	0.16	8.78	0.01	<0.01	0.02
GB3	69.50	3.97	0.36	9.16	0.11	4.93	0.03	<0.01	0.01
PBG1	23.50	26.63	0.36	155.37	0.02	2.89	1.49	0	<0.01
DRG1	8.30	40.07	3.16	258.53	0.06	1.55	0.01	0	0
DRG2	12.50	27.38	5.58	347.03	<0.01	0.20	0	0	0.01
B2+	31.00	13.21	0.40	457.69	0.02	0.01	0	0	<0.01
B2	4.50	22.93	2.96	149.02	0.01	0	0	0	0.01
VDB2	35.50	13.75	0.02	262.57	0.02	<0.01	1.00	0	<0.01

6. Conclusions

Hall and Smith's (2000) brief examination of the Little Muck assemblage, as they phrased it, has been compared to the new data. It shows general similarities, namely in the increase and decrease of artefact densities, but in some instances, this does not match, particularly with regard to the high density of stone tools found in the lower strata of the newly excavated squares. We identified additional strata that have improved our understanding of the site's sequence. These allowed us to generate a refined understanding of the relative cultural chronology and create eight phases, one of which includes two periods due to a lack of clarity. None of the absolute dates were accepted but the strong relative chronology enabled us to define the sequence with confidence. By comparing the density of cultural remains we were able to observe changes in the sequence that appear related to the chronological phases. This is similar to other findings in the area in which changes in the forager sequence relate to changes in the broader social landscape. Although our density analysis offers only a broad perspective of change, there are indictors that these relate to specific behavioural patterns, such as a preference for working bone during the ceramic phase. It also shows that trade goods appear fairly early, as though exchanges began rapidly once farmers arrived in the area, and increased in density as time passed. Finally, the cultural association with the strata reiterates the continued use of the shelter during the second millennium CE, when it was thought the site was abandoned by foragers. However, the nature of social relations during this time is not entirely clear and might in fact represent modalities across the region.

Ongoing work has revealed several features of the sequence that need to be looked at more closely. The appearance of focussed bone tool manufacturing requires further examination. Bone working was carried out using a scraper assemblage that was morphologically consistent across vast time periods, and the increase in scrapers, along with evidence of bone work, corresponds with trade goods arriving at the site that increase in density. These finds may indicate that Little Muck was a specialised trade centre, but this is a prospect that will be considered using multiple lines of evidence. Specific artefact types are also currently being looked at, such as ostrich eggshell beads and their production, stone hunting implements, and bone tools. These will all provide clues as to the use of Little Muck and the social relations that were anchored at the shelter. This study highlights some of the key challenges in obtaining reliable chronometric dates and examines how site-preservation conditions can affect datable materials. The data presented here provide a rigid backdrop for ongoing work at the site and will be useful for contact-period studies elsewhere in southern Africa that investigate changing cultural sequences

Acknowledgements
We are grateful for the financial support provided by the National Research Foundation's African Origins Platform (136506) and Competitive Programme for Rated Researcher (120399) grants (TF), and postgraduate research grants from the Palaeontological Scientific Trust (SvZ, CB, SK). We would also like to acknowledge the support provided by the South African National Parks (Permit ID: FORT1660). The excavations were carried out under a permit provided by the South African Heritage Resources Agency (ID 3124) to TF.

References

Acocks, J.P.H. 1988. Veld Types of South Africa. Third Edition. Pretoria: Memoirs of the Botanical Survey of South Africa, The Government Printer.

Antonites, A. & Ashley, C.Z. 2016. The mobilities turn and archaeology: New perspectives on socio-political complexity in thirteenth-century northern South Africa. Azania: Archaeological Research in Africa, 51: 469-488.

Barnard, C. 2024. Foragers and trade at Little Muck Shelter, middle Limpopo Valley. Masters Dissertation. Pretoria: University of Pretoria.

Calabrese, J.A. 2007. The Emergence of Social and Political Complexity in the Shashi-Limpopo Valley of Southern Africa, AD 900 to 1300: Ethnicity, Class, and Polity. Oxford: British Archaeological Reports.

Chirikure, S., Manyanga, M., Pollard, A.M., et al. 2014. Zimbabwe culture before Mapungubwe: New evidence from Mapela Hill, south-western Zimbabwe. PLoS ONE, 9: e111224.

du Piesanie, J. 2008. Understanding the socio-political status of Leokwe society during the Middle Iron Age in the Shashe-Limpopo Basin through a landscape approach. Masters Dissertation. Johannesburg: University of the Witwatersrand.

du Toit, J.T. & Cumming, D.H.M. 1999. Functional significance of ungulate diversity in African savannas and the ecological implications of the spread of pastoralism. Biodiversity and Conservation, 8: 1643-1661.

Eastwood, E.B. & Blundell, G. 1999. Rediscovering the rock art of the Limpopo-Shashi confluence area, Southern Africa. Southern African Field Archaeology, 8: 17-27.

Eastwood, E.B. & Smith, B.W. 2005. Fingerprints of the Khoekhoen: Geometric and handprinted rock art in the Central Limpopo Basin, southern Africa. South African Archaeology Society Goodwin Series, 9: 63-76.

Forssman, T. 2013. Missing pieces: Later Stone Age surface assemblages on the greater Mapungubwe landscape, South Africa. Southern African Humanities, 25: 65-85.

Forssman, T. 2014a. The spaces between places: A landscape study of foragers on the Greater Mapungubwe Landscape, southern Africa. Doctoral Thesis. Oxford: University of Oxford.

Forssman, T. 2014b. Dzombo Shelter: A contribution to the Later Stone Age sequence of the greater Mapungubwe landscape. South African Archaeological Bulletin, 69: 182-191.

Forssman, T. 2015. A macro-fracture investigation of the backed stone tools from Dzombo Shelter, eastern Botswana. Journal of Archaeological Science: Reports, 3: 265-274.

Forssman, T. 2016a. The Late Holocene occupation of Mafunyane Shelter, eastern Botswana. International Journal of Student Research in Archaeology, 2: 23-42.

Forssman, T. 2016b. Blurring boundaries: Forager–farmer interactions in the middle Limpopo Valley. In: Sadr, K., Esterhuysen, A. & Sievers, C. (eds) African Archaeology Without Frontiers: 143-164. Johannesburg: Wits University Press.

Forssman, T. 2020. Foragers in the Middle Limpopo Valley: Trade, Place-Making, and Social Complexity. Oxford: Archaeopress.

Forssman, T., Kuhlase, S., Barnard, C., et al. 2023. Foragers during a period of social upheaval at Little Muck Shelter, southern Africa. Azania: Archaeological Research in Africa, 58: 114-150.

Forssman, T., Seiler, T., Rossouw, A., et al. 2022. Social landscapes of Euphorbia Kop: A K2 farmer settlement with a forager presence in southern Africa. Journal of Field Archaeology, 47: 421-434.

Forssman, T., Seiler, T. & Witelson, D. 2018. A pilot investigation into forager craft activities in the middle Limpopo Valley, southern Africa. Journal of Archaeological Science: Reports, 19: 287-300.

Gotze, A.R., Cilliers, S.S. & Bezuidenhout, H. 2008. Analysis of the vegetation of the sandstone ridges (Ib land type) of the north-eastern parts of the Mapungubwe National Park, Limpopo Province, South Africa. Koedoe, 50: 72-81.

Hall, S. & Smith, B.W. 2000. Empowering places: Rock shelters and ritual control in farmer-forager interactions in the Northern Province. South African Archaeological Society Goodwin Series, 8: 30-46.

Hanisch, E.O. 1981. The northern Transvaal: Environment and archaeology. In: Voigt, E.A. (ed.) Guide to Archaeological Sites in the Northern and Eastern Transvaal: 1-6. Pretoria: Transvaal Museum.

Hogg, A.G., Heaton, T.J., Hua, Q., et al. 2020. SHCal20 Southern Hemisphere calibration, 0–55,000 years cal BP. Radiocarbon, 62: 759-778.

Huffman, T.N. 2005. The stylistic origin of Bambata and the spread of mixed farming in southern Africa. Southern African Humanities, 17: 57-79.

Huffman, T.N. 2007. A Handbook to the Iron Age: The Archaeology of Pre-Colonial Societies of Southern Africa. Pietermaritzburg: University of KwaZulu-Natal Press.

Huffman, T.N. 2009a. A cultural proxy for drought: Ritual burning in the Iron Age of southern Africa. Journal of Archaeological Science, 36: 991-1005.

Huffman, T.N. 2009b. Mapungubwe and Great Zimbabwe: The origin and spread of social complexity in southern Africa. Journal of Anthropological Archaeology, 28: 37-54.

Huffman, T.N. 2015. Mapela, Mapungubwe and the origins of states in southern Africa. South African Archaeological Bulletin, 70: 15-27.

Huffman, T.N. & Woodborne, S. 2021. New AMS dates for the Middle Iron Age in the Mapungubwe landscape. South African Journal of Science, 117: 1-5.

Kuhlase, S. 2023. People in spaces: Early second millennium AD occupation sequence at the Mbere Complex. Masters Dissertation. Pretoria: University of Pretoria.

Kuman, K., Gibbon, R.J., Kempson, H., et al. 2005. Stone Age signatures in northernmost South Africa: Early archaeology of the Mapungubwe National Park and vicinity. In: Toth, N. (ed.) From Tools to Symbols: From Early Hominids to Modern Humans: 163-182. Johannesburg: Wits University Press.

Mitchell, P.J. 2003. Anyone for hxaro? Thoughts on the theory and practice of exchange in southern African Later Stone Age archaeology. In: Mitchell, P.J., Haour, A. & Hobart, J. (eds) Researching Africa's Past: New Perspectives from British Archaeology: 35-43. Oxford: Oxbow Books.

Parsons, I. 2008. Five Later Stone Age artefact assemblages from the interior Northern Cape province. South African Archaeological Bulletin, 63: 51-60.

Pentz, J.A., Sherwood, N.L. & Forssman, T. 2024. Preliminary analysis of forager stone technology at Little Muck Shelter: Pre- to contact levels. Koedoe, 66: a1789.

Ramsey, C.B. 2009. Bayesian analysis of radiocarbon dates. Radiocarbon, 51: 337-360.

Rutherford, M.C., Mucina, L. & Powrie, L.W. 2006. Biomes and bioregions of southern Africa. In: Mucina L. & Rutherford M.C. (eds) The Vegetation of South Africa, Lesotho and Swaziland: 30-51. Pretoria: South African National Biodiversity Institute.

Schoeman, M.H. 2006. Clouding power? Rain control, space, landscapes and ideology in Shashe-Limpopo state formation. Doctoral Thesis. Johannesburg: University of the Witwatersrand.

Sherwood, N.L. & Forssman, T. 2023. Macro use-wear identifiers on lithic scrapers and behavioural shifts at Little Muck Shelter, SLCA. Journal of Archaeological Science: Reports, 49: 104034.

van Doornum, B.L. 2005. Changing places, spaces and identity in the Shashe Limpopo region of Limpopo Province, South Africa. Doctoral Thesis. Johannesburg: University of the Witwatersrand.

van Doornum, B.L. 2008. Sheltered from change: Hunter-gatherer occupation of Balerno Main Shelter, Shashe-Limpopo confluence area, South Africa. Southern African Humanities, 20: 249-284.

van Doornum, B.L. 2014. Balerno Shelter 3: A Later Stone Age site in the Shashe-Limpopo confluence area, South Africa. Southern African Humanities, 26: 129-155.

Wadley, L. 1987. Later Stone Age Hunters and Gatherers of the Southern Transvaal. Oxford: British Archaeological Reports.

Walker, N.J. 1994. The Late Stone Age of Botswana: Some recent excavations. Botswana Notes and Records, 26:

1-35.
Walker, N.J. 1995. Late Pleistocene and Holocene Hunter-Gatherers of the Matopos: An Archaeological Study of Change and Continuity in Zimbabwe. Uppsala: Societas Archaeologica Upsaliensis.
Wood, M. 2012. Interconnections: Glass Beads and Trade in Southern and Eastern Africa and the Indian Ocean-7th to 16th centuries AD. Uppsala: Department of Archaeology and Ancient History, Uppsala University.
Wright, D.K. 2017. Accuracy vs. precision: Understanding potential errors from radiocarbon dating on African landscapes. African Archaeological Review, 34: 303-319.

Southern African Field Archaeology
2025 Vol. 20: Article 4068
Research report (peer-reviewed): Received March 2025; Revised July 2025; Published September 2025
DOI: https://doi.org/10.36615/safa.20.4068.2025

ISSN 1019-5785
ISSN 2789-1844

The points from Primrose Ridge: A possible Still Bay workshop on the Gauteng Grassland of South Africa

Marlize Lombard [a, *], Matthew V. Caruana [a] & Anders Högberg [a, b]

[a]Palaeo-Research Institute, University of Johannesburg, P.O. Box 524, Auckland Park 2006, Johannesburg, South Africa
[b]School of Cultural Studies, Archaeology, Linnaeus University, SE-391 82 Kalmar, Sweden
**Corresponding author email: mlombard@uj.ac.za*

ABSTRACT
With this contribution we re-introduce a Middle Stone Age point assemblage from the Gauteng Grassland. Whilst the open-air site can no longer be excavated or dated, an updated interpretation of the Primrose Ridge points has the potential to shed new light on the Middle Stone Age occupation of the Witwatersrand. We apply a fine-grained approach, developed for compiling intra- and inter-assemblage comparative data, to assess how the Primrose Ridge points compare to some other Middle Stone Age point assemblages. We demonstrate that most of the points from Primrose Ridge conform to what can be expected from Still Bay point assemblages in terms of invasive bifacial retouch, lenticular cross sections and semi-circular or pointed butts as originally defined. *In situ* anvil boulders surrounded by fresh quartz chips recorded in the 1940s, and knapping mistakes provide reasons to think of Primrose Ridge as a workshop or production site for Still Bay-like quartz points. If our interpretation is correct, Primrose Ridge could have been used during the Still Bay phase – in terms of relative chronology – representing the first tentative record of this technocomplex on the Grassland Biome of interior South Africa.

Keywords: point production, Pietersburg Industry, *Levallois*, bifacial retouch

1. Reintroducing the Primrose Ridge assemblage

Harcus (1945) reported on *A Middle Stone Age Industry from Primrose Ridge District, Germiston, Transvaal*, which he excavated during 1943-1944, and selected specimens that he thought were worthy of display from the thousands found during the dig. On 14 December 2023, Matt Lotter (then of the Palaeo-Research Institute, University of Johannesburg), visited the Bill Stewart Municipal Nature Reserve in the Gauteng Province adjacent to Plot 170, where the Primrose Ridge deposit was excavated, finding that the site was destroyed by urban development (Fig. 1). Harcus' report and curated assemblage are the only records of the people who once used the site located on an outcrop in the Grassland Biome of South Africa. We suggest that the assemblage is worth revisiting and rethinking with our current understanding of the Middle Stone Age sequence in southern Africa (Lombard et al. 2022).

Harcus' attention was drawn to the archaeology of Primrose Ridge when he found yellowish brown quartzite Stone Age artefacts in the flat plain (the floodplain of the Jukskei River) north of and below the ridge (Harcus 1943). A cleaver and two handaxes all exceeding ~15 cm in length seemed to represent the Acheulean (see Lotter et al. 2022). Smaller (<8 cm in length), completely retouched pointed artefacts amongst the tools (Harcus 1943), however, alluded to the Middle Stone Age. Subsequently, house-foundation trenches erroneously dug on Plot 170 (Primrose Hill Township) inadvertently exposed a ~45 cm deep, stratified anthropogenic deposit on underlying red and yellow shale located on the sunny north-facing, wind-protected slope of Primrose Ridge, just below a six-foot high rocky outcrop (Harcus 1945). From the foundation trench Harcus collected a white quartz ovoid bifacial point that he interpreted as being pressure-flaked and in excellent condition except for its missing tip, and chips suggesting a factory site. He went on to excavate the site of ~15x5.5 m in ~12 cm spits to bedrock – selecting artefacts from the sieving station as the digging progressed.

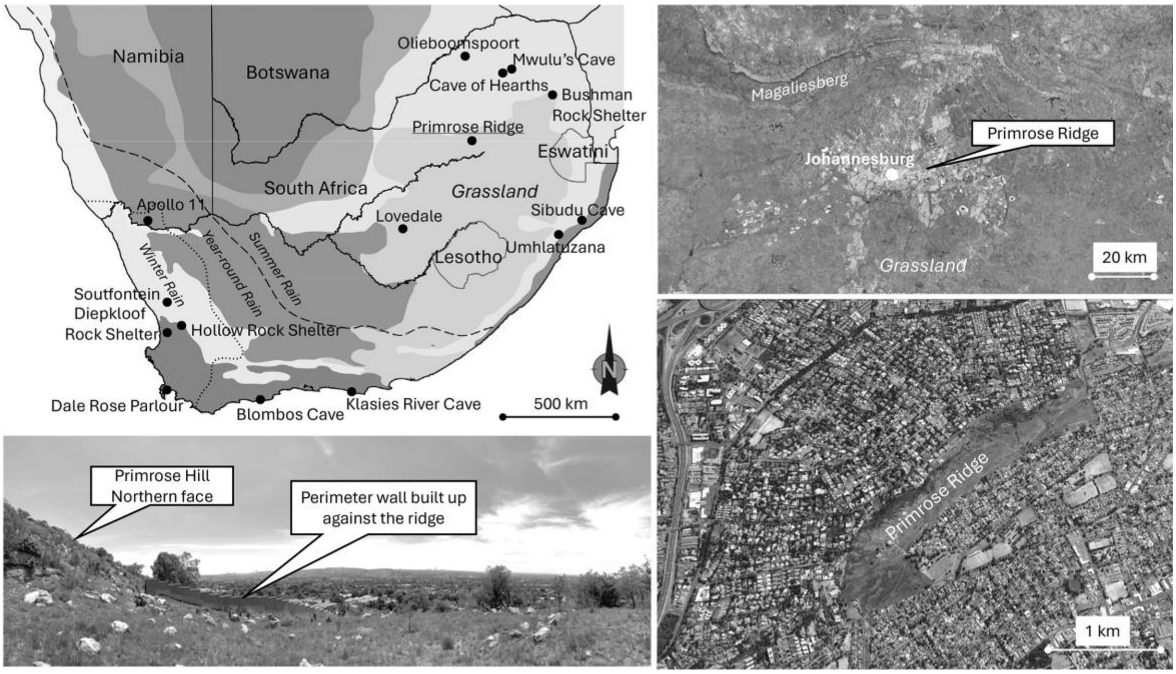


Figure 1. Top left: map of South Africa demarcating the Grassland Biome in the medium grey area (darker and lighter areas indicate other biomes as described in Rutherford et al. 2006), with the location of Primrose Ridge and other sites mentioned in our text. Bottom left: the northern face of Primrose Hill today (Photo ©Matt Lotter). Top right: satellite image of the Witwatersrand area and the city of Johannesburg surrounding Primrose Ridge with the Magaliesberg forming the northern boundary of the Grassland Biome. Bottom right: the Primrose Ridge located within the Bill Stewart Municipal Nature Reserve.

Harcus' (1945) interpretation of Primrose Ridge being a factory site was confirmed when the excavation revealed boulders with scars that seem to have served as *in situ* anvils surrounded by fresh chips (i.e., flakes and debitage). He described the excavated assemblage as being predominated by carinated points shaped like up-turned boats (which he dubbed *Navis* points – *navis* being Latin for ship), averaging ~90 mm in length, 28 mm wide and 25 mm thick. Another type was represented by delicately pressure trimmed, bifacial pointed ovoid "blades or spearheads" (Harcus 1945: 460). These measured about 95x44x13 mm, and sometimes were produced on dark quartzites. He observed no dark quartzite chips in the sieve, suggesting that these artefacts were not knapped on site, and reported only six so-called typical Pietersburg points, and two "equilateral triangular points with transversely concave flake undersides, carefully trimmed on the upper or convex face" (Harcus 1945: 460). He concluded that the Primrose Ridge assemblage does not represent the Pietersburg Industry, but that it represents a new type-centre, with novel ideals and a more extensive use of materials such as chert, climaxing in the use of white vein quartz – the "Primrose Ridge Culture" (Harcus 1945: 462).

Mason (1957) included the Primrose Ridge assemblage in his statistical analysis of the Transvaal Middle Stone Age, based on the six-bed Middle Stone Age sequence at the Cave of Hearths. He (Mason 1959: 120) reported 1570 "primary class specimens with statistical significance", including what he termed quadrilateral and rectangular flakes, backed end-struck flakes, hemi-lemniscates (bifacial points), opposed arcs (double pointed tools), ellipticals, ogives (probably unifacial points), and *outils écaillés*. In general, he found the Primrose Ridge assemblage to be smaller compared to what he thought of as the Pietersburg Standard Series range, with a less extensive use of the *Levallois* technique, a more extensive use of plain platforms, a tendency to remove the platform altogether and more frequent bifacial production strategies (Mason 1957). Like Harcus, Mason therefore excluded the Primrose Ridge assemblage from the Pietersburg, instead lumping it with that of the neighbouring Linksfield Ridge into a Transvaal variant of the later Sangoan. The Sangoan is used commonly, but vaguely, further north in sub-Saharan Africa for industries that are later than the final Acheulean and that contain rather massive picks in addition to other large tool types. According to Taylor (2022), an age of ~300-250 ka may be an underestimation, but the paucity of well-stratified Sangoan assemblages prohibits the understanding of its technological characteristics and variability.

In southern Africa, Davies (1952) initially thought that the so-called Tugela Industry of KwaZulu-Natal (see Cramb 1937) had an affinity with the Sangoan of central Africa. He later self-corrected – concluding that the term was misapplied to industries that were too widely separated in age and distribution and too poorly defined to allow for its use in South Africa (Davies 1976). However, he described how at several sites the Tugela Industry or Natal Sangoan was overlain stratigraphically by Middle Stone Age layers, some of which contained Still Bay points, that have now been described from stratified contexts at Sibudu Cave (Wadley 2007) and Umhlatuzana Rock Shelter (Högberg & Lombard 2016a, b), generally dating to >70 ka (Jacobs et al. 2008; Lombard et al. 2010). The Primrose Ridge assemblage lacks the large picks and other large tools associated with the Sangoan but does have a relatively large non-*Levallois* retouched point assemblage.

Clark (1959) likened what Harcus (1945) described as tea cosy fabricators and high-backed boat-shaped tools worked on the dorsal side only, to the proto-Still Bay or Lupemban Industry of the Upper Zambezi Savannah and Grassland regions. The type-fossil of the Lupemban is the elongated bifacial lanceolate point that may exceed 30 cm in length (Taylor 2022); core-axes, points of different shapes and dimensions, blades, and other small tools are all also attributed to the Lupemban (Taylor 2021). Similar to the Sangoan, the Lupemban remains poorly dated, and where dates exist, they are disputed (Herries 2011) and range from >200 ka (Barham 2012), to as young as MIS 3 (57-29 ka) at some sites (Basell 2013). Thus, the Lupemban remains poorly defined and understood (Taylor 2021), and the Primrose Ridge assemblage lacks its elongated bifacial lanceolate type-fossil and core axes.

The Pietersburg, defined as containing bifacial points shaped like “wide almonds” with “perfectly round” butts measuring between ~50 and 64 mm and thought to represent a “step towards” making Still Bay points (Goodwin and van Riet Lowe 1929: 110, 119), too remains poorly defined although generally dated from stratified Middle Stone Age contexts (see de la Peña et al. 2019 for full historical discussion of the Pietersburg). Mason speculatively placed the Pietersburg of the Transvaal earlier than the Mossel Bay and Still Bay (at the time thought to be only present in the Cape) in his Middle Stone Age sequence, concluding that: “most important is the need for additional dynamic, evolutionary evidence that can come only from the excavation of more long-sequence sites such as the Cave of Hearths” (Mason 1957: 136). Such long-sequence Middle Stone Age sites have been excavated, and some contexts dated. For example, age estimates for so-called Pietersburg assemblages included in Mason’s (1959) analysis are that of Olieboomspoort now dated to ~150±14 ka (Val et al. 2021) and Mwulu’s Cave dated to ~90 ka (Feathers et al. 2020). At Olieboomspoort Val et al. (2021) found that it does not represent a clear chrono-cultural unit, and for Mwulu’s Cave, Feathers et al. (2020: 15) do not assume that Pietersburg is a proper label for its stone tools, seeing it as more of a “catch-all category” rather than a useful archaeological entity.

Whilst their point descriptions remain unreported, at Border Cave in KwaZulu-Natal, the Pietersburg phase has been dated to MIS 5 (130-80 ka) (Grün & Beaumont 2001; Grün et al. 2003), and Porraz et al. (2018) dated it at Bushman Rock Shelter, Mpumalanga, to 73±6 ka and 75±6 ka on quartz and to 91±10 ka and 97±10 ka on feldspar. The numerical age estimates suggest a probable duration of ~132-73 ka with a median age of ~91 ka. Age estimates for the Mossel Bay at Blombos Cave, Hollow Rock Shelter, and Klasies River in the Western Cape have a median value of 88.2 ka with the most probable duration of the technocomplex currently seen as 98.4-77.4 ka (Lombard et al. 2022). Based on 117 dating data points, from sites such as Klasies River, Blombos Cave, Sibudu Cave, Umhlatuzana Rock Shelter, Diepkloof Rock Shelter and Apollo 11, the probable duration of the Still Bay technocomplex lies at 88.8-67.4 ka with a median age of 75.2 ka (Lombard et al. 2022). These dating outcomes would place the Pietersburg generally earlier than the Still Bay technocomplex, should it become clearly defined as a southern African technocomplex.

For the invasively retouched *Navis* points from Primrose Ridge, Harcus (1945: 461) reported pointed, semi-circular as well as straight butts, expressing the sentiment that: “it will be interesting to know if there are any specimens of this type, the *Navis*, in other collections”. He further acknowledges that he has not done justice to the smaller (~50x19x10 mm), very fine and delicate bifacial points in white quartz with rounded butts, “bespeaking highly skilled technique in this difficult material” (Harcus 1945:

461-462). Working on the Grassland interior, it perhaps did not cross his mind to look at Goodwin and van Riet Lowe's (1929) definition of the Still Bay type fossil as a thin (≤10 mm), invasively retouched, bifacial, foliate or lanceolate point with semi-circular or wide-angled pointed butt, and lenticular cross-section.

Our work on the complete Still Bay point assemblages from Hollow Rock Shelter, Umhlatuzana Rock Shelter, Apollo 11 and Sibudu Cave, as well as some points from Blombos Cave, revealed at least five point-production strategies with four phases each, resulting in a range of cross-sections (e.g., lenticular, rhombic, wedge-shaped, semi-circular and triangular), and pointed, semi-circular as well as straight butts (Högberg & Lombard 2016a; Lombard & Högberg 2018), configurations of which may vary through time and across space throughout the Still Bay phase (Lombard et al. 2019). Although at the KwaZulu-Natal sites of Sibudu and Umhlatuzana bifacial point production occurs intermittently throughout their sequences (e.g., Kaplan 1990; Wadley 2012; de la Peña et al. 2013; Mohapi 2013), points from non-Still Bay contexts mostly lack the typical semi-circular or pointed butts and slender shape, so that Still Bay point assemblages remain relatively distinct. At first glance, Harcus' descriptions and illustrations are reminiscent of Still Bay point assemblages (see plates Y and Z in Harcus 1945: 463-464). This observation provided the impetus for the study we present below where we apply our approach for comparative analysis of retouched point-production strategies and morphometric attributes to assess to which extent the Primrose Ridge point assemblage is similar or different from other Still Bay point assemblages or point assemblages pre- or post-dating the Still Bay phase, and whether it could represent a point-manufacturing workshop on the Gauteng Grassland.

2. Sample and approach

The Primrose Ridge assemblage is curated by the Archaeology Division of the University of the Witwatersrand without field notes, and artefacts are in boxes without any stratigraphic context. We were thus unable to reconstruct a possible artefact sequence from Harcus' layered excavation. Our purpose with this study is to assess whether the Primrose Ridge assemblage contains a point assemblage consistent with what can be expected for the Still Bay technocomplex, and if so, how it compares to other Still Bay point assemblages. To achieve this, we follow the approach outlined in Högberg and Lombard (2016a), and Lombard and Högberg (2018) wherein qualitative data for each point are presented in supporting online material (SOM) 1, with analyses conducted in a replicable quantitative manner conducive of directly comparing large samples – not possible with more traditional and subjectively descriptive *chaîne opératoire* approaches. We found 112 points and point fragments from Primrose Ridge in different phases of production, that could be analysed in the same manner we used for Still Bay point production, which we therefore refer to below as Still Bay-like. We found six more points (5% of the point assemblage) that could not be analysed in the same way, because they were made with a *Levallois* knapping strategy. We provide their description following the method published for *Levallois* point production described in Högberg and Lombard (2022)[1].

We gave each point a unique study number, and recorded its basic morphometric attributes (maximum length, width and thickness). Alongside details such as raw material and dimensions, we documented qualitatively fragment type/completeness, base shape, cross-section, the alignment of the dorsal ridge at bilateral equilibrium, the position of the bilateral equilibrium plane, whether the point was worked on one or both sides, indication of pressure flaking, and the type of blank used for producing the point (Table 1; Fig. 2; SOM 1). Based on these criteria, we interpret the production phase and point-production strategy for each Still Bay-like piece according to Högberg and Lombard (2016a; Fig. 3; and see Table 1 in SOM 2 for previously published phase definitions). Note that, because both whole and fragmented points are included in our study, the total number of points for the analysis of each attribute varies.

[1] We did not find all the 'prime' artefacts depicted by Harcus (1943: plate B, 1945: plates Y & Z), some of which may have been used for displays or other purposes throughout the years and not reintegrated into the assemblage.

Table 1. Attributes, definitions and labels used for the Still Bay-like assemblage from Primrose Ridge. When not specified, definitions are from Högberg and Lombard (2016a).

Number	Each tool has been given a unique number for our analysis
Raw material	Quartz; Quartzite; Hornfels; Chert; Dolerite/Andesite; Siltstone
Dimension (Högberg & Larsson 2011: table 2)	Length: the longest line of the artefact, measured in mm along the length axis Width: the widest part of the artefact, measured in mm at a right angle to the length axis Thickness: the thickest part of the artefact measured in mm
Fragment type/completeness (Villa et al. 2009: table 4; Fig. 2)	Tip (T); Distal part (D); Medial part (M); Proximal part (P); Base (B); Distal+Medial part (D+M); Proximal+Medial part (P+M); Complete point (C); Almost complete point, missing the tip only (AC); Almost complete point, missing the base only (ACB)
Base shape (Villa et al. 2009: figure 1)	Pointed (PT); Straight (ST); Semi-circular (SC), is distinguished from straight by a continuous line with no 'corners'
Cross-section (Fig. 2)	Lenticular (L); Lenticular, irregular (LI); Rhombic, biconvex (RB); Diamond-shaped (DS); Wedge-shaped (WS); Semi-circular (SC); Dislocated semi-circular (DSC); Triangular (T)
Ridge at the bilateral equilibrium, on each face on the point	Not clearly defined (1); Centred (2); Off-centred, located towards one of the edges (3); Following original ridge on one side, no ridge on the other side (4); Following original ridge on one side, indistinct, not centred or centred on the other side (5)
Position of the bifacial equilibrium plane	Centred (C); Not centred (NC)
Worked on both sides	Yes (Y); No (N)
Indication of use of pressure flaking	Yes (Y); No (N)
Blank type	Nodule (N); Blade (B); Flake (F)
Production phase (Fig. 3 and SOM 2)	A blank, unmodified or slightly worked flake, blade or a nodule (1); Represents the initial shaping of a piece, showing the intentions of the knapper to produce a point (2); Is the point preform with several invasive surface-covering negative flake-removal scars and regular edges, but still larger than finished points from the same contexts (3); Represents advanced shaping with well-balanced point proportions, defined tip, base and edges, but lacking final retouch (4); A finished point (5)
Point-production strategy (pps) (Fig. 3).	Bifacial nodule pps 1 (BNPPS 1); Bifacial nodule pps 2 (BNPPS 2); Bifacial blade pps (BBPPS); Bifacial flake pps (BFPPS); Unifacial pps (UPPS)

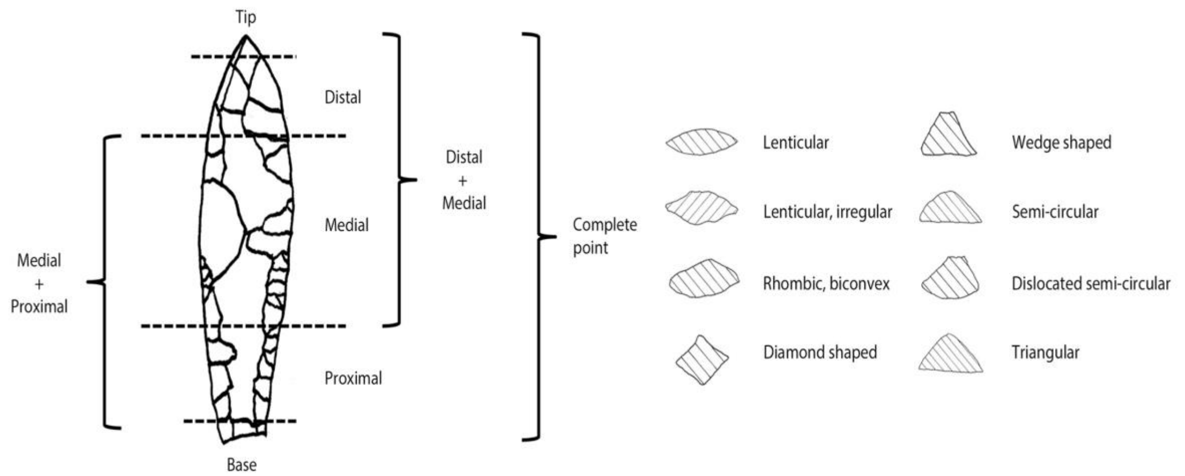


Figure 2. Illustration, fragment type/completeness and cross sections for Still Bay-like points (re-worked from Högberg & Lombard 2022: S3 figure 2).

To assess similarities or differences with known Still Bay assemblages, we compare the results of the Primrose Ridge point assemblage with those of other sites for which we have appropriate comparative data. At Sibudu we found that the points of the pre-Still Bay phase dated to ≥77.3±2.7 ka were relatively distinct from the Still Bay phases dated to ~73-65 ka (Lombard et al. 2019), we therefore present these two phases separately in our comparative trait analysis, because they may reveal temporal trends in point-production strategies and morphologies. We also compare the Primrose Ridge points with those excavated at Hollow Rock Shelter dated to ~85-68 ka (Högberg & Lombard 2022), Umhlatuzana dated to ≥71±5 ka (Lombard et al. 2010), and Apollo 11 dated to 71±3 ka (Vogelsang et al. 2010). We do not have point-production or cross-section and base-shape data for the following point assemblages: Blombos Cave Still Bay dated to ~78-68 ka (Jacobs et al. 2020), Diepkloof Rock Shelter Still Bay ~88-65 ka (Jacobs & Roberts 2017), Bushman Rock Shelter Pietersburg dated to ~ 97-73 ka (Porraz et al. 2018), Olieboomspoort Pietersburg dated to ~164-134 ka (Val et al. 2021), as well as White Painting Shelter and ≠Gi Pan in Botswana dated, respectively, to ≥66 ka (Robbins et al. 2000) and ~77 ka

(Brooks et al. 1990), but we do have morphometric data which we include in our analysis. We also include the undated Still Bay assemblages from Clanwilliam Dam, Dale Rose Parlour and Soutfontein, as well as the Pietersburg points from Cave of Hearths in our morphometric analysis. Our purpose for including all these Middle Stone Age point assemblages is to assess as best as possible where the Primrose Ridge point assemblage may fit in the sequence.

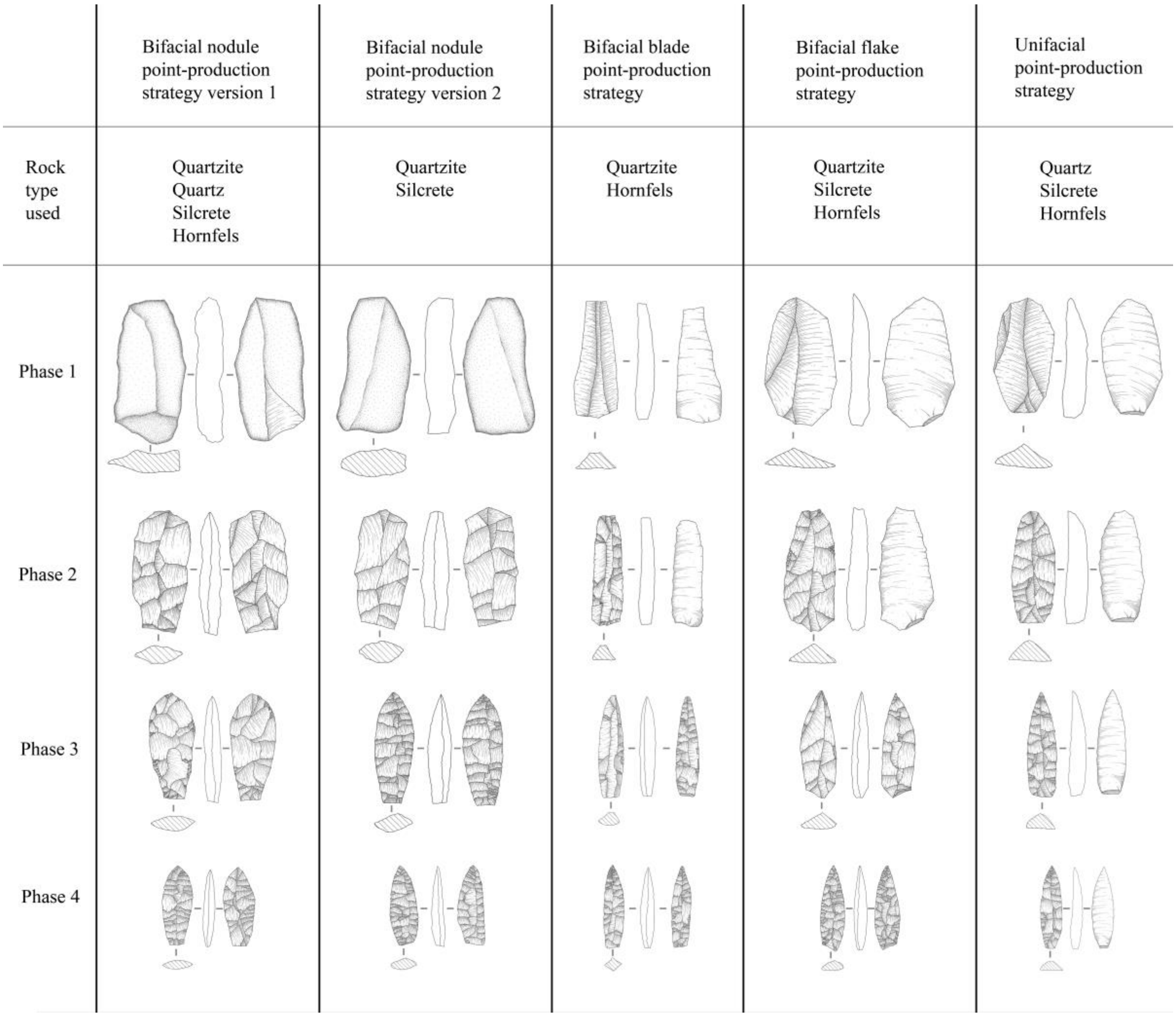


Figure 3. Illustration of identified point-production phases and point-production strategy (pps) for the Still Bay-like points from Primrose Ridge (see SOM 2 for detailed discussion of the production phases as previously published in Högberg & Lombard 2016a)[2]. Phase 5, i.e. a finished point, is not illustrated in the figure.

3. Results

Description of the Primrose Ridge point assemblage

We identified six raw materials used for Still Bay-like point production at Primrose Ridge with most points made on quartz (n=54, 48%), followed by quartzite (n=48, 43%), five (4%) on hornfels, three (3%) on chert and one each (1%) on dolerite and siltstone (Table 2; Fig. 4). Most of the quartz points were made with the bifacial flake point-production strategy (n=28, 52%), followed by the unifacial point-production strategy (n=14, 26%), the bifacial nodule point-production 1 strategy (n=11, 20%), and one (2%) quartz point was made using the bifacial blade point-production strategy. For making the quartzite points, the Primrose Ridge knappers preferred the unifacial point-production strategy (n=21; 44%), followed by the bifacial flake point-production strategy (n=14, 29%), and the bifacial nodule 1 and bifacial blade point-production strategies were each used for making six (13%) points, whereas

[2] Wedge/triangular/semi-circular/dislocated semi-circular=keeled or double keeled=carinated points shaped like ‘up-turned boats’.

only one (2%) was made with the bifacial nodule point-production strategy 2. The numbers of points made on the other raw materials are too small for interpreting preferred point-production strategies, but their data are presented in Table 2. Cumulatively, it would seem that most of the Primrose Ridge points were made with the bifacial flake (n=44, 39%), and unifacial (n=38, 34%) point-production strategies. The bifacial nodule 1 (n=19, 17%), bifacial blade (n=8, 7%), and bifacial nodule 2 (n=3, 3%) point-production strategies are all less represented.

Table 2. Summary of Primrose Ridge point material use, point-production strategies, morphometric data, and cross section and base shape. Number of points analysed=112 (see SOM 1 for qualitative details of each point). Percentage values are rounded off so that the totals may differ up to 1% from those of subdivisions.

Summary of materials used for point production

Material	**Quartz**		**Quartzite**		**Hornfels**		**Chert**		**Dolerite**		**Siltstone**	
	n	%	n	%	n	%	n	%	n	%	n	%
Total=112	54	48	48	43	5	4	3	3	1	1	1	1

Production strategy	**Bifacial nodule pps 1**		**Bifacial nodule pps 2**		**Bifacial blade pps**		**Bifacial flake pps**		**Unifacial pps**		**Indeterminate pps**	
	n	%	n	%	n	%	n	%	n	%	n	%
Quartz	11	20	0	0	1	2	28	52	14	26	0	0
Quartzite	6	13	1	2	6	13	14	29	21	44	0	0
Hornfels	0	0	2	40	1	20	1	20	1	20	0	0
Chert	2	67	0	0	0	0	1	33	0	0	0	0
Dolerite	0	0	0	0	0	0	0	0	1	100	0	0
Siltstone	0	0	0	0	0	0	0	0	1	100	0	0
Total=112	**19**	**17**	**3**	**3**	**8**	**7**	**44**	**39**	**38**	**34**	**0**	**0**

Summary of morphometric data
(note: all length data include only complete and almost complete pieces; other data include complete pieces and those for which maximum width and thickness could be measured)

Morphology	**Length**			**Width**			**Thickness**			**Ratios**		
	Average	SD	CV	Average	SD	CV	Average	SD	CV	L:W	L:T	W:T
Quartz	58	11.4	19.6	31.1	5.8	18.6	14.9	4.2	28.2	1.9	3.9	2.1
Quartzite	72	15	20.8	35.3	6.6	18.7	14.7	3.9	26.5	2	4.8	3.6
Other	69.2	7.7	11.1	32.2	5.6	17.4	13.6	4.7	34.6	2.1	5	2.4
Total	**65**	**14**	**21.5**	**33**	**6**	**18.2**	**15**	**4**	**27**	**2**	**4.3**	**2.2**

Cross sections and base shapes in relation to material use
(note: 30 (27%) of base shapes not known)

Shapes	**Cross sections, total=112**										**Base shapes, total=82**					
	Lenticular/ Lent. Irr.		**Rhomboid**		**Wedge-shaped**		**Semi-circ./ Disloc. s-c**		**Triangular**		**Pointed**		**Semi-circular**		**Straight**	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Quartz	25	46	2	4	0	0	22	41	3	6	15	28	16	30	13	24
Quartzite	8	17	2	4	2	4	26	54	10	21	8	17	1	2	21	44
Hornfels	2	40	0	0	0	0	3	60	0	0	1	20	2	40	0	0
Chert	2	67	0	0	0	0	1	33	0	0	1	33	2	67	0	0
Dolerite	0	0	0	0	0	0	1	100	0	0	1	100	0	0	0	0
Siltstone	0	0	0	0	0	0	1	100	0	0	0	0	0	0	1	100
Total	**37**	**33**	**4**	**4**	**2**	**2**	**54**	**48**	**13**	**12**	**26**	**23**	**21**	**19**	**35**	**31**

Most of the Still Bay-like quartz points from Primrose Ridge have lenticular cross sections (n=25, 46%), followed by points with semi-circular cross sections (n=22, 41%) (Table 2). Three quartz points (6%) have triangular, and two (4%) have rhomboid cross sections. The base shapes are relatively equally distributed across the quartz points with 16 (30%) having semi-circular, 15 (28%) having pointed and 13 (24%) having straight bases. By contrast, the predominant cross section amongst the quartzite points is semi-circular (n=26, 54%), followed by triangular (n=10, 21%), lenticular (n=8, 17%), with two points each (4%) having either rhomboid or wedge-shaped cross sections. Also different from their quartz counterparts, the quartzite points from Primrose Ridge mostly have straight bases (n=21, 44%), eight (17%) have pointed bases, and only a single quartzite point has a semi-circular base (Table 2). Again, the number of points for the other materials is too small for comparative purposes, but as a whole, most of the points (n=54, 48%) have semi-circular cross sections, followed by lenticular (n=37, 33%) and triangular (n=13, 12%) ones, with only a few having rhomboid or wedge-shaped cross sections. The predominant base shape is straight (n=35, 31%), followed by pointed (n=26, 23%), and semi-circular (n=21, 19%) (Table 2). Morphometrically, there are no significant differences between the quartz and quartzite points from Primrose Ridge (p=0.4525; SOM 3), so that for the inter-site comparisons we do not separate between the two main raw material groups from the site.

Figure 4. Still Bay-like points from Primrose Ridge showing various raw materials, phases of production and point-production strategies: Point 001: quartzite, phase 4 and BFPPS; point 003: quartzite, phase 5 and BBPPS; point 016: quartzite, phase 4 and UPPS; point 019: quartzite, phase 3 and BNPPS1; point 031: quartzite, phase 2 and BBPPS; point 033: quartzite, phase 5 and UPPS; point 047: quartz, phase 3 and BNPPS1; point 053: hornfels, phase 3 and BNPPS2; point 056: hornfels, phase 3 and BFPPS; point 065: quartz, phase 3 and BFPPS; point 072: quartz, phase 3 and BFPPS; point 075: quartz, phase 3 and BFPPS; point 092: quartz, phase 5 and UPPS. See Table 3 in SOM 2 for more detailed examples of points defined according to production phases and strategies.

Six additional points were produced with a *Levallois* knapping strategy (SOM 1). These points were all made on quartzite, and three of them have plain butts formed by having the original flake-blank platform removed with a tranchet blow, resulting in a flat un-modified surface (Fig. 5). Two have faceted butts, and one was retouched so that the platform is no longer distinguishable. All six points were worked on their dorsal sides only, and four have extensive dorsal surface-covering flaking resulting in the same shape as a classic *Levallois* point. The remaining two points were retouched on both their left and right lateral sides of their tips covering the whole point (SOM 1).

The points from Primrose Ridge compared to Still Bay and other relevant assemblages

First, we present an inter-assemblage comparison of criteria originally used to define the Still Bay technocomplex, i.e., bifacial retouch, semi-circular or pointed butts, and lenticular cross-sections (e.g., Goodwin & van Riet Lowe 1929). In terms of invasive bifacial retouch, the frequency of the Primrose Ridge Still Bay-like points (82%) is most similar to that of other Still Bay assemblages with relatively high proportions of points with such retouch, e.g., the Hollow Rock (82.1%) and Umhlatuzana Still Bay assemblages (87.7%) (Fig. 6). Proportions of points with lenticular cross sections are relatively high for the Still Bay point assemblages of Sibudu (55.6%) and Umhlatuzana (48%), but the Still Bay-like points from Primrose Ridge with 33% are most similar to those from the Hollow Rock Still Bay (35.8%) and the Sibudu pre-Still Bay (28.6%) assemblages (Fig. 6). The Umhlatuzana Still Bay point assemblage has the highest frequency (61%) of points with semi-circular and pointed butts, followed by the Primrose Ridge Still Bay-like points (42%) and the Sibudu Still Bay assemblage (23.5%) (Fig. 6). Similar to the Still Bay knappers from Hollow Rock and Umhlatuzana, those at Primrose Ridge used the full suite of point-production strategies thus far recorded for Still Bay assemblages, and raw material use for point knapping varies between the sites (Fig. 6).

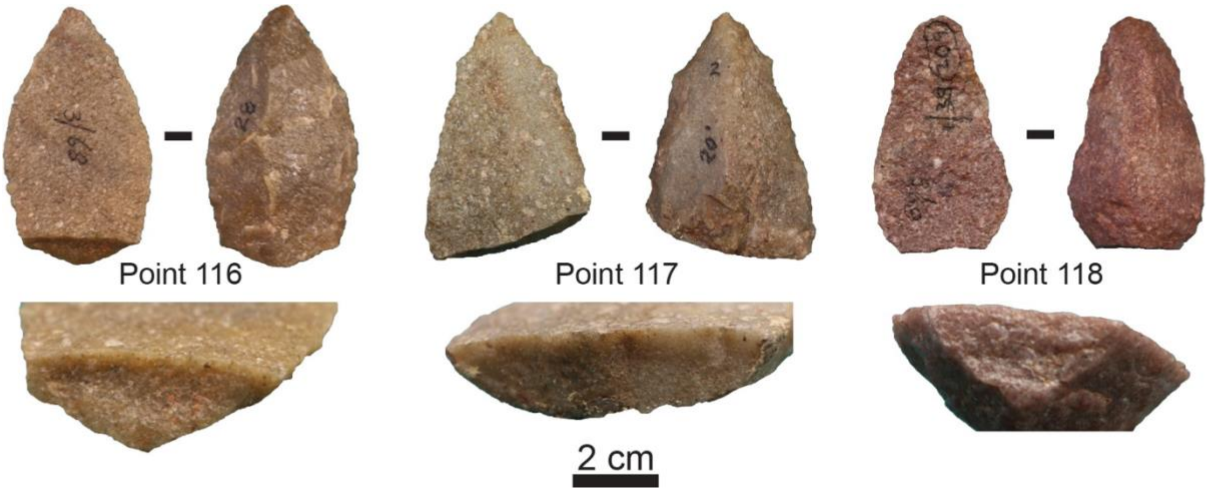
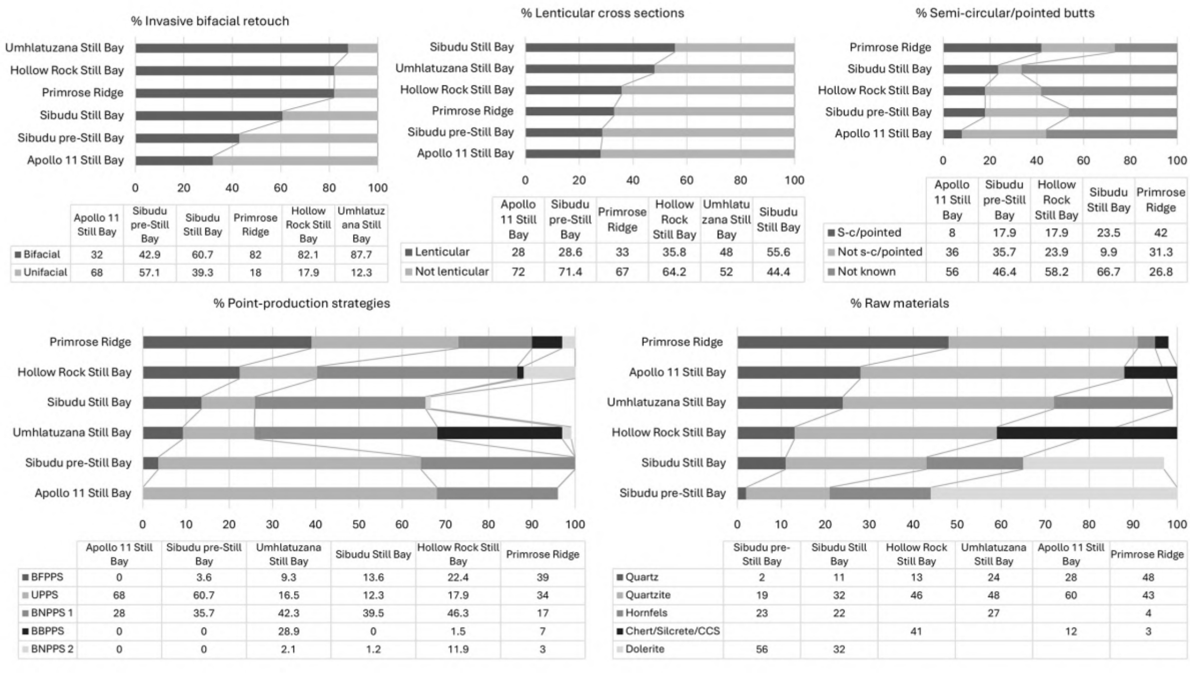


Figure 5. *Levallois* points from Primrose Ridge, point number 116, 117 and 118. Close up of each point's butt, formed by a tranchet blow (not to scale).



	Apollo 11 Still Bay	Sibudu pre-Still Bay	Sibudu Still Bay	Primrose Ridge	Hollow Rock Still Bay	Umhlatuzana Still Bay
Bifacial	32	42.9	60.7	82	82.1	87.7
Unifacial	68	57.1	39.3	18	17.9	12.3

	Apollo 11 Still Bay	Sibudu pre-Still Bay	Primrose Ridge	Hollow Rock Still Bay	Umhlatuzana Still Bay	Sibudu Still Bay
Lenticular	28	28.6	33	35.8	48	55.6
Not lenticular	72	71.4	67	64.2	52	44.4

	Apollo 11 Still Bay	Sibudu pre-Still Bay	Hollow Rock Still Bay	Sibudu Still Bay	Primrose Ridge
S-c/pointed	8	17.9	17.9	23.5	42
Not s-c/pointed	36	35.7	23.9	9.9	31.3
Not known	56	46.4	58.2	66.7	26.8

	Apollo 11 Still Bay	Sibudu pre-Still Bay	Umhlatuzana Still Bay	Sibudu Still Bay	Hollow Rock Still Bay	Primrose Ridge
BFPPS	0	3.6	9.3	13.6	22.4	39
UPPS	68	60.7	16.5	12.3	17.9	34
BNPPS 1	28	35.7	42.3	39.5	46.3	17
BBPPS	0	0	28.9	0	1.5	7
BNPPS 2	0	0	2.1	1.2	11.9	3

	Sibudu pre-Still Bay	Sibudu Still Bay	Hollow Rock Still Bay	Umhlatuzana Still Bay	Apollo 11 Still Bay	Primrose Ridge
Quartz	2	11	13	24	28	48
Quartzite	19	32	46	48	60	43
Hornfels	23	22		27		4
Chert/Silcrete/CCS			41		12	3
Dolerite	56	32				

Figure 6. Some technical traits of Primrose Ridge Still Bay-like points compared to dated Still Bay/pre-Still Bay assemblages.

Box and whisker plots demonstrate that in terms of shape ratios, the Primrose Ridge Still Bay-like assemblage clusters most closely with some other Still Bay assemblages, whilst the six *Levallois* points cluster with post-Howiesons Poort points in terms of their length:width (L:W) ratios, the points from ≠Gi Pan and White Paintings in Botswana in terms of length:thickness (L:T), and some Still Bay assemblages in terms of width:thickness (W:T) (Fig. 7). Statistically (Mann-Whitney U-tests; SOM 3), there are no significant ($p<0.05$) differences between: a) The L:W ratios of the Primrose Ridge Still Bay-like points and those from the Apollo 11 ($p=0.3502$) and Soutfontein ($p=0.1158$) Still Bay assemblages; b) the L:T ratios of the Primrose Ridge Still Bay-like points and those from the Soutfontein ($p=0.9473$), Clanwilliam Dam ($p=0.6881$), and Diepkloof ($p=0.5918$) Still Bay assemblages; and c) the W:T ratios of the Primrose Ridge Still Bay-like points and those from the Umhlatuzana ($p=0.36$) and Soutfontein ($p=0.3348$) Still Bay assemblages (Fig. 7). All other shape-ratio comparisons, apart from the Primrose Ridge *Levallois* points, show significant or highly significant ($p<0.001$) differences (SOM 3).

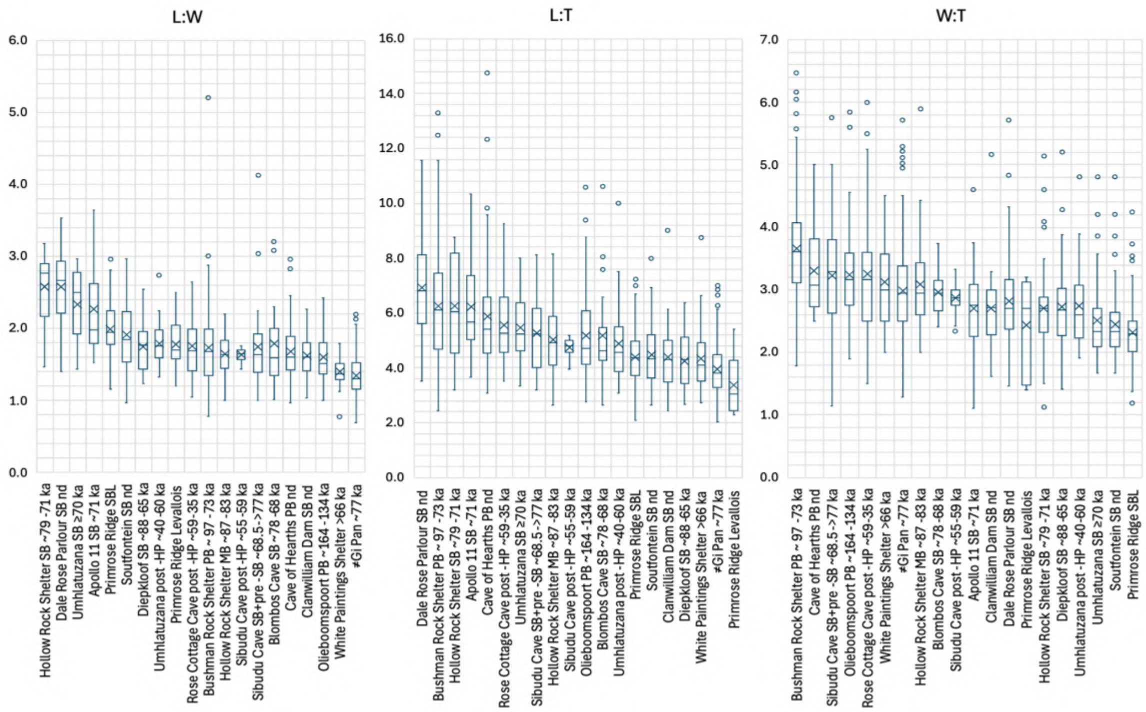


Figure 7. Comparative analysis of shape ratios arranged according to descending median values (horizontal lines within the bars).

4. Concluding discussion

Less than two decades ago, it was still thought that the Still Bay technocomplex was restricted to the Cape coastal regions of South Africa, and the so-called Pietersburg to the Savanna-Grassland Biomes north of the Vaal River. Both Harcus (1945) and Mason (1957) separated the Primrose Ridge point assemblage from what they perceived to be the Pietersburg Industry. Harcus, however thought that six pieces – probably those we identified as made with the *Levallois* technique – may represent the Pietersburg. The Pietersburg on the Gauteng Grassland, as well as at Cave of Hearths further northwest on the Savanna is *Levallois* based, but the six Primrose Ridge *Levallois* points do not group morphometrically with those from the purported Cave of Hearths and Olieboomspoort Pietersburg point assemblages. Instead, they group either with the younger post-Howiesons Poort assemblages dating to <60 ka (also *Levallois* based, e.g., Dusseldorp 2014; Timbrell et al. 2022), or with the non-Still Bay assemblages from Botswana with age estimates contemporaneous with the Still Bay. At Hollow Rock Shelter, we found a Mossel Bay *Levallois* point-making tradition that may have started there at ~87 ka, and after ~83 ka the knappers started to also make Still Bay points even though some *Levallois*-type points remained in use throughout the site's Still Bay sequence until ~71 ka (Högberg & Lombard 2022). Thus, the six *Levallois* points from Primrose Ridge may be seen as: a) contemporaneous with the Still Bay-like points from the site; b) part of an earlier Mossel Bay-like technocomplex; or c) a younger intrusion into the Still Bay-like assemblage. Because they are so few and because the site itself cannot be re-excavated or dated, we may never know which is the more likely.

We demonstrated, however, that the Still Bay-like points from Primrose Ridge conform to what can be expected from Still Bay point assemblages in terms of invasive bifacial retouch, lenticular cross sections and semi-circular or pointed butts as originally defined by Goodwin and van Riet Lowe (1929), and subsequently recorded for points from dated Still Bay contexts (e.g., Wadley 2007; Porraz et al. 2008; Villa et al. 2009; Lombard et al. 2010; Högberg & Larsson 2011; Lombard & Högberg 2018). To our knowledge no other technocomplexes in southern Africa display this trait combination, even when they contain bifacially retouched points such as the final Middle Stone Age hollow-based points from Sibudu and Umhlatuzana in KwaZulu-Natal (Wadley 2005; Mohapi 2013). Pressure flaking has been confirmed for Still Bay assemblages from Blombos and Umhlatuzana (Mourre et al. 2010; Högberg & Lombard 2016b), but contrary to Harcus' (1945) interpretation of quartz pressure flaking at Primrose Ridge, we only found evidence of this knapping technique on two hornfels points (Fig. 8). Thus far, pressure flaking has not been consistently reported for any southern African Middle Stone Age technocomplexes other than the Still Bay. However, the bifacial and unifacial points from Sibebe in eSwatini dated to ~43 ka (Bader et al. 2022), require closer scrutiny with comparative work.

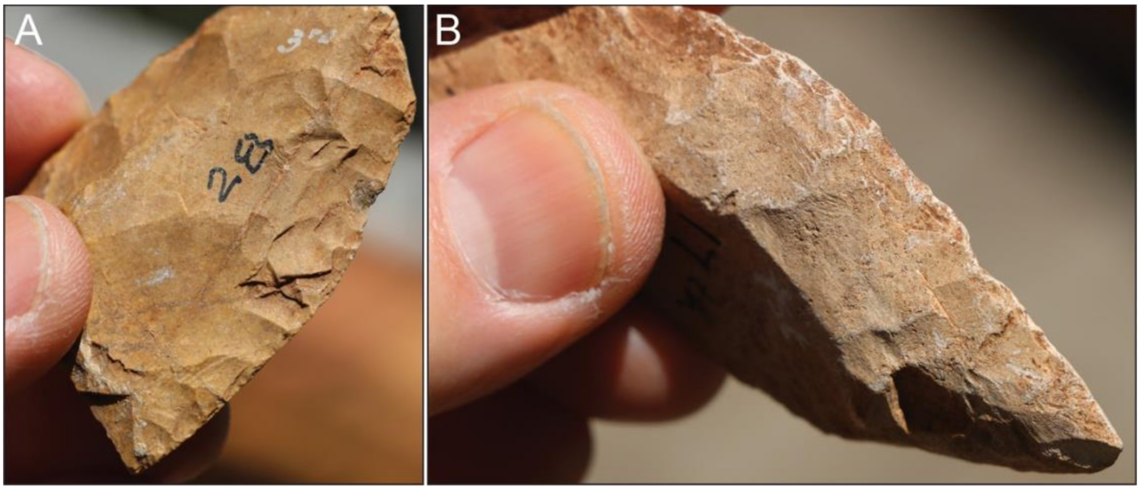


Figure 8. Close-up of the edges of Still Bay-like points number 053 (left) and number 054 (right), showing evidence of pressure flaking at Primrose Ridge. Both points are made from hornfels.

In terms of their shape ratios, the Primrose Ridge Still Bay-like points are almost indistinguishable from the undated points reported from Soutfontein, and show similarities with those from the Still Bay contexts of Apollo 11 (~71 ka), Diepkloof (~88-65 ka), Umhlatuzana (≥70 ka) and Clanwilliam Dam (undated). The Soutfontein points were recorded from an open-air site in the winter rainfall zone of the Western Cape (Mackay et al. 2010). Similar to the Primrose Ridge Still Bay-like points, they were mostly (66%) produced on local white vein quartz, show invasive bifacial retouch with a few unifacial points, and both semi-circular and pointed butts (Mackay et al. 2010, 2018). Hallinan and Parkington (2017) place the Soutfontein and Clanwilliam Dam assemblages within the Still Bay of the Olifants River Valley landscape, and Dewar and Stewart (2017: 17) see the Soutfontein assemblage as containing "tool forms diagnostic of the Still Bay". The Soutfontein quartz pieces show breakage patterns consistent with knapping errors, suggesting that the points were produced onsite (Mackay et al. 2010). Because of the collection and curation history of the Primrose Ridge assemblage, we were unable to conduct a technological flake analysis (e.g., Högberg & Lombard 2016b), yet we found similar knapping errors on some of the quartz pieces from Primrose Ridge. Together with Harcus' (1945) observation about *in situ* anvil boulders surrounded by fresh quartz chips, it is reasonable to suggest that Primrose Ridge too served as a workshop or knapping site for quartz points (for discussion about earlier workshop sites on the Gauteng Grassland-Savanna ecotone see Lotter et al. 2024).

Mackay et al.'s (2022) reconstruction of Still Bay mobility patterns shows that Still Bay point knappers selected their raw materials in response to geological resources within river catchments. Along these catchments, open-air Still Bay point knapping sites show low raw material diversity, with local rocks dominating the assemblages. Primrose Ridge is located <2 km south of the Jukskei River on one of several ridges with quartz veins and pebble conglomerates in the Witwatersrand Basin (Tucker et al.

2016). Just north of the Jukskei River, a white quartzite ridge (Linksfield Ridge) with Orange Grove Quartzite, represents the lowermost stratigraphic layer of the basin. The 'dark' quartzite artefacts, that Harcus (1945) saw as having been knapped elsewhere, may come from the iron rich quartzites of the West Rand Group ~40 km west of Primrose Ridge (Tucker et al. 2016). This would be consistent with Mackay et al.'s (2022) suggestion that Still Bay points were transported regularly over distances of 30-60 km, and the possibility that patterns in raw material selection and artefact transport were part of socially mediated choices and territory boundaries (also see Hallinan 2019).

Understood as a technocomplex – not a culture-historical unit (see discussion in Lombard et al. 2022) – Still Bay assemblages will share a place in the Stone Age sequence of southern Africa (i.e., above/younger than Mossel Bay-like *Levallois* horizons) and artefact classes (i.e., relatively slender, invasively retouched bifacial and unifacial points with rounded or pointed butts). Not all properties will, however, be identical through time (phases) or across space (local/regional knapping traditions). Each Still Bay assemblage is thus expected to include variations of the same family of artefacts as a response to socio-economic and/or environmental factors (e.g., Clarke 1968). A technocomplex, such as the Still Bay, can therefore be widespread, with subtle shifts in regional tool frequencies or design, whilst retaining broad similarities (e.g., Deacon 1980). Sackett (1982, 1986) discuss artefact shape as linked to shared traditions, but we see the fact that the Primrose Ridge Still Bay-like points so closely resemble the shape of those from far-away (>1000 km) Soutfontein as a result of raw material use within a spatiotemporally variable Still Bay technocomplex as mentioned above (also see Mackay et al. 2014; Högberg & Lombard 2016a).

Seen in this context, the technical traits (i.e., invasive bifacial retouch, lenticular cross sections and semi-circular or pointed butts) remained the shared stylistic tradition, but Still Bay shape ratios varied based on the quality and size restrictions of the different raw materials and perhaps on regional or intra-site shifts in point-making and maintenance traditions and phases (also see Archer et al. 2016, 2018; Lombard et al. 2019; Way & Hiscock 2021). We have previously demonstrated how ideas and/or artefacts can spread throughout the South African landscape within less than 15 years through social networks with travelling radii of up to 100 km operating along the coastline and river systems (Högberg & Lombard 2020) – with travelling radii of up to 60 km it will take ~25 years to spread across the landscape, i.e., within a single human generation. We now also know that, different from most other regions in the world, the southern African hunter-gatherer population show genetic continuity and similarity from the Cape to KwaZulu-Natal throughout the Holocene (Gretzinger et al. 2024). This implies social networks and the exchange of genes across the landscape for at least the last 12 000 years, perhaps reaching back into the Pleistocene – especially when considering the widespread appearance of technocomplexes such as the Howiesons Poort and Still Bay (Wadley 2015; Wurz 2021).

Primrose Ridge is forever lost as an archaeological site – only the Harcus (1945) report and the artefacts he collected remain. Two developments over the last decade, however, made it possible to revisit the assemblage and present its artefacts in a new light. First, we now have a much better understanding of the distribution and dating of Stone Age technocomplexes across southern Africa (summarised in Lombard et al. 2012, 2022) – including the Still Bay that was previously discarded by Sampson (1974) and Volman (1984) – allowing for interpreting undated open-air sites in the broader chronological framework. Secondly, we developed and implemented the approach used here, specifically designed for comparative techno-morphometric analysis of non-*Levallois* bifacial and unifacial points from various sites and contexts. Different from exclusively morphometric studies (e.g., Archer et al. 2016, 2018; Way & Hiscock 2021), or traditionally descriptive *chaîne opératoire* approaches (e.g., Villa et al. 2009; Porraz et al. 2018; de la Peña et al. 2019) our approach is also able to describe and quantify variation and similarities in point-production strategies and the resulting technical traits.

When Harcus (1945) reported on the three butt varieties of the Primrose Ridge *Navis* points, he wondered whether there were any other point assemblages with similar traits, and he understood that he did not do justice to the smaller, finely made white quartz bifacial points with rounded butts. Here we demonstrated that, yes, there are assemblages with similar traits and some of them, such as the points from Soutfontein, Apollo 11, and Umhlatuzana also have relatively small points made on quartz with rounded butts – all of which have been identified as Still Bay point assemblages. We therefore conclude that the best-fit interpretation of the Primrose Ridge point assemblage is that it is consistent with what can be expected for Still Bay point assemblages, and that they do not signal the "novel ideals" of a "Primrose Ridge Culture" proposed by Harcus (1945: 462). If our interpretation is correct, Primrose Ridge could have been used as a knapping site for quartz Still Bay points, perhaps sometime between ~89 ka and 67 ka, representing a provisional record of the Still Bay technocomplex on the Grassland interior of South Africa. The only other possible Grassland Still Bay site could be Lovedale in the Free State dated to ~70 ka (Wroth et al. 2022), but its point assemblage awaits formal description. Today, Gauteng is the most densely populated and built-up province of South Africa, but our hope is that this paper will stimulate new open-air Grassland research in areas still available for surveys, and that it may lead to research that could provide more robust evidence of a Grassland Still Bay.

Acknowledgements
We thank Faye Lander for providing access to the Primrose Ridge assemblage, and Matt Lotter for visiting the location of the site, confirming its destruction (both from the University of the Witwatersrand). Emily Hallinan together with an anonymous reviewer and the Editor provided useful feedback that helped us to improve on our reporting, and we appreciate the time they spent with reading and commenting on our work. No funding was received for this study.

Supporting online material
Lombard et al. Supporting Online Material File 1
Lombard et al. Supporting Online Material File 2
Lombard et al. Supporting Online Material File 3

References
Archer, W., Pop, C.M., Gunz, P., et al. 2016. What is Still Bay? Human biogeography and bifacial point variability. Journal of Human Evolution, 97: 58-72.
Archer, W., Pop, C.M., Rezek, Z., et al. 2018. A geometric morphometric relationship predicts stone flake shape and size variability. Archaeological and Anthropological Sciences, 10(8): 1991-2003.
Bader, G.D., Mabuza, A., Williams, D.P., et al. 2022. Rethinking the Middle to Later Stone Age transition in southern Africa: A perspective from the highveld of Eswatini. Quaternary Science Reviews, 286: 107540.
Barham, L. 2012. Clarifying some fundamental errors in Herries' "A chronological perspective on the Acheulian and its transition to the Middle Stone Age in southern Africa: The question of the Fauresmith". International Journal of Evolutionary Biology, 2012(1): 230156.
Basell, L. 2013. The Middle Stone Age of eastern Africa. In: Mitchell, P. & Lane, P. (eds) The Oxford Handbook of African Archaeology: 387-410. Oxford: Oxford University Press.
Brooks, A.S., Hare, P.E., Kokis, J.E., et al. 1990. Dating Pleistocene archeological sites by protein diagenesis in ostrich eggshell. Science, 248(4951): 60-64.
Clark, J.D. 1959. Equatorial influences in the Prehistoric cultures of southern Africa. Trabalhos de Antropologia e Etnologia, 17(1-4): 257-265.
Clarke, D.L. 1968. Analytical Archaeology. London: Methuen.
Cramb, J.G. 1937. Further notes on the Tugela industry. South African Journal of Science, 33(3): 950-959.
Davies, O. 1952. The Natal Sangoan Culture. South African Journal of Science, 48(7): 212-214.
Davies, O. 1976. The 'Sangoan' Industries. Annals of the Natal Museum, 22(3): 885-911.
Deacon, J. 1980. Comments on Parkington: Time and place: Some observations on spatial and temporal patterning in the Later Stone Age sequence in South Africa. South African Archaeological Bulletin, 35: 89-93.
de la Peña, P., Val, A., Stratford, D.J., et al. 2019. Revisiting Mwulu's Cave: New insights into the Middle Stone Age in the southern African Savanna Biome. Archaeological and Anthropological Sciences, 11: 3239-3266.
de la Peña, P., Wadley, L. & Lombard, M. 2013. Quartz bifacial points in the Howiesons Poort of Sibudu. South African Archaeological Bulletin, 68(198): 119-136.
Dewar, G. & Stewart, B.A. 2017. Early maritime desert dwellers in Namaqualand, South Africa: A Holocene perspective on Pleistocene peopling. The Journal of Island and Coastal Archaeology, 12(1): 44-64.
Dusseldorp, G.L. 2014. Explaining the Howiesons Poort to post-Howiesons Poort transition: A review of demographic and foraging adaptation models. Azania, 49: 317-353.
Feathers, J.K., Evans, M., Stratford, D.J., et al. 2020. Exploring complexity in luminescence dating of quartz and feldspars at the Middle Stone Age site of Mwulu's Cave (Limpopo, South Africa). Quaternary

Geochronology, 59: 101092.
Goodwin, A.J.H. & van Riet Lowe, C. 1929. The Stone Age cultures of South Africa. Annals of the South African Museum, 27: 1-289.
Gretzinger, J., Gibbon, V.E., Penske, S.E., et al. 2024. 9,000 years of genetic continuity in southernmost Africa demonstrated at Oakhurst Rockshelter. Nature Ecology & Evolution, 8(11): 2121-2134.
Grün, R. & Beaumont, P. 2001. Border Cave revisited: A revised ESR chronology. Journal of Human Evolution, 40(6): 467-482.
Grün, R., Beaumont, P., Tobias, P.V., et al. 2003. On the age of Border Cave 5 human mandible. Journal of Human Evolution, 45(2): 155-167.
Hallinan, E. 2019. Variation and modernity in Middle Stone Age landscape use in the Western and Northern Cape, South Africa. Doctoral Thesis. Cape Town: University of Cape Town.
Hallinan, E. & Parkington, J. 2017. Stone Age landscape use in the Olifants River Valley, Clanwilliam, Western Cape, South Africa. Azania: Archaeological Research in Africa, 52(3): 324-372.
Harcus, J. 1943. Middle Stone Age types from Bedfordview. South African Journal of Science, 40(11): 330-331.
Harcus, J. 1945. A Middle Stone Age industry from Primrose Ridge district, Germiston, Transvaal. South African Journal of Science, 41(07): 459-464.
Herries, A.I. 2011. A chronological perspective on the Acheulian and its transition to the Middle Stone Age in southern Africa: The question of the Fauresmith. International Journal of Evolutionary Biology, 2011(1): 961401.
Högberg, A. & Larsson, L. 2011. Lithic technology and behavioural modernity: New results from the Still Bay site, Hollow Rock Shelter, Western Cape Province, South Africa. Journal of Human Evolution, 61(2): 133-155.
Högberg, A. & Lombard, M. 2016a. Still Bay point-production strategies at Hollow Rock Shelter and Umhlatuzana Rock Shelter and knowledge-transfer systems in southern Africa at about 80-70 thousand years ago. PLoS ONE, 11(12): e0168012.
Högberg, A. & Lombard, M. 2016b. Indications of pressure flaking more than 70 thousand years ago at Umhlatuzana Rock Shelter. South African Archaeological Bulletin, 71(203): 53-59.
Högberg, A. & Lombard, M. 2020. 'I can do it' becomes 'we do it': Kimberley (Australia) and Still Bay (South Africa) points through a socio-technical framework lens. Journal of Paleolithic Archaeology, 3(4): 633-663.
Högberg, A. & Lombard, M. 2022. Was there a shift from Levallois to Still Bay point knapping at Hollow Rock Shelter, South Africa? Azania: Archaeological Research in Africa, 57(1): 5-36.
Jacobs, Z., Jones, B.G., Cawthra, H.C., et al. 2020. The chronological, sedimentary and environmental context for the archaeological deposits at Blombos Cave, South Africa. Quaternary Science Reviews, 235: 105850.
Jacobs, Z. & Roberts, R.G. 2017. Single-grain OSL chronologies for the Still Bay and Howiesons Poort industries and the transition between them: Further analyses and statistical modelling. Journal of Human Evolution, 107: 1-13.
Jacobs, Z., Roberts, R.G., Galbraith, R.F., et al. 2008. Ages for the Middle Stone Age of southern Africa: Implications for human behavior and dispersal. Science, 322(5902): 733-735.
Kaplan, J. 1990. The Umhlatuzana rock shelter sequence: 100 000 years of Stone Age history. Southern African Humanities, 2(11): 1-94.
Lombard, M., Bradfield, J., Caruana, M.V., et al. 2022. The southern African Stone Age sequence updated (II). South African Archaeological Bulletin, 77(217): 172-212.
Lombard, M. & Högberg, A. 2018. The Still Bay points of Apollo 11 rock shelter, Namibia: An inter-regional perspective. Azania: Archaeological Research in Africa, 53(3): 312-340.
Lombard, M., Högberg, A. & Wadley, L. 2019. Temporal perspectives on Still Bay point production at Sibudu Cave, KwaZulu-Natal, in the context of southern Africa. Azania: Archaeological Research in Africa, 54(2): 141-176.
Lombard, M., Wadley, L., Deacon, J., et al. 2012. South African and Lesotho stone Age sequence updated (I). South African Archaeological Bulletin, 67(195): 123-144.
Lombard, M., Wadley, L., Jacobs, Z., et al. 2010. Still Bay and serrated points from Umhlatuzana rock shelter, Kwazulu-Natal, South Africa. Journal of Archaeological Science, 37(7): 1773-1784.
Lotter, M.G., Caruana, M.V. & Lombard, M. 2022. The large cutting tools from Wonderboom, South Africa. Lithic Technology, 47(2): 117-132.
Lotter, M.G., Lombard, M. & Caruana, M.V. 2024. Wonderboom, South Africa: An Acheulean workshop with evidence of flake harvesting. Archaeological and Anthropological Sciences, 16(11): 1-22.
Mackay, A., Ames, C.J., McNeil, J.L., et al. 2022. Reconstructing Middle Stone Age mobility patterns from raw material transfers in South Africa's Still Bay (77-70 ka) technocomplex. Archaeological and Anthropological Sciences, 14(1): 14.

Mackay, A., Hallinan, E. & Steele, T.E. 2018. Provisioning responses to environmental change in South Africa's winter rainfall zone: MIS 5-2. In: Robinson, E. & Sellet, F. (eds) Lithic Technological Organization and Paleoenvironmental Change: Global and Diachronic Perspectives: 13-36. Cham: Springer International Publishing.

Mackay, A., Orton, J., Schwortz, S., et al. 2010. Soutfontein (SFT)-001: Preliminary report on an open-air site rich in bifacial points, southern Namaqualand, South Africa. South African Archaeological Bulletin, 65(191): 84-95.

Mackay, A., Stewart, B.A. & Chase, B.M. 2014. Coalescence and fragmentation in the late Pleistocene archaeology of southernmost Africa. Journal of Human Evolution, 72: 26-51.

Mason, R.J. 1957. The Transvaal Middle Stone Age and statistical analysis. South African Archaeological Bulletin, 12(48): 119-137.

Mason, R.J. 1959. Later Pleistocene stratigraphy in the Transvaal and its relation to the East African sequence. South African Archaeological Bulletin, 14(53): 3-8.

Mohapi, M. 2013. The Middle Stone Age point assemblage from Umhlatuzana rock shelter: A morphometric study. Southern African Humanities, 25(1): 25-51.

Mourre, V., Villa, P. & Henshilwood, C.S. 2010. Early use of pressure flaking on lithic artifacts at Blombos Cave, South Africa. Science, 330(6004): 659-662.

Rutherford, M.C., Mucina, L. & Powrie, L.W. 2006. Biomes and bioregions of southern Africa. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia, 19: 30-51.

Porraz, G., Texier, P.J., Rigaud, J.P., et al. 2008. Preliminary characterization of a Middle Stone Age lithic assemblage preceding the 'classic' Howieson's Poort complex at Diepkloof rock shelter, Western Cape Province, South Africa. Goodwin Series, 10: 105-121.

Porraz, G., Val, A., Tribolo, C., et al. 2018. The MIS 5 Pietersburg at Bushman Rock Shelter, Limpopo Province, South Africa. PLoS ONE, 13(10): e0202853.

Robbins, L.H., Murphy, M.L., Brook, G.A., et al. 2000. Archaeology, palaeoenvironment, and chronology of the Tsodilo Hills White Paintings rock shelter, northwest Kalahari Desert, Botswana. Journal of Archaeological Science, 27(11): 1085-1113.

Sackett, J.R. 1982. Approaches to style in lithic archaeology. Journal of Anthropological Archaeology, 1(1): 59-112.

Sackett, J.R. 1986. Style, function, and assemblage variability: A reply to Binford. American Antiquity, 51(3): 628-634.

Sampson, C.G. 1974. The Stone Age Archaeology of Southern Africa. New York: Academic Press.

Taylor, N. 2021. Lupemban. Oxford Research Encyclopaedia of Anthropology. Available from: https://doi.org/10.1093/acrefore/9780190854584.013.36 (Accessed 2025).

Taylor, N. 2022. Riddles wrapped inside an enigma. Lupemban MSA technology as a rainforest adaptation: Revisiting the lanceolate point. Philosophical Transactions of the Royal Society B, 377(1849): 20200484.

Timbrell, L., de la Peña, P., Way, A., et al. 2022. Technological and geometric morphometric analysis of 'post-Howiesons Poort points' from Border Cave, KwaZulu-Natal, South Africa. Quaternary Science Reviews, 297: 107813.

Tucker, R.F., Viljoen, R.P. & Viljoen, M.J. 2016. A Review of the Witwatersrand Basin: The world's greatest goldfield. Episodes, 39(2): 105-133.

Val, A., de la Peña, P., Duval, M., et al. 2021. The place beyond the trees: Renewed excavations of the Middle Stone Age deposits at Olieboomspoort in the Waterberg Mountains of the South African Savanna Biome. Archaeological and Anthropological Sciences, 13(7): 116.

Villa, P., Soressi, M., Henshilwood, C.S., et al. 2009. The still bay points of Blombos Cave (South Africa). Journal of Archaeological Science, 36(2): 441-460.

Vogelsang, R., Richter, J., Jacobs, Z., et al. 2010. New excavations of Middle Stone Age deposits at Apollo 11 Rockshelter, Namibia: Stratigraphy, archaeology, chronology and past environments. Journal of African Archaeology, 8(2): 185-218.

Volman, T. 1984. The early prehistory of southern Africa. In: Klein, R.G. (ed.) Southern African Prehistory and Palaeoenvironments: 361-395. Boston: AA Balkema.

Wadley, L. 2005. A typological study of the final Middle Stone Age stone tools from Sibudu Cave, KwaZulu-Natal. South African Archaeological Bulletin, 60(182): 51-63.

Wadley, L. 2007. Announcing a Still Bay industry at Sibudu Cave, South Africa. Journal of Human Evolution, 52(6): 681-689.

Wadley, L. 2012. Two 'moments in time' during Middle Stone Age occupations of Sibudu, South Africa. Southern African Humanities, 24(1): 79-97.

Wadley, L. 2015. Those marvellous millennia: The Middle Stone Age of southern Africa. Azania: Archaeological Research in Africa, 50(2): 155-226.

Way, A.M. & Hiscock, P. 2021. The evolution of Still Bay points at Sibudu. Archaeological and Anthropological Sciences, 13(7): 122.

Wroth, K., Tribolo, C., Bousman, C.B., et al. 2022. Human occupation of the semi-arid grasslands of South Africa during MIS 4: New archaeological and paleoecological evidence from Lovedale, Free State. Quaternary Science Reviews, 283: 107455.

Wurz, S. 2021. Technocomplexes and chronostratigraphy for MIS 6-1 in southern Africa. South African Journal of Geology, 124(4): 1083-1092.

Southern African Field Archaeology
2025 Vol. 20: Article 3653 with Corrigenda [https://doi.org/10.36615/safa.21.4959.2026]
Research report (peer-reviewed): Received November 2024; Revised July 2025; Published September 2025
DOI: https://doi.org/10.36615/safa.20.3653.2025

ISSN 1019-5785
ISSN 2789-1844

A cave with agency: Ochre, blood and women at Keurbos 4

Emily-Jane Vowles [a,]* & John Parkington [b,]*

[a]Heritage Western Cape, Department of Cultural Affairs and Sports, Cape Town City Centre, 8000, Cape Town, South Africa
[b]Archaeology Department, University of Cape Town, Private Bag, Rondebosch, 7700, Cape Town, South Africa
**Corresponding author email: emily.vowles@westerncape.gov.za/john.parkington@uct.ac.za*

ABSTRACT
Keurbos 4 is a located on the Rondegat River in the Western Cape Province of South Africa. Rich in painted imagery, it is distinctive for several reasons. Its morphology and position atop a steep incline offer views from inside looking out, but not outside looking in, and afford a level of inaccessibility and seclusion. Within the cave, the rockface is pigmented by a prominent geologically formed red smear and, whilst having little by way of Later Stone Age domestic content, has a notable painted assemblage. The assemblage is predominated by female figures, particularly rows of splayed-legged, squatting or crouching figures shown in the front-facing perspective with one arm extended towards the groin. Alongside these squatting women are an elephant herd, and a series of parallel vertical lines of geologically formed and applied ochreous pigment. Given the location, morphology, geology, and painted contents of the site, we suggest that Keurbos 4 was a place chosen by women for women in the context of ritual and didactic events. Further, we believe the transformation of the space into this place is accompanied by an invoking of agency from the cave, which was far from a passive accident and much more an active participant.

Keywords: rock art, placemaking, ritual, gender, performance

1. Introduction

"Places not only are, they happen" (Casey 1996: 13).

In this article we address the identification of painted themes and of painter identities and motives in Holocene rock paintings at one of the sites at Keurbos along the Rondegat River in the northern Cederberg, Western Cape (Fig. 1) (see also Van Rijssen 1980: 65-74; Solomon 1995: 169-173). More specifically, we argue that this site, labelled Keurbos 4 in our surveys was, on several occasions, a place where paintings were made by women, about women and for women with didactic intent (Solomon 1992, 1995). In pursuing this objective, we consider the location of the cave in the landscape, the hypothesised **feel** of the cave for those painting, the minimal signs of domestic occupation at the cave and the character of some of the painted imagery. As did Van Rijssen (1980) and Solomon (1995) we conclude that this was an opportunity for women to engage in secluded, gendered behaviours that relate to the dynamic concept of womanhood that appears to be the prevailing thematic scheme around which the rock art at Keurbos 4 is structured: the theme may have incorporated instruction and guidance from older to younger women. We recognise that there were likely many motivations behind the million or so images distributed across the Folded Mountains of the Western Cape that were produced across many millennia.

As we have explained elsewhere (Parkington & Alfers 2022; Parkington & Paterson 2022) and following the lead of Martin Porr (2018) in his study of Australian Aboriginal art, we consider the paintings of the Northern Cederberg through a phenomenological lens; a lens that allows us to extract the meaning of things (phenomena) from the way people experienced them We apply this lens while considering the relational ontological lens through which the San experienced this place. Through this lens the boundaries of being appear undefined and indefinite, and all forms and phenomena lack independent existence outside of their interactions and relations with each other. As others have done elsewhere, we expand the suggestions of Mathias Guenther (2015) that the San painters of the area experienced the landscape in ways that differ from recent rock art recorders and archaeologists. Most importantly, this difference lies in their belief in ‘other than human persons’, a materialisation of their relational rather than classificatory approach to the empirical world and the way it is perceived to work. Binaries including nature/culture and animal/human were blurred (cf. Solomon 1995: chapter 3, 1997) so that a leather bag made from a steenbok skin remained a steenbok as well as a bag, a cloak made from an eland remained an eland as well as a cloak (Parkington & Paterson 2022), and an elephant may be **at the same time** a person (Parkington & Alfers 2022). Such ideas were introduced into archaeology as the new animism (Bird-David 1999; Dowson 2007; Low 2014; Guenther 2015), and encourage us to rethink relations between people, animals, plants and other, to us inanimate, natural, phenomena. In this ‘other’ we include rock shelters and argue that this shelter actively participated in the events that took place there (e.g., Solomon 1997; Morris 2022).

Figure 1. The location of Keurbos 4 (a) within the context of the Western Cape; within the context of the West Coast and Cederberg areas (b); and within the context of the Rondegat River valley (c).

To better understand the behaviours of past forager San people, we accept that we should ask how they experienced the environment in which they lived, looking for lived experiences and probing how painters saw themselves in their world alongside other beings and contexts (see Solomon 1997: 58-59, 71-72). San ethnographies, as well as those from hunter-gatherer groups across the globe, support the idea that this is what indigenous groups have been explaining to Western recorders for some time (Hallowell 1960; Martin 1987); this should surely shape our analyses of the archaeological record? In light of this we focus on the crucial differences between a **site** as a location where we find this record and a **place** as a location given meaning by dwelling (*sensu lato*) and giving meaning to dwelling (to use Ingold’s [2000] term). Hence Martin Porr can use the phrase “Australian Aboriginal enactment of landscape” (2018: 396) and we can expand (or contract?) this here to the San ‘enactment of place’. Using Collingwood’s (1946) phrasing we seek to re-enact the past at a place that we call Keurbos 4, a painted cave with a suggestive geomorphology and some very specific and repeated rock painting images.

Porr (2018) contrasts the **storied** knowledge of Aborigines with the **classificatory** knowledge of Western science and urges us to seek these stories. The implication of a posited relational ontology is that we can investigate and hypothesise what a place can **do**, as well as simply what people can do at a place. Once a place has evolved meaning through dwelling it can preserve and give it back, acting on people with agency. “In effect, there is no place without self and no self without place” (Casey 2001: 684). We seek to understand what that agency might have looked and felt like for the painters at Keurbos 4.

2. Images, events and representation: the enactment of place

Images on cave walls have obviously not moved since they were painted: they are where they were intended to be, and we may ask why their place should not be as significant as their time and their form (Solomon 1997: 59). This question is as important at the small scale (where the image is in the site) as at a larger one (where the site is in the landscape). If images have to be where they are, we may ask why and what is significant about that place, as Solomon (1995: 173) argues was the case at Keurbos 4. Does the image sometimes, or in some sense, reflect an occasion, or occasions, with relevance to that place? What, we can ask, is the connection between image, place and event? Whilst difficult, attempts to understand these relationships are facilitated by improved levels of detail from enhanced imagery, digital mapping of sites along with their surroundings, and the development of virtual reality models (Wessels et al. 2023). We now have the capacity to re-imagine landscapes as they were made by painters by fixing memories of place and occasion.

The stability of the place-to-painting relationship encourages us to look for the nature of that relationship in the lasting character of the place. In effect we seek to add practice to place and painting. Why are **these** paintings there and not **somewhere else**? And, what is it that has made **this place** appropriate for **these paintings**? This largely means understanding the feel of Keurbos 4, envisaging possible responses to its ambience and, as we argue later, its personality.

3. Site and place

There are many painted caves and rock shelters in the valley of the Rondegat River, a substantial east bank tributary of the Olifants River, but no other has such a steep, difficult approach as does Keurbos 4 (Fig. 2).

Figure 2. Looking across the mouth of Keurbos 4 to the right, with the steep slope down to the Rondegat river on the left.

All others are relatively easily accessible. Nor are many of the other sites so secluded in the sense of being shielded from the public gaze, yet with such a commanding view across the Rondegat topography. Any actions inside the cave would be private.

The overhang faces east-southeast, is long at 22 metres along the dripline, but shallow, only about 6 metres from the drip line to the rear wall (Fig. 3) Paintings are distributed across the whole width of the cave, but mostly at the right hand (looking in), northern end (encircled in white in Fig. 3), with few or no examples of superpositioning. Preservation of paint is reasonable, though residual, and not all images are easy to resolve or differentiate even with photographic enhancement. The result is a good deal of uncertainty about image outlines, making it difficult to offer a clear list of subject matter.

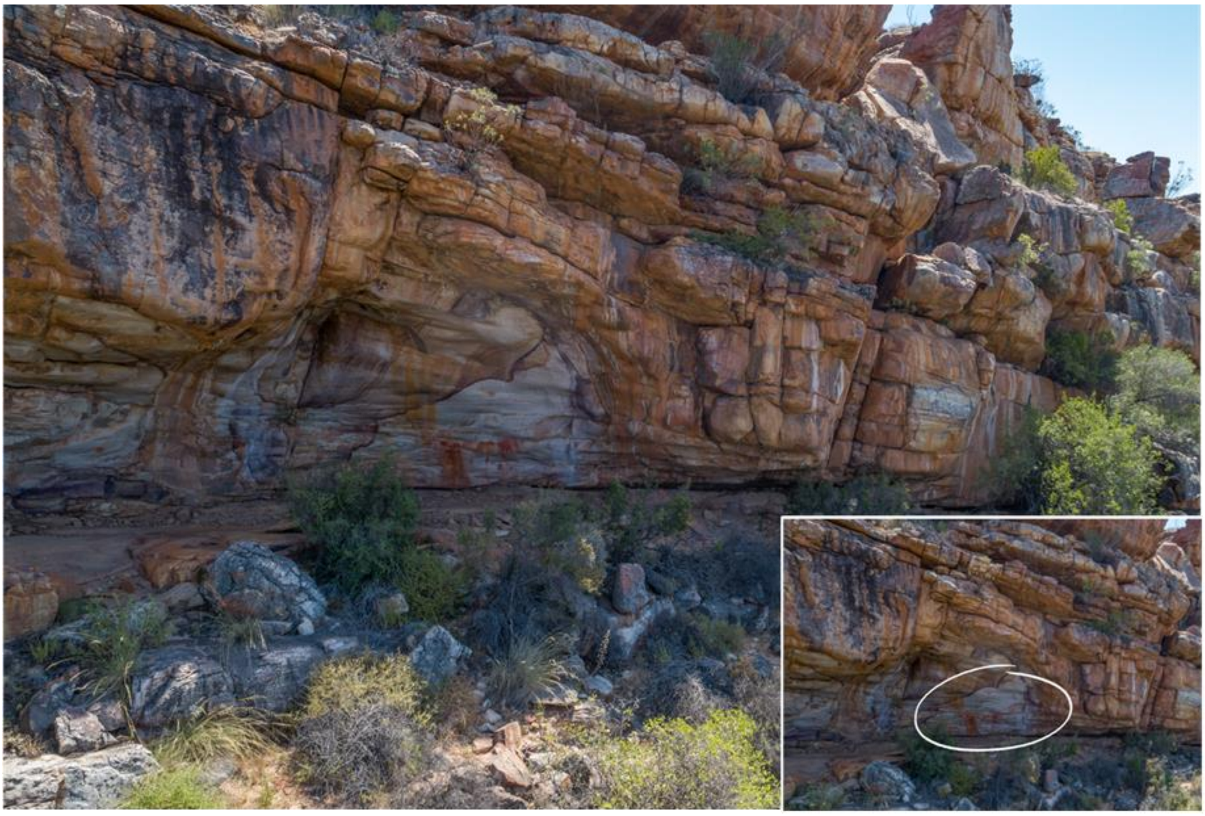


Figure 3. Cavewide view of the width of Keurbos 4. The northern end of the cave where the majority of images have been painted is encircled in white in the bottom right image.

The floor of the cave is a mix of loose, superficial sand overlying a rocky bedrock exposure with almost no sign of excavatable deposit and no traces of hearths or bedding patches. A previous recorder (Van Rijssen 1980) identified a broken bored stone from the cave, on which there are signs of two ostrich eggshell bead-shaping grooves. Bead making was an important contribution to San communities, a contribution made primarily by women, alongside plant food gathering aided by weighted digging sticks. There is no suggestion either inside the cave or below the cave on the talus slope that artefacts or other domestic debris have been deposited but failed to survive inside, and no dripline concentration of flaked stone artefacts. Inspection of the cave floor has revealed only a very small assemblage of flaked stone tools, with almost all of them likely of quartzite Middle Stone Age character. The implication is, we believe, that this place has been occasionally, almost certainly repetitively, used for painting but, in the late Holocene at least when Later Stone Age tools and rock paintings might have been expected, was very rarely used for domestic activities of any duration. The evidence suggests that this is a site to which people came to paint, perhaps because there were other domestic alternatives closer to the stream below. Our objective is to describe the place-making behaviours that changed the location into a particular place, perhaps a persistent place (*sensu* Schlanger 1992).

Of course, the morphology of every cave is different, a particular outcome of geological events that shaped the form, appearance and potentials for would-be painters. Keurbos 4 is no exception and presents a canvas with a very specific set of physical aspects and affordances. Following a phenomenological path, we would like to understand the response of a painter or painters to these prompts and to propose the **feel** of the site. Considering that the canvas is never neutral, how did painters experience the physical location and turn it, by painting, into an experienced place?

The area to the right of the cave offers a naturally uncoloured, smooth surface while to the left you find smaller, rougher, more disconnected patches of surface (points A and B in Fig. 4, respectively). Dividing these two distinct areas is a prominent vertical crack in the rock, visible in Figure 3, that extends from the cave roof overhang down to the ground where water follows a natural gravitational route. Vegetation grows in this crack. Dominating the cave wall, is a red internal feature of the rock that appears to flow down and away from either side of the crack (point C in Fig. 4). While we recognise this to be a natural feature of the bedrock caused by variations in sedimentary mineralogy, now exposed, this red colouration manifests as a very substantial smear of natural pigment. It is redder and thicker at the leading edge and flows almost tangibly across the rock surface, rather like a painted feature. Internal to the smear are sets of parallel red lines characteristic of Cederberg quartzites, locally and superficially hard to distinguish from painted red lines.

Figure 4. An internal view of the most densely painted portion of Keurbos 4 with the relevant points (a-c) indicated; uncoloured, smooth surface (a); smaller, rougher, more disconnected patches of surface (b); natural red colouration of the rock that appears as a 'smear' and the parallel red lines within (c).

How would this feature have been understood, explained, and perhaps utilised by people contemplating contributing their own imagery to the canvas? Painters experienced the landscape through a relational ontological perspective in which distinctions were not made between animate and inanimate, natural and cultural, living and non-living, and similar binaries that we might ourselves entertain (Guenther 2015). For San painters this was a living canvas, part of a living landscape and as agential as any other element contributing to this landscape (see for example, Riley 2007).

Red iron oxide stratified colourations, usually sets of linear parallel lines in the rock, are fairly common in this region, but this configuration is meaningful in our experience. We suggest that painters were influenced by this very noticeable feature whilst they were in the cave and painting because of the impression it gives of flowing blood. As Janette Deacon notes in her seminal paper on the *Power of a place* when quoting from an Australian parallel: "Rapoport (1975: 49) has expressed the concept of meaning and places in Australian Aborigines' beliefs as the congruence of natural features and mythical structures to humani[s]e the landscape" (1988: 138). Both she in the /Xam homeland and David Morris, describing the context of rock engravings on the bed of the Riet River at Driekopseiland (Morris 2022), refer to the active participation of natural features in the development of mythical narratives that enable and enrich ritual and life history practices. As Morris continues "strands from /Xam oral literature and historical sources indicate the way in which landforms embody or give substance to myths and legends" (Morris 2022: 256).

4. Place and painting

Within Keurbos 4, paintings are predominantly placed to the right of the red geological smear on the uncoloured surface while none seem to engage with or directly respond to this natural feature. They include, but are not limited to, human figures, elephant figures, intentional or unintentional paint runs, intentional paint smears, and intentional, short painted lines (Points A, B, C, D and E, respectively, in Fig. 5).

Figure 5. An internal view of the most densely painted portion of Keurbos 4; examples of the squatting figures (a); the herd of elephant (b); the paint 'runs' (c); an example of the paint smears (d); short lines suggested to be a 'tally' (e).

The human figures at Keurbos 4 (exemplified in Points A1-A4 in Fig. 5) are scattered and varied in posture, but arguably include only one (out of about 30) possibly anatomically male individual (contra Solomon 1995: 169, 183), painted in a very unusual cartwheeling posture; all the remaining figures appear to be female. Significantly, almost half of these female figures are organised into five rows across the site and are painted in a highly standardised form (Fig. 6).

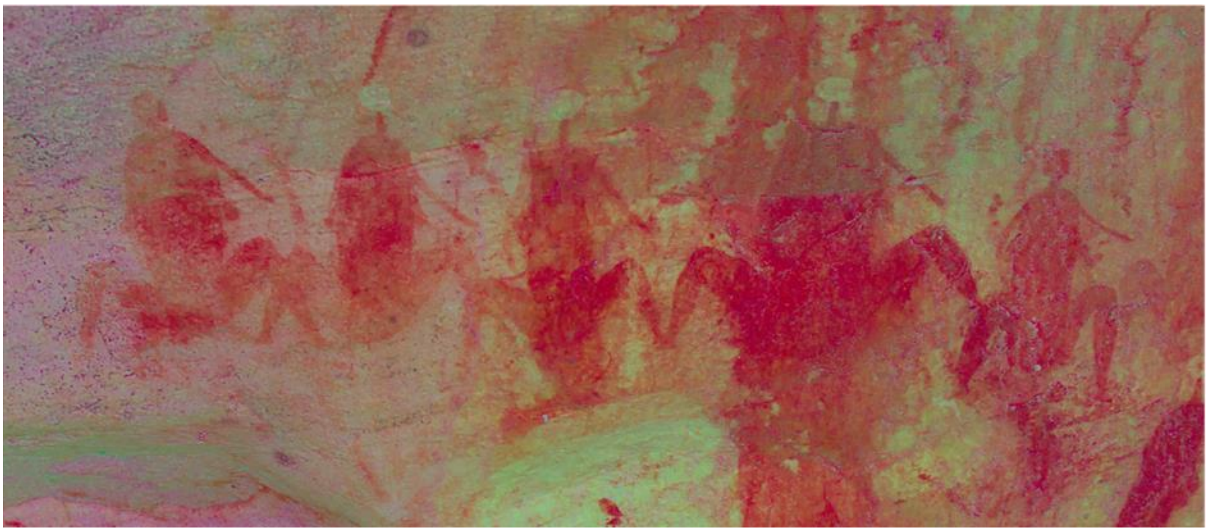


Figure 6. A row of squatting (the predominant standardised form) women enhanced by D-Stretch CRGB with breasts on either side of their torsos, one arm directed towards the groin, and the other extended outwardly from the body.

They appear as front facing, squatting or crouching, with their legs parted. They are almost all clearly (some more faintly) anatomically female due to the presence of breasts depicted on either side of the torso, and with one arm, their right one, shown reaching down toward the groin, the other outstretched left (the viewer's right) of the torso at about 30° to 40° (Fig. 7).

Paintings of this form have previously been linked to the 'mythic women' concept proposed by Anne Solomon (1994, 1995, 1996), following Elisabeth Goodall's (1962) lead. Having been earlier recorded by WJJ (Bill) Van Rijssen (1980), Vowles (2021: 27) notes:

> Solomon identifies a possible 12 mythic women figures at Keurbos, identifiable as anthropomorphs unusually depicted in the frontal perspective, with splayed legs and raised arm/s, and the possible inclusion of a combination of other characteristics such as steatopygia, holding a stick, bow, or crescent-shaped object aloft, and genital emissions or genital emphasis (Solomon 1995).

Probably because she was referring to a geographically widespread set of imagery with examples from Zimbabwe, the Drakensberg as well as the Western Cape, Anne Solomon rightly spent some time justifying the coherence of the group of mythic women, not least the issue of whether all are female. We suggest that hers was a polythetic set (Clarke 1968) in which several variables play a role in category definition but none of them on their own define or exclude membership (Needham 1975). As Solomon (1995: chapter 7) found, the complications faced are far fewer when reference, as here, is only to the Keurbos 4 images, where none are male, none are armed, none carry objects in the hand and none have lines or streams emanating from the groin, although there may be paint smears below the groin on some figures (see illustrations in Solomon 1995: figs 9-41). Solomon (1995: 132, tables 3 & 4) placed the Keurbos images in Group B of her "mythic women proper" category. Our intent here is to refer to the coherence of what we, following Van Rijssen (1980: 66) and Solomon (1995: 170), have informally called 'squatting women' at Keurbos 4 and to delay comment on how widespread and how variable the group might become if we extend our attention across the Cederberg, southern Africa, or even more widely (Sutterlin 1989; Garlake 1995; Chaloupka 1999; Hodder 2010). In our view this near global ubiquity of front-facing female squatting (*sensu lato*) figures reflects the near universality of ritual associations of female genitalia and their extension to gendered approaches to ritual seclusion and avoidance rules. There are other squatting figures in nearby northern Cederberg painted caves, perhaps 25 known so far, but nowhere else is there a duplicated concentration at a single site such as at Keurbos 4. We suggest that these squatting women reflect actual, living women, their gendered experiences, and the ontologies through which they structured their womanhood (see Solomon 1995: 173, chapter 9).

These squatting women were painted in such a manner so as to draw attention to the groin and, by extension, to associations with female genitalia (Van Rijssen 1980: 66; Solomon 1995: 172). These associations include menstruation, sexual intercourse, pregnancy and birth and their relationship with notions of womanhood. Choice of posture, orientation toward the viewer, preference for a stationary perspective and insistence on female identity contribute to an apparent communicative or instructional intent. These are, at least at one level, props for use in verbal instruction and education. Established women used these intentionally private opportunities to impart their experience and knowledge onto menarcheal women while they were in the process of coming to terms with their newfound womanhood and the cultural association therein. The very variable body morphologies within this coherent set, perhaps even within a single row (Figs 6-8), leads us to suggest revisitation of the site on a number of occasions, and multiple painting events and multiple painters informed by the same, pedagogic, intent (cf. Solomon 1995: 172-173).

As is demonstrated by the preponderance of female figures, we suggest that Keurbos 4 was a place dedicated to female ritual (Van Rijssen 1980: 72; Solomon 1995: 173). The likelihood of separate and isolated male and female ritual initiation spaces among San groups is well supported in the ethnographic and ethno-historic literature (e.g., Schapera 1930; Hewitt 1986; Barnard 1992). In a region marked by rock outcrops and numerous caves and shelters, we suggest that these secluded spaces were designated for use by sexually segregated subgroups as the locations for ritual events. Such scenarios would accord well with events described among San groups further afield (e.g., Viestad 2018). That they were not described locally by early colonial observers at the Cape may well be a function of the isolation of the area and the subsequent speed of social destruction (Parkington & Paterson 2021; Parkington & Alfers 2022).

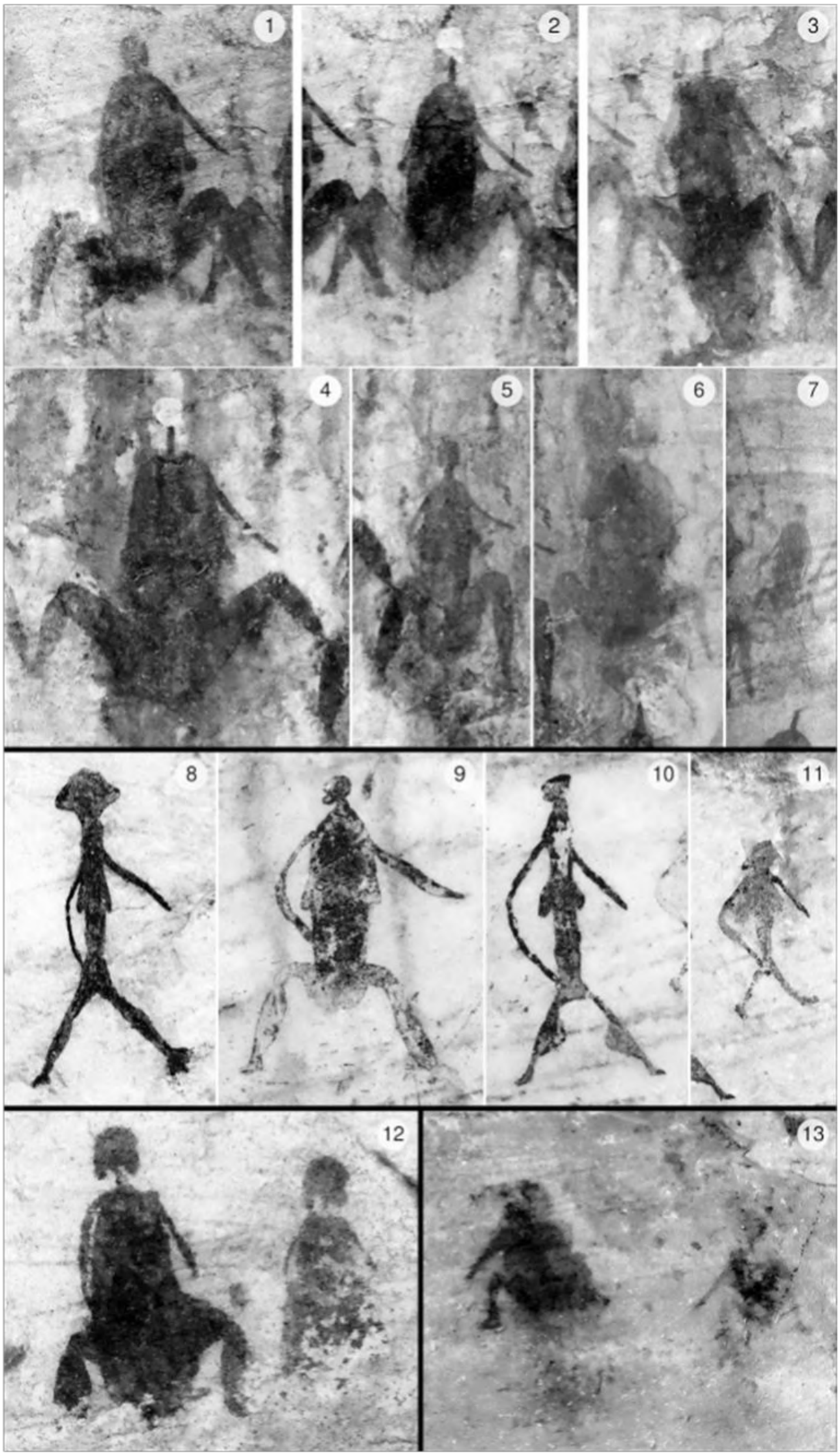


Figure 7. A black and white composite of the splayed-legged women from across the Keurbos 4 painted imagery.

Figure 8. A row of three splayed-legged women showing significant variation in body morphology while in the same position.

Just below the red, geological discolouration of the cave there is a prominently placed group of about 11 elephants (some distinctions are not clear) (Point B in Fig. 5; see Figs 9 and 10). They are all painted to face the right, and the inclusion of presumably adult, sub-adult, juvenile and infant individuals, based on their size in juxtaposed positions within the painted herd, suggest that it is a domestic, matriarch-led group. As we have explained elsewhere (Vowles 2021), within San ontologies there is a conflation of women with elephants (Solomon 1995: 170, 172). One such conflation allows women and elephants to be meat but not the meat that you eat. Ontologically, women were the equivalent of herbivores and prey, while men were carnivores and hunters who kill and eat this prey, where hunting is conflated with courtship and sex with eating (Biesele 1993). Fables from the mythopoeic time where society was not yet differentiated into people and animals warned against men confusing the meat they marry with the meat they eat. As we have detailed elsewhere (Vowles 2021), amongst the Ju/'hoansi, these fables often revolve around the elephant-girl; a character who is both elephant and girl, eaten by her husband when he confuses her with meat (Biesele 1993). The San continued to view the elephant as meat one cannot eat due to their ontological conflation with women and the recognition of physical and behavioural similarities between them (Biesele 1993).

Additionally, both women and elephants have a similar relationship with rain. Rain animals, typically large herbivores like elephants, are metaphorically slaughtered for the spilling of their blood ushers in the spilling of the rain (Bleek 1933). Women, specifically pubescent, menstruating and pregnant women, had a similar potency. "The menstruating woman, in /Xam mythology, produces blood imbued with potency similarly to that of the rain-animal whose blood must be spilled to produce desirable rain (Bleek 1933)" (Vowles 2021: 40; also Solomon 1989 [e.g., 46, 71, 72, 102; 1992: 297, 298, 313], 2019). Due to the centrality of the mother-child relationship to the organisation of their respective societies, the San also revered women and female elephants for their child-rearing capacities (Parkington & de Prada-Samper 2021; Vowles 2021). As the latter author concludes, the conflation of women with elephants throughout San ontologies suggests that the elephant imagery at Keurbos 4 may contribute to a gendered intention for the painted assemblage.

The elephants and female figures are painted alongside three distinguishable types of vertical imagery. The first are paint 'runs', which may be unintentional and the result of too much pigment being applied to the surface of the cave, or its consistency being too thin (Fig. 9). The second are intentional finger-width smears of pigment, some of which are juxtaposed over other imagery (Point D in Fig. 5). And the third are intentional, short, somewhat perpendicular, finger-width lines (Point E in Fig. 5). The addition of this vertical, red imagery may contribute to the gendered associations of rain and blood established within the cave by the female figures and elephants. We posit that the short lines may be tally marks which suggests a counting motive. Both the menstrual cycle and gestation period are structured by the measurable passing of time. The menstrual cycle is typically 30-days long with significant fertile and infertile phases, while the gestation period is 9-months long. The tallies may reflect the counting of the days and months associated with these two physiological cycles in response to gendered understandings of time and its quantification (see for example, Solomon 1995: 178-182).

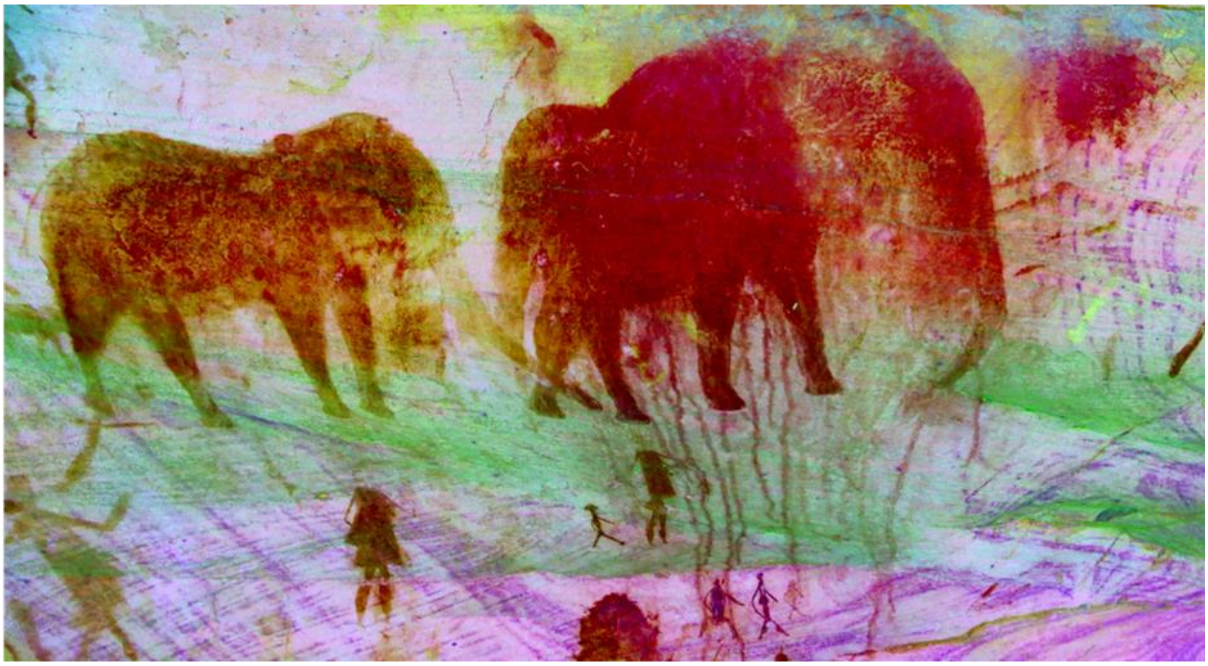


Figure 9. Two elephant figures enhanced by D-Stretch CRGB. Note the paint runs coming from the elephant on the right.

Figure 10. Two elephant figures, above a row of elephant figures, enhanced by D-Stretch CRGB. Note the variability in size and the juxtaposed positions.

5. Discussion: Living landscapes and the agency of the cave

David Morris has wrestled with the meaning of the rock art-place relationship (Morris 2022), in his case the rock engravings at Driekopseiland on surfaces in the bed of the Riet River (see also Solomon 1995: 189-190). We quote Morris here (2022: 257, 258, 262):

> Through the lens of a relational or new animist perspective (Bird-David 1999), the interpretation [Morris here refers to his 2002 dissertation] proposed that Driekopseiland, as a powerful place (Deacon 1988), was a site used in rituals, arguably those specifically linked with the "new maiden", who according to ǂKamme-an, mother of Dia!kwain, possessed "the rain's magic power" (Lewis-Williams 2000: 273). It was proposed that the place itself became an active element in the rites, no longer as mere physical space but indeed becoming a virtual subject in itself, as Michael Houseman (1998) would argue with reference to the redefinition of social personhood that initiation entails.
>
> One of the conclusions of the new interpretation of Driekopseiland was that a metaphorical understanding of landscape and a relational appreciation of how particular places may take on a form of emergent personhood – and the possibility that different parts of the landscape could vary in ritual significance (hilltops in different assemblages associated with rain-making rites, for instance) – may be factors more germane to the questions of variability in the rock art here than the repeated attempts to work out the ethnic and cultural affinities of the engravings.
>
> Houseman (1998: 461), cited earlier, writes of the way particular places in landscapes become powerful adjuncts in rites of passage, becoming no longer mere objects, but virtual subjects themselves. It is not that rituals create the links between individuals and places, Houseman emphasises, for initiates would already know the landscapes in which they live. Rather, the rites, as emotionally laden haptic events, re-contextualise the pre-existing links, instituting particular locations as depositories of "social personhood" (Houseman 1998).

Morris and Houseman introduce place as a participant in ritual, imbuing it with personhood. This coincides with our reading of the existential feeling of Keurbos 4 as a place and our suggestion here of the lived experiences of women in the cave (Ingold 2000). That this phenomenological and ontological perspective on enacting the place and the landscape was one held by San, in this case /Xam, people is supported by an oft-quoted poem/song offered by Dia!kwain to Lucy Lloyd in July 1875 included below. The poem/song repeats the words "feel" and "place" in reference to each other in a manner that suggests that a place has a "feel" as equally as people impart feeling to a place (Bleek & Lloyd 1911: 236-237 original lineation):

> The Broken String
> People were those who
> Broke for me the string.
> Therefore,
> The place became like this to me
> On account of it
> Because the string was that which broke for me.
> Therefore,
> The place does not feel to me
> On account of it.
> For,
> The place feels as if it stood open before me
> Because the string has broken for me.
> Therefore,
> The place does not feel pleasant to me
> On account of it.

6. Ochre, blood and ritual

The nexus of our argument for repetitively held events at Keurbos 4 focused on and for women, and their menstrual rituals, lies in the symbolic connection between ochre (haematite) and blood (haemoglobin) and the requirements of seclusion, intimacy and privacy. In an intellectual lineage stretching back to Durkheim (1915), in the wider evolutionary sense this nexus has been argued forcibly by Watts (2009) and his colleagues (Knight 2009; Power 2009) who have shown that San conceptually link the blood of women's menstruation with the blood of a hunting kill (Solomon 1992: 313-316). This linkage leads to a wide range of prohibitions and observances relating to the dangers of menstruating and menarcheal women for active hunting males.

The Bleek and Lloyd literature associates powdered ochre with the activities of the new maiden, reliably thought to be a newly menstruating young girl, who is isolated, particularly from men of the age to participate in hunting, and who is cared for by the other mature women in the group. In Hewitt's words (1986: 281), on her release from isolation she:

> Had to treat all the members of her household with buchu and give the women of the band red haematite with which they were to paint their cheeks and decorate their *karosses*. She was also expected to paint haematite stripes 'like a zebra' on the young men of the band to protect them from death by lightning caused by !Khwa (a mythical water being or, in some views, the animated water itself [de Prada Samper 2018]).

He goes on to say that "apart from the treatment of members of the band, the water source in current use also had to be thoroughly sprinkled with powdered haematite to appease !Khwa, who, it was believed, might cause the pool to dry up completely" (Hewitt 1986: 281). !Khwa took a special interest in new maidens who had to be extremely careful not to anger this potent force. These observances underline the intimate connections thought to link menstruants, blood, ochre, and the potency of rain and water.

The underlying structures of these menstruation rituals, we argue, are privacy, intimacy, female social cohesion and the presence of ritual danger. In a topographic circumstance differing from that of the flat, arid karoo of the /Xam, we might expect women to take advantage of the availability of an isolated and very private cave, as Van Rijssen suggested (1980). A cave naturally exhibiting strong haematite-like, seemingly artificial, but actually geological, mural patterns of red colouration might have been particularly appropriate for the locating of ritual events, with the place itself acting in the way Houseman (1998) and Morris (2022) describe above.

We therefore suggest that the secluded locality of Keurbos 4 and the preponderance of female-associated imagery therein are related to the pigmented rockface. With the rockface being naturally imbued with blood-like stains that could be conceptually referential to the lived experiences of woman and concepts of womanhood, where "…the canvas itself may have attracted San women as they sought a secluded and sheltered site in which to produce art meant only for themselves and generations of women to come" (Vowles 2021: 43). In this light, we view the women as actual, living women rather than mythic, seemingly involved in repeated ritual of a gendered nature, situated in a place embedded with a feel. And that place could only be Keurbos 4 as "places not only are, they happen" (Casey 1996: 13).

Acknowledgements
We are very grateful to Royden Yates and Stephen Wessels for advice and help with the visualisation and interpretation of the Keurbos 4 imagery. Heinz Reuther led the original laser scanning initiative, for which we thank him. We recognise the valuable insights drawn by Bill Van Rijssen 40 years ago that were ahead of their time and by Anne Solomon within the 'mythic women' framework. We are grateful to Jeremy Hollmann, David Morris, and an unnamed reviewer for their contributions to this paper and the process.

References

Barnard, A. 1992. Hunters and Herders of Southern Africa. A Comparative Ethnography of the Khoisan Peoples. Cambridge: Cambridge University Press.

Biesele, M. 1993. Women Like Meat: The Folklore and Foraging Ideology of the Kalahari Ju/'hoan. Johannesburg: University of Witwatersrand Press.

Bird-David, N. 1999. "Animism" revisited: Personhood, environment and relational epistemology. Current Anthropology, 40(Supplement): S67-91.

Bleek, D.F. 1933. Beliefs and customs of the /Xam Bushmen: Part V, the rain. Bantu Studies, 7: 297-312
Bleek, W.H.I. & Lloyd, L.C. 1911. Specimens of Bushman Folklore. London: George Allen.
Casey, E.S. 1996. How to get from space to place in a fairly short stretch of time: Phenomenological prolegomena. In: Feld, S. & Basso, K.H. (eds) Senses of Place: 13-52. Santa Fe: School of American Research.
Casey, E.S. 2001. Between geography and philosophy: What does it mean to be in the place-world? Annals of the Association of American Geographers, 91(4): 683-693.
Chaloupka, G. 1999. Journey in Time. Sydney: Reed New Holland.
Clarke, D.L. 1968. Analytical Archaeology. London: Methuen.
Collingwood, R.G. 1946. The Idea of History. Oxford: Oxford University Press.
Deacon, J. 1988. The power of a place in understanding Southern San rock engravings. World Archaeology, 20(1): 129-140.
de Prada Samper, J. 2018. “I have already seen in the clouds”: The nature of the water-creature among the /Xam Bushmen and their modern descendants. Folkloristika, 3(1): 13-37.
Dowson, T.A. 2007. Debating shamanism in southern African rock art: Time to move on. South African Archaeological Bulletin, 62(183): 49-61.
Durkheim, E. 1915. The Elementary Forms of Religious Life. London: George Allen and Unwin Limited.
Garlake, P. 1995. The Hunters Vision: The Prehistoric Art of Zimbabwe. Seattle: University of Washington Press.
Goodall, E. 1962. A distinctive mythical figure appearing in the rock paintings of Southern Rhodesia. In: Mortelmans, G. & Nenquin, J. (eds) Actes du IV Congress Panafricain de Prehistoire: 399-405. Tervuren: Musée Royale.
Guenther, M.G. 2015. ‘Therefore their parts resemble humans, for they feel that they are people’: Ontological flux in San myth, cosmology and belief. Hunter-Gatherer Research, 1(3): 277-315.
Hallowell, A.I. 1960. Ojibwa ontology, behaviour and worldview. In: Diamond, S. (ed.) Culture in History: Essays in Honour of Paul Radin: 19-52. New York: Columbia University Press.
Hewitt, R.L. 1986. Structure, Meaning and Ritual in the Narratives of the Southern San. Quellen zur Khoisan-Forschung 2. Hamburg: Helmut Buske Verlag.
Hodder, I. (ed.) 2010. Religion in the Emergence of Civilization. Cambridge: Cambridge University Press.
Houseman, M. 1998. Painful places: Ritual encounters with one’s homelands. Journal of the Royal Anthropological Institute, 4(3): 447-467.
Ingold, T. 2000. The Perception of the Environment: Essays on Livelihood, Dwelling and Skill. London: Routledge.
Knight, C. 2009. Language, ochre and the rule of law. In: Botha, R. & Knight, C. (eds) The Cradle of Language: 281-303. Oxford: Oxford University Press.
Lewis-Williams, J.D. (ed.) 2000. Stories That Float From Afar: Ancestral Folklore of the San of Southern Africa. Cape Town: David Philip.
Low, C. 2014. Khoe-San ethnography, ‘new animism’ and the interpretation of southern African rock art. South African Archaeological Bulletin, 69: 164-172.
Martin, C. (ed.) 1987. The American Indian and the Problem of History. Oxford: Oxford University Press.
Morris, D. 2002. Driekopseiland and the 'rain's magic power': History and landscape in a new interpretation of a Northern Cape rock engraving site. Masters Dissertation. Cape Town: University of the Western Cape.
Morris, D. 2022. River, rock and ‘the rain’s magic power’: Rock art and memory in the Northern Cape, South Africa. In: Zubieta, L.F. (ed.) Rock Art and Memory in the Transmission of Cultural Knowledge: 245-267. Cham: Springer Nature.
Needham, R. 1975. Polythetic classification: Convergence and consequences. Man, 10(3): 349-369.
Parkington, J. & de Prada-Samper, J. 2021. When elephants were people. In: Abadia, O.M. & Porr, M. (eds) Ontologies of Rock Art: Images, Relational Approaches, and Indigenous Knowledges: 233-244. London: Routledge.
Parkington, J. & Alfers, J. 2022. Entangled lives, relational ontology and rock paintings: Elephant and human figures in the rock art of the Western Cape, South Africa. Southern African Field Archaeology, 17: 1228.
Parkington, J. & Paterson, A. 2022. Cloaks and torsos: Image recognition, ethnography and male initiation events in the rock art of the Western Cape. Azania, 56(4): 463-481.
Porr, M. 2018. Country and relational ontology in the Kimberley, Northwest Australia: Implications for understanding and representing archaeological evidence. Cambridge Archaeological Journal, 28(3): 395-409.
Power, C. 2009. Sexual selection models for the emergence of symbolic communication: Why they should be reversed. In: Botha, R. & Knight, C. (eds) The Cradle of Language: 257-280. Oxford: Oxford University Press.
Rapoport, A. 1975. Australian Aborigines and definition of place. In: Oliver, P. (ed.) Shelter, Sign and Symbol: 38-51. London: Barrie and Jenkins.
Riley, E. 2007. The hunting ground’s doings: /Xam narratives of animals, hunting and the veld. In: Skotnes, P.

(ed.) Claim to the Country: 291-311. Johannesburg: Jacana.
Schapera, I. 1930. The Khoisan Peoples of South Africa. London: Routledge and Kegan Paul.
Schlanger, S.H. 1992. Recognizing persistent places in Anasazi settlement systems. In: Rossignol, J. & Wandsnider, L. (eds) Space, Time and Archaeological Landscapes: 91-112. New York: Plenum Press.
Solomon, A. 1989. Division of the Earth: Gender, symbolism and the archaeology of the southern San. Masters Dissertation. Cape Town: University of Cape Town.
Solomon 1992. Gender, representation, and power in San ethnography and rock art. Journal of Anthropological Archaeology, 11: 291-329.
Solomon, A. 1994. 'Mythic women': A study in variability in San art. In: Dowson, T.A. & Lewis-Williams, J.D. (eds) Contested Images: Diversity in Southern African Rock Art Research: 331-372. Johannesburg: Wits University Press.
Solomon, A. 1995. Rock art incorporated: An archaeological and interdisciplinary study of certain human figures in San art. Doctoral Thesis. Cape Town: University of Cape Town.
Solomon, A. 1996. 'Mythic Women': A response to Humphreys. South African Archaeological Bulletin, 51(163): 33-35.
Solomon, A. 1997. Landscape, form and process: Some implications for San rock art research. Natal Museum Journal of Humanities, 9: 57-73.
Solomon, A. 2019. Rain Stories: Interpreting water beings in the folklore of the southern African Khoisan and their descendants. Folkloristika, 4(1): 193-210.
Sutterlin, C. 1989. Universals in apotropaic symbolism: A behavioural and comparative approach to some medieval sculptures. Leonardo, 22(1): 65-74.
Van Rijssen, W.J.J. 1980. Ways of seeing: Some aspects of the interpretation of rock paintings. Honours Report. Cape Town: University of Cape Town.
Viestad, V.M. 2018. Dress as Social Relations. An Interpretation of Bushman Dress. Johannesburg: Wits University Press.
Vowles, E-J. 2021. Women by women for women: An engendered ontological approach to the gynocentric San rock art of Keurbos. Honours Report. Cape Town: University of Cape Town.
Watts, I. 2009. Red ochre, body painting and language: Interpreting the Blombos ochre. In: Botha, R. & Knight, C. (eds) The Cradle of Language: 62-92. Oxford: Oxford University Press.
Wessels, S., Maape, S., Schoville, B.J., et al. 2023. The drone, the snake, and the crystal: Manifesting potency in 3D digital replicas of living heritage and archaeological places. Archaeologies, 19: 395-429.

Southern African Field Archaeology
2025 Vol. 20: Article 3969
Research report (peer-reviewed): Received February 2025; Revised September 2025; Published November 2025
DOI: https://doi.org/10.36615/safa.20.3969.2025

ISSN 1019-5785
ISSN 2789-1844

Mapping and excavation of the Plaatberg Mission Precinct, Free State, South Africa

Amanda Esterhuysen [a, b, *] & Tamsin Hunt [b]

[a]Archaeology Department, University of Cape Town, Private Bag, Rondebosch, 7700, Cape Town, South Africa
[b]School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, Private Bag 3, Wits 2050, South Africa
**Corresponding author email: amanda.esterhuysen@uct.ac.za*

ABSTRACT
This paper presents the results of an investigation into three structures situated at the centre of the 19th-century Plaatberg Mission Station, in the Free State province, South Africa. First, we locate the study site within the larger Mission Station. Second, excavated data are presented according to spatial context, and then variations within the midden dataset are used to suggest different periods of occupation and missionary presence. Lastly, these findings are interpreted against the broader context of historical events.

ABSTRACT IN SESOTHO
Pampiri ena e phatlalatsa sephetho sa liphuputso tsa likarolo tse tharo tse fumanoeng botebong ba 'mishone oa Plaatberg lilemong tsa bo 1800s. Re qala ka ho hlakisa sebaka sa liphuputso ka hare ho 'mishone ka kakaretso. Ebe seo se lateloa ke lintlha tse epollotsoeng li hlahisoa ka har'a moelelo oa sebaka, 'me ho fapakanngoa ha data e bohareng ho sebelisoa ho totobatsa mekhahlelo e fapaneng ea mesebetsi hammoho le boteng ba baromuoa. Qetellong, liphetho tsena li hlalosoa ka ho bapisoa le moelelo o pharaletseng oa liketsahalo tsa nalane.

Keywords: Platberg, Wesleyan Mission Station, historical archaeology

1. A brief history of the Plaatberg Mission Station

The Wesleyan Methodist Missionary Society (WMMS) was established in England in 1811, with Methodism introduced to the Cape in 1813 by Reverend Barnabas Shaw. By 1832, Methodist centres were established throughout the Western Cape and were steadily expanding northwards into the interior.

The Plaatberg (also known as Platberg) Mission Station was founded in what is now the Free State in 1833 to serve a group referred to as Bastaards or Newlanders. Between 1833 and 1839, five itinerant missionaries passed through before James Cameron brought stability in 1840, overseeing the planning and construction of its physical infrastructure (van Heerden 1993; Esterhuysen et al. 2019). Richard Giddy managed the station from 1845 until 1855 (WMMS 1856), although war between the British and Moshoeshoe left the station largely unoccupied between 1851 and 1853 (Esterhuysen et al. 2019).

In 1854, British sovereignty was withdrawn, and the Vrystaatse Republiek (Free State Republic) was declared (Venter 1960). Over the next 10 years, three different missionaries tried to navigate the conflict between the BaSotho and the Free State Republic. By November 1865, the station was abandoned, and in 1866, the land was subdivided into farms for Boer settlers (Bosch 1967). Plaatberg fell within this 'conquered territory', and when the BaSotho continued to fight to reclaim their land, additional Boer commandos were dispatched to expel them (Bosch 1967; Esterhuysen et al. 2019).

The site

The Plaatberg Wesleyan Mission Station is located within a gorge on the southern aspect of a sandstone escarpment on a farm called Pinekloof (portion 291), 5 km south-west of Ladybrand, and 10 km west of the Caledon River (Fig. 1). Notably, the name Plaatberg or Platberg, despite being an appropriate descriptor of the topography, originates from an earlier Wesleyan Bechuana Mission Station on the Vaal River that was abandoned in 1833 (Broadbent 1865).

This temperate grassland region receives an annual rainfall of between 600 and 750 mm, with most of the precipitation falling during the summer months (Mucina & Rutherford 2006). However, the presence of a perennial spring contributes to the abundant growth of shrubs and trees, including *Buddleja*, *Euclea*, *Olea*, *Leucosidea*, *Rhamnus*, and *Searsia* (*Rhus*) in the deep, sheltered kloofs.

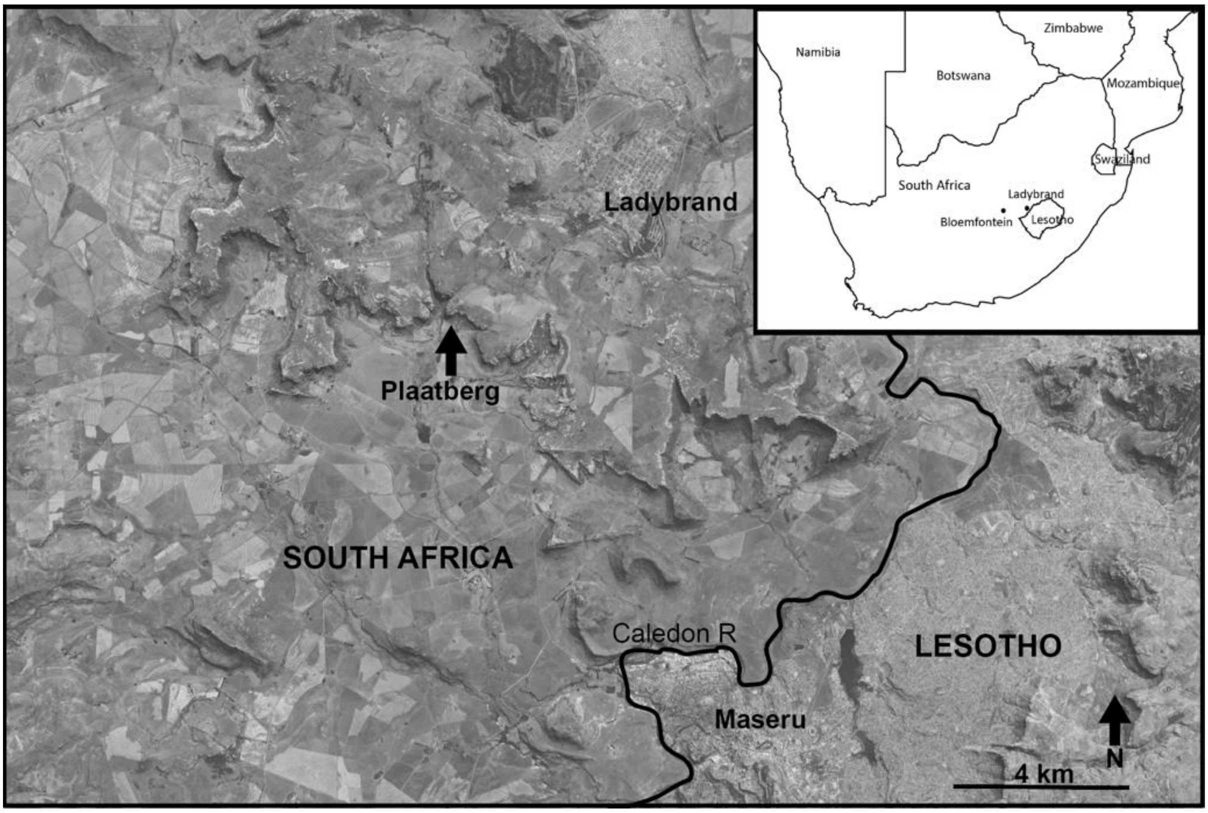


Figure 1. Google map showing the topography and location of Plaatberg Wesleyan Mission Station in relation to present-day Ladybrand, South Africa and Maseru, Lesotho.

This paper reports on excavations of three structures at the Mission Station. The purpose is to situate the site within the wider mission layout and present spatially, and where possible, chronologically contextualised excavation data.

2. Methods

Mapping the Mission Station

Over four seasons, all visible walling and structures were mapped and documented. The process began with a foot survey, during which notable features such as walling and vegetation – including non-native plants like cypress, rosehip, almond, peach, and pomegranate – were recorded using a Garmin Oregon 550 GPS device. These data points were uploaded to Google Earth Pro and used to generate a foundational reference map.

Over the next three years, the site was systematically mapped using a Nikon Total Station (DTM-330). Data points gathered in the field were uploaded into AutoCAD and QGIS in the field, allowing for immediate verification and checking. Google Earth Pro and 1:50 000 digital maps were used to cross-check and verify the constructed maps.

The Mission Station featured a main north-south street, lined with houses (Fig. 2). The houses were often connected to enclosure walls and were either mudbrick, reed-walled hartebeest houses or a combination of both (see Klatzow 2023). Enclosed fields and/or gardens extend away from the main street. A secondary north/south street may have existed further west, but the area has since been converted into ploughed fields. The ephemeral walling in this ploughed field is represented by dotted lines (Fig. 2).

To the east of the station, more ephemeral remnants of circular structures were documented. Material eroding out of the north-west side of the hill (wash) led to a platform with circular stonewalling concealed from plain view. Structures on the west-facing hillslope, also concealed within the treeline, may also have served the purpose of hiding stock or people if the vegetation line was the same in the past.

A graveyard was located to the north, across a small ravine formed by a mountain spring (Fig. 2). It consists of approximately 105 graves distinguished by stone capping and/or headstones, or cypress trees planted in the grave surround. Due to substantial overgrowth, each grave was numbered to mitigate against double counting. In this area no other building foundations were visible, and there was minimal animal or insect disturbance, unlike the settlement, which has been extensively disturbed by ground squirrels, mice, termites and antbears. It should also be noted that, over the years, the sandstone foundation stones have been repurposed for construction elsewhere, and topsoil has been scraped or removed for agricultural activities. Features 'a' and 'b' (Fig. 2), for example, are suggestive of more recent human intervention. These mounds appear to have been created by a tractor scraper, or grader. We were later made aware that the farmer had used heavy machinery to extend his fields and obtain topsoil.

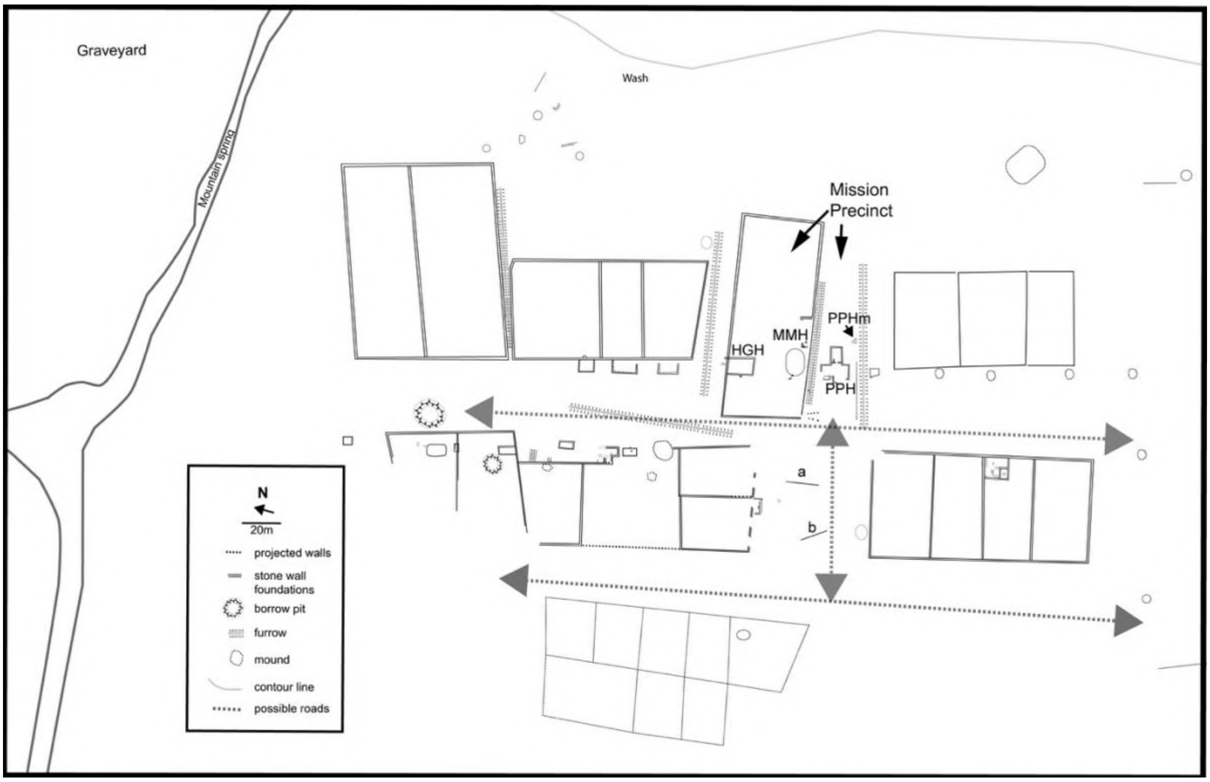


Figure 2. Map of the Plaatberg site showing excavated structures PPH, MMH and HGH, and midden PPHm, with possible recent earthworks indicated by a and b.

Excavation of the central precinct

In this section, we present the findings from our investigation of three structures situated at the centre of the station. Two of these structures are enclosed by an outer wall, while the third stands prominently between two furrows. Remnant walling suggest that this structure may have been enclosed separately. Collectively, we refer to this area as the 'mission precinct,' with the individual buildings designated as PPH, MMH, and HGH (Fig. 3; see also Esterhuysen et al. 2019).

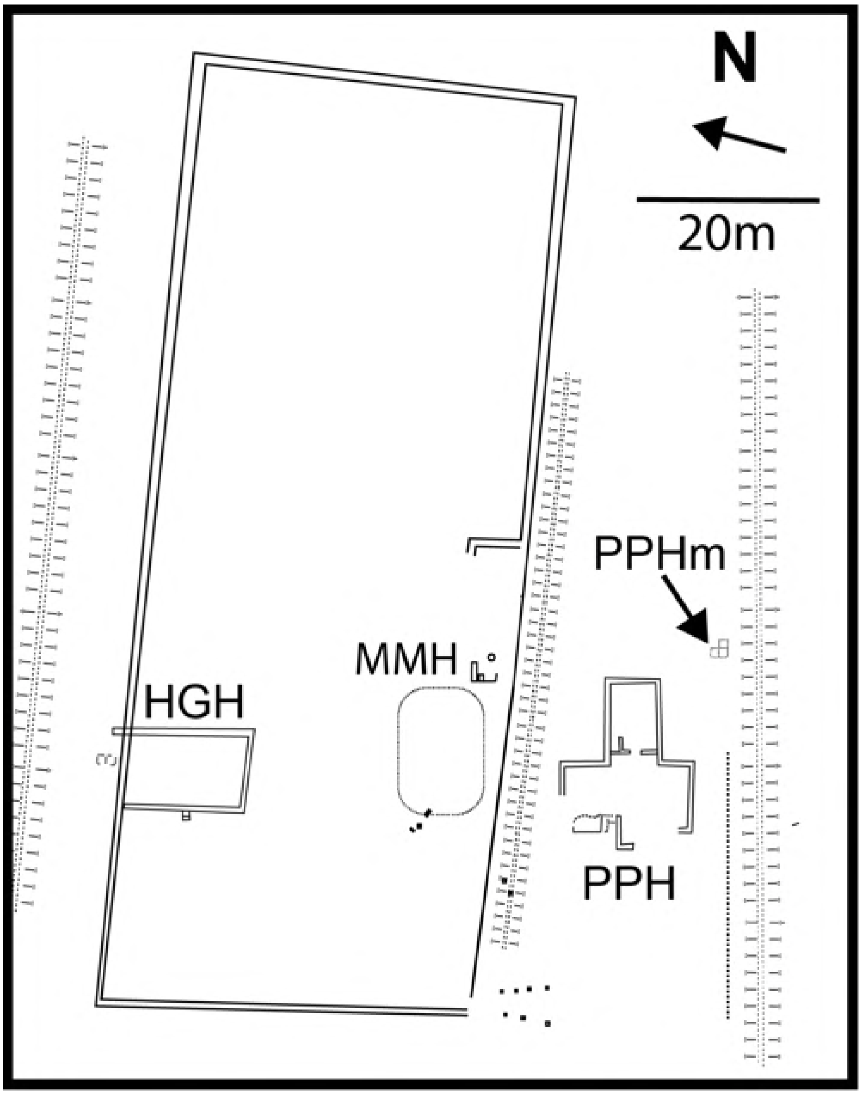


Figure 3. Map of the mission precinct showing the positions of structures PPH, MMH and HGH.

The foundations of structures for the most part consist of two wythes of dressed sandstone. The walls of structures are between 43-45 cm thick: each stone measuring approximately 20 cm in width. In instances where buildings retained their foundation stones, multiple tiers were observed, constructed to a height of up to 60 cm. Mudbrick, or reed walling with daub, were used to complete the various structures.

The boundary walls that enclosed the precinct and fields were wider (60 cm) with the gap between the wythes measuring 20-30 cm, potentially serving as a space for fence poles.

PPH: On the southern side of the mission precinct, the foundation of a distinctly cross-shaped structure was discovered, measuring 18 m in length and 15 m across (Fig. 4). The walls of the structure were exposed and subsequently mapped, along with associated artefacts. Small 25x25 cm test pits (STPs) were excavated in and around the structure. A witness trench (25x50 cm) was opened inside the eastern wall of the structure to reveal the stone foundations and expose a ledge that had been incorporated into the foundation wall to support joists for a wooden floor (Fig. 5).

Walling along the western front of the structure was inconsistent, and several attempts to probe for walling and define the building's shape proved unsuccessful. Two additional trenches, PPHt (1 & 2), were excavated to the base of the visible walls to explore the possibility of an entrance between the parallel walls, or to identify a foundational layer of connecting stones that might complete the corner (Fig. 6).

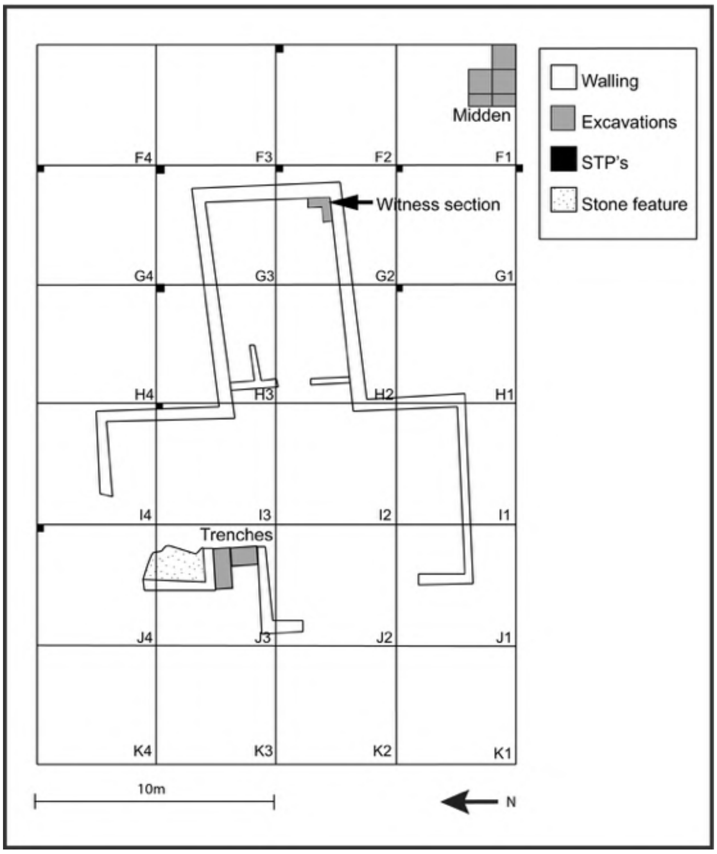


Figure 4. Foundations of PPH showing trenches (PPHt), midden (PPHm), STPs & witness trench.

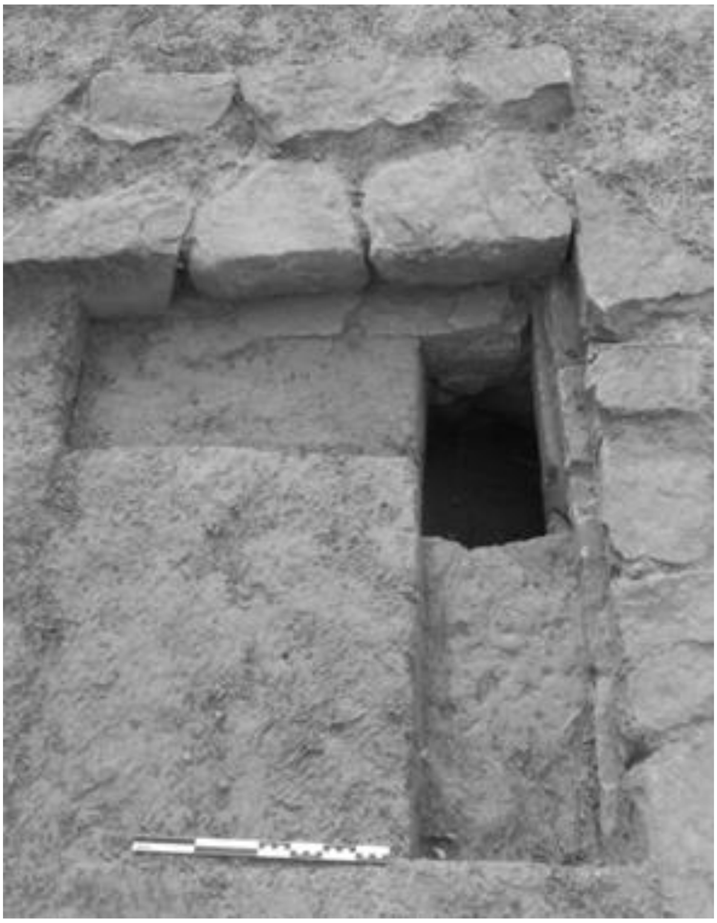


Figure 5. Photograph of the ledge in the stone foundations excavated at the PPH structure.

PPHt – Trench Excavation: PPH trenches reached the base of the sandstone foundations on both sides, but no connecting stones were found. Significant material remains and mud brick had accumulated between the walls, with the original walking surface located approximately 60 cm below the datum.

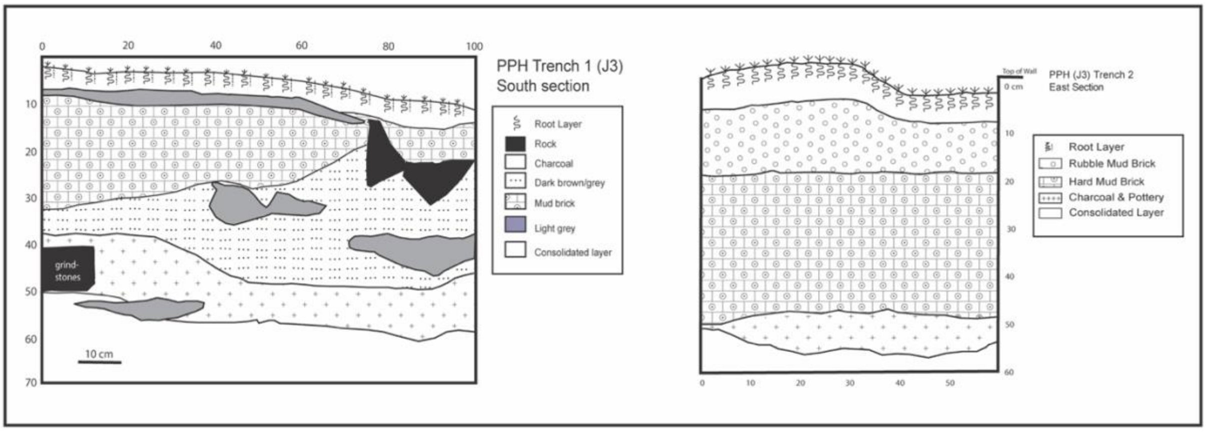


Figure 6. Drawing of the stratigraphy of the south wall of J3/T1 (left) & the east wall of J3/T2 (right).

The trenches were excavated in 20 cm spits because much of the material had either collapsed or washed in between the walls. However, some material, like a large earthenware pot and grindstone, at the base appeared to be *in situ,* and are suggestive of activity prior to the collapse of the structure.

PPHm – Midden Excavation: There was only one midden found in the mission precinct, located directly behind PPH. This extensive midden was utilised continuously over a significant period, resulting in a substantial accumulation of debris. The absence of any other nearby middens suggests that PPHm served the entire enclosed precinct.

The excavation of the midden took place over two field trips in 2015 and 2016. Four square metres were excavated, which represents only a fraction of the midden. The excavation targeted three full square-metres (F1.1, F1.2 and F1.7) and two half-square-metres (F1.3A and F1.8A). These were dug in 5 cm spits and reached a depth of approximately 80 cm below datum. Animal disturbance, caused by squirrels and termites, was evident (Fig. 7). Notably, due to burrowing and disturbance in F1.1, the deposit between 40-63 cm was analysed as a single unit.

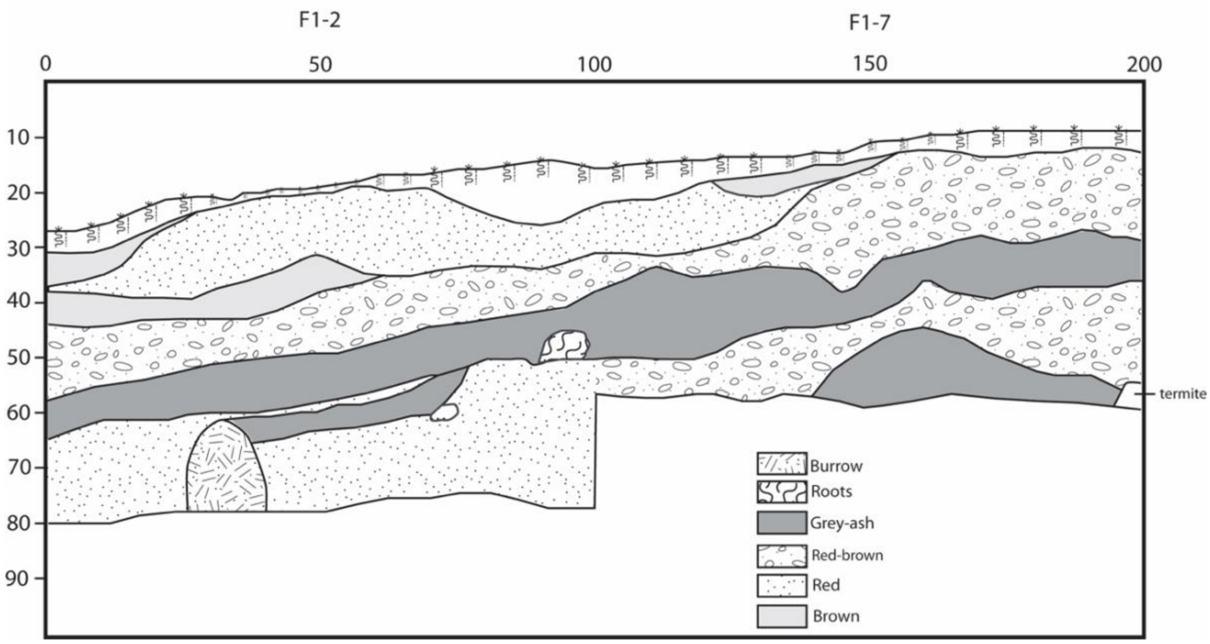


Figure 7. Stratigraphic drawing of the F1.2 and F1.7 west wall.

Square F1.7 was excavated down to about 60 cm, at which point a hard, red layer was encountered. This layer is labelled 'red' in Figure 7, and it also extends through F1.2. It was excavated down to 80 cm to investigate whether there were any artefacts beneath the mudbrick, but at that depth, a hard, stony layer was reached, believed to be the original surface.

MMH: The structure situated in the centre of the mission precinct stands out as the largest mudbrick mound on the site, possibly due to internal mudbrick wall divisions. The approximate dimensions of the mudbrick mound on MMH were 15-20 m north-south, and about 30 m east-west. The exact dimensions of the house were difficult to determine as the foundations were entirely covered in collapsed walling. Attempts to excavate the main structure proved futile, as we could not break through or lift the hardened mud brick without mechanical digging equipment. Consequently, most work around MMH involved trying to expose the outer structure, probing for a house midden, and excavating around stone features behind the main house.

There were two dressed flagstones situated on the western end of MMH (Fig. 8). These stones, and those below them, were cleared in the hopes of uncovering steps like those found at HGH (see HGH excavation). It appeared the stones had either collapsed or been removed. Only the two flagstones at the top, and possibly the large stone at the bottom, remained (Fig. 8).

Figure 8. Photograph of what may be the remains of steps at the western end of MMH.

Wall segments visible at the eastern end of the mound were exposed and excavated but were studied as two separate entities: MMH-a and MMH-b (Fig. 9), because MMH-a walling was much rougher in style and gave the impression of a different utility space. The MMH-a walls were exposed and surface soil was removed to a depth of 20 cm within the walled area (K10) (Fig. 10). A two-metre strip was then extended from the western end of the wall to establish whether the walling continued west to meet up with the main MMH structure. The walling did not extend beyond the L11 square. Part of the trench in M11 was dug deeper to check for foundational walls, considering the possibility that the top courses of stone had been repurposed or stolen. No walling was found, but the test trench revealed distinct layers of very hard mud brick followed by a very soft ashy deposit (Fig. 11). The excavations within and around the structure yielded little in the way of material culture.

MMH-b revealed an interesting feature with a distinctive shape (Fig 12). On the northern end, there was one long wall that ended abruptly, and in proximity a shorter U-shaped structure. Towards the east, a small circle of raised stones was observed that may have functioned as a plastered platform of some kind.

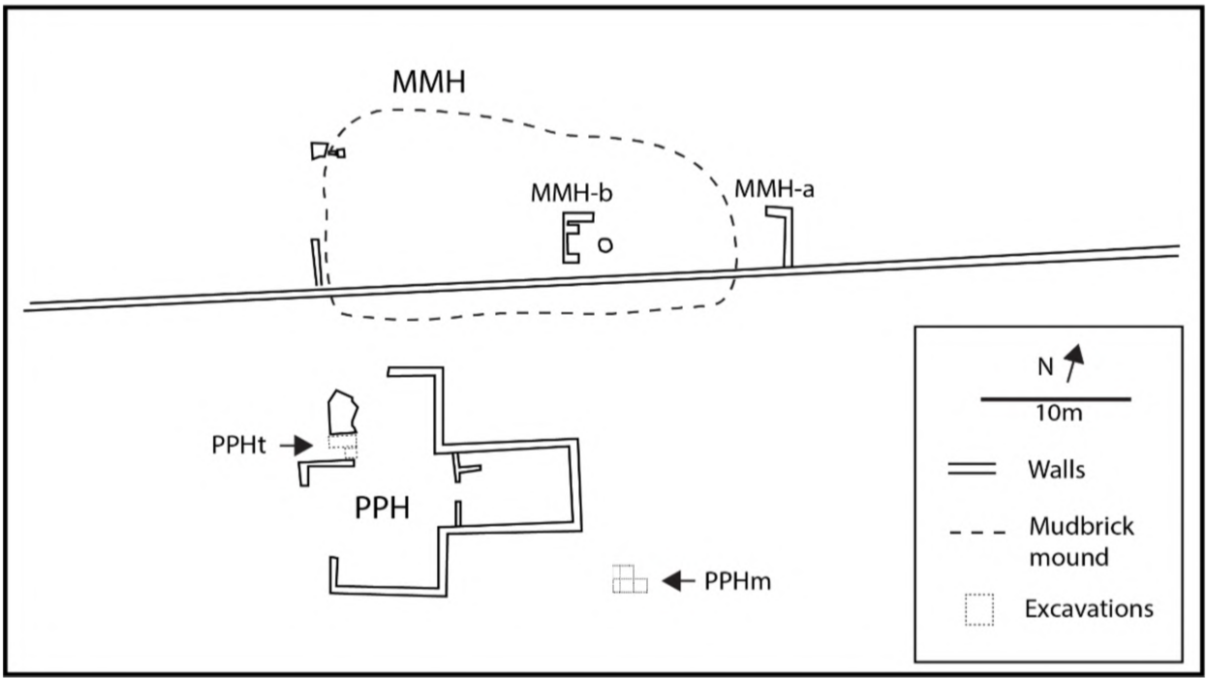


Figure 9. MMH-a & b position in relation to the mound of mud brick and relative to PPH.

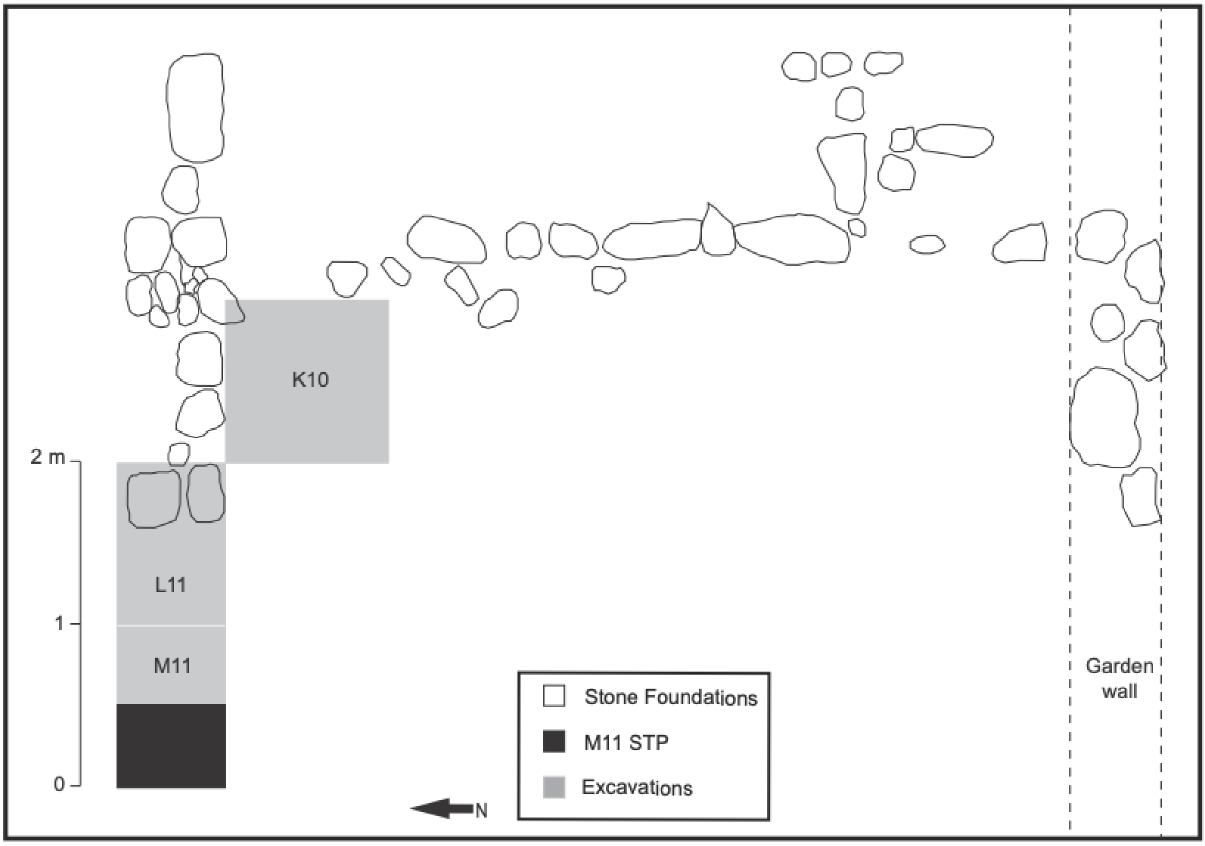


Figure 10. Plan drawing of the walling of MMH-a.

This area was cleared and the extent of the walling exposed. Two square metres were excavated in the U-shaped walling to establish its function. These two squares were labelled K-S and K-N; only K-S was excavated.

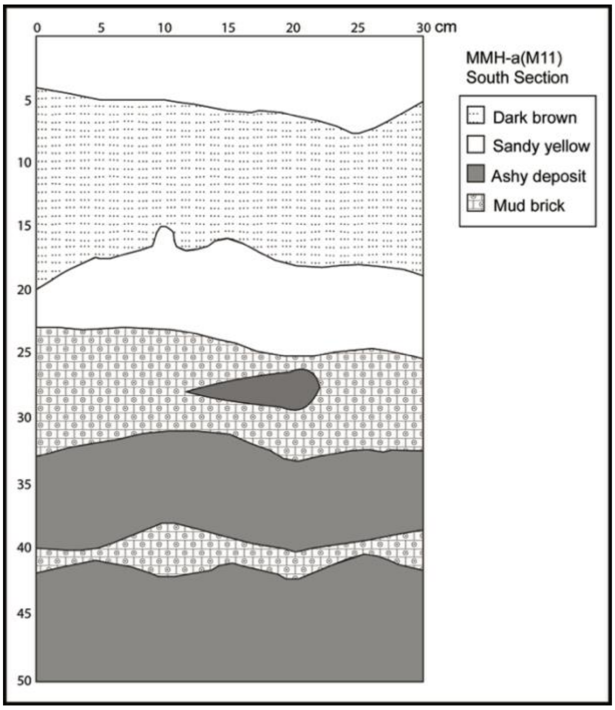


Figure 11. Section drawing of the southern wall of M11 (MMH-a).

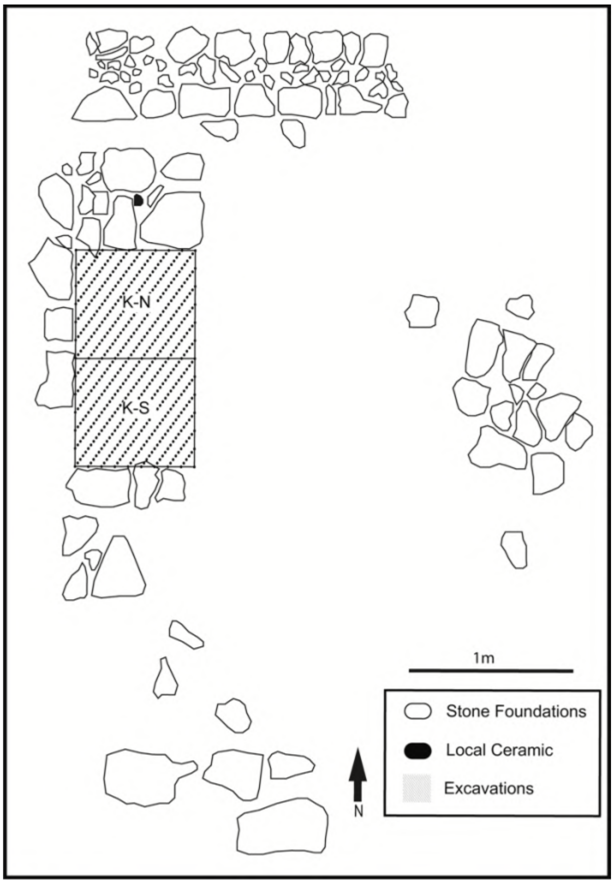


Figure 12. Plan drawing of the MMH-b walling.

The goal of excavating K-S was to uncover the base of the stonewalling, determine its depth, and identify any remains. The stonewalling extended approximately 40 cm below the surface and has a base of compacted mud brick (Fig. 13). From 40 cm downward, a large upright stone was found near the centre of the square, and between 45 and 60 cm below that, individual mud bricks were exposed and removed whole. The cluster of rocks on the eastern side of MMH-b was excavated down to the base of the stones to establish if the feature continued in any direction. The eastern corner of the feature was probed by digging a STP to establish whether more foundation stones existed deeper underground (Fig. 12). It was found that this was a solitary, circular stone feature.

HGH: Foundations on the northern end of the mission precinct (HGH) were uncovered, revealing a simple rectangular house (±15x8 m) with a set of steps located midway along the west-facing wall (Fig. 14). A door latch found next to the steps suggests that this was the formal entrance to the house, opening onto the main street.

Figure 13. K-S 40 cm below surface.

Figure 14. Map of HGH including the stairs, buttress and excavation (left). Photo of the steps on the western wall leading into the HGH structure (right).

Two square metres were excavated outside of the structure on the northern side of the foundations (M10 and M11). The decision to excavate in this area was prompted by numerous finds brought to surface by rodent activity. After two auger tests yielded some artefacts and identified an ash lens at 80 cm below the surface, the two squares were excavated to a depth of 120 cm.

The initial intention was to excavate in 10 cm spits, but the sloping ground made this impractical. Instead, we shifted to exposing layers and features (Fig. 15). Significant overburden caused by rodent burrowing was recorded with the most substantial displacement of soil in M10 (40-50 cm), coincident with a large burrow. Beneath this overburden we encountered a layer of mudbrick and broken window glass. The mudbrick was underlain by a sterile layer of clay. At the north end of the square, an ash layer emerged, extending into M11. Considering the lack of finds in M10, the decision was made not to excavate through the hard mudbrick in M11. The extent of the mudbrick suggested that the north wall of the house had collapsed outwards.

3. Results

For this paper, we first set out the data spatially to highlight palimpsests of material categories, which may loosely indicate different activities or provide information about structures across the precinct. In the case of PPH we distinguish between the midden (PPHm), in which material was intentionally discarded, and material found from PPHt, STPs, and surface clearing, which was incidental or event related. We then present the changes within the midden dataset that may point to different occupation periods and different missionaries. For detailed appendices of finds see Hunt (2020).

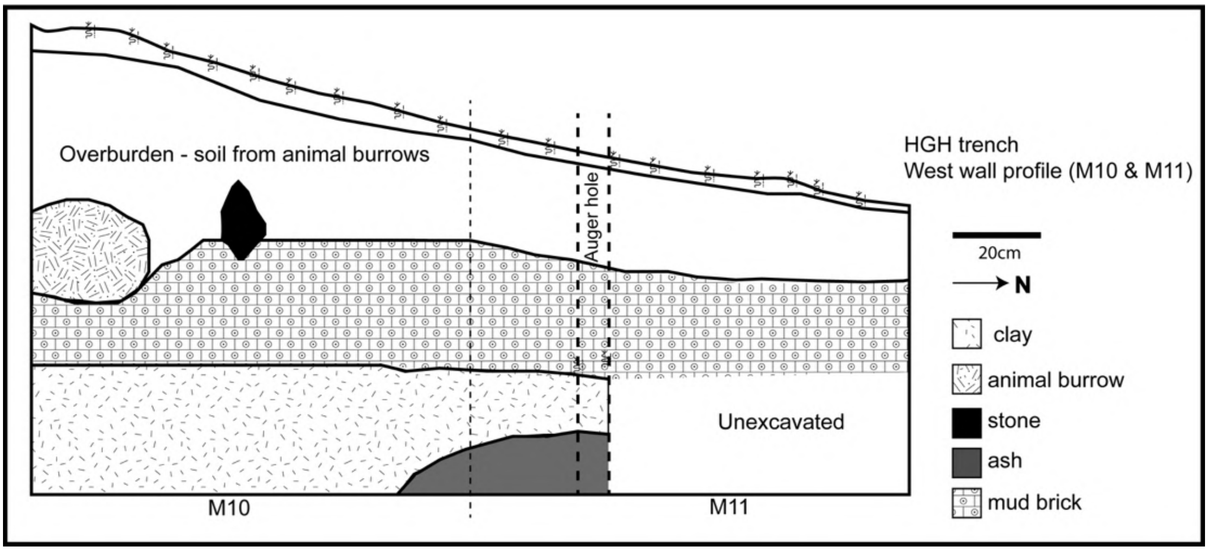


Figure 15. HGH excavation west wall.

Faunal remains

Most bones originated from domestic mammals such as cattle, sheep, and goats, with a few exceptions of wild animals (Table 1). Differentiating between sheep and goat was challenging, and only seven sheep and three goats were definitively identified from a total of 65. Most bovid bones were classified to size class.

PPH: PPHm contained over 2370 fragments of bone of which only 210 were diagnostic. Domestic animals predominated, but several bird bones, including those from chickens, possible Guinea fowl, and a duck or goose, were also recovered from PPHm, along with a fish bone and two bivalve mollusc shells, likely from a local stream or river. Additionally, bones from a wildebeest, a possible blesbok, and a domestic dog were found, as well as two pieces of ostrich eggshell (OES).

Twenty-seven diagnostic bones showed cut marks, three exhibited sawing marks, and one had been chopped. Among undiagnostic bones, only 58 fragments out of a sample of 2161 showed evidence of butchery. Just over half of the assemblage was unburnt (52.6%), while 42.6% were burnt brown. Only 12 bones were burnt black, grey, or white, indicating prolonged burning. Signs of weathering, including fractures, flaking, erosion, cracks, and root etching, affected roughly half of the assemblage.

Bone fragments from across the rest of PPH (n=567) were largely undiagnostic (91.1%). Only 25 from PPHt and 14 from the STPs were identifiable. Bones from the PPHm were generally in better condition than those found outside of the midden, suggesting regular use of the midden and therefore shorter exposure of discarded bones.

MMH: Only five out of 118 bones could be identified to species: two *Bos taurus* (cattle), one *Ovis/Capra* (sheep/goat), and two wild animals (*Connochaetes* sp. and *Herpestidae*). Additionally, two bones were identified as Bov I/II and Bov III, respectively. Most bones (63.6%) came from MMH-b, and 34.7% from MMH-a, with the remaining few bones recovered from test trenches (eight bones) and the western steps.

All bones from MMH-a were burnt black, grey, or white, indicating severe burning. In contrast, 54.1% of the bones from MMH-b were burnt brown, while the rest were burnt black, grey, or white. The severely burnt bones from MMH-b were primarily from the K-S excavation. Five bones from MMH showed signs of butchery, with four from MMH-b and one recovered during wall clearing.

Table 1. Number of Identified Specimens.

Species	**PPHm**	**PPHt**	**PPH STPs**	**MMH**	**HGH**
Canidae (canid)	1				
Bos taurus	24	1	1	2	7
cf. *Bos taurus* (probably cattle)	3		3		
Ovis aries (sheep)	7				
cf. *Ovis aries* (probably sheep)	1				
Capra hircus (goat)	3				
cf. *Capra hircus* (probably goat)	2				
Ovis/*Capra* (sheep/goat)	34	11	1	1	3
cf. *Ovis/Capra* (probably sheep/goat)	1	1			
cf. *Damaliscus pygargus phillipsi* (probably blesbok)	1				
Connochaetes sp. (wildebeest)	1			1	
Bovidae I (small bovid)	1				
Bovidae I/II (small/medium bovid)	2			1	
Bovidae II (medium bovid)	73	9	4		2
Bovidae II (medium bovid - wild)	1				
Bovidae II/III (medium/large bovid)	2				
Bovidae III (large bovid)	23	1	4	1	
Bovidae III/IV (large/very large bovid)	1				
Xerus inauris (South African ground squirrel)			1		
Rodentia (rodent)	9				
cf. Leporidae (hare)	1				
Mammalia (small mammal)	6				
Gallus/Numididae (chicken/guinefowl)	4				
Gallus gallus domesticus (chicken)	2				
cf. *Gallus gallus domesticus* (probably chicken)	3				
Herpestidae				1	
Anatidae (duck/goose)	1				
Aves (bird)	2				
Anura (frog)		1			
Anura/Reptilia (frog/reptile)		1			
Fish	1				
Total	**210**	**25**	**14**	**7**	**12**

HGH: HGH produced a small bone sample (n=116). Only 33 of the total bones showed signs of having been burnt, and all of these were burnt brown. Two bones showed cut marks, while six showed carnivore damage. Eight out of the twelve diagnostic bones (cattle [7], sheep/goat [3] and Bov II [2]) were severely weathered, with large cracks, fine-line fractures, flaking, and erosion present. All diagnostic bones were recovered from M10 and M11.

Flora

Plant remains were recovered through sieving and flotation of soil samples from PPHm, PPHt and the STPs. A small charcoal sample from PPHt was analysed using a dark field microscope at 50 and 100X magnification. Seeds and charcoal included *Celtis africana*, *Leucosidea sericea*, and *Searsia* (*Rhus*), species commonly found in ravines and near the spring in the area (Esterhuysen 1992, 1996). The seeds also mark the introduction of 'foreign' trees to the Mission Station, as evidenced by *Melia azedarach* (Pride of India) and remains of *Prunus persica* (peach) and *Prunus dulcis* (almond). Other trees, such as pomegranate, rose, and cedar, which are still growing on the site, may have been introduced as early as the 1840s.

Both peach and almond were reportedly planted by the missionaries; but, the outer shells of the *Prunus* pits are nearly identical, so they were classified collectively in this study. Interestingly, all the shells (n=24) found in PPHm were broken, with 79.2% showing signs of burning. Of the 508 *Prunus* shells recovered from PPHt, 89.6% were broken and 96.7% were burnt. This suggests the shells were broken to remove the kernel and may have been almonds. A total of 71 whole pits, potentially then peach pits, were identified in the assemblage (Table 2).

Cereal remains in PPHt included burnt and broken *Zea mays* (corn) cobs, while sorghum seeds were found in PPHm. Additional plant remains from test trenches and around the walls comprised mostly burs and corms from local flora (n=429 and 168, respectively), together with numerous White Stinkwood seeds (n=130) and a significant number of broken peach/almond seeds (n=105).

Table 2. Number of identified seeds and pieces of charcoal.

Species	**PPHm**	Burnt	Broken	**PPHt**	Burnt	Broken	**STPs**	Burnt	Broken	**PPH Total**
Celtis africana	32	0	7	24	1	7	130	0	14	**186**
Searsia sp.	10	10	-	0	-	-	0	-	-	**10**
Leucosidea sericea (charcoal)	8	8	-	0	-	-	0	-	-	**8**
Melia azedarach	1	0	0	1	0	1	1	0	0	**3**
Prunus persica/dulcis	24	19	24	508	491	455	105	16	89	**637**
Sorghum bicolor	8	0	5	0	-	-	0	-	-	**8**
Zea mays	0	-	-	77	77	77	0	-	-	**77**

Glass

Over 4000 fragments of glass were recovered from the precinct. A total of 154 shards were classified as ‘bottle’ due to their colour, curvature, or shape. Five bottlenecks were recovered, one of which from the PPHm midden, with a clear screw-top rim, belonged to a later period. A perfume bottle stopper, the most elaborate item found, was recovered from the surface of PPH (H1), without a firm context.

The flat glass varied in thickness and colour, indicating different uses such as window glass, flat-panelled bottles, or cabinet glass. Most of the glass was clear but with heavy patination.

Weiland (2009) argued that window glass could be dated by its thickness, noting that as the 19th century progressed, people wanted bigger windows, requiring thicker glass. This trend continued until the early 20th century when machine-manufactured window glass standardised the thickness to between 3 and 3.3 mm (Weiland 2009). The average thickness of flat glass across the precinct is approximately ±1.8 mm, suggesting small panes were transported in by wagon from trade centres (see Hunt 2020).

A concentration of window glass was found around the flagstone in MMH, and in the excavation next to HGH. Many flat glass shards were found in the PPHm midden (744), but these panes would have been broken elsewhere and discarded here. The distribution of flat glass around the PPH structure is possibly the most interesting. Figure 16 represents the distribution of flat glass on the map of PPH. Each circle represents the relative number of shards of flat glass, suggesting the presence of windows. The glass clusters predominantly around the west-facing side of the structure, with smaller amounts to the north and south.

Ceramics

The ceramic assemblage was divided into local and imported ceramic. Local ceramic is traditional coarse earthenware, while imported ceramics predominantly comprise refined industrial ware and stoneware. The local ceramic component was sorted into diagnostic (shape, rim and body, burnish, and decoration) and undiagnostic categories.

Local ceramics

PPH: Few sherds (64) were found while looking for wall foundations and carrying out STP surveys. Local ceramics were almost equally divided between the F1 midden (259) and the J3 Trenches (219). A total of 24 rim sherds were found across PPH: 12 from the F1 midden, 11 from the J3 Trenches, and one from the K3 STP. Of the 11 from the J3 Trenches, four belonged to a single pot (Fig. 17).

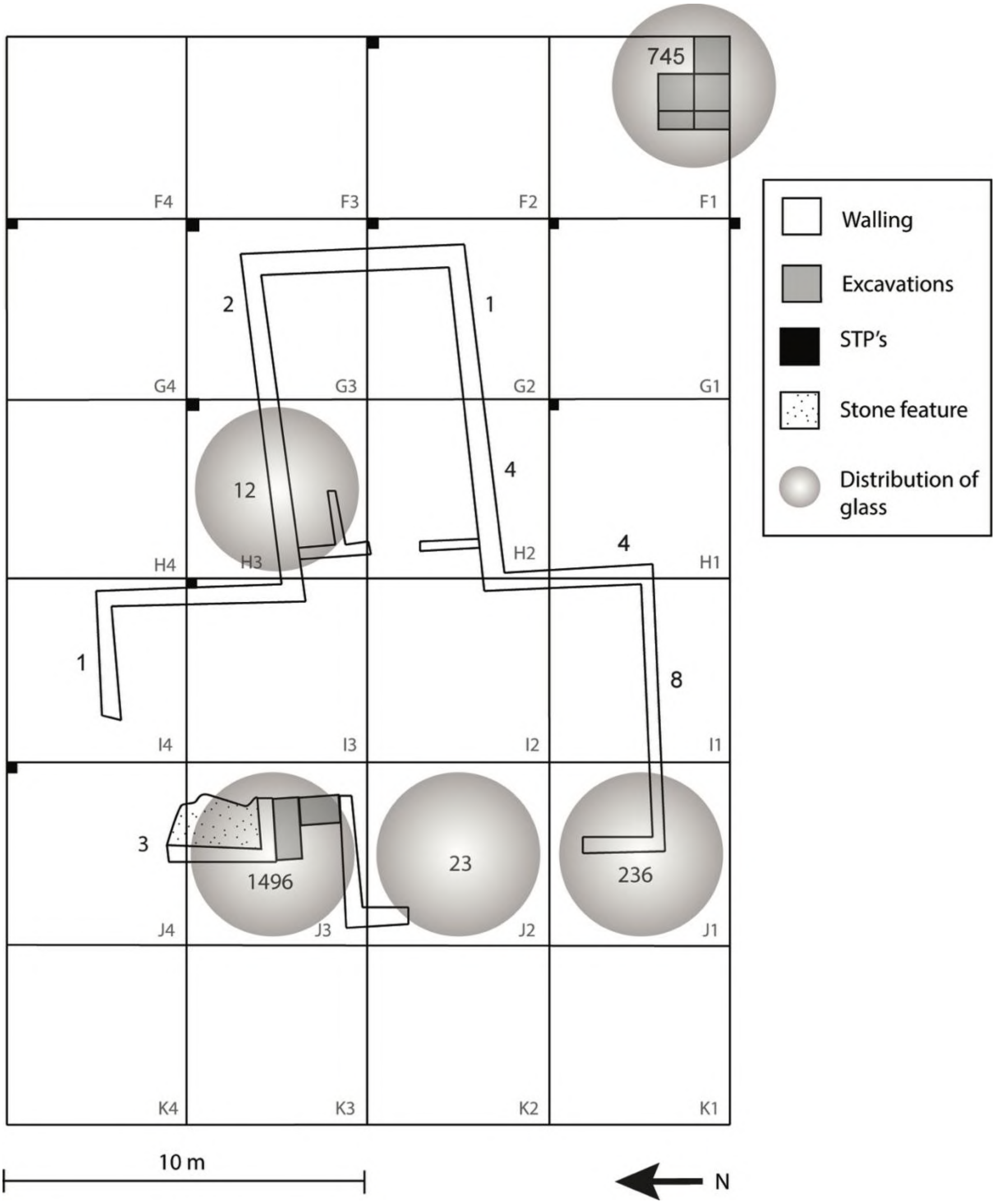


Figure 16. Distribution of flat glass around PPH. Numbers in circles show the exact number of shards found in each context.

Sherds recovered from the STPs, wall-exposure, and the F1 midden were generally very small, with few pieces that could be refitted. In contrast, nine fragments from PPHt were successfully refitted, revealing the profile of a large pot featuring a decorative ridge running perpendicular to the rim (Fig. 17). This pot is one of the few examples of decorated ceramic in the local assemblage. Additionally, PPHt sherds exhibited a higher proportion of burnishing compared to those from PPHm. Only five decorated sherds were found: two with single incision (PPHm), one with multiple incisions and the other with a ridge (PPHt), and one with comb-stamping (F2/STP).

Figure 17. Refitted pot from the base of the PPHt J3 trench (40-60cm Ash lens).

MMH: At MMH, 160 sherds were distributed mainly towards the eastern end of the structure, with four found on the main house mound. At MMH-b, 69 of the 95 sherds were found at or near the surface during clearing and wall exposure. MMH-a yielded a total of 61 sherds, four of which were burnished. Most of these sherds were also close to the surface. There were 15 undecorated rim sherds. Most of the burnished pieces were found at MMH-b (51) with the remaining pieces (4) occurring in MMH-a, and these were burnished either black (six) or a deep red (49). Nine sherds showed evidence of burning and were found in MMH-a (six), MMH-b (two) and on the northern edge of the enclosure (one).

HGH: At HGH, 27 local ceramic sherds were found, all very small, with the largest measuring 68 mm long. Only one was a rim sherd, and none were decorated. Most of these ceramics (70.4%) were found in M10 and M11, with a few others found augering, and foundation exposure. Six sherds were burnished (four red, two black), nine showed evidence of burning.

Imported Ceramic

A wide range of decorated, imported ceramic – mostly from England, with some Asian porcelain – was recovered from the mission precinct. The analysis followed the methods set out by Klose (2007).

PPH: A total of 709 sherds were recovered from PPHm, with a working count of 707 due to evidence of fresh breakage. The minimum number of vessels (MNV) was 104. Most of the decorated sherds were transfer printed (TP) in various colours, but primarily blue, and with Willow Pattern or other designs present (Table 3). Three sherds refitted to form a carinated bowl decorated with industrial slipware. The ceramics found in the midden were generally very broken and incomplete, suggesting that whole or mendable vessels were not being discarded even when chipped or slightly broken.

At PPHt 185 sherds were recovered (174 working count); TP blue earthenware predominated (46.6% of the assemblage), with three sherds of European porcelain also being identified. Three ceramic pieces, coloured red, blue and green, were reshaped into round discs, possibly for a game or for educational purpose (Fig. 18).

A total of 130 imported ceramic sherds were found during the wall exposure and STP surveys (working count of 119). The assemblage included five pieces of stoneware and six pieces of porcelain (two Asian and three European). The rest were white-bodied ware, decorated with TP in various colours (Table 3).

Figure 18. Repurposed ceramic pieces found in PPHt include pink and blue (J3/T1 surface-20cm), and green-black (J3/T2/surface-20cm).

Table 3. Imported ceramics from PPH (total number of sherds).

WARE	PPHm	PPHt	STPs
Stoneware			
British/European	50	2	5
Porcelain			
Asian	3	0	2
European	15	3	4
RIW (white bodied white wares)			
Hand painted harsh	10	11	7
Transfer printed: blue Willow	142	10	12
Transfer printed: blue other	175	50	28
Transfer printed: flow blue	38	26	11
Transfer printed: brown	10	7	7
Transfer printed: green	10	4	5
Transfer printed: pink	11	0	3
Transfer printed: purple	0	5	0
Transfer printed: black	44	4	6
Transfer printed: black. Colour-glazed	9	0	0
Sponge	31	5	3
Feather	0	1	0
Moulded	9	0	10
Industrial slipware	39	16	0
Colour-glazed light green	11	0	0
Colour-glazed blue	4	0	0
Colour-glazed green	3	0	0
Colour-glazed brown	5	0	0
Undecorated	85	31	23
RIW (colour-bodied wares)			
Jasper	0	1	0
Red-bodied ware	2	0	0
Unidentified	3	9	4
Total	**709**	**185**	**130**

MMH: The 136 pieces of imported ceramic pieces mostly came from MMH-b (66%), with few found at MMH-a (7%) (Table 4). The MNV for MMH is 34, which includes a total of 18 rim sherds and four foot-rings. Some sherds were diagnostic of their original forms, such as TP blue sherds forming a small bowl and TP black sherds forming a vessel lid. One large rim sherd found in spit 1 of the excavation of K-S appeared burnt or stained with charcoal.

Sixteen pieces of porcelain were found, one from Asia and the rest from Europe. Four sherds were found at MMH-b, and the rest were found on the northern edge of the MMH near an animal burrow. The small European porcelain assemblage included two rim sherds, and two-foot rings. Fourteen pieces of stoneware were found, one from MMH-a, eight from MMH-b and five from test trenches.

HGH: A total of 46 imported ceramic sherds were found across HGH, 39% of which were found in and around the structure, and the rest found in M10 and M11 (MNV=19). Ten rim sherds, and three-foot rings were identified. White-bodied wares comprised 60.5% of the sherds of which 53.8% of them were decorated in TP in various colours (Table 5). Only one sherd of European porcelain was found in M10.

Fourteen stoneware sherds were found (nine found in M10 and M11, and five around the foundation). The MNV for the stoneware was estimated at eight. It is possible that these stoneware vessels were used to transport ink when considering the high number of printing press pieces (see section on printing press pieces). Two red-bodied earthen-ware sherds (see Klose 2007), possibly from the same vessel, were found in M10 and M11 respectively.

Table 4. Imported ceramics MMH (total number of sherds).

WARE	MMHa	MMHb	MMH STP & exposure
Stoneware			
British/European	1	8	5
Porcelain			
Asian	0	1	0
European	0	4	11
RIW (white bodied white wares)			
Handpainted harsh	0	13	3
Transfer printed: blue Willow	0	0	1
Transfer printed: blue other	4	11	6
Transfer printed: flow blue	0	13	1
Transfer printed: brown	0	0	0
Transfer printed: green	1	0	0
Transfer printed: purple	0	2	0
Tranfer printed: black	0	7	2
Transfer printed: black. Colour-glazed	0	0	0
Embossed	1	0	1
Sponge	0	4	0
Notched	0	1	0
Moulded	0	1	0
Industrial slipware	2	3	3
Embossed	0	1	0
Colour-glazed blue	0	0	0
Colour-glazed green	0	0	0
Colour-glazed brown	0	0	1
Undecorated	1	19	2
RIW (colour-bodied wares)			
Red-bodied ware	0	0	0
Unidentified	0	2	
Total	**10**	**90**	**36**

Buttons, buckles and fasteners
A single metal button was recovered from PPHm (F1.1/spit 9), one buckle from (F1.1/spit 4), and two hook fasteners (F1.2/surface and F1.7/spit 4). Six buttons were found in PPHt. Three of the buttons appeared to be made of mother-of-pearl, two of metal, and one of either ceramic or glass. The metal button found in J3/T1 was a large (18 mm diameter), flat button, with a shank on the back that has since fallen away. Eyes of hook and eye fasteners were excavated from MMH-b (K-S spit 4) and HGH (M11 spit 2), respectively.

Beads
The bead analysis followed Marilee Wood's (2005) method, which includes noting characteristics such as the manufacturing process, shape, end treatment, size, length, and diaphaneity.

PPH: A total of 972 beads was recovered from PPH; this included the PPHm midden, the PPHt Trenches, STPs and those found during the process of exposing the walls. The midden yielded the most beads (795), followed by PPHt (143).

All the beads recovered from the midden were drawn beads of different shapes. There was only one barrel-shaped bead and four sphere-shaped beads, while the rest were almost evenly split between cylinder (41.3%) and oblate (55.3%) beads. Twenty-two beads were broken and could not be measured accurately. Most of the sample consisted of small beads (65.6%). Minute beads (those smaller than 2.5 mm) comprised 24.8% of the sample, medium beads 9% and there were five large beads in this assemblage.

Table 5. Imported ceramics HGH (total number of sherds).

WARE	M10/11	Auger wall exposure
Stoneware		
British/European	9	5
Porcelain		
Asian	0	0
European	1	0
RIW (white bodied white wares)		
Handpainted harsh	0	0
Transfer printed: blue Willow	0	2
Transfer printed: blue other	5	3
Transfer printed: flow blue	1	1
Transfer printed: brown	0	0
Transfer printed: green	0	1
Transfer printed: purple	1	0
Transfer printed: pink	0	0
Transfer printed: black	1	0
Feather	0	0
Sponge	1	0
Moulded	0	0
Industrial slipware	2	3
Undecorated	5	3
RIW (colour-bodied wares)		
Red-bodied/terracotta	2	0
Unidentified	0	0
Total	**28**	**18**

White beads and white-hearts (a translucent red bead with a white centre) predominate, making up 80% of the PPH bead assemblage (Table 6). In terms of diaphaneity, 54.6% of the assemblage was opaque, while 45% were translucent. Most of the white-hearts were heavily patinated and some of the beads extremely fragile. Only one bead was completely transparent, and this was a clear, cylinder-shaped bead with a diamond pattern on the surface. The length categories revealed one disc (extremely short bead) and three long beads, while the majority were either short (69.5%) or standard in length (30%).

The beads collected from PPHt included one wound bead, while the rest were drawn beads. Cylindrical-shaped beads were slightly more prevalent than oblate, making up 56.6% and 39.2% of the assemblage, respectively. Additionally, there was one spherical bead and one ellipsoid bead. Only three beads in this assemblage were broken, which corresponded with the relatively low level of patination. The colours of the beads were like those of the F1 midden, with a large proportion of them being either white or white-hearts (Table 6).

Thirty-four drawn beads were found during the wall-clearing and STP processes (Table 6), and three of these were broken. The sizes varied between minute (45.5%) and small (54.5%) and in terms of shape, they were either cylindrical (36.4%) or oblate (60.6%) with only one being spherical. Almost all the beads were short in length, with only three being of standard length. Very few beads were heavily patinated (21%). In terms of diaphaneity, 63.6% of this small assemblage were classified as opaque, while the rest were translucent.

MMH: A total of 28 beads were found at MMH, with 21 recovered from MMH-a and the remaining seven from MMH-b. This distribution contrasts with other artefacts, where most were collected at MMH-b and comparatively fewer at MMH-a. The discrepancy may be attributed to the use of a very fine, 2 mm mesh sieve during the MMH-a excavation, while a slightly larger mesh was used at MMH-b, potentially causing some beads to be lost in the sieving process.

Of the total beads, 13 were classified as minute, 12 as small, and only three as medium-sized, suggesting that sieve mesh size impacted bead recovery. The most common colours were white followed by white-hearts (Table 6). Diaphaneity was predominantly determined by colour: all white-hearts and one pale blue bead were translucent, while the black, blue, pink, and white beads were opaque.

In terms of length ratios, most beads were either short (16) or standard (11), with only one pale pink bead categorised as long. The beads fell into two shape categories: 15 were cylindrical and 13 were oblate.

HGH: Only nine beads were found at HGH (Table 6). Two beads (one blue and one white) were minute in size, four were small, and two were medium, aligning with the trend of most beads being small or minute. All the beads were short in length. Five beads were opaque, while the translucent ones included the white-heart, the blue bead, and one white bead. In terms of shape, five were cylindrical, and three were oblate.

Table 6. The number of individual beads according to colour from across the mission precinct.

Beads	PPHm	PPHt	STP & Walls	MMH	HGHt	Totals
White-hearts	336	41	11	7	1	**396**
White	297	75	13	11	4	**400**
Black	50	5	3	3	2	**63**
Blue	35	8	4	5	0	**52**
Green	40	7	0	0	0	**47**
Red	11	0	2	0	0	**13**
Brown	1	0	0	0	0	**1**
Pink	17	6	1	2	1	**27**
Yellow	2	0	0	0	0	**2**
Orange	2	0	0	0	0	**2**
Clear	1	0	0	0	0	**1**
Striped	2	1	0	0	0	**3**
Unidentified	1	0	0	0	1	**2**
Total	**795**	**143**	**34**	**28**	**9**	**1009**

Slate

A total of 64 flat pieces of slate, including five with ruled lines and seven slate pencils, were found in the midden. Several flat pieces of slate had multiple, non-parallel scratches etched into their surfaces. Three unlined flat pieces were found at PPHt, and 10 (one lined) were found during the exposure of the foundation and STP surveys. Thirty-one flat pieces were recovered from MMH-b, along with two from around the house, and one pencil. Additionally, 10 flat pieces were recovered from HGH, with nine coming from the trench.

Metal

A total of 120 nails were found around PPH, 95 of which came from the midden. Of the nails that were not too corroded, 20 were handmade and three were early machine-made. Diagnostic forms included rose-headed (13), round flat-headed (16), rectangular flat-headed (12), and T-headed nails (seven). A few bolts (one), nuts (three) or washers were recovered from PPH, and four pins/needles were found in the midden, but only one, still with its head, could definitively be identified as a pin.

A total of 19 nails were collected at MMH, with 12 from MMH-b, three from MMH-a, and two from the west steps. Nine nails were handmade, with rose-headed (six), T-headed (one) and L-shaped forms identified. An iron brace drill was also recovered from MMH-b (E13 sub-surface). At HGH, 15 nails were found in total: one during wall-clearing, one during augering, and the remainder in M10 and M11. Most were degraded, with only three possible T-headed and one rose-headed nail being identifiable. A door latch was found at the top of the steps on the western wall and a small padlock was recovered from along the same wall. The front of the padlock preserves the arm that once covered the keyhole, while the back cover has fallen away, exposing the corroded lock mechanism inside.

Printing press pieces

A total of 14 printing press pieces, or moveable type, were found in the midden. All these pieces were made of the same lead alloy that survived very well over time. Only five of the 14 pieces had a letter. The remaining nine pieces of metal were of similar shape and had the same indented notches along the long edges. These were presumably either used as spacing tools to break up words, or have since been broken and the letters not found. At MMH, three printing press pieces were found, all at MMH-b. Two could be classified as letter pieces but the letter was only identifiable on one: a very ornate capital E. The third press item was a miscellaneous piece.

A total of 58 pieces of printing press metal was found across HGH, a far higher number than those found elsewhere on the precinct. Of these 58, 16 were definite letter pieces with the letters still visible on the end.

Other
A ring was found in the PPHm (F1.1/40-63) and analysed by the School of Earth Sciences at Wits University, using an electron microprobe. The ring comprised a metal alloy with two blue/green glass stones. A pipe stem and a few pieces of embossed tin, and a container roughly the size of a modern sardine tin, was also recovered from the midden. A sample of lead shot pieces (15) was also found in the F1 midden, of varying sizes (from 2 to 10 mm).

In PPHt (J3 40-60 ash lens) a piece of the inner workings of a musical instrument, like a harmonica or accordion, was recovered.

Chronological markers
We present items using stacked bar charts to identify patterns or trends in the midden over time. In the first chart (Fig. 19), we have selected items with known or associated dates of arrival, or periods of high demand, as in the case of lead shot. Most of these items cluster between spit 2 and 12. In the second graph, European ceramics are displayed to detect changes over time. Flow blue and blue TP are ubiquitous, while sponge and hand painted occur above spit 13 and TP green between spit 10 and surface. These trends are further explored in the discussion section.

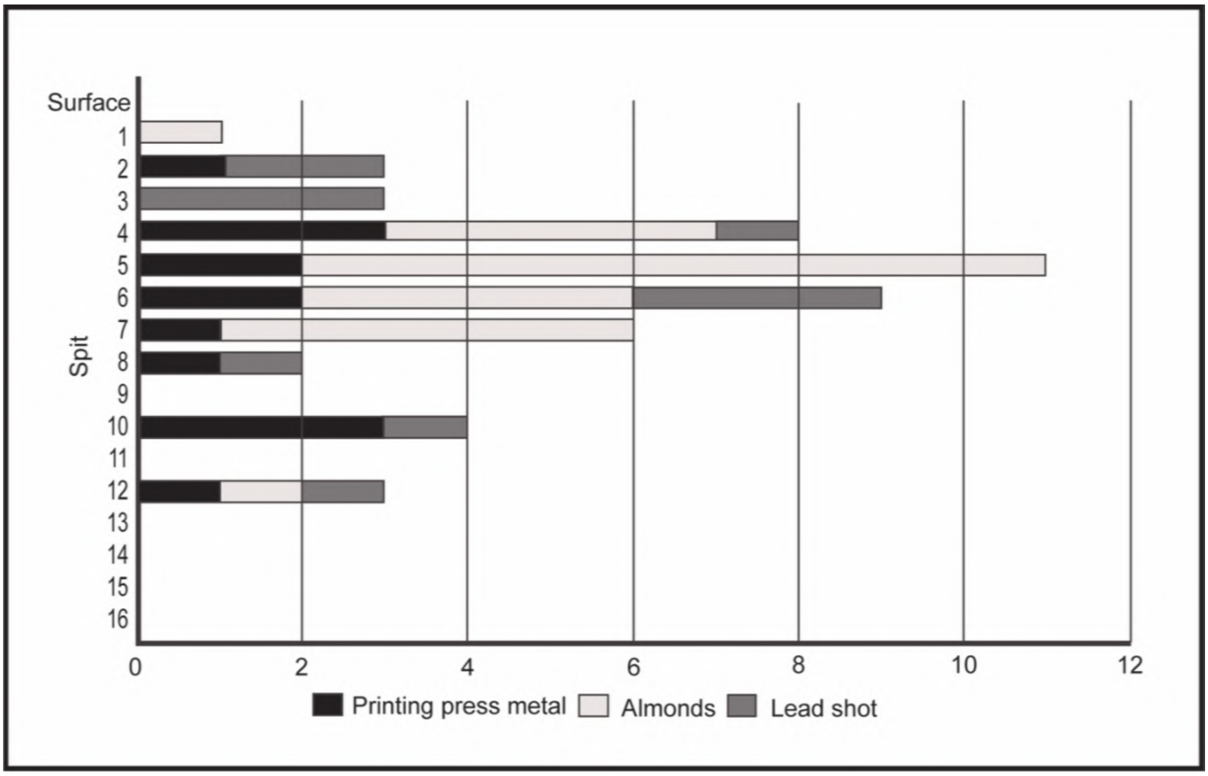


Figure 19. Items associated with Rev. Richard Giddy.

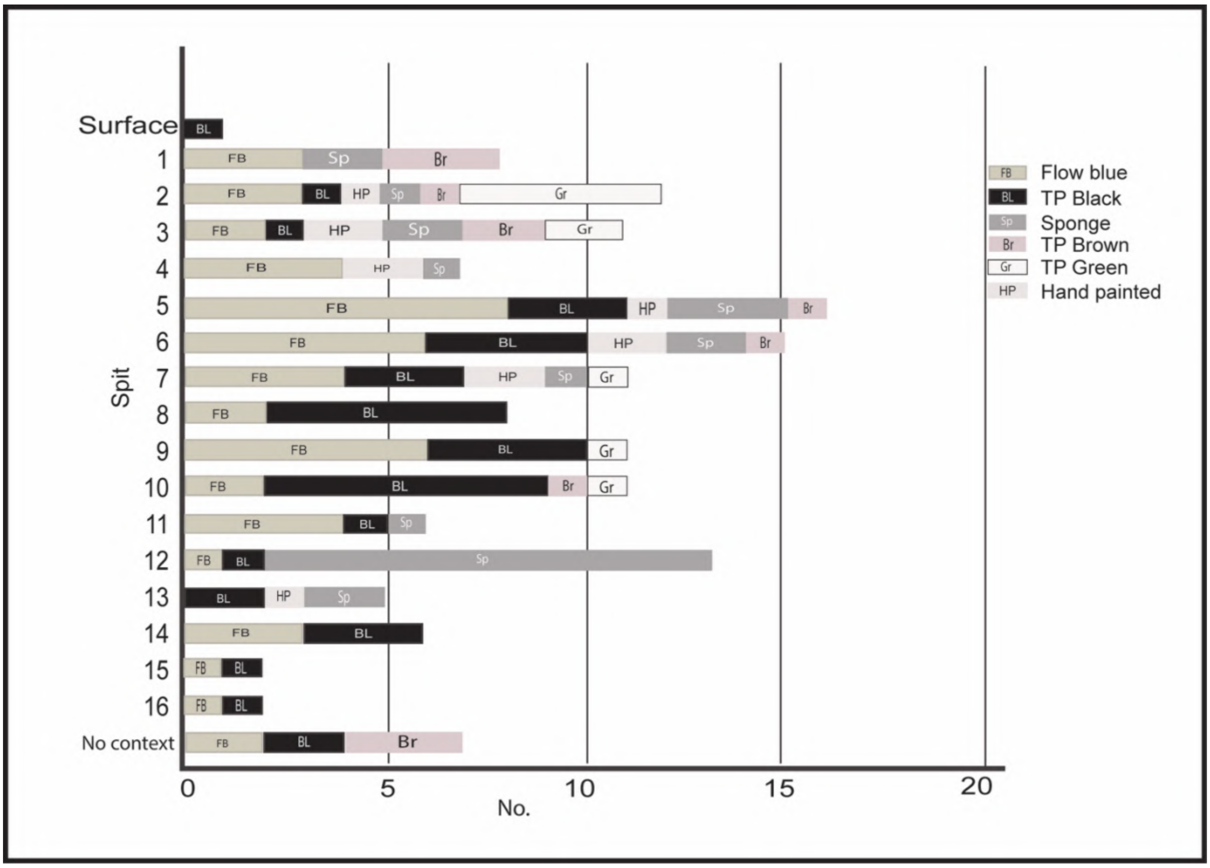


Figure 20. Change in European ceramics over time based on raw counts.

4. Discussion

The PPH structure was possibly enclosed by a wall and strategically positioned at the main intersection's crossroads. It is cross-shaped, matching the shape and dimensions depicted in Wesleyan missionary John Ayliff's sketch of a chapel (ca. 1861) (Fig. 21) and is situated at the highest point on the site, standing approximately 5 m above the station's northern edge and about 6 m higher than the western edge. Based on its shape and prominent location, we propose that this structure is the chapel. The centrality and visibility of this whitewashed building arguably symbolised the chapel's pivotal role in daily life. Its commanding position on the landscape would have conveyed both a sense of protection (watching over) and surveillance (watching) of the community (Spencer-Wood 2002). This dual purpose may also be reflected in the placement of the windows facing the road. Elsewhere, we have argued that the crossroads and walled enclosures created an illusion of 'order', 'class', and 'industry', allowing the missionaries to shape and control social, religious, and legal perceptions of community membership and land ownership (Esterhuysen et al. 2019).

Unfortunately, from an archaeological standpoint, the home and domestic spaces of the missionaries and their families remain largely elusive. The evidence for spatially defined activities or subdivided spaces that might have represented the 'ideal' missionary home (Ashley 2018) is obscured beneath collapsed walls and within disturbed deposits.

The archival records, however, provide some insight into the mission house, as described in a letter by Cameron (n.d.: 148) dated 10 March (*Letter to the secretaries of the Wesleyan Missions. Thaba N'chu 10 March 1845 in the James Cameron. Letter Book, OFS Archive, Bloemfontein*):

> The Mission House at Platberg is a very good one of the kind, affording ample and comfortable accommodation for a missionary and his family. It consists of five rooms, a kitchen, and a pantry, stands near the Chapel, and is otherwise very pleasantly situated.

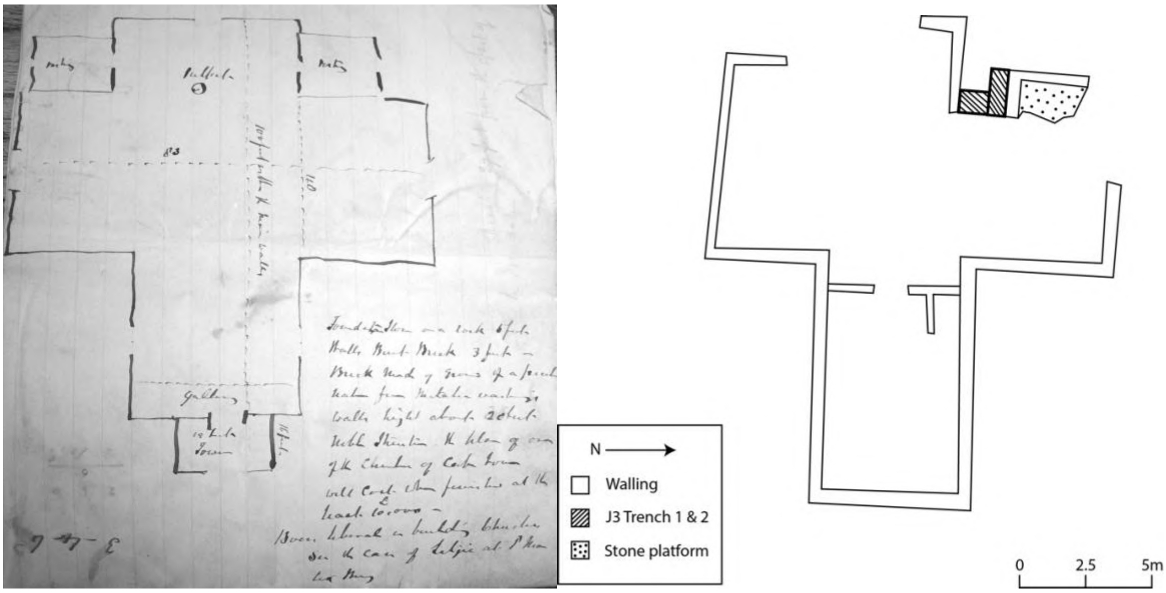


Figure 21. Drawing of a chapel from Ayliff's diaries 1861 placed alongside the map of PPH.

The proximity to the chapel and the size of the mudbrick mound suggests that MMH, with its internal brick divisions, was the original missionary's house. HGH may have housed additional family members, but the discovery of numerous printing press pieces (of moveable type) and stoneware ink bottles suggests that this building also served as Richard Giddy's printing office. As a trained printer (Smith 1971; Picton 1982), Giddy reinstated the printing press in Thaba N'Chu in 1840 and later moved it to Plaatberg in 1845 (Picton 1982). The presence of printing press pieces in PPHm thus provides a marker of Giddy's occupation. The majority were concentrated in levels 4-10 (Fig. 19). Notably, this coincides with almond pips. Trees planted by Cameron would have reached reproductive maturity during Giddy's tenure and anecdotal evidence passed down through the Giddy family suggests that Giddy significantly expanded the variety of fruit at the site (Taylor 1927). The unpublished document suggests that a member of the Sephton family, from Giddy's second marriage, planted almond trees along with a large orchard of pomegranates, figs, cherries and other fruits.

The mission precinct survived attacks by the BaSotho and was probably only destroyed by the Boers in the 1860s, as a measure to prevent the BaSotho from using the structures and surrounding hills for shelter. The protection afforded to the missionaries by the BaSotho allowed Giddy to continue printing several publications between 1851 and 1853. This protection was likely a strategic and diplomatic move by Moshoeshoe, possibly influenced by the Paris Evangelical Missionaries (PEMS) stationed at Morija. This immunity enabled Giddy to collaborate with the PEMS missionary Joseph Ludorf to print the SeSotho versions of the Epistle of St. John and Revelation (Picton 1982). In 1855, Giddy also printed Psalms for Arbousset, another PEMS missionary (Smith 1971). The Wesleyan-Methodist Report for the year (1856: 59) praises the press for printing two proclamations issued by Moshoeshoe against witchcraft and "the strong drink of the white people".

The chapel served as a public space, frequently used for sermons and as a schoolhouse for teaching literacy and religion to both adults and children (WMMS 1848, 1857). The 'home-made' counting pieces and slate tablets and pencils are testament to these activities.

By contrast, the missionary's home next door was a more private space, reserved for the missionary and his family. The midden (PPHm) at the back of the precinct seems to have served the entire precinct. The area behind MMH may have had various functions over time, possibly as a workshop, cooking area, or even a space for more private instruction of the missionary's children.

Regarding European ceramics, blue TP ware and Willow Pattern was ubiquitous across the mission precinct. This is unsurprising, as blue was the most popular colour for printing on English earthenware

(Samford 1997) and the Willow Pattern gained popularity during the 19th century in both the Cape and Britain. Its popularity may have been linked to it being one of the first patterns to have its price fixed by potters to below that of other transfer prints (Miller 1980; Copeland 1999; Klose & Malan 2000). Levels 4-10, which correspond to the transition from Cameron to Giddy, are also associated with inexpensive hand-painted, dipped, and sponge-decorated ceramics (Fig. 20). These types of ceramics were among the most affordable decorated wares on the market, as their decoration was applied by relatively unskilled labour (Miller 1980). Sponged refined industrial ware became popular in the mid-19th century (Majewski & O'Brien 1987; Klose & Malan 2000), as did the introduction of flow blue ceramics into the American and South African markets (Samford 1997; Klose & Malan 2000; Klose 2007). However, unlike standard TP and hand-painted plates, flow blue ceramics were considered much more expensive (Miller 1980). It is tempting to suggest that the smaller number of flow blue pieces reflects a distinction between everyday crockery and those reserved for special occasions (Miller 1980), but a larger sample size would be needed to confirm this. Overall, the utilitarian nature of the ceramic assemblage reflects both the Wesleyan ethos and the general affordability and availability of British tableware in South Africa during the mid-19th century.

The beads recovered from the site are also typical of the period and were no doubt cached by the missionaries for trading purposes. The white hearts, made in Venice, arrived in South Africa sometime after the mid-1830s, and together with white beads appear at contemporary sites (1840s-1860s) in the interior of South Africa (Wood 2008). The presence of pink and some of the green beads suggest a possible trade link with Port Natal or trade through the Natal mission (Wood 2008). It should be noted that some of the beads were heavily patinated and disintegrated into powder when lifted from the soil. It has been suggested that the pH of the soil – and in this regard the presence of termites – may have played a role in altering the chemistry of the glass. The original elemental composition of the glass, however, would determine the response of the glass to corrosive agents including acidic and basic solutions, water and general atmospheric substances (Pollard & Heron 2008). This would also hold true for some of the flat glass that was highly leached and patinated.

The bone analysis reveals the presence of domesticated animals that were reportedly kept at the station. Notably, very few wild animal remains were recovered from the mission precinct. Only a possible Blesbok (*Damaliscus* sp.), a Wildebeest (*Connochaetes* sp.), and a waterfowl were identified. These wild animals were found in the section of the midden associated with Reverend Giddy, suggesting that the missionaries may have resorted to hunting for game meat after Carolus Baatjes' people left with the British in 1851 to fight against the BaSotho at the Battle of Viervoet. According to the British Resident's memorandum, approximately 90 wagons, 800 women and children, along with cattle, marched with the British troops, fearing an attack by the BaSotho while the fighting men were away (Theal 1883). These fears were not unfounded, as the British lost the battle, and the BaSotho attacked, set fire to houses, and destroyed properties outside of the precinct at Plaatberg (Lucas 1878; Schoeman 1991), and no doubt claimed the remaining livestock. The situation worsened when Carolus' men, along with Fingo and Barolong, retaliated on October 17th, seizing significant numbers of cattle and horses from both the station and the BaSotho who had settled around the abandoned area (Midgley 1949; Kirk 1989).

However, the limited presence of these game animals may also reflect the dwindling numbers of large antelope in the region (Grab & Nash 2022). By 1856, members of the Paris Mission Society began to note the stark decline in what was once a hunting ground for big game (Grab & Nash 2022), a change driven by the shift from hunting to agropastoralism and undoubtedly exacerbated by the ongoing conflict in the area.

Once the station and chapel fell into disuse, sections of the buildings and the hills were variously used to take refuge, shelter and to cook or process food. The high number of locally made earthenware ceramics together with the fruit pips and a grinding stone indicate some activity at the entrance to the chapel prior to the final collapse of the walls. The final collapse of the station was brought about by the Boers repeatedly 'sweeping' through to 'clean out' all the BaSotho from in and around the Plaatberg (Bosch 1967).

Later disturbances caused by both humans and animals have contributed to the loss of contextual information. Accordingly, although the site was initially approached with caution and excavated in spits, excavation strategies were adapted in response to these disturbances and shifted towards the excavation of features. Klatzow (2023) successfully excavated domestic structures along the street, and forthcoming publications are expected to provide comparative analyses and assess different approaches.

5. Conclusion

The study of the mission precinct reveals various activities and events that took place over time. The shape and position of PPH suggest it was the chapel, while MMH likely served as the associated mission house. The concentration of moveable type printing press items suggests that HGH also functioned as the printing office. The other areas behind MMH are less defined and may have been multipurpose spaces, adapted to the missionary's needs. The midden offers insight into the different occupations of the site, while other sections around the chapel hint at the later use of the space before it ultimately fell into disuse. The collapsed walls and remains of burnt structures point to the final destruction of the station during the 1860s.

Acknowledgements

We should like to thank Joanna Behrens, Natalie Swanepoel, Francois Coetzee and the UNISA field school students who helped to excavate and expose walling in 2015 and 2016. In 2016, Chrissie Sievers and the Wits Honours students also assisted with the excavation and clearing walls, as did Vanessa Maitland and Saran Maitland-Donald. Jeannette Smith helped to map the walls in 2015. Simon Hall and Shelona Klatzow, funded by UCT, gave invaluable insight into the history of the area, as well as assistance in the field over the years 2015 to 2018. Thank you to all those who helped with the analysis of the finds. Annie Antonites assisted with the analysis of the faunal remains, Joanna Behrens with the ceramics, Shannon Hardwick and Chrissie Sievers with the seeds. The National Research Foundation (grant number 91015) funded the University of the Witwatersrand part of this study, as well as awarding the DAAD-NRF In-Country scholarship to Tamsin Hunt in 2016. We thank the Cory Library for granting access to Cameron’s diaries. 'Mamokuena Makhema assisted with the translation of the abstract.

References

Ashley, C. 2018. (Re)making landscape and place: An archaeology of the Lake Ngami Mission (1893-96), Khwebe Hills, Botswana. Journal of Southern African Studies, 44(4): 703-722. https://doi.org/10.1080/03057070.2018.1491517

Ayliff, J. 1861. Rough diary of a visit to Platberg and neighbouring areas and Smithfield. Unpublished source. N.P. Ms 15 542, Methodist Archives Collection. Grahamstown: Cory Library.

Bosch, J.A. 1967. Ladybrand. Ladybrand: Ladybrand Municipality.

Broadbent, S. 1865. A Narrative of the First Introduction of Christianity Amongst the Barolong Tribe, South Africa. London: Wesleyan Mission House.

Cameron, J. n.d. No title. Unpublished letter book. No 11.2 Henderson Collection. Bloemfontein: Orange Free State Archives.

Copeland, R. 1999. Spode’s Willow Pattern and Other Designs After the Chinese. Third Edition. London: Studio Vista Cassell.

Esterhuysen, A.B. 1992. Charcoal from Leliehoek Shelter, eastern Orange Free State, South Africa. Palaeoecology of Africa, 23: 193-201. https://www.jstor.org/stable/3889225

Esterhuysen, A.B. 1996. Palaeoenvironmental reconstruction from Pleistocene to present: An analysis of charcoal from sites in the eastern Free State and Lesotho. Masters Dissertation. Johannesburg: University of the Witwatersrand.

Esterhuysen, A.B., Klatzow, S. & Hunt, T. 2019. Opening enclosure: A study of Plaatberg a Wesleyan Mission Station, Free State, South Africa. Azania: Archaeological Research in Africa, 54(1): 107-123. https://doi.org/10.1080/0067270X.2019.1583466

Grab, S.W. & Nash, D.J. 2022. “But what silence! No more gazelles…”: Occurrence and extinction of fauna in Lesotho, southern Africa, since the late Pleistocene. Quaternary International, 611: 87-101. https://doi.org/10.1016/j.quaint.2020.04.030

Hunt, T. 2020. The Platberg Wesleyan Mission Station: A landscape revealed. Doctoral Thesis. Johannesburg: University of the Witwatersrand. https://wiredspace.wits.ac.za/bitstreams/7ebf1034-87c1-419f-a199-b5d0bc232dc1/download

Kirk, M.J. 1989. Memoirs of Grannie Kirk (1823-1906). In: Schoeman, K. (ed.) The Early Days of the Orange Free State: 47-88. Cape Town: Human & Rousseau.

Klatzow, S 2023. Plaatberg on the Caledon Bastaards: Hunters, raiders and traders or pious converts of the Wesleyan Missionary Society. Doctoral Thesis. Cape Town: University of Cape Town. http://hdl.handle.net/11427/39683

Klose, J. 2007. Identifying Ceramics: An Introduction to the Analysis and Interpretation of Ceramics Excavated from 17th to 20th Century Archaeological Sites and Shipwrecks in the South-Western Cape. Second Edition. Cape Town: Historical Archaeology Research Group, University of Cape Town.

Klose, J. & Malan, A. 2000. The ceramic signature of the Cape in the nineteenth century, with particular reference to the Tennant Street site, Cape Town. The South African Archaeological Bulletin, 55: 49-59. https://doi.org/10.2307/3888892

Lucas, T.J. 1878. Camp Life and Sport in South Africa: Experiences of Kaffir Warfare with the Cape Mounted Rifles. London: Chapman and Hall.

Majewski, T. & O'Brien, M.J. 1987. The use and misuse of nineteenth-century English and American ceramics in archaeological analysis. Advances in Archaeological Method and Theory, 11: 97-209. https://doi.org/10.1016/B978-0-12-003111-5.50006-3

Midgley, J.F. 1949. The Orange River Sovereignty (1848-1854). Archives Year Book for South African History, Twelfth Year – Volume 2. Cape Town: Minister of Education, Arts and Science.

Miller, G.L. 1980. Classification and economic scaling of 19th century ceramics. Historical Archaeology, 14: 1-40. https://doi.org/10.1007/BF03373454

Mucina, L. & Rutherford, M. 2006. The Vegetation of South Africa, Lesotho and Swaziland. Pretoria: South African National Biodiversity Institute.

Picton, L.J. 1982. Wesleyan Mission Presses and the Xhosa Bible. Limited Edition for the Centenary Year of the Southern African Conference: Cape Town. Thornton: Private Distribution.

Pollard, A.M. & Heron, C. 2008. Archaeological Chemistry in Archaeology. Cambridge: Cambridge University Press.

Samford, P. 1997. Response to a market: Dating English underglaze transfer-printed wares. Historical Archaeology, 31(2): 1-30. https://doi.org/10.1007/BF03373600

Schoeman, K. 1991. The Wesleyan Mission in the Orange Free State 1833-1854: As Described in Contemporary Accounts. Cape Town: Human & Rousseau.

Smith, A. 1971. The Spread of Printing (South Africa). Amsterdam: Van Gendt & Co.

Spencer-Wood, S. 2002. The historical archaeology of nineteenth century American cultural landscapes: A review. Landscape Journal, 21(1): 173-182. https://doi.org/10.3368/lj.21.1.173

Taylor, M . 1927. Agnes' tales or tales of the Giddy Family 1840-1890, as told to Agnes Helen by her mother and notes on her own life. Recorded by her daughter Mrs Maggie Taylor ca. 1927, or written at an earlier date. Unpublished source. The Giddy Family.

Theal, G.M. 1883. Basutoland records. Copies of official documents of various kinds, accounts of traveller, &c., collected and arranged by order of the Honourable J.W. Sauer, esp., secretary for native affairs. Vol. III 1862-1868. Cape Town: W.A. Richards & Sons.

van Heerden, G.P. 1993. The work of the Reverend James Cameron of the Wesleyan Methodist Missionary Society from 1829 to 1835. Masters Dissertation. Grahamstown: Rhodes University.

Venter, I.S.J. 1960. Die Sendingstasie Thaba Nchu, 1833-1900: Die Werk wat op die Gebied van Kerk en Skool Deur die Wesleyane Onder die Barolong Gedoen is. Pretoria: Mededelings van die Universiteit van Suid-Afrika.

Weiland, J. 2009. A comparison and review of window glass analysis approaches in historical archaeology. Technical Briefs in Historical Archaeology, 4: 29-40.

Wesleyan Methodist Missionary Society (WMMS). 1848. The Report of the Wesleyan-Methodist Missionary Society for the Year Ending April, 1848. London: Wesleyan Missionary Society.

Wesleyan Methodist Missionary Society (WMMS). 1856. The Report of the Wesleyan-Methodist Missionary Society for the Year Ending April, 1856. London: Wesleyan Missionary Society.

Wesleyan Methodist Missionary Society (WMMS). 1857. The Report of the Wesleyan-Methodist Missionary Society for the Year Ending April, 1857. London: Wesleyan Missionary Society.

Wood, M.H. 2005. Glass beads and pre-European trade in the Shashe-Limpopo region. Masters Dissertation. Johannesburg: University of the Witwatersrand. https://wiredspace.wits.ac.za/items/ae7ad448-d70f-4321-97e8-1f66ff27c16f

Wood, M.H. 2008. Post-European contact glass beads from the southern African interior: A tentative look at trade, consumption and identities. In: Swanepoel, N.J., Esterhuysen, A.B. & Bonner, P. (eds) Five Hundred Years Rediscovered: Southern African Precedents and Prospects: 183-196. Johannesburg: Wits University Press.

Southern African Field Archaeology
2025 Vol. 20: Article 4135
Overview (peer-reviewed): Received March 2025; Revised August 2025; Published December 2025
DOI: https://doi.org/10.36615/safa.20.4135.2025

ISSN 1019-5785
ISSN 2789-1844

Arthropod presence and their relevance in South African archaeological deposits

Michelle Mouton [a, *], Annie R. Antonites [b, c], Tharina L. Bird [b, d] & James du G. Harrison [e]

[a]Department of Anthropology, Archaeology and Development Studies, University of Pretoria, Private Bag X20, Hatfield 0023, South Africa
[b]Ditsong National Museum of Natural History, P.O. Box 4197, Tshwane 0001, South Africa
[c]Department of Anthropology and Archaeology, University of South Africa, P.O. Box 392, Tshwane 0003, South Africa
[d]Department of Zoology and Entomology, University of Pretoria, Private Bag X20, Hatfield 0023, South Africa
[e]School of Animal, Plant and Environmental Sciences, University of the Witwatersrand, Private Bag 3, Wits 2050, South Africa
Corresponding author email: michelle.mouton@tuks.co.za

ABSTRACT
Arthropod biology, entomology and forensic entomology are well-established fields in South Africa, yet their application in local archaeological studies is underdeveloped. Here, we discuss the nature of arthropod (mainly insects) presence reporting from excavation and laboratory analyses of archaeological materials in South Africa. We assess the shortcomings of reporting trends, explore interpretive possibilities based on a case study from two Early Iron Age sites (Le6 and Le7) and a Middle Iron Age site (Evelyn) in the Limpopo Province, and suggest the way forward for optimal recording of arthropod presence in archaeological deposits. In addition to presenting a case for entomology *sensu lato* in understanding past environments, site formation processes, agricultural practices and living conditions, we also highlight the role archaeologists can play in entomological research by gathering present-day data on subterranean arthropod presence and behaviour.

ABSTRACT IN NORTHERN SOTHO
Payolotši ya dikhunkhwane, thutadikhunkhwane le thutadikhunkhwane ditopong ke makala ao a hlomilwego gabotse kudu ka Afrika Borwa, le ge e le gore phethagatšo ya makala a go thuto ya dilo tša kgale ga se ya hlabollwa gabotse. Mo, re ahlaahla sebopego sa go fa dipego ka ga go ba gona ga diphoofotšwana tša go hloka lerapo la mokokotlo (kudukudu dikhunkhwane) ge go sekasekwa dilo tša kgale tše di epollotšwego le tša ka laporathoring ka Afrika Borwa. Re sekaseka ditlamorago tša go se kgahliše tša mekgwa ya go fa dipego, ra lekola dikgonagalo tša tlhathollo go ya ka dinyakišišo ka ga seemo le go akanya gore go iwa pele bjang go gatiša ka botlalo go ba gona ga dikhunkhwane ka megogolweng ya kgale. Go tlaleletša go hlagiša tiragalo ya go ba gona ga dikhunkhwane go kwešiša ditikologo tša kgale, ditshepedišo tša tlhamego ya lefelo, ditiro tša bolemi le maemo a go phela, re gatelela gape tema yeo bašomi ba diepollwa tša kgale ba ka e ralokago ka go dinyakišišo tša dikhunkhwane ka go kgoboketša tshedimošo ya lehono ka ga dikhunkhwane tša ka fase ga mobu le go ba gona ga diphoofotšwana tše dingwe tša go hloka lerapo la mokokotlo le maitshwaro a tšona.

Keywords: archaeoentomology, arthropods, bioturbation, entomo-archaeology, human-insect interaction

1. Introduction

Arthropods – animals with hard exoskeletons and jointed appendages in the phylum Arthropoda – are the most diverse group of animals on the planet (Miller & Rogo 2002), and the African continent boasts a rich arthropod species diversity (Scholtz & Chown 1995; Foord et al. 2011; Scholtz & Mansell 2017). In terrestrial environments, familiar taxa include spiders, scorpions and kin (Arachnida), millipedes and centipedes (Myriapoda), and numerous insects and kin (Hexapoda), and for societies that live near water bodies, crabs and kin (Crustaceans). In addition to arthropods, other invertebrates such as earthworms (Oligochaeta), and slugs and snails (Gastropoda) are also of relevance in archaeoentomology (Versteegh et al. 2013; Backwell et al. 2022). Different groups of arthropods offer different avenues from which to explore past human societies, or to interpret the environment in which these humans lived.

Insects and arachnids are critical for maintaining ecosystem functioning (e.g., for nutrient cycling and pollination, and as predators and prey). Insects such as aphids (Hemiptera, Aphididae), caterpillars of moths and butterflies (Lepidoptera), beetles (Coleoptera), and grasshoppers, crickets, and locusts (Orthoptera) can impact agricultural systems as pests, while predators such as spiders (Araneae) and parasitoids such as wasps (Hymenoptera) act as biocontrol agents that keep pest numbers in check (Nyffeler & Birkhofer 2017). Some insects such as tsetse flies (Diptera, Glossinidae) and malaria mosquitoes (Diptera, Culicidae) are vectors of disease to both humans and livestock, while medically important arthropods include poisonous and venomous insects and arachnids (Mullen & Durden 2002; Goddard 2012).

Arthropods, in particular insects, are a well-known food source; in Africa, they are often referred to as ‘small meats’ and supply a rich source of protein and other dietary nutrients to its inhabitants (see van Huis 2003; van Huis et al. 2013; Egonyu et al. 2021). Specific methods were developed on the continent to collect insects for food using, for example, glue, light, and sound traps, and remarkably complicated devices such as clay pipes to detect, attract, and/or trap insects (e.g., Junod 1913; van Huis 2003). Today, entomophagy (the consumption of insects) is common throughout Africa, where many species across different insect orders are consumed, as larvae and/or adults depending on the species, of beetles, moths and butterflies, grasshoppers and crickets, termites (Blattodea, Termitoidea), and ants, bees, and wasps (van Huis 2003: table 1; Kelemu et al. 2015; Farr 2021). People keep bees or collect wild honey, and the soil of termite mounds (termitaria) is consumed because of its nutrient value (e.g., Grivetti 1979; Hunter 1984; Yamashina 2010; Fairhead 2016; Farr 2021).

Insects and many other arthropods are also exploited for their medicinal value across various localities (Meyer-Rochow 2017). In Africa, for example, traditional healers use insects as medicine for humans and livestock, including the use of crushed wasps to treat headaches, the consumption of mantis (Mantodea) ootheca (egg case) to treat earache, and stick insects (Phasmatodea) to lose weight (van Huis 2003, 2021). Termites also feature prominently in San healing symbolism (Mguni 2006, 2015). An interesting example of contemporary medicinal use that includes both the organism and its burrow is the use of baboon spiders (Araneae, Theraphosidae) to treat wounds. Here, a potion (*muthi*) is produced by crushing the whole spider and mixing it with the root of a lily. This mixture is then stored in the spider’s burrow to preserve its curing properties, after which it is applied to the wound (Manamela 2003).

Beyond their caloric and medicinal value, arthropods are part of various other aspects of human societies. Arthropods are used in biomimicry, biotechnology and biomedical research (Bonning 2009; Pulsifer et al. 2011; Bloemberg et al. 2021). Today, arthropods are used in forensic entomology where specialist knowledge on the identification of (especially) insects, and their behaviour, biology and ecology, provide evidence in civil and criminal cases (Williams & Villet 2006). In South Africa, forensic entomology has aided in medico-legal investigations in criminal cases since the 1980s (e.g., Prins 1983, 1984a, b). The accumulation of research on carrion-associated insects and stored product pests, combined with the long history of taxonomy in southern Africa, form the foundation of forensic entomology in the region.

Arthropods further provide building material, such as soil from termitaria, for the construction of housing (Marchand 2009; Yamashina 2010; Farr 2021), while their body parts serve as ingredients for hunting poisons (Bradfield et al. 2015; Bird et al. 2023). They are also used as material for ritual, ornamental and musical objects. For example, the colourful elytra or hard forewings of jewel beetles (Buprestidae) are incorporated into necklaces, and dancing rattles are made from the silken cocoons of

Lasiocampidae and Saturniidae moths (van Huis 2019, 2021). Trade in insects such as mopane caterpillars *Gonimbrasia belina* Westwood 1849[1], longhorn grasshoppers *Ruspolia differens* (Serville 1838), and insect products such as honey, or termitaria soil, have helped to establish significant rural economies across Africa (Yamashina 2010; Mmari et al. 2017; Nemadodzi et al. 2023).

Arthropods are a source of stories, superstition, and symbolism; in particular, insects and arachnids feature strongly in the folklore of many African cultures (e.g., Junod 1913; Mguni 2015; Schmidt 2020). Among Namibian Khoisan, the praying mantis holds special importance, both as an oracle and as an omen, while southern African Bantu-speaking groups similarly consult a mantis to help locate lost cattle (Schmidt 2018). For many groups in South Africa, stick insects have healing properties and promote wellbeing; they are seen as a vessel through which ancestors visit a sick family member (Junod 1913). Bees and termites are 'honey-fat' creatures, substances that hold symbolic value for the southern African San associated with concepts of creation in ritual symbolism (see discussion in Mguni 2015). San groups believe that honey and fat possess supernatural potency and they are used for anointing and are often linked with rain symbolism (Mguni 2015; see also Russell & Lander 2015). In West Africa, the spider-like trickster, Anansi, plays a central role in folklore (Marshall 2007), while termites and termitaria feature strongly in many African creation myths (e.g., Geissler 2000; Mguni 2006; Fairhead 2016; Farr 2021).

These examples show that insects and other arthropods were, and in many cases still are, often welcomed in the living spaces and symbolic worlds of various sub-Saharan communities. The question arises whether we can trace arthropod presence in archaeological contexts, and what their presence might reveal about past peoples and environments, and how they may have impacted the formation and preservation of archaeological deposits. We aim here to provide an overview of archaeoentomological studies, assess the gaps in local reporting trends, and explore interpretive possibilities based on a case study from two archaeological sites in South Africa. We suggest the way forward for optimal recording of insect presence in archaeological deposits, to contribute to both potential research avenues and current biodiversity research in sub-Saharan Africa.

2. Arthropods in archaeology

Arthropod presence in the archaeological record can be detected from the preservation of complete insects or their body parts, or indirectly through ichnological proxies such as casts or imprints of burrows and tunnels, as well as from taphonomic damage left on archaeological materials such as bone (Baucon et al. 2008; Nascimento et al. 2021; Backwell et al. 2022; Bradfield 2023). The preservation of arthropod body components is rare, requiring specific environmental conditions. Although the conditions in which arthropods survive in archaeological deposits is understudied (see Robbiola et al. 2011), preservation is most noted for anaerobic, waterlogged, or desiccated environments (Buckland 1990; Elias 2009; Robbiola et al. 2011). Although rare, arthropod body parts can preserve, particularly sclerites (the chitinous components of exoskeletons) when carbonised (Panagiotakopulu & Buckland 1991).

These remains and trace evidence of arthropods – largely insects and arachnids – are often encountered during archaeological and palaeontological excavations from various localities around the world and may be linked to post-depositional disturbances. Conversely, when deposited within the archaeological timeframe, such remains and signs of arthropods can make an important contribution to the reconstruction of anthropogenic and natural environments and provide insight to the activities and behaviours of the past peoples.

[1] Throughout the text, genus and species identifications include taxon authorities. These are the surnames, and in some cases surname and initials, of the person(s) who first described the species. If a species is described under the same genus where it is currently placed, the taxon authority does not get parentheses; if the species was described by a particular author but the species was since moved to another genus, the taxon authority is placed in parentheses. In Botany, additional taxon authorities are listed to indicate the authors involved in the name changes.

The reconstruction of palaeoenvironments through insect and other arthropod proxies is well known (Elias 1994; Eggermont et al. 2008; Buckland 2014; Dickson & Walker 2015). For example, Versteegh et al. (2013) found that earthworm-secreted calcite granules provide a reliable measure of ancient climates. Similarly, the cells in the nests of social bees (ichnogenus *Celliforma* Brown 1924) provided an indication of the local palaeoclimate in which the 'Taung Child' Australopithecine had lived (Parker et al. 2016). However, there remains a need to explore the activities of past peoples in relation to their environments (e.g., Sutton 1995). As such, greater emphasis needs to be placed on the use of arthropod traces and remains as archaeological indicators of human activity, by which settlements and past economic landscapes can be reconstructed (Elias 1994, 2009; Sutton 1995; Ponel et al. 2000).

When arthropod remains can be identified to sufficient taxonomic resolution, various detailed questions related to past economy, life, and society can be answered. For example, by exploring the macro-remains of synanthropic beetle species (beetles associated with human settlements) at a multicomponent settlement in Calvados, France, Ponel et al. (2000) were able to reconstruct anthropogenic components in the formation of certain deposits spanning the La Tène and Gallo-Roman periods. Crop pests such as the pea weevil *Bruchus pisorum* (Linnaeus 1758) and the grain weevil *Sitophilus granarius* (Linnaeus 1758), contributed to the characterisation of the site's agricultural activities, while the diversity of phytophagous (plant eating) and the absence of silvicolous (species associated with forest habitats) beetle taxa allowed for the reconstruction of the site's environment and immediate surroundings. As *S. granarius* is not native to France, its identification also helped to reconstruct its introduction into the area. Buckland (1981) similarly used *S. granarius* and other invasive synanthropic beetles to reconstruct the expansion of agriculture across Europe. These studies not only help characterise prehistoric exchange networks, but also allow for the reconstruction of the species' introduction and changes in their distribution because of such exchanges (e.g., Panagiotakopulu & Buckland 1991, 2009; Panagiotakopulu 2001; King et al. 2009; Tuccia et al. 2022).

Insects can also inform on animal management activities. The presence of parasitic sheep ked *Melophagus ovinus* (Linnaeus 1758) and chewing lice *Bovicola ovis* (Schrank 1781), both ectoparasites specific to sheep, in late medieval deposits at Stóraborg on the south coast of Iceland confirmed the presence of sheep, which can be difficult to distinguish from goats based solely on osteology. Ectoparasites, along with coprophagous beetles, e.g., dung beetles (Scarabaeinae), indicate areas where livestock were kept, and areas where wool was likely processed (e.g., Buckland & Perry 1989; Smith 1998; Grove 2001). The contributions of these archaeoentomological studies all address questions archaeologists seek to answer (e.g., Allentuck & Greenfield 2010).

Tracing the antiquity of arthropods as food is difficult, but insect remains, and parasites associated with entomophagy, have been successfully identified in palaeofaeces across the Americas (Reinhard & Bryant 1992; Sutton 1995; Elias 2009), offering a potential means of reconstructing prehistoric diets. In the absence of insect remains, some scholars have suggested studying use-wear patterns (microscopic striations produced by use over time) on stone and bone tools to determine their function, which could provide evidence for the harvesting of insects in prehistoric diets (e.g., Tommaseo-Ponzetta 2005; McGrew 2014). For example, Backwell & d'Errico (2001) argued that the micro-striations on bone tools from Swartkrans, South Africa, were produced by digging into mounds for termites, supporting the role of entomophagy in the early hominid diet.

The strong cross-disciplinary character of forensic sciences, drawing from various fields of knowledge and research, is a good model to follow in archaeological investigations. Taphonomic studies focused on the effects that carrion-associated insects have on organic materials, for example, also feature in archaeological discourse. Archaeological interpretation relies on sound understandings of the formation of archaeological deposits and associated artefacts. Under ideal conditions, insects are collected from graves, tombs and mummified remains of humans and animals (e.g., Panagiotakopulu 2001; Mosothwane 2011; Tuccia et al. 2022). Another example of research relevant to archaeology is how vertebrate remains are modified by beetles, moths, termites, fly larvae, and ants, bees, and wasps (Backwell et al. 2022; Mahomed 2022; Parkinson 2023). Such studies focus on the effects that certain arthropods have on the preservation and interpretation of faunal remains (Backwell et al. 2012, 2022).

3. Methods

To get a general sense of the nature of archaeologists' reporting on the presence of insects and other arthropods in southern Africa, we reviewed literature in two major southern African archaeology journals for reference to insects and other arthropods: the *South African Archaeological Bulletin* (*SAAB*, 1950-2022) and *Southern African Field Archaeology* (*SAFA*, 1992-2022). To get a broad idea of the kind of arthropod fragments present in southern African archaeological deposits, their possible interpretations, and to identify potential specialised areas of research, we surveyed archaeological materials originating from two Iron Age archaeological excavations (Fig. 1).

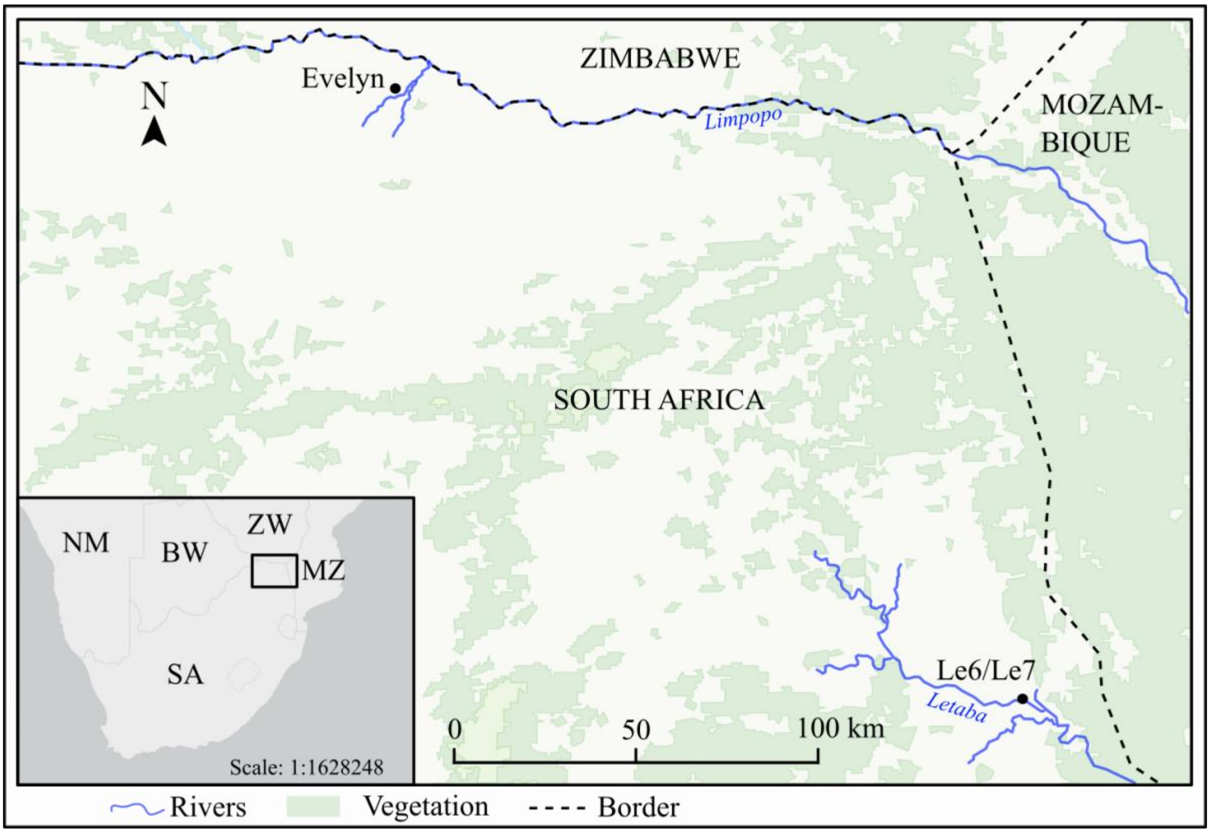


Figure 1. Location of the Letaba and Evelyn sites in South Africa.

Letaba is a first millennium AD settlement located on the southern banks of the Letaba River in the Kruger National Park, South Africa (Antonites 2024). Materials in this study originate from areas Le7.50, Le7.54, Le6.27 and Le6.52 (see Antonites 2025 for details). Evelyn is a 12^{th}-13^{th} century AD settlement located in the Klein Bolayi Game Lodge in the Limpopo Province, South Africa (Mouton 2025), and the study materials originate from Trench V. At both sites, 10 litre bulk soil samples were systematically collected from the centre of each locus – the discrete excavated context defined by the archaeologist during excavation – within a 2x2 m unit (see Antonites 2025).

These samples were processed using a water-separation technique often referred to as flotation (e.g., Limp 1974). Through a flotation system, a gentle current separates different substances (e.g., stone, silt, clay, bone, botanicals) into heavy and light fractions. A small sample of heavy fraction material was selected to investigate the presence of arthropod remains and trace elements, which might otherwise not have been collected using dry screening (Fig. 2a). Potential insect traces were identified from the light fraction material (Fig. 2b) and sorted into groups based on texture, colour, and morphology (Fig. 2c) (see Fowler et al. 2004). Within each group, specimens were examined under a stereo microscope for similarity, familiar patterns, and embedded fragments of insect skeletal remains or other trace evidence that could link the specimens to the behaviour or morphology of arthropods. Skeletal remains (e.g., elytra, mandibles, etc.) were identified through morphological comparison with modern species by trained entomologists.

We use **trace evidence** here to refer to the remains or traces of an animal's lifestyle, for example burrows, earthworm casts, and silk, in line with the use of **trace fossil** in palaeontology. **Features**, or **activity areas** refer to features within a site, such as refuse pits and livestock enclosures.

Figure 2. Processing of potential insect traces. Unsorted heavy fraction material containing vertebrate remains, charcoal, ceramics, and other debris (a); collection of potential insect traces (b); grouped insect traces based on texture, colour, and morphology (c). Scale bar=10 mm.

4. Results

Literature overview: Arthropod reporting trends in southern African archaeology

Arthropods are mentioned in 26 of 722 *SAAB* articles and in 8 of 148 *SAFA* articles. Although the archaeological themes of these articles varied, the majority note insect disturbances – usually from termites – when describing excavated deposits (e.g., Humphreys 1982; Webley 2001; Cain 2009). In one detailed example, nest structures and "head capsules" were used to identify *Microhodotermes viator* (Latreille 1804) (identified as *Hodotermes viator*) as the termite species responsible for disturbing a rock shelter deposit in southwestern South Africa (Manhire 1993: 5). The presence of actual arthropod remains was sometimes noted, such as a possible mopane worm (*G. belina*) or larvae of related species from a mummified human burial in northeastern Botswana (Mosothwane 2011).

Beyond exploring arthropods and their effects on the formation of archaeological deposits, other topics include:

- The use of plants and ochre as insect pesticides/repellents in the past (Binneman 2000; Rifkin 2015);
- Reference to historical records of San and Khoi insect use as food and medicine (Prins & Rousseau 1992; Wilson 1993);
- Ethnographic examples where San and Khoi cosmology draw on insect imagery, such as the mythical trickster that can take the form of the praying mantis (Schmidt 2020).

From a rock art perspective, Mguni (2015) provides several examples, especially from the Matopo Hills, Zimbabwe, of termites and termitaria represented in southern African rock art, while Mguni (2013) described several paintings from the Cederberg depicting anthropomorphic forms influenced by San belief and cosmology inspired by the life cycle of dragonflies (Odonata, Anisoptera).

Extending the literature survey beyond the *SAAB* and *SAFA*, the depiction of insects in southern African rock art have been noted elsewhere, such as:

- Moths in South Africa's uKhahlamba-Drakensberg Mountains and at the Brandberg in Namibia (Hollman 2007);
- Bees, honeycombs and/or bee's nests in the Drakensberg at Ndedema Gorge (Pager 1971);
- Locusts or grasshoppers (Acrididae) in San rock art in the Mapungubwe National Park (Mguni 2015).

Arthropod traces and skeletal elements in archaeological deposits are explored in more detail in other publications. From a methodological point, Fowler et al. (2004), for example, discuss ancient biotic activity at the first millennium AD site of Ndondondwane in KwaZulu-Natal, South Africa. They described the methods used to identify ceramic ecofacts (organic and environmental remains that are not cultural objects), and their ecological and cultural significance. In doing so, they provide a helpful methodology for analysing the physical and mineralogical properties, and the morphological characteristics, of unusually shaped baked-clay specimens. These specimens were originally thought to be ceramic figurine fragments. Macroscopic and microscopic examination of the baked-clay fragments, however, identified these as earthworm faecal casts, and as plant stalk casts caused by termite activities. They based this interpretation on detailed investigations of the properties of the ecofacts, coupled with a consideration of archaeological provenience and invertebrate ecology and behaviour. In considering the interstitial spaces of different grasses and grass crops, and by comparing these to the shapes of the plant stalk casts, they hypothesised that stalk-like casts are the result of soils baked within sorghum (*Sorghum* Moench 1794) plant stalks. At some point during the settlement's occupation, these faecal and plant stalk casts were exposed to heat, which preserved them in a baked form. Importantly, the preserved remnants of insect activities suggested first millennium AD sorghum cultivation in the absence of macro-botanical evidence (Fowler et al. 2004).

The link between past and present termite activities and people are also noted elsewhere. At Nanda, another first millennium site in KwaZulu-Natal, Whitelaw (1993) mentions the use of termitaria constructed by fungus growing termite species (Termitidae, Macrotermitinae) as burial locales. He suggests that the termitaria at Nanda might signal a higher status of the individuals buried there (see also Hammond-Tooke 1981; Walker 1991). Farr (2021) similarly emphasises the cultural significance of human-termite interactions in sub-Saharan Africa. Deeply rooted in ideology and cultural practice, he highlights how human action is both a response to and motivated by termite behaviour. Termite mounds are a sign of a healthy ecosystem, a fact which farmers exploit in selecting locations suitable for crop cultivation and raising livestock. Further, termitaria are also an important building material for household structures, kilns and pottery, and furnaces for smelting iron, while women consume the soils from termite mounds (geophaghy) for conditions related to fertility, antenatal and postnatal care (Farr 2021; see also Geissler 2000). As these practices, and the spaces and activities associated with them, are often associated with gendered roles (see Moffett 2023 for overview and critiques), Farr (2021) highlights the significance of human-termite interactions and its implications for understanding gendered interactions, ecological knowledge, and the spatial relationship between termite mounds and past human settlements.

The literature survey provides compelling examples of the spiritual and economic significance of arthropods to farming communities in the past and how exploring such topics can contribute to archaeological studies of southern African farming systems.

Case study: Letaba and Evelyn archaeological sites

Here we describe and discuss the potential significance of arthropod traces collected from the Iron Age sites of Letaba and Evelyn in South Africa. The purpose is not to provide a detailed specialist analysis of the different arthropod fragments and traces, but to provide an overview of the range of remains and traces typically collected during archaeological excavations, provide potential avenues for interpretation, and to suggest ideas for further research into these finds. Evidence related to arthropods from these two sites primarily consisted of trace evidence such as burrows, tunnels, and grass/plant encasings and casts, while direct evidence was less common but included insect bodies and pupal casings.

Tunnels, burrows, and encasings: During excavation, numerous subterranean burrows and tunnels were encountered at both Evelyn and Letaba. Various groups of arthropods construct burrows and tunnels where the depth and shape of burrows are linked to microhabitat, animal body size, substrate characteristics, and slope, and are taxon-specific (Nascimento et al. 2021). Taxon-based modifications include more than one chamber, and side burrows/chambers to hide in, which may provide an escape route to the outside via a second opening (Uchman et al. 2018; Nascimento et al. 2021). Others, for example the species-rich burrowing scorpions *Opisthopthalmus* Koch 1837 of southern Africa, have spiralling burrows for environmental control and predator protection (Adams et al. 2016). Trace evidence in the form of burrows therefore have the potential to inform on a large variety of issues, from the identity of arthropods that shared the environment with humans, and potentially impacted on the life of the humans, to environmental and soil conditions at the time of burrow construction.

Many of the subterranean structures encountered at Letaba and Evelyn consisted of single, vertical tunnels varying in size from <2 mm to 20 mm, with some having a chamber at the base. Small, nest-like structures with interconnected tunnels were also present. These were mostly modern intrusions by insects such as ants (Formicidae), beetles, and termites, and arachnids such as scorpions (Scorpiones), and solifuges (Solifugae). These intrusions were noted on the recording sheets but were not collected intact.

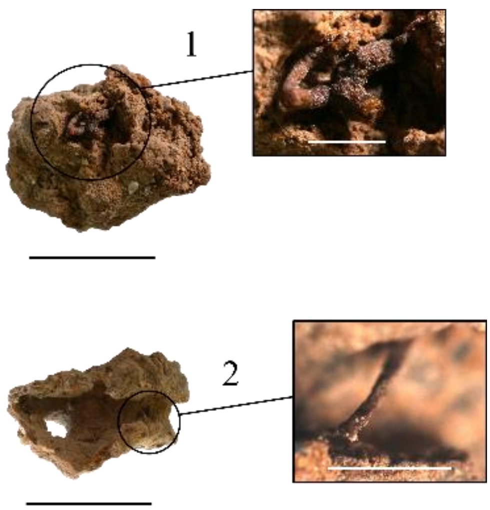
In terms of the flotation samples, numerous tunnel-like structures were present (Table 1). Sedimentary structures of irregular shape, with interconnected tunnels throughout, resemble broken parts of termite nests (Table 1a). As social insects, their nests contain numerous subterranean tunnels that connect to each other, to various chambers such as brooding chambers, and to the surface aboveground (see Mguni 2015 for discussion). Micro-tunnels (<1 mm in diameter) of smaller invertebrates were also present (Table 1b). Most specimens consisted of hollow, cylindrical sedimentary structures (Table 1c). These can consist of either subterranean tunnels or tunnels and encasings produced by insects aboveground.

Most of the tunnel-like specimens consisted of individual tunnels of relatively consistent diameter throughout, with diameters ranging from 3 to 8 mm. The outer surfaces were uneven with many protrusions, while the inner surfaces were relatively smooth and even. Of these, many contained inclusions such as charcoal and vertebrate bone fragments, indicating the reworking of archaeological deposits by micro-animals. If these are subterranean tunnels, a potential explanation for their isolation from the soil matrix in which they were constructed is the use of saliva to strengthen the wall of the tunnel. The surrounding soil was removed during the flotation process and the tunnels remained.

Alternatively, some specimens could represent tunnels or encasings constructed aboveground. Many wasps, for example, construct nest entrances (turrets) which lead to subterranean burrows (see Gess & Gess 2014: fig. II.2.7). Further, most termite species forage aboveground, constructing feeding tunnels that connect the nest to the food source (commonly grass) to protect the termites against the sun and other dangers (Fig. 3a). When the encased plant or wood disintegrates, the tunnels and encasings remain. This could be due to heat exposure baking the soil matrix, or a potential chemical reaction where the cohesive properties of their saliva cures like cement (e.g., van Thuyne & Verrecchia 2021). Branching, dendritic filaments fixed to the walls in cavities of apparent tunnel fragments have also been noted at Letaba (Table 1d). These are almost certainly fungal hyphae, based on the branching pattern. The association of these fungal hyphae with tunnels is significant and suggests the presence of fungus-growing termites in various areas across Letaba. The sprouting body of the fungus cultivated by the termite genus *Macrotermes* Holmgren 1910 appears after rain at the base of termite mounds (Fig. 3b); a delicacy commonly known as *omajova* in Namibia (Dieckmann 2014).

Burrows or cavities were also present in the sample (Table 2). Of these, the shape and presence of emergence holes suggests an underground pupal chamber (Table 2a). Various insects such as moths, beetles, soil nesting wasps, and solitary bees construct subterranean pupal chambers. The Letaba specimens have a distinct formation at one end suggesting a burrow was attached to the chamber before being sealed. These almost certainly belong to wasps (Gess & Gess 2014: fig. II.2.8). The morphology of the Letaba specimens is, for example, similar in shape and size to those produced by species in the *Ceramius* Latreille 1810 and *Celonites* Latreille 1802 genera (see Gess & Gess 2014: fig. II.2.19). A collection of dung beetle pupal chambers was also exposed *in situ* at Letaba in area Le7.54 (Table 2b), and a specimen of animal silk was recovered from Evelyn (Table 2c). Various arthropods produce silk, including spiders (Araneae), and insects such as Lepidoptera larvae and some Tenebrionidae beetle larvae (Schulze & Brown 1975).

Table 1. Examples of tunnels, burrows, and encasings.

Specimen type and count; site and area; unit; layer	**Specimens**	**Description**
a) Animal trace (n=numerous) Le7.50; N331, E784; Locus 1010/1		Interconnected termite tunnels in soil matrix. Scale bar=10 mm
b) Animal trace (n=numerous) Le7.50; N331, E784; Locus 1010/1		Invertebrate-created micro tunnels in soil matrix. Scale bar=5 mm
c) Animal trace (n=numerous) Le7.50; N331, E784; Locus 1010/1 and 1010/4		Cylindrical, hollow formations constructed of a soil matrix. Uneven shape but diameter relatively consistent throughout. External surface uneven with protrusions and inclusions (e.g., sand grains, small rocks). Note embedded pieces of charcoal and vertebrate bone (circled in the photo). Some of these specimens are distinctly flat on one side (arrow). Scale bar=10 mm
d) Animal/fungal trace (n=2) Le7.50; N331, E784; Le7.50; N331, E784		• Stringlike/dendritic filaments embedded in soil clod (1). Small cavities appear to be tunnels. • Tunnel fragment with embedded dendritic filament (2). Black scale bar=10 mm White scale bar=2 mm

Further specimens from Letaba resemble nest-like sedimentary structures (Table 2d). All these specimens were fire hardened and recovered from a secure context dating to the time the site was occupied. They comprised multiple parallel-walled cells forming honeycomb-like structures. The shape of individual cells varied slightly between quarter circles or more circular shapes, but the size of the cells was relatively similar, measuring 7x10 mm. Fungus-growing termites construct similar structures – termed fungus combs – in which they cultivate fungus (e.g., species of *Termitomyces* R. Heim 1942, Basidiomycota) (Anwar et al. 2020) for consumption from digested grass and/or wood deep inside their mounds. However, the Letaba specimens lack the nodules (mylospheres – a mixture of digested plant materials and saliva) typically visible on extant fungus combs (e.g., Anwar et al. 2020: fig. 7). The lack of mylospheres could be the result of weathering or damage to the structure. However, the parallel-sided nature of the cells suggests pupal cells, which rules out any hemimetabolous (insects without a distinct pupal phase) insects such as termites. Further, the cells are isolated from one another, whereas the chambers in fungal combs are interconnected. The Letaba specimens are therefore most similar to the mud nests constructed by solitary female wasps. Several dauber wasps construct similar nests including species in the genus *Sceliphron* Klug 1801 (Sphecidae) and *Synagris* Latreille 1802 (Vespidae), as well as some potter wasps of the genus *Delta* de Saussure 1855 (Vespidae) (Terence Bellingan; John Midgley; Simon van Noort pers. comm. March 2025) (see also Gess & Gess 2014).

Figure 3. Modern insect traces. Termite feeding tunnels, constructed above ground, encasing plant materials (a; scale bar=50 mm); termite mound of a fungus cultivating species with fungal fruiting bodies at the base (b; scale bar=50 mm).

Plant/animal casts: Some specimens are solid, cylindrical sedimentary structures with smooth surfaces and a generally uniform diameter (Table 3). These appear fire hardened and are non-friable or dispersible in water (Table 3a). Various agents could be responsible for these structures. They could resemble inner casts of plant stems or roots. Some termite species burrow into and hollow out plant and grass stalks, which they then fill with a mixture of soil and faeces (e.g., Anyango et al. 2019; see also Fowler et al. 2004). When the plant decays, the mud constructs remain (e.g., Fowler et al. 2004). Some wasp taxa, for example *Cerceris* Latreille 1802, produce 'sand sausages' in clearing soil from their burrows (Gess & Gess 2014: fig. 1.4.7). Other specimens appear more organic in nature and might be of a different origin, such as earthworm faecal casts (Table 1c) (e.g., Fowler et al. 2004). Voids are common throughout and could represent decayed organic matter.

Larger, solid, cylindrical soil formations with relatively uniform shapes and smooth surfaces were also present (Table 3b). Among these, several specimens of baked soil with transecting arthropod burrows from Letaba were encased in an organic epidermis. These specimens most closely resemble tree root casts – in this instance, they consist of sediments that filled decaying tree roots. They were often encountered in the archaeological deposits at Letaba as the site is situated within mopane, *Colophospernum mopane* (J. Kirk ex Benth.) J. Léonard 1949, woodlands. It is unclear if arthropods transported soil into decaying roots, or if soil filled the roots by means of abiotic processes. Nevertheless, these samples all have distinct burrows indicative of significant bioturbation at the site.

Table 2. Examples of burrows, cavities, and chambers from Letaba and Evelyn.

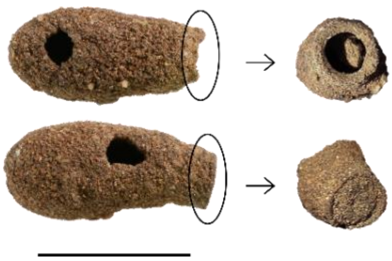
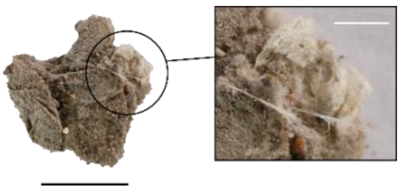
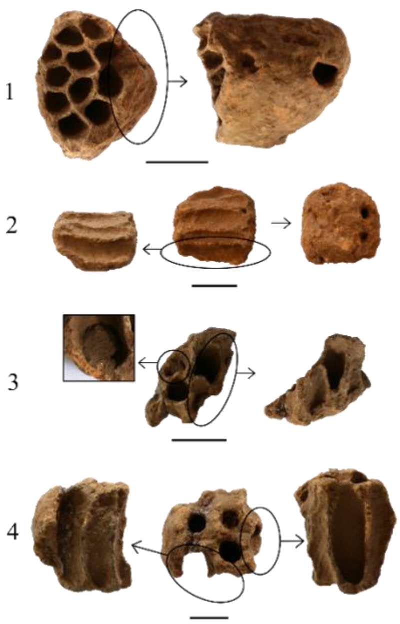
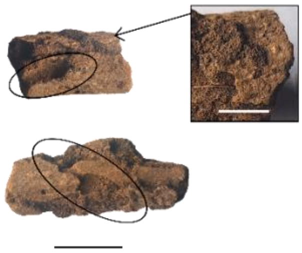
Specimen type and count; site and area; unit; layer	**Specimens**	**Description**
a) Animal trace (n=4) Le6.27; N331, E784; Locus 1173		Underground pupal chamber constructed of a soil matrix. Outer surface smooth with few inclusions. Clear indications that a shaft/burrow was attached at one end; suggests soil nesting wasp pupal chamber. Scale bar=10 mm
b) Animal trace (n=7) Le7.54; N376, E714; Locus 1128	 © Michelle van Aswegen	*In situ* underground pupal chambers of dung beetles (Scarabaeinae). The formations are fire hardened. Scale bar=50 mm
c) Animal (n=1) EV01; N985, E1000; Locus 128		Animal silk. Black scale bar=5 mm White scale bar=1 mm
d) Animal trace (n=4) Le6.52; N402, E351; Locus 1218		Aerial mud nests constructed by wasps: • Single complete specimen (1): The outer surface is smooth, but uneven, while the inner surface of individual cells is smooth. Cell shapes vary slightly between quarter circles and more circular shapes. • Broken fragment (2): The outer surface is smooth, but uneven, while the inner surface of individual cells is smooth. Cell shapes are quarter circles. • Broken fragments (3-4): The cell openings are more circular. The outer surface is uneven, while the inner surface of individual cells is smooth. Scale bars=20 mm

Table 3. Examples of plant and animal casts from Letaba.

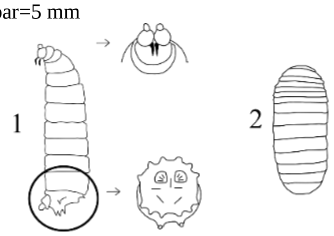
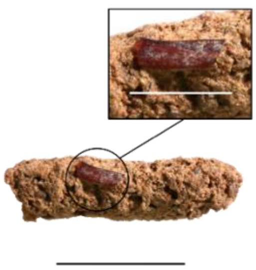
Specimen type and count; site and area; unit; layer	**Specimens**	**Description**
a) Animal/plant trace (n=numerous) Le7.50; N331, E784; Locus 1010/1 and 1010/4		Cylindrical, solid soil-like formations. Smooth outer surface with few inclusions. Even shape and diameter throughout with no external protrusions. Scale bar=10 mm
b) Animal/plant trace (n=numerous) Le6.27; N500, E378; Locus 1174/2		Cylindrical, solid sedimentary structures with invertebrate burrows or tunnels (circled in photo) and preserved portions of an organic epidermis (arrow). Black scale bar=20 mm White scale bar=10 mm
c) Animal/plant trace (n=10) Le7.50; N331, E784; Locus 1010/1 and 1010/4	1  2 	Cylindrical, solid soil-like formations. Some fragments (e.g., no. 1) are granular with a distinct reddish colouration, while others (e.g., no. 2) are smooth with a sandy colour. Voids are common throughout. (1) scale bar=5 mm (2) scale bar=10 mm

Insect remains: Several insect or larvae bodies were present (Table 4). Three fragments had distinct segments or spiral patterns (Table 4a). Two of these had external protrusions similar to the posterior end, with spiracles of larvae, of some fly taxa, while the other, an oval-shaped specimen, matched with one of these posterior ends. We speculate that the specimens are of dipteran larvae or puparia. The latter would represent a non-feeding stage and the final stage of development. Several beetle specimens were present. One of these, a weevil in the Brentidae family, was well preserved, with the eyes, antennae, and legs intact (Table 4b). This specimen is not carbonised and was collected from a disturbed context in Le7.50 near the base of the excavation. Considering the depth at which it was recovered, the specimen potentially represents a recent intrusion in the archaeological deposits by way of bioturbation or small vertebrate burrowing. Further beetle specimens (Table 4c) were identified as belonging to *Ocladius* Schönherr 1825 (Curculionidae) (Riaan Stals pers. comm. August 2024). These appear carbonised and could be contemporaneous with the formation of the archaeological deposits. The faecal pellet of a small vertebrate contains a suspected beetle elytron (a hardened beetle fore wing) (Table 4d), and its shape and size suggest it derives from a small insectivorous animal such as a gecko (Gekkonidae), rodent (Muridae), or shrew (Soricidae) (e.g., Olsen 1984). The voids and cavities present across the surface are typically the result of decayed organic matter. The pellet is hard and not dispersible in water, potentially representing micro-animal activity contemporaneous with the formation of the archaeological deposits.

Arthropod damage to archaeological bone: Analysis of the vertebrate skeletal remains also preserved evidence of arthropod activities (Fig. 4). Osteophagia is a common behaviour among many invertebrates, including snails (Gastropoda), millipedes (Diplopoda), and insects such as beetles, moths, termites, cockroaches (Blattodea), fly larvae, and ants, bees, and wasps (Backwell et al. 2022). At Evelyn and Letaba, evidence of such behaviour manifested as five bone surface modification patterns:

- Pits with emanating striae often forming star-like shapes, comparable to the damage inflicted by termite activities (Fig. 4a) (e.g., Backwell et al. 2012, 2022);
- Boring/etching resembling modifications from the mycelium of fungi (Fig. 4b) (Ozeki et al. 2020). Such modifications often occurred in dense concentrations, resulting in extreme surface alteration (Mouton 2025);
- Distinct parallel incisions, often occurring in clusters, on vertebrate bone (Fig. 4c). These incisions resemble gnawing activities of Blattodea such as termites and cockroaches (e.g., *Periplaneta americana* Linnaeus 1758), carrion-associated beetles (e.g., Dermestidae), and potentially from sapro-detritiphagous beetles (e.g., Tenebrionidae) (Parkinson 2013: fig. 17; Backwell et al. 2022: figs 18.4 & 18.7);
- Small surface pits of various shapes and sizes, often surrounded by a distinct ring or pathway of discolouration (Fig. 4d). Similar modifications are associated with the activities of cockroaches (Parkinson 2013: fig. 13);
- Furrows and pits penetrating through cancellous bone (Fig. 4e), which resemble those produced by the feeding habits of larvae of dermestid and tenebrionid beetles and flies (Blackwell et al. 2022: fig. 18.12; Mahomed 2022).

Table 4. Examples of insect remains from Letaba.

Specimen type and count; site and area; unit; layer	Specimens	Description
a) Animal specimens (n=3) Le7.50; N331, E784; Locus 1010/4		Organic fly (Diptera) maggot pupa (1) or pupal case (2) with visible segments or spiral patterns and protrusions. Patterns typical of end-breathing holes of spiracles (1; circled). Scale bar=5 mm  (Figure adapted from Mégnin 1894).
b) Animal specimen (n=1) Le7.50; N331, E784; Locus 1010		Weevil (family Brentidae). Scale bar=5 mm
c) Animal specimens (n=numerous) Le6.27; N502, E374; Locus 1173/2 Le7.50; N331, E784; Locus 1010		Weevil specimens belonging to *Ocladius* Schönherr 1825 (Curculionidae: Erirhinini). Scale bar=5 mm
d) Animal specimen (n=1) Le7.50; N331, E784; Locus 1010/4		Soil-like clod with embedded arthropod fragment. Voids and indentations are also present across the surface. Black scale bar=5 mm White scale bar=2 mm

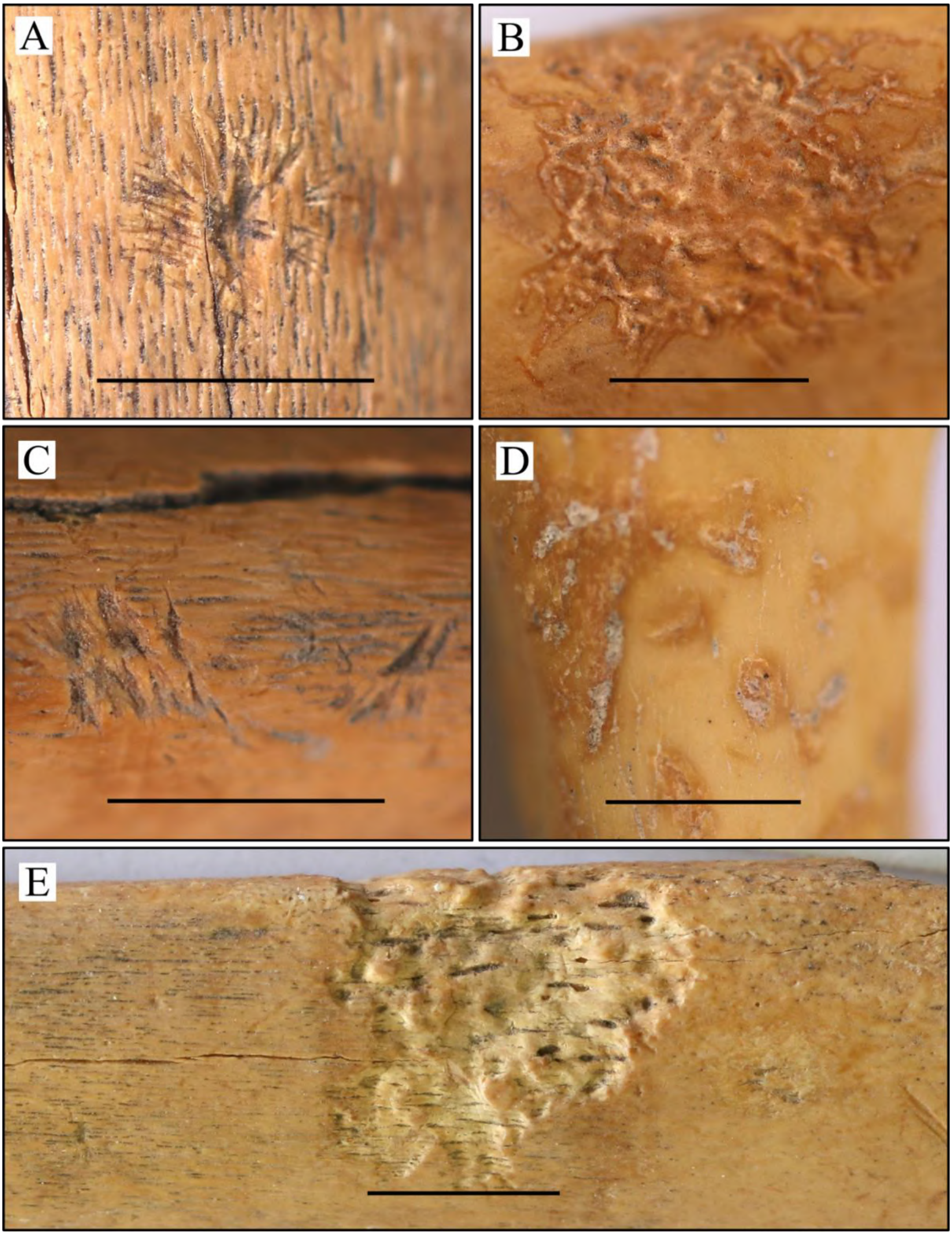


Figure 4. Vertebrate bone specimens exhibiting biological modification. Pits with emanating striae (a; scale bar=3 mm); boring and etching forming a branching pattern (b; scale bar=5 mm); clustered parallel incisions (c; scale bar=3 mm); small surface pits surrounded by a ring or pathway of discolouration (d; scale bar=3 mm); furrows and pits clustered together (e; scale bar=5 mm).

Distinguishing between different arthropod agents is not straightforward, and the vertebrate bone modifications observed at Evelyn and Letaba indicate that both carrion feeders such as *Dermestes* Linnaeus 1758 species, osteophagous behaviour by termites, and etching from the mycelium of fungi impacted the preservation of faunal materials.

5. Discussion

Although there is a general increase in recognising arthropods, particularly insects, in archaeological research, arthropods continue to be ignored, especially in sub-Saharan Africa. Arthropods, their remains, and trace evidence could be: 1) from the same period as the archaeological deposits, thus providing a direct indication of human-insect entanglements and environmental conditions at the time of occupation; 2) post-depositional, whether negatively compromising the site due to bioturbation, or positively contributing to site interpretations such as indicating change in soils that in turn could highlight a previous site feature (for example changed soils due to an animal holding pen); or 3) current, either as living specimens or current occupation of retreats such as burrows.

The arthropod remains and their trace evidence recovered at Letaba and Evelyn can clarify deposit formation and past human activities. Such evidence extends across various contexts from household structures to middens and refuse pits. The latter was particularly rich in arthropod evidence such as fly larvae, beetle remains, and the modification of vertebrate bone, which indicates significant insect activity in these deposits. Although the osteophagous behaviour of termites includes both fresh and old bones, the identification of necrophagous beetle damage and fly larvae does indicate decaying organic matter. These, and other insect activities, inform on deposit formation within these pit features and other refuse disposal areas.

The numerous burrows and tunnels removed *in situ* and from the flotation samples further indicate significant arthropod presence at Letaba. These aid in reconstructing potential deposit formation and the potential extent of bioturbation. At Letaba, tunnels, encasings, and damage to vertebrate bone indicate both recent and past termite activities across the site. As of yet, no direct evidence for the use of termitaria clay by the inhabitants has been identified, but the wide distribution of termite activities could help to clarify the location of certain features, and environmental and ecological conditions at the time of occupation. Yamashina (2010) found that termite mounds are situated nearest to huts in Zemba communities in northern Namibia, as some tree species germinate inside termitaria. This phenomenon is likely because of the rich nutrient content of termitaria. Their location near human activity areas, such as the household at Le6.27, might indicate the presence of trees that provided shade. Fowler et al. (2004) made a similar prediction at Ndondondwane in Kwa-Zulu Natal. The distribution of termitaria could also point to areas of relative water abundance as termites need access to ground water (Yamashina 2010).

The preserved aerial wasp nest further highlights that the community at Letaba shared their homes and the environment with a variety of insects. The nest was potentially constructed onto a household structure such as a hut before being deposited into the archaeological record, either from falling off or being removed by the hut users. Although the specific taxon responsible for the nest is not known, most mud nest constructors such as *Sceliphron spirifex* (Linnaeus 1758) collect mud near the edge of water, also informing on environmental conditions at the time of Letaba's occupation.

Arthropods are often specific to their substrates or resources. Concentrations of a species of arthropod, identified from arthropod remains, ecofacts and other trace evidence (e.g., burrows), could therefore indicate that a particular material was present (grains, wood, dung, medicinal plants), even though the material itself has since decayed. The identification of weevils (Curculionoidea) at Letaba could inform indirectly on agricultural practices. In particular, the cluster of true weevils identified at Le6.27 were recovered from a context associated with potential grain bins (see Antonites 2025). Some Curculionoidea are known stored product pests (Oberprieler et al. 2007) and their concentration at Le6.27, and in Le7.50, could indicate grain storage in the absence of seed preservation. The latter context is particularly interesting as it is a subterranean pit feature. The formation processes of such pit features are currently poorly understood, and the presence of potential stored product pests could provide insights into the purpose of these features at Letaba.

Small numbers of livestock have been identified at Letaba (Plug 1989; Grody 2016), but their management is poorly understood for this period in the Kruger National Park. The identification of dung beetle nests at Letaba in area Le7.54 could indicate the presence of livestock holding pens, or animal latrines (dung mounds) (Jankielsohn 2006). Paracoprid dung beetles collect dung or faeces and bury it underground as feeding (for themselves) or brooding balls for their young. Dung balls are robust and preserve well.

Insect and other arthropod traces exist in the archaeological record, but more care could be taken to recognise and interpret these remains. Methodologies for the optimal recovery, recording, and interpretation of insect-related data have been suggested (Graham 1965; Coope 1986; Sutton 1995). As ancient insects are fragile, the use of a smaller sieve screen to increase recovery might not be sufficient (Graham 1965). In fact, Buckland (1981) blamed the paucity of insects and mites in archaeological data on processing techniques. The addition of flotation techniques and collection of soil samples have been shown to significantly increase the recovery rate of arthropods and their traces (Rousseau 2011). However, similar methodologies were employed at Letaba and Evelyn, but at the latter, no insect remains beyond the animal silk was present. Although excavators noted insects in flotation samples, they were not collected as they were assumed not to be archaeological. As such, the lack of arthropod specimens at Evelyn reflects a flotation-processing bias. As with other fauna, reference collections could be developed to aid in identification (e.g., Nacimento et al. 2021; Toriti et al. 2021). Further, the application of advanced techniques, such as fluorescence light microscopy, can improve the identification of arthropod skeletal remains from archaeological deposits (Bradfield 2023), while petrographic and chemical analysis of pottery and building materials for houses and granaries might identify the use of termite clays (Farr 2021).

Equally important would be the contribution archaeologists can make to current entomological research. During excavations at Letaba from 2021 to 2023, several living arthropod species were noted in and around archaeological deposits. These arthropods include insects, for example, colonies of ants such as *Odontomachus* Latreille 1804, *Camponotus* Mayr 1861, and *Messor* Forel 1890 species, termites, dung beetles, and antlions (Neuroptera); arachnids, for example solifuges, trapdoor spiders (Araneae, Mygalomorphae), and scorpions; and myriapods, namely millipedes. Notes made on arthropods and specimens collected can contribute data on arthropod historic and current distributions. Collecting and depositing voucher specimens at research institutions make these available for taxonomic, behavioural or ecological research. This will contribute directly to current taxonomic checklists and increase our knowledge on species biology.

For example, the arachnid order Solifugae (colloquially known as solifuges, sunspiders, romans) remains poorly understood and its taxonomy remains in disarray. Even basic knowledge such as where, and in which life stage, solifuges overwinter, is lacking (see Hebets et al. 2024). A major obstacle to the study of solifuges is the lack of specimens and observations. Not only do solifuges have a short period of activity, but their activity is also triggered by highly specific environmental conditions. Additionally, whereas males could be common during optimal activity periods, females and juveniles are not, which biases sampling towards males during these periods; thereafter, sampling is biased towards females due to the shorter lifespan of males. During archaeological excavations at Letaba and Evelyn, the unearthing of solifuges frequently occurred. Future collection of these specimens, together with detailed documentation (depth of burrow, time of year, soil), could contribute towards the collection of distribution, different life stages, and general biological data[2].

As such, archaeologists could keep a logbook containing information on modern arthropod and other invertebrate fauna. Specimens could be collected and deposited in scientific collections as voucher specimens. Most invertebrates can be placed directly into 70-75% ethanol. Basic data should accompany each specimen, preferably written on a label with a pencil or alcohol proof pen and placed inside the ethanol with the specimen. At a minimum, these should include locality data, collection date, name of collector, and name of archaeological site. Additional data such as time of day unearthed, depth at which the arthropod was found, retreat evidence and description, and soil information – provenience information archaeologists regularly record – would greatly increase the value of the specimen.

[2] The South African National Biodiversity Institute (SANBI) website lists the relevant biodiversity permitting authorities under the resource tab for collection of living specimens.

Greater detail should be provided when recording the presence of insects in archaeological deposits. A clear description of contemporary arthropod traces in both a qualitative and quantitative fashion – describing traces such as burrows, tracks, and nests (e.g., Baucon et al. 2008) – would not only allow for greater interpretation of site formation processes, but also the comparison of such activities between sites. Although arthropods may not necessarily directly relate to the site's occupation, as bioturbators, they impact artefact preservation and distribution (e.g., McBrearty 1990; Lancaster 2002; White & Miller 2008).

Beyond their taphonomic value, obtaining more detailed data on ancient insect activity may result in a greater understanding of past economy, life and society. The next step for the Letaba arthropod remains would be to confirm their contemporaneity with the site's occupation. Radiocarbon dating of specimens such as insect chitin can produce dates from relatively small samples, providing stratigraphic correlation between site occupation and insect activities (Holden & Southon 2016). Future research on dung beetles may also help to clarify the nature of livestock herding at Letaba. Dung beetle balls can be collected or sampled. For some dung beetle taxa, the dung beetle genus can be revealed based on the size, morphology and arrangement of the dung balls, either by using extant examples where their breeding biology has been documented (e.g., Kingston & Coe 1977), or through investigations on much older dung beetle traces and balls (Sánchez et al. 2013); the location of the nests and the proportion of dung beetles relative to other terrestrial insects could shed light on the presence of high densities of grazing animals (e.g., livestock) (e.g., Smith et al. 2014; Buckland & Buckland 2019). Samples could be collected from the dung balls in the case of good organic preservation for ancient DNA (aDNA) sequencing, phytolith and spherulite analysis, and stable isotope analysis, which might provide species-level identification of the dung beetle itself, determine the defecating species, and a record of the plants that occurred in the area (see Shahack-Gross 2011). The sequencing of insects and their food has the capacity to provide incredible resolution on species that may have shared the environment with early humans, from plants to animals to fungi.

Finally, the significance of arthropod remains is best interpreted within their spatial and cultural contexts, alongside other archaeological objects if we are to understand the various networks of association between arthropods and the range of cultural activities and formation processes at Letaba, and other past human settlements. For this, arthropod remains should first be considered within their unique archaeological features (e.g., granaries versus middens) and then compared between features and sites. Moving forward, arthropod remains, and their traces, will be collected from various archaeological features across Letaba to better explore both the anthropic and taphonomic factors that may have influenced their accumulation and preservation. No archaeoentomological data exist for other settlement types against which Letaba can be compared, so it is unclear how factors like settlement type, economy, or social life impact arthropod preservation and accumulation.

6. Conclusion

Human-insect interactions served both practical and cultural roles among recent communities yet tracing the antiquity of such entanglements remains largely unexplored for much of Africa. The ethnographic record suggests a rich social world intertwined by humans and insects. It is therefore worth exploring such relationships in antiquity. Insects, and other arthropods, offer interpretive value for reconstructing both cultural landscapes and the natural surroundings. Yet, the importance of insect remains, insect traces, or living insects found during the excavation of a site is not yet realised to the full; currently, such evidence is either not, or is insufficiently, documented. The sample of entomological remains and trace evidence presented here help demonstrate the interpretive value of such remains at Letaba. While similar methodologies were employed at Evelyn, no insects or their traces were identified. The abundance of insect modification of vertebrate remains, in contrast, indicate a range of insect activity. Rather than a lack of such activity, the absence of direct evidence instead reflects the effects of collection biases. Although not all the arthropod evidence is directly related to archaeological interpretations, it does indicate a greater range of arthropod influence in contrast to what is typically reported. Comparing archaeoentomological data with data from other sources would allow for more nuanced interpretations of past environments and the exploration of past activities where other data sources did not preserve well. Interpretations remain hypothetical and can only be supported by further research, more samples, and identifying patterns across samples.

Acknowledgements
The Letaba Archaeology Project is funded through the National Research Foundation (NRF) of South Africa awarded to Alexander Antonites, University of Pretoria, with additional support from SANParks Culture Heritage Division. Excavations at Letaba were conducted under SAHRA Permit 3296 and SANParks Research Agreement SS667. Excavations at Evelyn were funded through the NRF (AOP150925143015) and conducted under SAHRA Permit 2733. We are greatly indebted to Terence Bellingan, John Midgley, Riaan Stals, Werner Strümpher, and Simon van Noort for sharing their entomological knowledge.

References

Adams, A.M., Marais, E., Turner, J.S., et al. 2016. Similar burrow architecture of three arid-zone scorpion species implies similar ecological function. The Science of Nature, 103(7): 1-11. https://doi.org/10.1007/s00114-016-1374-z

Allentuck, A. & Greenfield, H.J. 2010. The organization of animal production in an early urban center: The zooarchaeological evidence from Early Bronze Age Titriş Höyük, southeast Turkey. In: Campana, D.V., Crabtree, P., deFrance, S.D., et al. (eds) Anthropological Approaches to Zooarchaeology: Colonialism, Complexity and Animal Transformations: 12-29. Oxford: Oxbow Books.

Antonites, A. 2024. Overview of the Early Iron Age in the Letaba region of the Kruger National Park. Koedoe: African Protected Area Conservation and Science, 66(2): a1805. https://doi.org/10.4102/koedoe.v66i2.1805

Antonites, A. 2025. Final Report for excavation of the Early Iron Age sites LE6 and LE7, 2021-2024, Permit 3296. Unpublished report compiled for South African Heritage Resources Agency, case number: 15719. Available from: https://www.sahris.org.za/node/157302

Anyango, J.J., Bautze, D., Fiaboe, K.K., et al. 2019. Termite-induced injuries to maize and baby corn under organic and conventional farming systems in the Central Highlands of Kenya. Insects, 10(10): 367. https://doi.org/10.3390/insects10100367

Anwar, K., Sudirman, L.I. & Nandika, D. 2020. Comb establishment of fungus-growing termites species Macrotermitinae (Isoptera: Termitidae) with *Termitomyces cylindricus* (Basidiomycota: Agaricales) basidiospores. Oriental Insects, 54(4): 591-606. https://doi.org/10.1080/00305316.2020.1762775

Backwell, L.R. & d'Errico, F. 2001. Evidence of termite foraging by Swartkrans early hominids. Proceedings of the National Academy of Sciences, 98(4): 1358-1363. https://doi.org/10.1073/pnas.98.4.1358

Backwell, L.R., Parkinson, A.H., Roberts, E.M., et al. 2012. Criteria for identifying bone modification by termites in the fossil record. Palaeogeography, Palaeoclimatology, Palaeoecology, 337-338: 72-87. https://doi.org/10.1016/j.palaeo.2012.03.032

Backwell, L., Huchet, J.B., Harrison, J.D.G., et al. 2022. Invertebrate modification of bone. In: Pokines, J.T., L'Abbe, E.N. & Symes, S.A. (eds) Manual of Forensic Taphonomy: 631-666. Boca Raton: CRC Press. https://doi.org/10.4324/9781003171492

Baucon, A., Privitera, S., Morandi Bonacossi, D., et al. 2008. Principles of Ichnoarchaeology: New frontiers for studying past times. Studi Trentini di Scienze Naturali, Acta Geologica, 83: 43-72.

Binneman, J. 2000. Results from two test excavations in the Baviaanskloof Mountains, Eastern Cape Province. Southern African Field Archaeology, 9: 83-96. https://journals.uj.ac.za/index.php/safa/1993_Vol_2_No_1

Bird, T.L., Moeti, S., Hitchcock, R.K., et al. 2023. Orb-web spider *Argiope* (Araneidae) as indigenous arrow poison of G/ui and G//ana San hunters in the Kalahari. PLoS ONE, 18(1): e0276557. https://doi.org/10.1371/journal.pone.0276557

Bloemberg, J., Stefanini, C. & Romano, D. 2021. The role of insects in medical engineering and bionics: Towards entomomedical engineering. IEEE Transactions on Medical Robotics and Bionics, 3(4): 909-918. https://doi.org/10.1109/TMRB.2021.3101693

Bonning, B.C. 2009. Biotechnology and insects. In: Resh, V.H. & Cardè, R.T. (eds) Encyclopedia of Insects. Second Edition: 105-108. Amsterdam: Academic Press. https://doi.org/10.1016/B978-0-12-374144-8.00035-7

Bradfield, J. 2023. Pilot study using fluorescence light microscopy to identify arthropod remains in archaeological sediments. South African Archaeological Bulletin, 78(219): 84-94. https://www.jstor.org/stable/27303675

Bradfield, J., Wadley, L. & Lombard, M. 2015. Southern African arrow poison recipes, their ingredients and implications for Stone Age archaeology. Southern African Humanities, 27: 29-64. https://hdl.handle.net/10520/EJC179773

Buckland, P.C. 1981. The early dispersal of insect pests of stored products as indicated by archaeological records. Journal of Stored Products Research, 17: 1-12. https://doi.org/10.1016/0022-474X(81)90025-4
Buckland, P.C. 1990. Insects, granaries and stores: The archaeology of insect synanthropy. In: Fournier, D. & Sigaut, F. (eds) La Prèparation Alimentaire des Cèreals: 69-81. Belgium: PACT.
Buckland, P.I. 2014. The Bugs Coleopteran Ecology Package (BugsCEP) database: 1000 sites and half a million fossils later. Quaternary International, 341: 272-282. https://doi.org/10.1016/j.quaint.2014.01.030
Buckland, P.I. & Buckland, P.C. 2019. When a 'waterhole' is full of dung: An illustration of the importance of environmental evidence for refining archaeological interpretation of excavated features. Archaeometry, 61(4): 977-990. https://doi.org/10.1111/arcm.12461
Buckland, P.C. & Perry, D.W. 1989. Ectoparasites of sheep from Stóraborg, Iceland and their interpretation: Piss, parasites and people, a palaeoecological perspective. Hikuin, 15: 37-46. https://tidsskrift.dk/Hikuin/article/view/150609
Cain, C.R. 2009. Cultural heritage survey of Lesotho for the Maloti-Drakensberg Transfrontier Project, 2005-2006: Palaeontology, archaeology, history and heritage management. South African Archaeological Bulletin, 64(189): 33-44. https://www.jstor.org/stable/40588133
Coope, G.R. 1986. Coleoptera analysis. In: Berglund, B.E. (ed.) Handbook of Holocene Palaeoecology and Palaeohydrology: 703-713. Chichester: Wiley & Sons.
Dickson, T.R. & Walker, I.R. 2015. Midge (Diptera: Chironomidae and Ceratopogonidae) emergence responses to temperature: Experiments to assess midges' capacity as paleotemperature indicators. Journal of Paleolimnology, 53: 165-176. https://doi.org/10.1007/s10933-014-9814-2
Dieckmann, U. 2014. Kunene, Oshana and Oshikoto regions. In: Dieckmann, U., Thiem, M., Dirkx, E., et al. (eds) Scraping the Pot: San in Namibia Two Decades After Independence: 173-232. Windhoek: Legal Assistance Centre.
Elias, S.A. 1994. Quaternary Insects and Their Environments. Washington: Smithsonian Institution Press.
Elias, S.A. 2009. Advances in Quaternary Entomology. Developments in Quaternary Science No. 12. London: Elsevier.
Eggermont, H., Kennedy, D., Hasiotis, S.T., et al. 2008. Distribution of living larval Chironomidae (Insecta: Diptera) along a depth transect at Kigoma Bay, Lake Tanganyika: Implications for palaeoenvironmental reconstruction. African Entomology, 16(2): 162-184. https://hdl.handle.net/10520/EJC32786
Egonyu, J.P., Kinyuru, J., Fombong, F., et al. 2021. Advances in insects for food and feed. International Journal of Tropical Insect Science, 41: 1903-1911. https://doi.org/10.1007/s42690-021-00610-8
Farr, J. 2021. Islands of fertility: A multispecies ethnography of human-termite interactions and their implications for human ecology and the archaeology of gender in the tropics. World Archaeology, 53(4): 667-687. https://doi.org/10.1080/00438243.2021.1997637
Fairhead, J.R. 2016. Termites, mud daubers and their earths: A multispecies approach to fertility and power in West Africa. Conservation and Society, 14(4): 359-367. https://www.jstor.org/stable/26393258
Foord, S.H., Dippenaar-Schoeman, A.S. & Haddad, C.R. 2011. South African spider diversity: African perspectives on the conservation of a mega-diverse group. In: Grillo, O. & Venora, G. (eds) Changing Diversity in Changing Environment: 163-182. Croatia: InTech.
Fowler, K.D., Greenfield, H.J. & van Schalkwyk, L.O. 2004. The effects of burrowing activity on archaeological sites: Ndondondwane, South Africa. Geoarchaeology, 19(5): 441-470. https://doi.org/10.1002/gea.20005
Geissler, P.W. 2000. The significance of earth-eating: Social and cultural aspects of geophagy among Luo children. Africa, 70(4): 653-682. https://doi.org/10.3366/afr.2000.70.4.653
Gess, S.K. & Gess, F.W. 2014. Wasps and Bees in Southern Africa. SANBI Biodiversity Series 24. Pretoria: South African National Biodiversity Institute. www.sanbi.org/documents/sanbi-biodiversity-series-24-wasps-and-bees-in-south-africa/
Goddard, J. 2012. Physician's Guide to Arthropods of Medical Importance. Sixth Edition. London: CRC press.
Graham, S.A. 1965. Entomology: An aid in archaeological studies. Memoirs of the Society for American Archaeology, 19: 167-174 https://doi.org/10.1017/S0081130000004512
Grivetti, L.E. 1979. Kalahari agro-pastoral-hunter-gatherers: The Tswana example. Ecology of Food and Nutrition, 7(4): 235-256. https://doi.org/10.1080/03670244.1979.9990535
Grody, E. 2016. Of buffalo and butchers: Coupling traditional procurement studies with taphonomic analyses to explore intensive wild animal processing patterns at two Early Iron Age sites in the Kruger National Park. African Archaeological Review, 33(4): 385-409. https://doi.org/10.1007/s10437-016-9236-9
Grove, K.J. 2001. Discerning beetles, an entomo-archaeological study of Coleopteran faunas in relation to place and time. Doctoral Thesis. Sheffield: University of Sheffield.
Hammond-Tooke, W.D. 1981. Boundaries and Belief: The Structure of a Sotho Worldview. Johannesburg: Witwatersrand University Press.
Hebets, E.A., Oviedo-Diego, M., Cargnelutti, F., et al. 2024. A scientist's guide to Solifugae: How solifuges could advance research in ecology, evolution and behavior. Zoological Journal of the Linnean Society, 202: 1-

27. https://doi.org/10.1093/zoolinnean/zlad174.
Holden, A.R. & Southon, J.R. 2016. Radiocarbon dating and stable isotopic analysis of insect chitin from the Rancho La Brea tar pits, Southern California. Radiocarbon, 58(01): 99-113. https://doi.org/10.1017/RDC.2015.9
Hollman, J. 2007. Kaggen's code: Paintings of moths in southern African hunter-gatherer rock art. Southern African Humanities, 19: 83-101. https://hdl.handle.net/10520/EJC84788
Humphreys, A.J.B. 1982. Cultural material from burials on the farm St. Clair, Douglas area, Northern Cape. South African Archaeological Bulletin, 37(136): 68-70. https://www.jstor.org/stable/3888678
Hunter, J.M. 1984. Insect clay geophagy in Sierra Leone. Journal of Cultural Geography, 4(2): 2-13. https://doi.org/10.1080/08873638409478570
Jankielsohn, A. 2006. The effect of habitat change on the structure of dung beetle assemblages in the north-eastern Free State: A comparison of conserved and farmed land. Doctoral Thesis. Pretoria: University of Pretoria.
Junod, H.A. 1913. The Life of a South African Tribe. Volume 2. London: MacMillan.
Kelemu, S., Niassy, S., Torto, B., et al. 2015. African edible insects for food and feed: Inventory, diversity, commonalities and contribution to food security. Journal of Insects as Food and Feed, 1: 103-119. https://doi.org/10.3920/JIFF2014.0016
King, G.A., Gilbert, M.T.P., Willerslev, E., et al. 2009. Recovery of DNA from archaeological insect remains: First results, problems and potential. Journal of Archaeological Science, 36: 1179-1183. https://doi.org/10.1016/j.jas.2009.01.006
Kingston, T.J. & Coe, M. 1977. The biology of a giant dung-beetle (*Heliocopris dilloni*) (Coleoptera: Scarabaeidae). Journal of Zoology, 181: 243-263. https://doi.org/10.1111/j.1469-7998.1977.tb03239.x
Lancaster, S. 2002. Invertebrate faunalturbation of archaeological sites: Assessing the impact on archaeological stratigraphy. Doctoral Thesis. Sterling: University of Sterling.
Limp, W.F. 1974. Water separation and flotation processes. Journal of Field Archaeology, 1: 337-342. https://doi.org/10.1179/009346974791491386
Manamela, K. 2003. Traditional beliefs and uses of arachnids in Africa. Annals of the Transvaal Museum, 40: 151-153. https://hdl.handle.net/10520/AJA00411752_4
Mahomed, T. 2022. An experimental study of invertebrate damage to bone and its application to archaeology. Masters Dissertation. Johannesburg: University of the Witwatersrand.
Manhire, A. 1993. A report on the excavations at Faraoskop Rock Shelter in the Graafwater district of the south-western Cape. Southern African Field Archaeology, 2: 3-23. https://hdl.handle.net/10520/AJA10195785_27
Marchand, T.H.J. 2009. The Masons of Djenné. Indianapolis: Indiana University Press.
Marshall, E.Z. 2007. Liminal Anansi: Symbol of order and chaos an exploration of Anansi's roots amongst the Asante of Ghana. Caribbean Quarterly, 53(3): 30-40. https://doi.org/10.1080/00086495.2007.11672326
McBrearty, S. 1990. Consider the humble termite: Termites as agents of post-depositional disturbance at African archaeological sites. Journal of Archaeological Science, 17(2): 111-143. https://doi.org/10.1016/0305-4403(90)90054-9
McGrew, W.C. 2014. The 'other faunivory' revisited: Insectivory in human and non-human primates and the evolution of human diet. Journal of Human Evolution, 71: 4-11. https://doi.org/10.1016/j.jhevol.2013.07.016
Mégnin, P. 1894. La Faune des Cadavres. Application de l'Entomologie a la Médicine Légale. Encyclopdie Scientifique des Aides-Mémoire, Paris: G. Masson & Gauthier-Villars et Fils. http://resource.nlm.nih.gov/28421710R
Meyer-Rochow, V.B. 2017. Therapeutic arthropods and other, largely terrestrial, folk-medicinally important invertebrates: A comparative survey and review. Journal of Ethnobiology and Ethnomedicine, 13: 9. https://doi.org/10.1186/s13002-017-0136-0
Mguni, S. 2006. Iconography of termites' nests and termites: Symbolic nuances of formlings in southern African San rock art. Cambridge Archaeological Journal, 16(1): 53-71. https://doi.org/10.1017/S0959774306000047
Mguni, S. 2013. Enigmatic rock paintings of insectiforms in the Cederberg, Western Cape, South Africa. South African Archaeological Bulletin, 68(198): 160-172. https://www.jstor.org/stable/23631441
Mguni, S. 2015. Termites of the Gods: San Cosmology in Southern African Rock Art. Johannesburg: Wits University Press.
Miller, S.E. & Rogo, L.M. 2002. Challenges and opportunities in understanding and utilisation of African insect diversity. Cimbebasia, 17: 197-218.
Mmari, M.W., Kinyuru, J.N., Laswai, H.S., et al. 2017. Traditions, beliefs and indigenous technologies in connection with the edible longhorn grasshopper *Ruspolia differens* (Serville 1838) in Tanzania. Journal of Ethnobiology and Ethnomedicine, 13: 1-11. https://doi.org/10.1186/s13002-017-0191-6
Moffett, A.J. 2023. Decoupling identities: Moving beyond gendered binaries in the southern African

archaeological record. Southern African Humanities, 36(1): 149-162. https://hdl-handle-net.uplib.idm.oclc.org/10520/ejc-nmsa_sah_v36_n1_a8

Mouton, M. 2025. Changes in animal use during the development of class-based society, 12th to 13th century CE, Limpopo Valley. Doctoral Thesis. Pretoria: University of Pretoria.

Mosothwane, M.N. 2011. The Tuli mummy: A preliminary report from northeastern Botswana. South African Archaeological Bulletin, 66(194): 157-160. https://www.jstor.org/stable/23631418

Mullen, G.R. & Durden, L.A. (eds). 2002. Medical and Veterinary Entomology. London: Academic Press.

Nascimento, D.L., Netto, R.G. & Indicatti, R.P. 2021. Neoichnology of mygalomorph spiders: Improving the recognition of spider burrows in the geological record. Journal of South American Earth Sciences, 108: 103178. https://doi.org/10.1016/j.jsames.2021.103178

Nemadodzi, L.E., Managa, G.M. & Prinsloo, G. 2023. The use of *Gonimbrasia belina* (Westwood, 1849) and *Cirina forda* (Westwood, 1849) caterpillars (Lepidoptera: Sarturniidae) as food sources and income generators in Africa. Foods, 12(11): 2184. https://doi.org/10.3390/foods12112184

Nyffeler, M. & Birkhofer, K. 2017. An estimated 400–800 million tons of prey are annually killed by the global spider community. The Science of Nature, 104(3): 1-12. https://doi.org/10.1007/s00114-017-1440-1

Oberprieler, R.O.L.F., Marvaldi, A. & Anderson, R.S. 2007. Weevils, weevils, weevils everywhere. Zootaxa, 1668: 491-520. https://doi.org/10.11646/zootaxa.1668.1.24

Olsen, A.R. 1984. Fecal pellets from a commensal shrew (*Suncus murinus*) and a house gecko (Gekkonidae). Journal of the Association of Official Analytical Chemists, 67(6): 1035-1036. https://doi.org/10.1093/jaoac/67.6.1035

Ozeki, C.S., Martill, D.M., Smith, R.E., et al. 2020. Biological modification of bones in the Cretaceous of North Africa. Cretaceous Research, 114: 104529. https://doi.org/10.1016/j.cretres.2020.104529

Pager, H. 1971. Ndedema: A Documentation of the Rock Paintings of Ndedema Gorge. Graz: Akademische Druck- und Verlagsanstalt.

Panagiotakopulu, E. 2001. New records for ancient pests: Archaeoentomology in Egypt. Journal of Archaeological Science, 28: 1235-1246. https://doi.org/10.1006/jasc.2001.0697

Panagiotakopulu, E. & Buckland, P.C. 1991. Insect pests of stored products from Late Bronze Age Santorini, Greece. Journal of Stored Products Research, 27: 179-184. https://doi.org/10.1016/0022-474X(91)90043-C

Panagiotakopulu, E. & Buckland, P.C. 2009. Environment, insects and the archaeology of Egypt. In: Ikram, S. & Dodson, A. (eds) Beyond the Horizon: Studies in Egyptian Art, Archaeology and History in Honour of Barry J. Kemp: 347-361. Cairo: American University in Cairo Press.

Parker, J.F., Hopley, P.J. & Kuhn, B.F. 2016. Fossil carder bee's nest from the hominin locality of Taung, South Africa. PLoS ONE, 11(9): e0161198. https://doi.org/10.1371/journal.pone.0161198

Parkinson, A. 2013. *Dermestes maculatus* and *Periplaneta americana*: Bone modification criteria and establishing their potential as climatic indicators. Masters Dissertation. Johannesburg: University of Witwatersrand.

Parkinson, A. 2023. Modern bone modification by *Dermestes maculatus* and criteria for the recognition of dermestid traces in the fossil record. Historical Biology, 35: 567-579. https://doi.org/10.1080/08912963.2022.2054714

Plug, I. 1989. Aspects of life in the Kruger National Park during the Early Iron Age. South African Archaeological Society Goodwin Series, 6: 62-68. https://doi.org/10.2307/3858133

Ponel, P., Matterne, V., Coulthard, N., et al. 2000. La Tène and Gallo-Roman natural environments and human impact at the Touffréville rural settlement, reconstructed from Coleoptera and plant macroremains (Calvados, France). Journal of Archaeological Science, 27: 1055-1072. https://doi.org/10.1006/jasc.1999.0514

Prins, A.J. 1983. Morphological and biological notes on some South African arthropods associated with decaying organic matter. Part 1. Chilopoda, Diplopoda, Arachnida, Crustacea, and Insecta. Annals of the South African Museum, 92(2): 53-112.

Prins, A.J. 1984a. Morphological and biological notes on some South African arthropods associated with decaying organic matter. Part 2. The predatory families Carabidae, Hydrophilidae, Histeridae, Staphylinidae and Silphidae (Coleoptera). Annals of the South African Museum, 92(4): 295-356.

Prins, A.J. 1984b. Morphological and biological notes on some South African arthropods associated with decaying organic matter. Part 3. The families Dermestidae, Cantharidae, Melyridae, Tenebrionidae and Scarabaeidae (Coleoptera). Annals of the South African Museum, 94(4): 203-304.

Prins, F. & Rousseau, L. 1992. Magico-religious interactions, dreams, and ritual transformations: Towards a better understanding of trance experience among the Khoi. Southern African Field Archaeology, 1: 33-39. https://journals.uj.ac.za/index.php/safa/1992_Vol_1_No_2

Pulsifer, D.P., Lakhtakia, A., Martín-Palma, R.J., et al. 2011. Engineered biomimicry: Polymeric replication of surface features found on insects. Proceedings of SPIE 7975, Bioinspiration, Biomimetics, and Bioreplication: 79750O. https://doi.org/10.1117/12.876479

Reinhard, K.J. & Bryant, V.M. 1992. Coprolite analysis: A biological perspective on archaeology. Archaeological Method and Theory, 4: 245-288. https://www.jstor.org/stable/20170225

Rifkin, R.F. 2015. Ethnographic and experimental perspectives on the efficacy of ochre as a mosquito repellent. South African Archaeological Bulletin, 70(201): 64-75. https://www.jstor.org/stable/24643609

Robbiola, L., Moret, P. & Lejars, T. 2011. A case study of arthropods preserved on archaeological bronzes–micro-archaeological investigation helps reconstructing past environments. Archaeometry, 53(6): 1249-1256. https://doi.org/10.1111/j.1475-4754.2011.00607.x

Rousseau, M. 2011. Paraffin flotation for archaeoentomological research: Is it really efficient? Environmental Archaeology, 16(1): 58-64. https://doi.org/10.1179/146141010X12640787648342

Russell, T. & Lander, F. 2015. 'The bees are our sheep': The role of honey and fat in the transition to livestock keeping during the last two thousand years in southernmost Africa. Azania: Archaeological Research in Africa, 50(3): 318-342. https://doi.org/10.1080/0067270X.2015.1051793

Sánchez, M.V., Genise, J.F., Bellosi, E.S., et al. 2013. Dung beetle brood balls from Pleistocene highland palaeosols of Andean Ecuador: A reassessment of Sauer's Coprinisphaera and their palaeoenvironments. Palaeogeography, Palaeoclimatology, Palaeoecology, 386: 257-274. https://doi.org/10.1016/j.palaeo.2013.05.028

Schmidt, S. 2018. The praying mantis in Namibian folklore. Southern African Humanities, 31: 63-77. https://hdl.handle.net/10520/EJC-15405be4f7

Schmidt, S. 2020. Animals and spirits of the road in Nama and Damara folklore and folk belief. South African Archaeological Bulletin, 75(213): 120-127. https://www.jstor.org/stable/26978074

Scholtz, C.H. & Chown, S.L. 1995. Insects in southern Africa: How many species are there? South African Journal of Science, 91(3): 124-126. https://hdl.handle.net/10520/AJA00382353_10229

Scholtz, C.H. & Mansell, M.W. 2017. Insect biodiversity in the Afrotropical Region. In: Foottit, R.G. & Adler, P.H. (eds) Insect Biodiversity: Science and Society: 93-109. Oxford: Wiley-Blackwell. https://doi.org/10.1002/9781118945568

Schulze, L. & Brown, J.M.M. 1975. A Review of Silk Production and Spinning Activities in Arthropoda with Special Reference to Spinning in Tenebrionid Larvae, Coleoptera. Pretoria: Transvaal Museum.

Shahack-Gross, R. 2011. Herbivorous livestock dung: Formation, taphonomy, methods for identification, and archaeological significance. Journal of Archaeological Science, 38(2): 205-218. https://doi.org/10.1016/j.jas.2010.09.019

Smith, D. 1998. Beyond the barn beetles: Difficulties in using some Coleoptera as indicators of stored fodder. Environmental Archaeology, 1: 63-70. https://doi.org/10.1179/env.1996.1.1.63

Smith, D., Nayyar, K., Schreve, D., et al. 2014. Can dung beetles from the palaeoecological and archaeological record indicate herd concentration and the identity of herbivores? Quaternary International, 341: 119-130. https://doi.org/10.1016/j.quaint.2013.11.032

Sutton, M.Q. 1995. Archaeological aspects of insect use. Journal of Archaeological Method and Theory, 2: 253-298. https://doi.org/10.1007/BF02229009

Tommaseo-Ponzetta, M. 2005. Insects: Food for human evolution. In: Paoletti, M.G. (ed.) Ecological Implications of Minilivestock: Potential of Insects, Rodents, Frogs and Snails: 141-162. Enfield: Science Publishers. https://doi.org/10.1201/9781482294439

Toriti, M., Durand, A., Excoffon, P., et al. 2021. Xylophagous insects of the wooden floor of Camelin block (Fréjus, France): An interdisciplinary approach combining archaeology and anthraco-entomology. Quaternary International, 593: 60-70. https://doi.org/10.1016/j.quaint.2020.09.034

Tuccia, F., Giordani, G. & Vanin, S. 2022. State of the art of the funerary archaeoentomological investigations in Italy. Archaeological and Anthropological Sciences, 14: 70. https://doi.org/10.1007/s12520-022-01524-3

Uchman, A., Vrenozi, B. & Muceku, B. 2018. Spider burrows in ichnological context: A review of literature data and burrows of the wolf spider *Trochosa hispanica* Simon, 1870 from Albania. Rendiconti Lincei. Scienze Fisiche e Naturali, 29: 67-79. https://doi.org/10.1007/s12210-017-0662-7

van Huis, A. 2003. Insects as food in Sub-Saharan Africa. International Journal of Tropical Insect Science, 23(3): 163-185. https://doi.org/10.1017/S1742758400023572

van Huis, A. 2019. Cultural significance of Lepidoptera in sub-Saharan Africa. Journal of Ethnobiology and Ethnomedicine, 15: 1-13. https://doi.org/10.1186/s13002-019-0306-3

van Huis, A. 2021. Cultural aspects of ants, bees and wasps, and their products in sub-Saharan Africa. International Journal of Tropical Insect Science, 41: 2223-2235. https://doi.org/10.1007/s42690-020-00410-6

van Huis, A., van Itterbeeck, J., Klunder, H., et al. 2013. Edible insects: Future prospects for food and feed security. Rome: FAO Forestry Paper 171.

van Thuyne, J. & Verrecchia, E.P. 2021. Impacts of fungus-growing termites on surficial geology parameters: A review. Earth-Science Reviews, 223: 103862. https://doi.org/10.1016/j.earscirev.2021.103862

Versteegh, E.A., Black, S., Canti, M.G., et al. 2013. Earthworm-produced calcite granules: A new terrestrial

palaeothermometer? Geochimica et Cosmochimica Acta, 123: 351-357. https://doi.org/10.1016/j.gca.2013.06.020
Webley, L. 2001. Excavations at /Hei-/Khomas (Vaalhoek) in the Richtersveld, Northern Cape. Southern African Field Archaeology, 10: 46-74. https://journals.uj.ac.za/index.php/safa/2001_Vol_10
Walker, N. 1991. Report on a burial at Castle Kopje Wedza. South African Archaeological Bulletin, 46(154): 142-148. https://doi.org/10.2307/3889094
White, D.S. & Miller, M.F. 2008. Benthic invertebrate activity in lakes: Linking present and historical bioturbation patterns. Aquatic Biology, 2: 269-277. https://doi.org/10.3354/ab00056
Whitelaw, G. 1993. Customs and settlement patterns in the first millennium AD: Evidence from Nanda, an Early Iron Age site in the Mngeni Valley, Natal. Natal Museum Journal of Humanities, 5: 47-81. https://hdl.handle.net/10520/AJA16815564_364
Williams, K.A. & Villet, M.H. 2006. A history of southern African research relevant to forensic entomology. South African Journal of Science, 102: 59-65. https://hdl.handle.net/10520/EJC96497
Wilson, M.L. 1993. Early records of some flora and fauna used by the Khoisan of the Western Cape. Southern African Field Archaeology, 2: 67-73. https://hdl.handle.net/10520/AJA10195785_37
Yamashina, C. 2010. Interactions between termite mounds, trees, and the Zemba people in the Mopane savanna in northwestern Namibia. African Study Monographs, 40: 115-128. https://doi.org/10.14989/96293

Southern African Field Archaeology
2025 Vol. 20: Article 3573
Critique/discussion (peer-reviewed): Received October 2024; Revised January 2025; Published March 2025
DOI: https://doi.org/10.36615/safa.20.3573.2025

ISSN 1019-5785
ISSN 2789-1844

Unearthed potential: Reflecting on the past and shaping the future of Middle Stone Age research in Zimbabwe

Precious Chiwara-Maenzanise

Human Evolution Research Institute (HERI), University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa
Department of Geological Sciences, University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa
**Corresponding author email: precious.maenzanise@uct.ac.za*

ABSTRACT
Zimbabwe is home to numerous well-preserved deposits spanning from the Earlier to the Later Stone Age. However, research on the Middle Stone Age has been limited, with most studies conducted during the colonial era. Following independence, economic decline and political challenges have led to sporadic research efforts, leaving Zimbabwe marginalised in discussions on *Homo sapiens*' origins. As a result, key questions about early human behaviours and adaptations remain unresolved. Renewed Middle Stone Age research could provide valuable insights into behavioural evolution, contributing to a more nuanced understanding of human origins and supporting polycentric theories of our species' emergence.

Keywords: Middle Stone Age, early modern humans, economic downturn, understudied, future prospects

1. Introduction

The Middle Stone Age (MSA; ~300-20 ka) is a pivotal period in African prehistory, crucial for investigating the emergence and spread of intricate human behaviours (McBrearty & Brooks 2000; d'Errico 2003; Willoughby 2006; Wadley 2015; Sahle et al. 2019; Bader et al. 2022; Blackwood & Wilkins 2022; Sahle & Wilkins 2024; Chiwara-Maenzanise et al. 2025). Fossil and archaeological evidence strongly support the emergence of *Homo sapiens* during the MSA (Fig. 1; e.g., Grün et al. 1996; Bouzouggar et al. 2007; Johnson & McBrearty 2010; Harvati et al. 2011; Wadley 2015; Dirks et al. 2017; Hublin et al. 2017; Brooks et al. 2018; Wilkins 2021; Wilkins et al. 2021). Notable fossils include the Florisbad cranium (~260 ka) and *Homo naledi* remains from the Rising Star Cave in South Africa (~330-230 ka; Grün et al. 1996; Dirks et al. 2017). Additional *Homo sapiens* remains have been found at Herto (~160 ka) and Omo Kibish (~195 ka) in Ethiopia (White et al. 2003; McDougall et al. 2005), as well as at Jebel Irhoud, Morocco (~300 ka; Hublin et al. 2017). The discovery of a calvaria from Iwo Eleru, Nigeria (~16-11 ka), further expands our understanding of early human distribution across the African continent (Harvati et al. 2011).

These fossil discoveries are supported by archaeological evidence reflecting complex, innovative technologies linked to *Homo sapiens* across Africa. In southern Africa, key examples include a ~100 ka ochre-processing workshop, geometric engravings on ochre, and ~75 ka evidence of shell beads at Blombos Cave (d'Errico et al. 2005, 2015; Henshilwood et al. 2009, 2011). Other significant findings include geometric engravings at Diepkloof Rockshelter (~105 ka; Porraz et al. 2021), calcite crystals at Ga-Mohana Hill North Rockshelter (~105 ka), and collected seashells from Pinnacle Point (~110 ka; Jerardino & Marean 2010; Wilkins et al. 2021). The utilisation of ostrich eggshells (OES) at Diepkloof and Ga-Mohana Hill North Rockshelters (~105 ka; Parkington et al. 2005; Wilkins et al. 2021), early blade production at Kathu Pan (~500 ka; Wilkins & Chazan 2012), and laminar stone tool reduction at Klasies River (~85-115 ka; Wurz 2002) further highlight advanced behaviours. The emergence of formal tools, such as scrapers at Bushman Rockshelter (~73-97 ka; Porraz et al. 2018), underscores the complexity of early human technologies.

Similar patterns emerged in eastern Africa, where blade production is evident at Kapthurin (~500 ka; Johnson & McBrearty 2010). Pigment use at Olorgesailie, Kenya (~300 ka; Brooks et al. 2018), and evidence of beads (~67 ka) and backed pieces (~51 ka), possibly used as multicomponent hunting weapons at Panga Ya Saidi (Ranhorn & Tryon 2018; Shipton et al. 2018), further highlight the technological sophistication of MSA populations. In northern Africa, seashell beads at Grotte des Pigeons (~80 ka; Bouzouggar et al. 2007) provide additional evidence. These discoveries have fuelled debates about whether early human populations originated from a single location or multiple regions (Wilkins 2021). Current evidence supports a wide distribution for *Homo sapiens*, with cultural exchange and genetic intermingling also suggesting a multi-locational origin (Wilkins 2021).

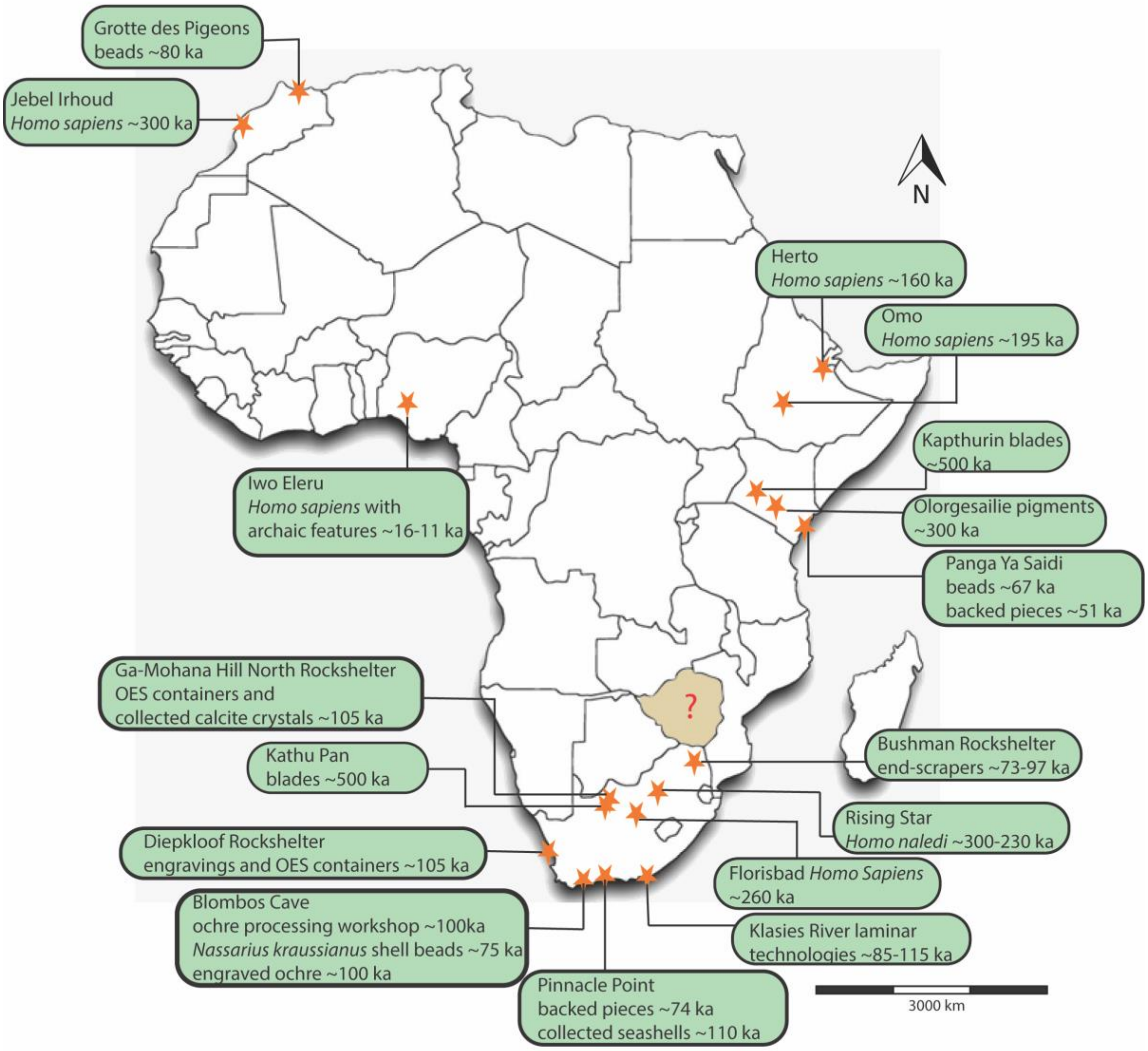


Figure 1. Key sites with archaeological and fossil evidence related to the origins of *Homo sapiens* in Africa. The question mark indicates that there is currently no research on modern human behaviour in Zimbabwe.

Despite the possibility that early modern humans were widely distributed across Africa and may have had a multi-location origin, MSA research in southern Africa has been largely concentrated in South Africa, even though over a century has passed since Stone Age research began in Zimbabwe (e.g., see early research by White 1900, 1905; Mennen 1904; Arnold & Jones 1919). During the colonial period, MSA research in Zimbabwe was comparable with research being conducted in South Africa (Nhamo-Katsamudanga & Chiwara-Maenzanise 2023). However, since Zimbabwe's independence, progress in MSA research has been limited. The foundation of MSA research was laid in the 1930s, with the most significant contributions occurring between the 1950s and 1970s (e.g., Armstrong 1931; Jones 1933, 1938, 1940, 1949; Cooke 1950, 1957, 1963, 1971, 1975a, b, 1978; Brain & Cooke 1967; Brain 1969;

Cruz-Uribe 1983). Only occasional efforts have been made in the ensuing decades (e.g., Walker 1995; Klimowicz & Haynes 1996; Larsson 2001; Chiwara-Maenzanise et al. 2017; Matembo 2019).

Nevertheless, Zimbabwe hosts well-preserved cave deposits with long cultural sequences that could provide valuable data on early modern human development in this interior region (Table 1). Notable cave sites include Zombepata, Redcliff, Ruchera, and the Matobo Cave cluster, which includes Pomongwe, Bambata, Tshangula, and Nswatugi (Fig. 2; Jones 1933; Cooke 1963, 1971, 1978; Walker 1995; Larsson 2001). MSA open-air sites are also found at Bembesi, Khami Waterworks, and in Hwange (Jones 1938; Cooke 1950; Klimowicz & Haynes 1996). However, these cave and open-air sites have not been extensively studied. No radiometric dates exist for the MSA layers at these sites as most research predates the development of dating techniques that extend beyond the radiocarbon range. Additionally, while the MSA field has advanced across Africa with the introduction of new analytical methods, these techniques have not been applied in Zimbabwe due to the lack of ongoing research. As significant questions about MSA human behaviour are now being explored elsewhere, Zimbabwe remains absent from the conversation on early complex human behaviour. This lack of updated research has created a substantial knowledge gap, not only in Zimbabwe's MSA record but also in the broader interior of southern Africa. Given evidence supporting the widespread presence of *Homo sapiens* across different African regions, revitalising MSA research in Zimbabwe is essential for a fuller understanding of human evolution in the interior of southern Africa. While research in South Africa has provided invaluable insights into early human behaviour and technological advancements, it is crucial to explore MSA adaptations in these understudied regions.

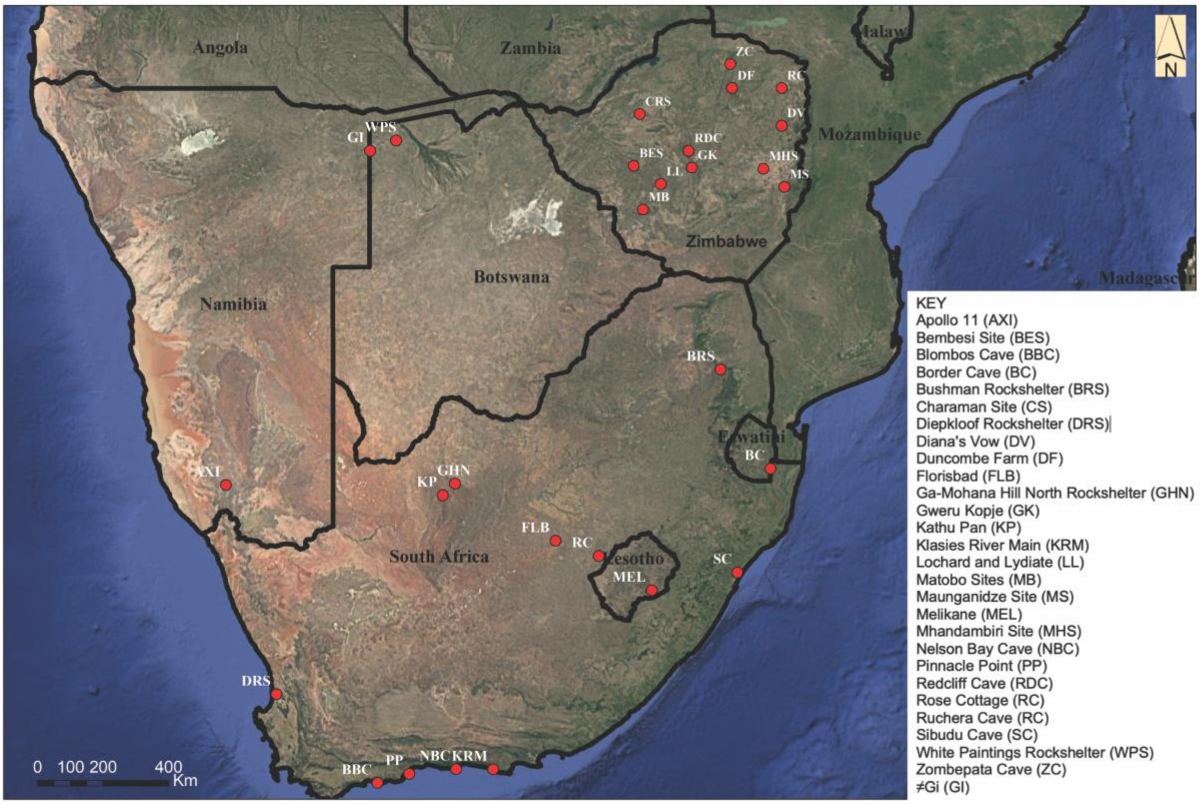


Figure 2. Map showing Stone Age sites in Zimbabwe in relation to other key sites in the region. Note that Matobo (MB) represents a cluster of MSA sites in the area, including Bambata, Nswatugi, Pomongwe, and Tshangula.

In addition, while MSA research has begun to expand in the interior regions of southern Africa, such as the Kalahari, Lesotho, and Limpopo (e.g., de la Peña et al. 2018; Porraz et al. 2018; Pazan et al. 2020; Wilkins et al. 2020, 2021; Chiwara-Maenzanise et al. 2025), much of it remains concentrated in South Africa's coastal and near-coastal areas (e.g., Wurz 2002; Thompson & Marean 2008; Henshilwood et al. 2009, 2011; Thompson et al. 2010; Tribolo et al. 2013; Will et al. 2013; Mackay et al. 2015; Rots et al. 2017; Wilkins et al. 2017; Schmid et al. 2019; Niespolo et al. 2021; Porraz et al. 2021; O'Driscoll & Mackay 2023). These regions are often regarded as more hospitable to human populations compared to the arid and semi-arid interior (Wilkins et al. 2021). The well-preserved and datable rockshelter sites found in coastal regions, along with their extensive cultural sequences, have yielded invaluable insights into early human behaviour, significantly enhancing our understanding of when and how modern humans first exhibited advanced capacities for innovation. Wilkins (2021), however, highlights the potential of interior regions to further enrich our knowledge of human origins.

Table 1. Key MSA sites in Zimbabwe along with available data for relevant layers (i.e., radiometric dates [when available], key artefacts, and the latest publications on their MSA records).

Site	Site type	Radiometric dates	Artefacts recovered	Publications
Zombepata	Cave	~37 290±1140 bp	Flakes, blades, *Levallois* points, prepared cores, unifacial points, backed pieces, scrapers, OES beads	Cooke 1971; Larsson 2001
Redcliff	Cave	-	Flakes, blades, *Levallois* points, prepared cores, scrapers, OES beads, bone artefacts, fauna	Cooke 1978; Cruz-Uribe 1983; Chiwara-Maenzanise et al. 2017
Ruchera	Cave	-	Flakes, blades, cores, scrapers, OES beads, fauna	Larsson 2001; Marufu 2012
Pomongwe	Cave	-	Flakes, blades, cores, bladelet cores, scrapers, bone artefacts, OES beads, fauna	Cooke 1963; Walker 1995; Matembo 2019
Bambata	Cave	-	*Levallois* flakes, blades, prepared cores, backed pieces, fauna	Jones 1940; Walker 1995
Tshangula	Cave	-	Flakes, blades, prepared cores, bladelets, bladelet cores, bone artefacts, OES beads, fauna	Cooke 1963
Nswatugi	Cave	-	Flakes, blades, unifacial points, scrapers, fauna	Jones 1933, Walker 1995
Bembesi	Open-air	-	Flakes, blades, cores, scrapers, points	Jones 1938
Khami Waterworks	Open-air	-	Flakes, blades, unifacial points, scrapers, bladelet cores, bone artefacts, OES beads	Cooke 1950, 1957
Hwange	Open-air	-	Triangular flakes with reduced bulbs and lips, blades, *Levallois* points, bifacial points, scrapers, denticulates, prepared cores, hammerstones	Klimowicz & Haynes 1996

From a Zimbabwean perspective, post-colonial archaeological research has tended to emphasise Iron Age studies in recent years, with comparatively less attention given to deep-time heritage, particularly Stone Age research. Zimbabwe has attracted considerable interest for its Iron Age and stone-walled sites, including Great Zimbabwe, Khami, Chumnungwa, and recent studies on the Nambya (e.g., Chirikure et al. 2018; Mukwende et al. 2018; Chirikure 2020; Machiridza 2020; Shenjere-Nyabezi & Gronenborn 2021; Shenjere-Nyabezi et al. 2023; Nyamushosho et al. 2024). While the significance of these studies in advancing our understanding of later cultural developments is widely recognised, there is also a pressing need to explore Zimbabwe's MSA record. This holds key evidence for the evolution of *Homo sapiens* and the emergence of distinct early human behaviours that predate the advent of farming communities.

Some of the challenges contributing to the imbalance and stagnation of Zimbabwean MSA research stem from the interplay of post-colonial economic and political difficulties that have profoundly impacted the country. Issues such as political dysfunction have led to economic decline, creating an environment in which scientific research, including archaeology, is severely constrained. Economic stagnation limits funding for research, with scientific endeavours competing against more immediate concerns like basic survival. In such situations, essential research often loses out to bread-and-butter issues. Even when funding is allocated by local organisations or governing bodies, it is often eroded by high inflation rates before it can be used for meaningful research.

In addition, these economic and funding issues pose significant challenges to conducting meaningful analytical work in Zimbabwe due to underdeveloped laboratory infrastructure. The scarcity of financial resources hampers the acquisition of advanced equipment for universities and museums, including equipment for dating and other essential research tools. The lack of well-equipped laboratory spaces further restricts researchers from analysing material culture effectively. For example, X-ray fluorescence (XRF) analysers, which are critical for the geochemical analysis of artefacts, are largely unavailable. Similarly, the absence of high-resolution imaging microscopes or scanning electron microscopes (SEM) hinders detailed use-wear studies on stone tools. Furthermore, studying faunal remains is difficult given the lack of isotope laboratories, hindering efforts to reconstruct past environments. These challenges often compel researchers to rely on external collaborations, or on sending samples to neighbouring South Africa, where the economy has enabled the development of advanced laboratory facilities in universities. In some cases, samples must be sent abroad, requiring extensive paperwork to secure export permits, which inevitably delays progress and increases costs. Such limitations not only impede the advancement of MSA research but also reduce opportunities for the development and training of specialised personnel within Zimbabwe.

These economic challenges have not only disrupted local research, but they have also created an unfavourable environment for international researchers interested in the MSA. Such instability complicates financial planning, limits access to essential research resources, and increases logistical difficulties, making research collaborations challenging. With scarce funding opportunities and insufficient infrastructure, the potential for groundbreaking discoveries is severely hindered. As a result, many international researchers have opted for more stable environments like South Africa, where the political and economic conditions are more favourable. This shift further under-represents Zimbabwe in the broader context of MSA studies, skewing the regional focus and leaving a significant gap in the understanding of human evolution in the area.

Furthermore, the uncertainty surrounding funding, political, and economic limitations has created an environment in which many local researchers have been forced to leave the country in search of better opportunities. This exodus of talent exacerbates the already limited capacity for research within Zimbabwe. Many skilled archaeologists and related professionals have sought positions in other African countries or abroad, where research funding, academic resources, and career prospects are more secure. This brain drain has a direct impact on the availability of local expertise necessary for robust research, further deepening the disparity in regional representation and leaving Zimbabwe's MSA research largely underexplored.

The fact that Zimbabwe's institutions are often underfunded leaves them ill-equipped to support ambitious archaeological projects. Even when research is undertaken, it is frequently hindered by outdated technology, insufficient training opportunities, and a lack of collaboration with international partners. These factors create a cycle of underdevelopment in research capacity, which not only affects the quantity of MSA studies but also limits their quality. To break this cycle, there is an urgent need for investment in both local infrastructure and collaborative international partnerships, alongside political and economic reforms to stabilise the environment for scientific research. Only through such measures can Zimbabwe's significant role in the understanding of human prehistory be fully realised.

This historical and ongoing trend has left Zimbabwe's MSA archaeology heavily reliant on research conducted during the colonial era. Much of this work was carried out by white male archaeologists who, influenced by the prevailing colonial ideologies of the time, may have interpreted Zimbabwe's MSA archaeological record through biased or Eurocentric perspectives. Consequently, the foundational understanding of Zimbabwe's MSA heritage is based on interpretations and methodologies that were developed during the colonial era. In the following sections, I provide a synthesis of existing research and propose future directions for advancing the field.

2. A retrospective on Zimbabwe's MSA research

Research on the MSA in Zimbabwe dates back to the early 20th century, when Franklin White first noted stone flakes scattered among the Khami Ruins (White 1900, 1905). However, research remained in its infancy until the 1930s and 1940s, a period marked by significant discoveries of Stone Age artefacts in the Matobo Hills. In 1931, Jones and Armstrong conducted the earliest excavations at the renowned Bambata Cave, uncovering a 3.2 m sequence of Stone Age occupations (see Armstrong 1931; Jones 2013). This was followed by investigations at Nswatugi in the Matobo Hills (Jones 1933), as well as sporadic discoveries at Gweru Kopje and Bembesi in central Zimbabwe (Gardner & Stapleton 1934; Jones 1938).

A renewed phase of research began in the second half of the 20th century, particularly during the 1950s and 1960s and led by the significant work of Cran Cooke. This period saw important advancements at Matobo. Building on earlier work at Bambata Cave, major excavations were carried out at sites such as Khami Waterworks (Cooke 1950, 1957), Tshangula, and Pomongwe (Cooke 1963). These excavations uncovered a rich archaeological record, and a series of technocomplexes were developed, later synthesised by Walker and Thorp (1997). Cooke's (1963) research laid the foundation for defining MSA chrono-cultural sequences in Zimbabwe and classified the MSA into two industries – Bambata and Tshangula – which are still in use today. This body of work, largely based on benchmark sites and assemblages from the Matobo, has become a key reference for Zimbabwe's MSA.

Outside the Matobo region, Cooke, Brain, and Cruz-Uribe spearheaded MSA research at Zombepata and Redcliff Caves, in northern and central Zimbabwe, respectively (Brain & Cooke 1967; Brain 1969; Cooke 1971, 1978; Cruz-Uribe 1983). Both sites are characterised by long cultural sequences and typical MSA artefacts, such as *Levallois* points, prepared cores, blades, and flakes, as well as formal tools like points, backed pieces, and scrapers. These discoveries played a crucial role in expanding MSA research in Zimbabwe beyond the Matobo region. However, the assemblages from Zombepata and Redcliff were classified into the Bambata and Tshangula industries, named after type sites in the Matobo, in western Zimbabwe. The Zombepata assemblages were radiocarbon dated to between 30 and 40 ka, although Cooke (1971) noted that many of the finds were beyond the range of radiocarbon dating, making the existing dates questionable.

The 1970s marked the beginning of Nicholas Walker's pivotal excavations in Matobo. His work, later published in 1995, focused on the terminal Pleistocene and Holocene phases, with emphasis on the Later Stone Age (LSA; Walker 1995). His research remains a key source for studying the LSA in Zimbabwe, utilising a range of archaeological evidence and providing a developmental and palaeoecological framework from the end of the Pleistocene to the final phases of the Holocene. Although Matobo has long been a focal point for Stone Age research given its renowned archaeological sites with extensive cultural sequences and exceptionally well-preserved organic materials, research there, like much of Zimbabwe, has remained disconnected from the latest findings and interpretations in southern Africa's MSA.

As previously mentioned, post-independence MSA research in Zimbabwe is limited. One of the contributions during this period came from Klimowicz and Haynes (1996), who excavated open-air MSA sites in Hwange. Their work uncovered typical MSA artefacts, including prepared cores, *Levallois* points, flakes, and blades with reduced bulbs and lipping, suggesting the use of soft-hammer percussion. This excavation advanced our understanding of MSA technological behaviours in the region, and particularly, of open-air MSA sites in Zimbabwe. However, their chronological context remains uncertain given the lack of radiometric dates.

Since 2000, MSA research in Zimbabwe has included Larsson's (2001) re-examination of materials from Zombepata, focusing on the transition from the MSA to the LSA and the Tshangula industry, which Cooke (1971) identified as being transitional. Marufu (2012) also conducted research at Ruchera Cave, which, while primarily centred on the Holocene, examined events marking the end of the MSA at the site. Additionally, Chiwara-Maenzanise and colleagues (2017) revisited museum collections from Redcliff and suggested that MSA lithics were likely used for various tasks, including butchery. In the same year, the multidisciplinary Matobart project was initiated to study rock art and the associated Stone Age record across the Matobo landscape (Bourdier 2019; Bourdier et al. 2020; Porraz et al. 2020, 2023). The project aimed to reopen trenches previously excavated by Cooke (1963) and Walker (1995) for chronometric dating, geoarchaeological analysis, and site formation studies. Additionally, there are ongoing examinations of the Matobo MSA museum collections (e.g., Matembo 2019), in addition to recent geoarchaeological investigations (Mnkandla 2019). A re-examination of late Holocene LSA-backed artefacts (Chiwara-Maenzanise 2018) and research on rock art from Pomongwe under the

Matobart (Nhunzvi et al. 2020) project have further contributed to enhancing the understanding of Zimbabwe's Stone Age record.

3. Key issues and the foci of the discipline, going forward

The synthesis above underscores that, despite Zimbabwe's rich array of cave sites with MSA deposits, MSA research in the country remains sporadic in the 21st century. Interest has diminished over the past five decades, resulting in Zimbabwe's MSA research failing to keep pace with advancements in the field. In this section, I propose a forward-looking synthesis outlining key areas of focus for the discipline, questions that should be addressed to fill critical knowledge gaps, and how to ensure that the country's archaeological narrative better reflects its rich and diverse past, interpreted through contemporary and inclusive perspectives.

Dating and chronology

There is an urgent need to establish comprehensive dating frameworks for MSA sites in Zimbabwe. Only a few sites have reliable chronometric age estimates, with the most widely used method being radiocarbon analysis, which dates layers up to approximately 40-50 ka. An example is Cooke's (1971) radiocarbon date of ~37 290±1140 bp for the later MSA layers at Zombepata Cave. There are no radiometric dates for older deposits in the country, thus the absence of reliable MSA dates presents significant challenges for understanding early human history. Without accurate dating, it is impossible to establish a clear timeline of technological and cultural developments, which hinders efforts to connect local findings to broader regional or global patterns. This temporal uncertainty prevents meaningful comparisons between sites, complicates interpretations of innovation and adaptation, and limits the identification of synchronicities or divergences in human behaviour across different environments. Additionally, the lack of precise chronologies diminishes the scientific value of these sites, making it harder to attract research funding or collaborations.

I propose the re-excavation of these sites to establish a reliable chronological sequence using modern geochronological techniques for dating older deposits, such as optically stimulated luminescence, electron spin resonance, palaeomagnetic, and uranium-series dating. Efforts to address this issue have already begun with the Matobart project, which aims to provide a chronology for Matobo sites, particularly Pomongwe and Bambata (Bourdier et al. 2020; Porraz et al. 2023). Additionally, there is a need to extend dating efforts beyond the Matobo region. Establishing a robust chronology for the MSA will also help refine the poorly defined MSA industries, namely Bambata and Tshangula, as their timing and defining characteristics remain unclear. Revisiting these sites would not only address these issues but would also help to establish whether the Named Stone Tool Industries (NASTIES) system (Shea 2014; Wilkins 2020) is the best way to characterise the MSA in Zimbabwe.

Technology

As highlighted earlier, the MSA is associated with the development of numerous technologies, typically linked to the appearance of early modern humans (Wadley 2015). Revisiting the MSA in Zimbabwe will help illuminate these technologies, such as lithic reduction techniques. Cooke's (1963, 1971, 1978) and Walker's (1995) excavations at key MSA sites have yielded several *Levallois* products, attesting to the use of these technologies in the region. Therefore, I am confident that these sites have the potential to provide valuable insights into innovative lithic technologies.

Re-excavation is also needed to obtain clear contextual lithic artefacts, as many curated finds have lost their context. In cases where context is still preserved, curated museum collections can be reanalysed. The analysis should employ modern lithic analytical frameworks, such as the *chaîne opératoire*, a methodological framework that outlines all phases of an artifact's life, from the acquisition of raw materials to its eventual disposal (Inizan et al. 1999). This approach illustrates the structure of a technological system within a prehistoric setting (Brenner 2019). It has been extensively applied in South Africa (e.g., Wurz 2000; Soriano et al. 2007; Porraz et al. 2018; Brenner 2019) and would thus enable comparisons between Zimbabwe's findings and those from nearby South Africa, providing a fuller picture of human evolution in the region.

I further suggest the use of methods such as use-wear and residue analysis to gain insights into technologies associated with the MSA, including hafting and hunting weaponry. Several MSA sites have yielded backed pieces in MSA layers (see Table 1). These sites may reveal how early humans adapted their technologies to different environmental and ecological contexts, shedding light on the innovation and spread of critical practices. Such findings not only fill gaps in understanding the development of complex toolmaking but also offer a more nuanced view of the technological ingenuity that characterised the MSA.

Subsistence

Homo sapiens is defined by the ability to exploit diverse food sources across a wide and adaptable ecological niche (Marean 2016; Wilkins 2021). Early excavations have shown that MSA sites in Zimbabwe exhibit excellent preservation, as evidenced by the large quantities of faunal and plant remains recovered at sites such as Redcliff, Pomongwe, and Bambata (Cooke 1971; Cruz-Uribe 1983; Walker 1995). Renewed research has the potential to uncover additional markers of subsistence strategies in the region. Animal remains and hunting weapons offer insights into prey selection, hunting methods, and meat processing techniques. Meanwhile, plant remains can reveal the role of plant resources in the diet, clarifying foraging strategies and seasonal patterns, and reflecting how MSA populations adapted to their environments and sustained themselves through flexible dietary practices.

Trade and interactions

Evidence of trade and social networking is present in the MSA record (Blackwood & Wilkins 2022; Chiwara-Maenzanise et al. 2025). Sites like Zombepata and Pomongwe yield large quantities of OES beads, which, if further explored, may reveal trade and social interactions between groups. In addition, the presence of non-local raw materials at Pomongwe (Walker 1995) may facilitate the exploration of long-distance trade, if studied in more detail. Analysis of similarities in tools, ornaments, and cultural artefacts may uncover social connections, including alliances and the transmission of technological knowledge. This research could clarify whether social networks were essential for the survival and development of early human societies in Zimbabwe.

Symbols and rituals

Renewed research on symbols and rituals in Zimbabwe can address important questions, such as how early humans used symbolic expression and ritualistic practices to communicate, form social bonds, and navigate their environments. It can also provide insights into the role of symbols in identity formation, belief systems, and group cohesion, as well as how these practices might have evolved in response to changing environmental and social conditions. I recommend a more detailed analysis of symbolic artefacts, decorative items like beads, pendants, and engraved tools, that are available in Zimbabwe’s MSA sites given their potential for symbolic meaning. Such analysis will offer a more comprehensive view of the cognitive and social development of early humans in Zimbabwe.

Environmental adaptations

Renewed research can address key questions, such as how early humans in Zimbabwe adapted to diverse and challenging environments, including semi-arid and savanna ecosystems. It can also provide insight into the strategies they used to cope with fluctuating climates, shifting landscapes, and varying resource availability, and whether they modified their behaviour or technology to thrive in these conditions. I suggest applying palaeoenvironmental methods, such as the analysis of stable isotopes (e.g., oxygen, carbon, nitrogen), pollen analysis, and sediment core analysis, to reconstruct past vegetation and climate changes. These methods will offer a deeper understanding of how the environment influenced early human adaptation.

Demographic trends

New research can also address questions related to population sizes, density, and mobility patterns of early humans, and how these trends evolved over time in response to social and environmental changes. Archaeological evidence, such as site distribution, artefact density, and the presence of habitation structures, can provide clues about these patterns, contributing to the broader understanding of human evolution in the interior of southern Africa.

4. Conclusion

To address the gaps and key issues in MSA research, it is vital to navigate the challenges posed by Zimbabwe's declining economy and political instability. Asking innovative and cutting-edge questions, applying advanced analytical techniques, and dating archaeological sites are undeniably necessary. However, these activities ideally need to take place within Zimbabwe and, ultimately, be spearheaded by Zimbabwean specialists. Achieving this requires the active involvement of the government, universities, and museums in fostering the national growth of the discipline.

While institutional support within the country remains limited, local researchers can explore alternative avenues, such as applying for international grants to secure funding and resources. This approach enables scholars to access financial support beyond the constraints of the national economy, reducing reliance on Zimbabwe's limited local resources. Additionally, international researchers can play a pivotal role by collaborating with local academics, offering both financial and logistical assistance. Such partnerships can facilitate access to advanced technologies and specialised expertise, ensuring the continuity and advancement of MSA research in Zimbabwe.

In summary, Zimbabwe preserves rich MSA sites with significant potential. The abundance of these sites indicates that early humans once inhabited the region. To gain a fuller understanding of what occurred in these areas, distant from South Africa's coastal zones, further research is essential. Instead of being marginal to discussions on the origins of our species, I have emphasised the important role these well-preserved sites can play in addressing key questions. While several challenges to MSA research have been identified, there is still an opportunity to overcome them. Revitalising research in Zimbabwe is crucial if the country is to be recognised as one of the contributors to human evolution studies in Africa; currently, it is absent from these discussions. Various cross-disciplinary research groups can examine this rich record using advanced excavation, dating, and analytical techniques to produce essential new data and deepen our understanding of the emergence of *Homo sapiens* in this region.

Acknowledgements

Thank you to the two reviewers and the editors of the Southern African Field Archaeology Journal for their comments, which greatly improved this manuscript. Thank you to Joseph Mujere for valuable discussions and for going through the manuscript draft. Precious Chiwara-Maenzanise is supported by GENUS (DSI-NRF Centre of Excellence in Palaeosciences, Grant No. 86073), the Palaeontological Scientific Trust (PAST Africa), and the French Institute of South Africa (IFAS).

References

Armstrong, A.L. 1931. Rhodesian archaeological expedition 1929: Excavations in Bambata Cave and researches on prehistoric sites in Southern Rhodesia. Journal of the Royal Anthropological Institute, 61: 239-276.

Arnold, G. & Jones, N. 1919. Notes on the Bushman cave at Bambata, Matopo. Proceedings of the Rhodesian Scientific Association, 17(1): 5-19.

Bader, G.D., Schmid, V.C. & Kandel, A.W. 2022. The Middle Stone Age of South Africa. Oxford Research Encyclopedia of Anthropology. Oxford: Oxford University Press.

Blackwood, A.F. & Wilkins, J. 2022. The African Middle Stone Age. Oxford Research Encyclopedia of Anthropology. Oxford: Oxford University Press.

Bourdier, C. 2019. Peintures rupestres et environnements culturels des Matobo, Zimbabwe. Lesedi, 23: 25-29.

Bourdier, C., Dudognon, C., Frouin, M., et al. 2020. Approche interdisciplinaire de la paroi ornée: Pomongwe cave et le program Matobart. Lesedi, 23: 13-18.

Bouzouggar, A., Barton, N., Vanhaeren, M., et al. 2007. 82,000-year-old shell beads from North Africa and implications for the origins of modern human behaviour. Proceedings of the National Academy of Sciences, 104(24): 9964-9969.

Brain, C.K. 1969. New evidence for climatic change during Middle and Late Stone Age times in Rhodesia. The South African Archaeological Bulletin, 24(96): 127-143.

Brain, C.K. & Cooke, C.K. 1967. A preliminary account of the Redcliff cave site in Rhodesia. The South African Archaeological Bulletin, 21(84): 171-187.

Brenner, M.J. 2019. The MIS 5 lithic assemblages of Klasies River. Doctoral Thesis. Johannesburg: University of the Witwatersrand.

Brooks, A.S., Yellen, J.E., Potts, R., et al. 2018. Long-distance stone transport and pigment use in the earliest

Middle Stone Age. Science, 360(6384): 90-94.

Chirikure, S. 2020. New perspectives on the political economy of Great Zimbabwe. Journal of Archaeological Research, 28: 139-186.

Chirikure, S., Nyamushosho, R., Bandama, F., et al. 2018. Elites and commoners at Great Zimbabwe: Archaeological and ethnographic insights on social power. Antiquity, 92(364): 1056-1075.

Chiwara-Maenzanise, P. 2018. Morpho-functional variability of the late Holocene microlithic backed tools from Pomongwe Cave, Matobo, Western Zimbabwe. Masters Dissertation. Harare: University of Zimbabwe.

Chiwara-Maenzanise, P., Nhamo, A. & Chikumbirike, J. 2017. A functional analysis of lithic material from Redcliff Cave, central Zimbabwe. In: Manyanga, M. & Chirikure, S. (eds) Archives, Objects, Places and Landscapes. Multidisciplinary Approaches to Decolonised Zimbabwean Pasts: 83-100. Bamenda: Langaa RPCIG.

Chiwara-Maenzanise, P., Schoville, B.J., Sahle, Y., et al. 2025. The Marine Isotope Stage 5 (~105 ka) lithic assemblage from Ga-Mohana Hill North Rockshelter and insights into social transmission across the Kalahari Basin and its environs. Journal of Human Evolution, 202 (103654): 1-20.

Cooke, C.K. 1950. The Middle Stone Age site at Khami Southern Rhodesia: A further examination. The South African Archaeological Bulletin, 5(18): 60-68.

Cooke, C.K. 1957. The Waterworks site at Khami, Southern Rhodesia: Stone Age and proto-historic. Occasional Papers of the National Museum of Southern Rhodesia, 21(A3): 1-43.

Cooke, C.K. 1963. Report on Excavations at Pomongwe and Tshangula Caves, Matopo Hills, Southern Rhodesia. The South African Archaeological Bulletin, 18(7): 73-151.

Cooke, C.K. 1971. Excavation at Zombepata Cave, Sipolilo District, Mashonaland, Rhodesia. The South African Archaeological Bulletin, 26(103): 104-126.

Cooke, C.K. 1975a. Two parts of arrowshafts: Pomongwe Cave excavations, 1960-61. The South African Archaeological Bulletin, 30: 41.

Cooke, C.K. 1975b. The Rhodesian Stone Age succession. Pan African Congress for Prehistory, 6: 36-46.

Cooke, C.K. 1978. The Redcliff Stone Age site, Rhodesia. Occasional Papers of the National Museum of Southern Rhodesia, 2: 43-73.

Cruz-Uribe, K. 1983. A mammalian fauna from Redcliff Cave Zimbabwe. The South African Archaeological Bulletin, 38(137): 7-16.

de la Peña, P., Val, A., Stratford, D.J., et al. 2018. Revisiting Mwulu's Cave: New insights into the Middle Stone Age in the southern African savanna biome. Archaeological and Anthropological Sciences, 11: 3239-3266.

Dirks, P.H., Roberts, E.M., Hilbert-Wolf, H., et al. 2017. The age of *Homo naledi* and associated sediments in the Rising Star Cave, South Africa. Elife, 6: e24231.

d'Errico, F. 2003. The invisible frontier. A multiple species model for the origin of behavioural modernity. Evolutionary Anthropology: Issues, News, and Reviews, 12(4): 188-202.

d'Errico, F., Henshilwood, C., Vanhaeren, M., et al. 2005. *Nassarius kraussianus* shell beads from Blombos Cave: Evidence for symbolic behaviour in the Middle Stone Age. Journal of Human Evolution, 48: 3-24.

d'Errico, F., Vanhaeren, M., Van Niekerk, K., et al. 2015. Assessing the accidental versus deliberate colour modification of shell beads: Case study on perforated *Nassarius kraussianus* from Blombos Cave Middle Stone Age levels. Archaeometry, 57(1): 51-76.

Gardner, T. & Stapleton, P. 1934. Gwelo Kopje-S Rhodesia. Proceedings and Transactions of the Rhodesian Scientific Association, 33: 4-14.

Grün, R., Brink, J.S., Spooner, N.A., et al. 1996. Direct dating of Florisbad hominid. Nature, 382(6591): 500-501.

Harvati, K., Stringer, C., Grün, R., et al. 2011. The Later Stone Age calvaria from Iwo Eleru, Nigeria: Morphology and chronology. PLoS ONE, 6(9): e24024.

Henshilwood, C.S., d'Errico, F. & Watts, I. 2009. Engraved ochres from the Middle Stone Age levels at Blombos Cave, South Africa. Journal of Human Evolution, 57(1): 27-47.

Henshilwood, C.S., d'Errico, F., Van Niekerk, K.L., et al. 2011. A 100,000-year-old ochre-processing workshop at Blombos Cave, South Africa. Science, 334(6053): 219-222.

Hublin, J.J., Ben-Ncer, A., Bailey, S.E., et al. 2017. New fossils from Jebel Irhoud, Morocco and the pan-African origin of *Homo sapiens*. Nature, 546(7657): 289-292.

Inizan, M.L., Reduron-Ballinger, M., Roche, H., et al. 1999. Technology and Terminology of Knapped Stone. Nanterre: CREP.

Jerardino, A. & Marean, C.W. 2010. Shellfish gathering, marine paleoecology and modern human behaviour: Perspectives from cave PP13B, Pinnacle Point, South Africa. Journal of Human Evolution, 59(3-4): 412-424.

Johnson, C.R. & McBrearty, S. 2010. 500,000 year old blades from the Kapthurin Formation, Kenya. Journal of Human Evolution, 58(2): 193-200.

Jones, N. 1933. Excavations at Nswatugi and Madiliyangwa, and notes on new sites located and examined in the

Matopo Hills, Southern Rhodesia, 1932. Occasional Papers of the National Museum of Southern Rhodesia, 1: 1-35.

Jones, N. 1938. The Bembesi industry. Occasional Papers of the National Museums and Monuments of Zimbabwe, 7(1): 7-31.

Jones, N. 1940. Bambata Cave: A reorientation. Occasional Papers of the National Museum of Southern Rhodesia, 9: 11-28.

Jones, N. 1949. The Prehistory of Southern Rhodesia. Cambridge: Cambridge University Press.

Jones, N. 2013. The Prehistory of Southern Rhodesia. Second Edition. Cambridge: Cambridge University Press.

Klimowicz, J. & Haynes, G. 1996. The Stone Age of Hwange National Park, Zimbabwe. In: Pwiti, G. & Soper, R. (eds) Aspects of African Archaeology. Papers from the 10th Congress of the Pan African Association for Prehistory and Related Studies: 121-128. Harare: University of Zimbabwe Press.

Larsson, L. 2001. The Middle Stone Age of northern Zimbabwe in a southern African perspective. Lund Archaeological Review, 2000: 61-84.

Machiridza, L.H. 2020. Landscapes and ethnicity: An historical archaeology of Khami-Phase sites in southwestern Zimbabwe. Historical Archaeology, 54(3): 647-675.

Mackay, A., Jacobs, Z. & Steele, T.E. 2015. Pleistocene archaeology and chronology of Putslaagte 8 (PL8) Rockshelter, Western Cape, South Africa. Journal of African Archaeology, 13(1): 71-98.

Marean, C.W. 2016. The transition to foraging for dense and predictable resources and its impact on the evolution of modern humans. Philosophical Transactions of the Royal Society B: Biological Sciences, 371(1698): 20150239.

Marufu, H. 2012. Foraging communities of the Murewa-Mutoko landscape: An archaeological study of human behaviour during the terminal Pleistocene and Holocene epochs. Doctoral Thesis. Dar es Salaam: University of Dar es Salaam.

Matembo, J. 2019. The Middle and Later Stone Age crystal quartz technologies of Pomongwe Cave, Matopos (Zimbabwe). Masters Dissertation. Johannesburg: University of Witwatersrand.

McBrearty, S. & Brooks, A.S. 2000. The revolution that wasn't: A new interpretation of the origin of modern human behaviour. Journal of Human Evolution, 39(5): 453-563.

McDougall, I., Brown, F.H. & Fleagle, J.G. 2005. Stratigraphic placement and age of modern humans from Kibish, Ethiopia. Nature, 433(7027): 733-736.

Mennen, F.P. 1904. Some stone implements in the Rhodesian Museum. Rhodesian Museum Annual Report 3, 6-7.

Mnkandla, T. 2019. A reconstruction of palaeoenvironmental conditions in Matobo World Heritage Landscape: A geoarchaeological perspective. Masters Dissertation. Harare: University of Zimbabwe.

Mukwende, T., Bandama, F., Chirikure, S., et al. 2018. The chronology, craft production and economy of the Butua capital of Khami, southwestern Zimbabwe. Azania: Archaeological Research in Africa, 53(4): 477-506.

Niespolo, E.M., Sharp, W.D., Avery, G., et al. 2021. Early, intensive marine resource exploitation by Middle Stone Age humans at Ysterfontein 1 rockshelter, South Africa. Proceedings of the National Academy of Sciences, 118(16): 1-12.

Nhamo-Katsamudanga, A. & Chiwara-Maenzanise, P. 2023. Pleistocene archaeology of Zimbabwe: An overview. In: Beyin, A., Wright, D.K., Wilkins J., et al. (eds) Handbook of Pleistocene Archaeology of Africa: Hominin Behaviour, Geography, and Chronology: 1203-1224. Cham: Springer.

Nhunzvi, J., Nhamo, A., Dayet, L., et al. 2020. Diversity in Late Stone Age art in Zimbabwe. Lesedi, 23: 23-26.

Nyamushosho, R.T., Moffett, A.J., Chirikure, S., et al. 2024. Chumnungwa glass beads: New insights into the geochemistry, circulation, and consumption patterns of pre-European glass beads in Iron Age southern Africa, CE 980-1650. African Archaeological Review, 41: 373-403.

O'Driscoll, C.A. & Mackay, A. 2023. Middle Stone Age technology from MIS 6 and MIS 5 at Klipfonteinrand 1, South Africa. Quaternary Science Reviews, 318: 108289.

Parkington, J., Poggenpoel, C., Rigaud, J.P., et al. 2005. From tool to symbol: The behavioural context of intentionally marked ostrich eggshell from Diepkloof, Western Cape. In: d'Errico, F., Backwell, L. & Malauzat, B. (eds) From Tools to Symbols: From Early Hominids to Modern Humans: 475-492. Johannesburg: University of Witwatersrand Press.

Pazan, K.R., Dewar, G. & Stewart, B.A. 2020. The MIS 5a (~ 80 ka) Middle Stone Age lithic assemblages from Melikane Rockshelter, Lesotho: Highland adaptation and social fragmentation. Quaternary International, 611: 115-133.

Porraz, G., Val, A., Tribolo, C., et al. 2018. The MIS 5 Pietersburg at '28' Bushman rockshelter, Limpopo Province, South Africa. PloS ONE, 13(10): e0202853.

Porraz, G., Chiwara-Maenzanise P., Haaland, M., et al. 2020. Les sous-sols de l'art rupestre à l'abri Pomongwe (Matobo, Zimbabwe). Lesedi, 23: 18-22.

Porraz, G., Parkington, J.E., Schmidt, P., et al. 2021. Experimentation preceding innovation in a MIS 5 Pre-Still

Bay layer from Diepkloof Rockshelter (South Africa): Emerging technologies and symbols. Peer Community Journal, 1: 1-33.

Porraz, G., Nhamo, A. & Bourdier, C. 2023. Pomongwe Cave, Zimbabwe. In: Beyin, A., Wright, D. K., Wilkins J., et al. (eds) Handbook of Pleistocene Archaeology of Africa: Hominin Behaviour, Geography, and Chronology: 1225-1237. Cham: Springer.

Ranhorn, K., & Tryon, C.A. 2018. New radiocarbon dates from Nasera Rockshelter (Tanzania): Implications for studying spatial patterns in late Pleistocene technology. Journal of African Archaeology, 16(2): 211-222.

Rots, V., Lentfer, C., Schmid, V.C., et al. 2017. Pressure flaking to serrate bifacial points for the hunt during the MIS 5 at Sibudu Cave (South Africa). PloS ONE, 12(4): e0175151.

Sahle, Y., Reyes-Centeno, H. & Bentz, C. 2019. Modern Human Origins and Dispersal. Tübingen: Kerns Verlag.

Sahle, Y. & Wilkins, J. 2024. Africa, South: Middle Stone Age. In: Rehren, T. & Nikita, E. (eds) Encyclopaedia of Archaeology. Second Edition: 21-28. London: Academic Press.

Schmid, V.C., Porraz, G., Zeidi, M., et al. 2019. Blade technology characterising the MIS 5 D-A layers of Sibudu Cave, South Africa. Lithic Technology, 44: 199-236.

Shea, J.J. 2014. Sink the Mousterian? Named stone tool industries (NASTIES) as obstacles to investigating hominin evolutionary relationships in the Later Middle Paleolithic Levant. Quaternary International, 350: 169-179.

Shenjere-Nyabezi, P. & Gronenborn, D. 2021. The Zimbabwe Culture and the development of the Nambya state in north-western Zimbabwe. Antiquity, 95(384): e34.

Shenjere-Nyabezi P., Pwiti, G. & Gronenborn, D. 2023. The Past in the Present: The Archaeology of North-western Zimbabwe and the Nambya State. Harare: Weaver Press.

Shipton, C., Roberts, P., Archer, W., et al. 2018. 78,000-year-old record of Middle and Later Stone Age innovation in an East African tropical forest. Nature Communications, 9(1): 1832.

Soriano, S., Villa, P. & Wadley, L. 2007. Blade technology and tool forms in the Middle Stone Age of South Africa: The Howiesons Poort and post-Howiesons Poort at Rose Cottage Cave. Journal of Archaeological Science, 34(5): 681-703.

Thompson, E. & Marean, C.W. 2008. The Mossel Bay lithic variant: 120 years of Middle Stone Age research from Cape St Blaize Cave to Pinnacle Point. Goodwin Series, 10: 90-104.

Thompson, E., Williams, H.M. & Minichillo, T. 2010. Middle and Late Pleistocene Middle Stone Age lithic technology from Pinnacle Point 13B (Mossel Bay, Western Cape Province, South Africa). Journal of Human Evolution, 59(3-4): 358-377.

Tribolo, C., Mercier, N., Douville, E., et al. 2013. OSL and TL dating of the Middle Stone Age sequence at Diepkloof Rockshelter (South Africa): A clarification. Journal of Archaeological Science, 40(9): 3401-3411.

Wadley, L. 2015. Those marvellous millennia: The Middle Stone Age of southern Africa. Azania, 50(2): 155-226.

Walker, N.J. 1995. Late Pleistocene and Holocene Hunter-gatherers of the Matopos: An Archaeological Study of Change and Continuity in Zimbabwe. Uppsala: Societas Archaeologica.

Walker, N.J. & Thorp, C. 1997. Stone Age archaeology in Zimbabwe. In: Pwiti, G. (ed.) Caves, Monuments and Texts. Zimbabwean Archaeology Today: 9-32. Uppsala: Societas Archaeologica.

White, F. 1900. On the Khami ruins, near Bulawayo. Rhodesia Science Association, 1: 11-18.

White, F. 1905. Notes on rock paintings and stone implements near World's View, Matopos. Proceedings of the Rhodesian Scientific Association, 5: 7-10.

White, E.T., Asfaw, B., DeGusta, D., et al. 2003. Pleistocene *Homo sapiens* from Middle Awash, Ethiopia. Nature, 423(6941): 742-747.

Wilkins, J. 2020. Is it time to retire NASTIES in southern Africa? Moving beyond the culture-historical framework for Middle Stone Age lithic assemblage variability. Lithic Technology, 45(4): 295-307.

Wilkins, J. 2021. *Homo sapiens* origins and evolution in the Kalahari Basin, southern Africa. Evolutionary Anthropology: Issues, News, and Reviews, 30(5): 327-344.

Wilkins, J. & Chazan, M. 2012. Blade production ∼500 thousand years ago at Kathu Pan 1, South Africa: Support for a multiple origins hypothesis for early Middle Pleistocene blade technologies. Journal of Archaeological Science, 39(6): 1883-1900.

Wilkins, J., Brown, K.S., Oestmo, S., et al. 2017. Lithic technological responses to late Pleistocene glacial cycling at Pinnacle Point Site 5-6, South Africa. PloS ONE, 12(3): e0174051.

Wilkins, J., Schoville, B.J., Brown, K.S., et al. 2020. Fabric analysis and chronology at Ga-Mohana Hill north rockshelter, southern Kalahari Basin: Evidence for in situ, stratified Middle and Later Stone Age deposits. Journal of Paleolithic Archaeology, 3(3): 336-361.

Wilkins, J., Schoville, B.J., Pickering, R., et al. 2021. Innovative *Homo sapiens* behaviours 105,000 years ago in a wetter Kalahari. Nature, 92(7853): 248-252.

Will, M., Parkington, J.E., Kandel, A.W., et al. 2013. Coastal adaptations and the Middle Stone Age lithic assemblages from Hoedjiespunt 1 in the Western Cape, South Africa. Journal of Human Evolution, 64(6): 518-537.

Willoughby, P.R. 2006. The Evolution of Modern Humans in Africa: A Comprehensive Guide. Lanham: Rowman Altamira Press.

Wurz, S. 2000. The Middle Stone Age at Klasies River, South Africa. Doctoral Thesis. Stellenbosch: Stellenbosch University.

Wurz, S. 2002. Variability in the Middle Stone Age lithic sequence, 115,000-60,000 years ago at Klasies River, South Africa. Journal of Archaeological Science, 29(9): 1001-1015.

Southern African Field Archaeology
2025 Vol. 20: Article 3962
Short note (non-peer-reviewed, but the journal invites discussion): Received February 2025; Revised July 2025; Published September 2025
DOI: https://doi.org/10.36615/safa.20.3962.2025
ISSN 1019-5785
ISSN 2789-1844

Sheep before cattle: The 'colonial' enterprise in the expansion of herding throughout southern Africa

Andrew B. Smith

Department of Archaeology, University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa
**Corresponding author email: andrew.smith@uct.ac.za*

1. Introduction

> If a man owns 100 sheep and one of them wanders away, will he not leave the 99 and go into the mountain to look for the one that wandered off? And, if he finds it he will be happier about that one sheep than all the others that did not wander (Matthew 18: 12-14).

Southern Africa historically was seen as a major cattle producer, as this was the product highly prized by the indigenous herders met by Europeans in the 15th century. The Portuguese visitors to the south coast, Bartolomeu Dias and Vasco da Gama, called their contact point *Angra dos Vaqueiros* (Bay of Cows) at Mossel Bay. The cattle of the Khoekhoen at the Cape became a major source of wealth to the first Dutch colonists after 1652 with the indigenous herders being subjugated and their lands expropriated.

In the early Holocene, climatic conditions in the Negev were amenable to pasture growth, including cereals used by humans (Horowitz 1977). Both cattle and sheep came into Africa via Gaza as noted in the domestic animal bones and pottery found at Qatif (Smith 1989) and Egypt. This occurred initially via the 'Green Sahara' 8000-9000 years ago. Another attraction of the Sahara at this time was the growth of wild sorghum and millet, which would have attracted people like the Natufians in Palestine (Marks & Larson 1977). As North Africa dried up ca. 4500 BP the herders moved southwards to East Africa, then on to southern Africa before 2000 BP (Smith 2022).

The connection between East and southern Africa has been confirmed by aDNA analysis of the skeleton of a young girl from Kasteelberg. She died 1300 years ago and shared 40% of her genome with a pastoralist skeleton from Tanzania (Skoglund et al. 2017). The movement to the Cape was primarily with sheep, although a few cattle bones have been identified (Orton et al. 2013). At first these were thin-tailed, but fat-tailed sheep came later (da Silva et al. 2024). Smaller animals may have been easier to handle as people moved into new lands. It is suggested that the Kalahari might have had more rainfall around 2300 BP (Thomas & Shaw 1991; Nash et al. 2006), and this could have facilitated herders moving through the area before modern drier conditions set in. Coming south into new areas also meant having to deal with the vagaries of vegetation, particularly if poisonous plants might have been encountered (Smith 2014). To maintain breeding flock numbers and food off-take, a minimum of 100 animals would have been needed (Dahl & Hjort 1976). Thus, migration was not a simple matter, requiring significant attention to the needs of the flocks.

The importance of sheep to the earliest pastoralists 2000 BP, however, has been shown by skeletal evidence and aDNA down along the west coast from Namibia (Smith & Jacobson 1995; Kinahan 2016) to Spoegriviermond (Webley 2001; Coutu et al. 2021), and on to Kasteelberg (Smith 2006). Even though sheep might be more vulnerable to predation, one major advantage of them being introduced first is that they have a reproductive rate up to four times that of cattle (Dahl & Hjort 1976). Additionally, they may also have two breeding periods in the year (Balasse et al. 2003), which would have encouraged the shepherds in maintaining their flocks. It is possible that the first shepherds into southern Africa had dogs (Mitchell 2014). If so, this would have made it easier to protect the flocks, even in new lands. It is estimated that with a dog, a herder might be able to handle as many as 500 animals. Without dogs the flock size would be limited to 300-400 (Dahl & Hjort 1976), but this would be in terrain known to the shepherds. Certainly, to just maintain flocks in good condition and have off-take, while keeping numbers secure, would require over 100 animals (Dahl & Hjort 1976)[1].

"Small stock, especially sheep, have to be watered more frequently than large stock"; in some areas "sheep need to be watered every fourth day in the dry season" (Dahl & Hjort 1976: 249). The West Coast route of introduction was first suggested by Schapera (1930) and Elphick (1977). The latter also showed the Kimberley area as a possible interior route where five rivers come together (Orange, Vaal, Modder, Riet, Harts), and on to the South Coast via the Seacow River Valley (Sampson 1984; Henshilwood 1996) and the Sundays River.

Another important element in the adaptation of herders to their environment and herd maintenance, is the need for their animals to have access to salt. "The need for a constant, preferably daily, supply of salt is particularly important for small stock" (Dahl & Hjort 1976: 250). Among modern farmers salt licks are provided, but what about transhumant herders arriving from elsewhere? Access to this mineral would have been easy on the West Coast, but moving south in the interior? Barrow (1801: 114, 122-126) notes that the "Sundays River in summer season is strongly impregnated with salt", and a further attraction might have been the salt lake at Algoa Bay, which still exists and was described by Barrow in 1797.

It took almost 1000 years before cattle became the dominant herded animals in southern Africa. By then herders knew more about the land their animals were adapting to. This was also the time when Late Iron Age farmers were keeping their animals in stone enclosures (Hall 1986). Does this coincidence mean that cattle, generally associated with the Khoekhoen at the Cape, were first introduced from the Eastern Cape along the South Coast?

2. Moving through uncharted waters: herd control and management in 'virgin soil' environments

Whether we can use modern examples as analogies for the initial spread of domesticated animals into new areas will depend on how closely the modern conditions match those when the animals first arrived. Certainly, the colonisation of North Africa and the Sahara would have been very different from a migration through East to southern Africa. North of the tsetse belts of West Africa, across the northern fringes of the equatorial forest, the effect of most biomes would have been fairly similar to what domestic stock had already encountered coming into Africa from the Levant or Arabian Peninsula, especially when conditions were ameliorated during the early Holocene. By contrast, those domestic animals entering East Africa, either through Ethiopia or the Sudd of Southern Sudan, would have been subject to a range of epizootic diseases to which they were totally unprepared (Gifford-Gonzalez 2000).

Thus, the initial immigration of alien species required major ecological adjustments, such as learning to avoid critical diseases unfamiliar to the new arrivals. Those diseases prevalent in cattle, sheep and goats that would have affected traditional pastoralist systems would have included epizootic threats, deficiency diseases, and toxic plants (Kellerman et al. 1988). The immigrant herders would have needed to learn to avoid such pitfalls, as do the Maasai today who empirically know the relationship between the proximity of new-born wildebeest and malignant catarrhal fever in East Africa, or East Coast fever and foot-and-mouth disease carried in wild African buffalo populations (Kellerman et al. 1988). This barrier to easy colonisation is suggested as the reason why there was a delay of 1000 years in the spread of cattle to southern Kenya and northern Tanzania by stock keepers as they learned to adjust and avoid the fatalities that could occur in these new lands (Kellerman et al. 1988).

Since both wildebeest and buffalo were to be found traditionally in southern Africa, we can assume that

[1] Among shepherds, learning to look after the flocks can occur at a very young age, and is not limited to sex as both girls and boys can help their families. I met two 10-year-old boys in the Malian Sahel who were looking after about 200 sheep. All they had with them was a short shirt and a wooden cup tied around their waist which they would have used to milk the ewes for food. They had not seen their families for a few days at this point.

the experience of pastoralists in East Africa would have helped in adjusting to the new lands of the south. In fact, Andersson (1856) saw wildebeest in the Swakop River along the Namibia Coast, which would suggest the former distribution would have been nearer the coast than that indicated in Gifford-Gonzalez (2000: fig. 1). Similarly, buffalo distribution in South Africa was wider than indicated in Gifford-Gonzalez (2000: fig. 2). Several travellers at the end of the 18th century saw buffalo herds east of Cape Hangklip (False Bay) along the south coast (cf. Skead 1980; Rookmaker 1989).

Another potential threat would have been the blue-tongue virus transmitted by the midge *Culicoides* sp. (also known as horse sickness, but it affects all ruminant livestock, as well as 'scab' or *brandziekte* in sheep) (Wallace 1896). The horse sickness was well-known to the Boers during the South African War (1899-1901), who knew to camp on top of hills or keep their horses in barns to avoid the midge (Wallace 1896). The British Army, however, did not know this, and, of course, were conducting a 'scorched earth policy' by torching farm buildings, so had no buildings to hold their horses at night, and over two-thirds of their horses died (Swart 2010).

The potential threat of toxic plants would have been an additional issue. Naudé et al. (1996) make the comparison in flora between East and southern Africa, noting a great deal of similarity. This can be seen in the incidence of *Senecio* sp. in both areas. Seneciosis is a hepatotoxicosis of stock which causes high mortality across its range, particularly: "…in stock grazing newly sprouted *Senecio* plants on veld denuded by droughts, overstocking or burning" (Naudé et al. 1996: 9). The distribution of *Senecio* in South Africa is mostly in the east and so would not have been important in new stock arriving via the route of dispersal to the Western Cape suggested here. Another toxic plant found in both areas is *Dichapetalum* sp. or gifblaar, which, in cattle, can cause: "sudden cardiac arrest a few hours after ingestion" (Naudé et al. 1996: 10). These would have required adjustment on the part of immigrating cattle keepers to East Africa, however, and must be added to the potential impediments listed by Gifford-Gonzalez (2000). Kellerman et al. (1988) describe 110 plants which are toxic to livestock in southern Africa. While some of these are exotic and introduced during colonial times, and others of minor significance, there are a considerable number which might give any introduction by inexperienced animals and their herders some anxious moments.

Different animals use different levels of the herb layer, and, of course, immigrant stock would be in competition with wild game. Studies of rate of intake by ungulates, in particular a selective grazer like sheep, showed reduced intake by the presence of unwanted or unpalatable components of the vegetation. One advantage of the arrival of domestic animals into the drier and western areas of South Africa south of the Zambesi would have been a tsetse-free environment. Once adjustment to local conditions had taken place, particularly with the hardy varieties of indigenous thin-tailed sheep, southern Africa was a good place for herding, albeit with vagaries of annual rainfall to which the herds would need to accommodate, either by movement, or access to groundwater sources.

Although 'scab' or *brandziekte* was a major disease threat to sheep farmers in the 19th century (Wallace 1896), the prevalence of death among sheep by ingesting poisonous plants must have been obvious for Brown (2007) to state that this caused higher mortality up to the 1920s than from contagious or infectious diseases. Kellerman et al. (1988: table 1) list the toxic plants that might have been of significance to domestic animals entering southern Africa from the north, to the northern Kalahari, then via northern Namibia before moving south to the Western Cape (Coutu et al. 2021). Of these, perhaps gifblaar and tulp poisoning would have been most dangerous. Gifblaar, from *Dichapetalum cymosum*, has a restricted distribution from the northern Kalahari to the Highveld north of Tshwane. Incoming herders could have moved through this area fairly rapidly and avoided or limited the effects of this plant: "…young leaves are more toxic in spring (August to November) and autumn (March) when new shoots appear" (Kellerman et al. 1988: 110). Tulp poisoning comes from two genera of plants, *Moraea* and *Homeria* sp., both widespread from Zimbabwe, Botswana and Namibia to the western and southern Cape: "Tulp poisoning is commonest in winter or early summer before the onset of rains, when sprouting *Homeria* or *Moraea* sp. might be the only greenery on the barren veld…[o]ne of the most important features of tulp poisoning is that newly introduced or hungry stock are most at risk" (Kellerman et al. 1988: 90). However, sheep passing through the Northern Cape may have been less affected, as Snyman et al. (2011) note that toxicity levels are low in this area, which might explain the absence of yellow tulp poisoning there.

Table 1. Common poisonous plants of southern Africa (after Kellerman et al. 1988).

Plant species	Common name	Distribution	Clinical effect
Dichapetalum cymosum	Gifblaar	N. Kalahari to Highveld north of Tshwane	Heart failure
Galenia africana	Waterpens	West Coast: Namibia-Cape	Liver damage
Homeria miniata	Tulp poisoning	West Coast, south of Orange River	Heart failure
Urginea physodes	Slangkop poisoning	West Coast: S. Namibia-Cape	Heart failure
Mesembryanthemum sp.	Pisgoed	S. Namibia-Namaqualand	Gastrointestinal damage
Thesium namaquense	Krimpsiekte	Namaqualand	Heart failure
Tylecodon wallichii	Krimpsiekte	West Coast: Namibia-Cape	Heart failure
Geigaria sp.	Vermeersiekte	Namibia	Gastrointestinal damage
Ricinus communis	Castor oil poisoning	West Coast: Namibia-Cape	Gastrointestinal damage
Pteronia pallens	Witbossie poisoning	S.W. Cape	Liver damage
Athanasia trifurcata	Klaaslouwbos poisoning	S.W. Cape	Liver damage
Ornithogalum thrysoides	Chinkerinchee poisoning	S.W. Cape	Gastrointestinal damage

3. The 'colonial' enterprise in the expansion of herding in southern Africa

"Colony: settlement…in new country…fully or partly subject to mother state; Colonial: state department in charge of the colonies" (Oxford Dictionary 1970: 237). These dictionary meanings show that colonialism is directly tied to the 'motherland'. In South Africa this would have been the initial Dutch headquarters of the *Vereenigde Oostindische Compagnie* (VOC; Dutch East India Company) in Amsterdam after 1652, and the Colonial Office in London after 1795 when the British took over. These definitions imply that colonisation only took place within the ambit of formal structures, and, as Brink (2004) has noted, this came with mapping and the allocation and ownership of space. This in turn allowed owners to have the rights to fence their properties.

While this became a formal definition, it limited the actual colonial experience to paperwork drawn up to allocate land, as this could then be documented back in the controlling state network in Europe. This was formal colonialism at the Cape. The original inhabitants (Sonqua=Bushmen hunters) were already almost invisible, and the Khoekhoen were losing their pasture territory as parcels of land were being allocated by the Dutch leaders along the Liesbeek River.

The procedure was following what had been decreed by Pope Urban II in 1095 to occupy '*terra nullius'* (empty land) by the First Crusade that assumed territory being used by hunters and transhumant pastoralists was 'empty', i.e., not being 'properly used' for agriculture. The order later sanctified the partition of Africa by European nations at the end of the 19th century.

Defining colonialism strictly by the association with formal political structures based in Europe would ignore the previous loss of land and livelihood that was invested by the original inhabitants of southern Africa. There is good archaeological evidence for hunters in the landscape for well over one million years (Mitchell 2002), so any group coming from the outside would have to be considered as intrusive, particularly with the arrival of domestic animals.

If we expand the definition of 'colonialism' to mean any intrusion into southern Africa by people and economies from the outside, then the arrival of herders into the Kalahari 2000 years ago would have to be considered. These people, known to linguists as Khoe-Kwadi, as they were identified in southern Angola (Güldemann et al. in press), had connections with East Africa, and brought both sheep and cattle with them.

Looking at colonialism as a form of intrusion offers a different perspective on what is usually meant by 'colonialism', i.e., only defined by the Colonial Office. This way we might suggest that colonial expansion would have occurred in several phases:

1. Arrival of cattle and sheep in the Kalahari, and sheep on to the southwestern and southern Cape by 2000 BP,

2. First appearance of Urewe farmers in southern Africa (Silver Leaves), Mozambique and Swaziland with sorghum and millet, then cattle, after 1700 BP,
3. Cattle arrive in numbers in the southwestern Cape ca. 1000 BP,
4. The Cape focus by the VOC, AD 1652 (mapping, firearms),
5. Occupation of the Cape by the British, AD 1795; Colonial Office in London takes charge of allocation of land (taxes) and expansion towards northeast and east by farmers (Laband 2020).

4. Discussion

The movement of food production from the north inspired Sadr (2003) to suggest a 'Neolithic' development in southern Africa using the model of 'hunters-with-sheep', i.e., local southern African hunters becoming pastoralists. This was followed by Gronenborn (2004) who compared the expansion of food producers out of the Near East to Europe with what happened in Africa. The similarities are the expansion of domesticates into lands already occupied by hunter-gatherers, and Sadr (2015) offered a two-step process for how this occurred. In both cases there was initial overlap where hunters and herders worked together. This meant that incoming males bringing the sheep, and possibly taking local wives, were able to learn about the landscape to the food producers' advantage. One aspect of this might have included the use of local fynbos plants, such as Watsonia, whose bulbs become cooked during veld fires and can be eaten.

Linguistic study of the arrival of the first herders, known as Khoe-Kwadi in southern Angola, indicates that "Khoe-Kwadi has special status in that it shows a northeast-to-southwest adaptation…the family as having expanded from the northeast, whereby pre-Khoe incorporated a Kx'a (northern Bushman) substrate and subsequently pre-Khoekhoe a Tuu (southern Bushman) substrate" (Güldemann et al. in press: 626). This indicates that the "spread of Khoe-Kwadi is a complex process involving extensive interaction with indigenous populations rather than a simple demic colonisation that spread among other things [a] new language[s]" (Güldemann et al. in press: 638).

This led to debates on the emergence of food production in southern Africa: were large numbers of newcomers arriving with stock, or did local hunters gradually become herders as they acquired sheep? The latter was certainly not the case when Lord Macartney introduced sheep to the hunters of the northern frontier hoping to make them herders at the end of the 18th century. This was an attempt to stop them raiding the colonial farmers as they expanded northwards, but the hunters just killed the sheep and ate them (Penn 2005).

I have previously argued against the idea of hunters becoming herders (Smith 2017), and here I have tried to show that there is a minimum flock size needed to maintain breeding and off-take. The dating of the movement was fast enough to suggest the herders with their flocks were constantly on the move southwards. This would argue against small, isolated numbers of sheep and shepherds trickling all the way from East Africa and ending up at the Cape, but, as the linguistics suggest, does not mean there was a single migration of people and animals.

Dewar and Marsh (2019) identified three phases of pastoral occupation in Namaqualand: 1) early AD 80-210; 2) middle AD 490-790; 3) late AD 1180-1690, which they suggest was the result of climatic shifts. The gap between the early and middle phases corresponds to a similar gap of non-occupation at Kasteelberg (Sadr et al. 2017). This is when there is a shift in pottery style from spouts to lugs. The lugged pottery may also be when cattle arrived at the Cape in larger numbers and the herders were later identified as Khoekhoen (Smith 2006). The arrival of cattle at the Cape in numbers allowed the food producers to become socially dominant over local hunters, as noted in Simon van der Stel's journal of his expedition to Namaqualand on 16 September 1685: "…these Sonquas [hunters] are just the same as the poor in Europe, each tribe of Hottentots[2] [Khoekhoen] having some of them and employing them to bring news of the approach of a strange tribe. They steal nothing from the kraals of their employers, but regularly from other kraals…possessing nothing…except what they acquire by theft" (Waterhouse 1932: 122).

[2] The term is employed in accordance with the original source, without any derogatory or superficial intent.

Without some help from local hunters the migration of shepherds through 'virgin soils' would have been all that more difficult, particularly when negotiating a landscape with poisonous plants. Since the migration southwards seems to have happened fairly rapidly, this lends support for a relatively easy passage.

Acknowledgments

The fieldwork for this paper was conducted while I was a member of staff of the Archaeology Department, UCT, prior to my retirement in 2006. I am grateful for the help of both staff and students, as well as Karim Sadr from Wits, for their input.

References

Andersson, C.J. 1856. Lake Ngami; or Explorations and Discoveries during Four Years' Wanderings in the Wilds of South Western Africa. London: Hurst & Blackett.

Balasse, M., Smith, A.B., Ambrose, S.H., et al. 2003. Determining birth seasonality by analysis of tooth enamel oxygen isotope ratios: The Late Stone Age site of Kasteelberg (South Africa). Journal of Archaeological Science, 30: 205-215. https://doi.org/10.1006/jasc.2002.0833

Barrow, J. 1801. An Account of Travels into the Interior of Southern Africa in the Years 1797 and 1798. London: Cadell & Davies.

Brink, Y. 2004. The transformation of indigenous societies in the southwestern Cape during the rule of the Dutch East India Company, 1652-1795. In Murray, T. (ed.) The Archaeology of Contact in Settler Societies: 91-108. Cambridge: Cambridge University Press.

Brown, K. 2007. Poisonous plants, pastoral knowledge and perceptions of environmental change in South Africa c. 1880-1940. Environment and History, 13(3): 307-332. https://www.jstor.org/stable/20723625

Coutu, A.N., Tauruzzi, A.J., Mackie, M., et al. 2021. Palaeoproteomics confirm earliest sheep in southern Africa ca. 2000 BP. Scientific Reports, 11: 6631. https://doi.org/10.1038/s41598-021-85756-8

Dahl, G. & Hjort, A. 1976. Having Herds: Pastoral Herd Growth and Household Economy. Stockholm: Stockholm Studies in Social Anthropology 2.

da Silva, A., Ahbara, A., Baazaoui, I., et al. 2024. History and genetic diversity of African sheep: Contrasting phenotype and genomic diversity. Animal Genetics, 56(1): e13488. https://doi.org/10.1111/age.13488

Dewar, G. & Marsh, E.J. 2019. The comings and goings of sheep and pottery in the coastal desert of Namaqualand, South Africa. Journal of Island and Coastal Archaeology, 14: 17-45. https://doi.org/10.1080/15564894.2018.1438538

Elphick, R. 1977. Kraal & Castle. New Haven: Yale University Press.

Gifford-Gonzalez, D. 2000. Animal disease challenges to the emergence of pastoralism in sub-Saharan Africa. African Archaeological Review, 17(3): 95-139. https://doi.org/10.1023/A:1006601020217

Gronenborn, D. 2004. Comparing contact-period archaeologies: The expansion of farming and pastoralist societies to continental temperate Europe and to southern Africa. Before Farming, 4: 22-60. https://doi.org/10.3828/bfarm.2004.4.3

Güldemann, T., Bajic, V. & Smith, A.B. in press. The archaeolinguistics of Kalahari Basin Area languages. In: Robbeets, M. & Hudson, M. (eds) The Oxford Handbook of Archaeology and Language: 619-647. Oxford: Oxford University Press.

Hall, M. 1986. The role of cattle in southern African agropastoral societies. More than bones can tell. South African Archaeological Society Goodwin Series, 5: 83-87. https://doi.org/10.2307/3858150

Henshilwood, C. 1996. A revised chronology for pastoralism in southernmost Africa: New evidence of sheep at c. 2000 BP from Blombos Cave, South Africa. Antiquity, 70: 945-949. https://doi.org/10.1017/S0003598X00084210

Horowitz, A. 1977. Pollen spectra from two Early Holocene Prehistoric sites in the Har Harif (West Central Negev). In: Marks, A.E. (ed.) Prehistory and Paleoenvironments in the Central Negev, Israel, Volume II: 323-326. Dallas: Southern Methodist University Press.

Kellerman T.S., Coetzer, J.A.W. & Naudé, T.W. 1988. Plant Poisonings and Mycotoxicoses of Livestock in Southern Africa. Oxford: Oxford University Press.

Kinahan, J. 2016. Archaeological evidence of domestic sheep in the Namib Desert during the first millennium AD. Journal of African Archaeology, 14: 7-17. https://doi.org/10.3213/2191-5784-10280

Laband, J. 2020. The Land Wars: The Dispossession of the Khoisan and AmaXhosa in the Cape Colony. South Africa: Penguin Random House.

Marks, A.E. & Larson, P. 1977. Test excavations at the Natufian site of Rosh Horesha. In: Marks, A.E. (ed.) Prehistory and Paleoenvironments in the Central Negev, Israel, Volume II: 191-232. Dallas: Southern Methodist University Press.

Matthew, The Holy Bible, New Testament, Chapter 18. Oxford: Oxford University Press.

Mitchell, P. 2002. The Archaeology of Southern Africa. Cambridge: Cambridge University Press.
Mitchell, P. 2014. The canine connection II: Dogs and southern African herders. Southern African Humanities, 26: 1-19. https://hdl.handle.net/10520/EJC158003
Nash, D.J., Meadows, M.E. & Gulliver, V.L. 2006. Holocene environmental change in the Okavango Panhandle, northwest Botswana. Quaternary Science Reviews, 25(11-12): 1302-1322. https://doi.org/10.1016/j.quascirev.2005.11.004
Naudé, T.W., Kellermann, T.S. & Coetzer, J.A.W. 1996. Plant poisonings and mycotoxicosis as constraints in livestock production in East Africa: The southern African experience. Journal of the South African Veterinary Association, 67: 8-11. https://hdl.handle.net/10520/AJA00382809_1614
Orton, J.D.J., Mitchell, P., Klein, R.G., et al. 2013. An early date for cattle from Namaqualand, South Africa: Implications for the origins of herding in southern Africa. Antiquity, 87: 108-120. https://doi.org/10.1017/S0003598X00048651
Oxford Concise Dictionary of Current English. 1970. Fifth Edition. Oxford: The Clarendon Press.
Penn, N. 2005. The Forgotten Frontier: Colonist and Khoisan on the Cape's Northern Frontier in the 18th Century. Cape Town: Double Storey Books.
Rookmaaker, L.C. 1989. The Zoological Exploration of Southern Africa 1650-1790. Rotterdam: Balkema.
Sadr, K. 2003. The Neolithic of southern Africa. Journal of African History, 44: 195-209. https://www.jstor.org/stable/4100863
Sadr, K., Bousman, B., Brown T.A., et al. 2017. New radiocarbon dates and herder occupation of Kasteelberg B, South Africa. Antiquity, 91: 1299-1313. https://doi.org/10.15184/aqy.2017.102
Sampson, C.G. 1984. A prehistoric pastoralist frontier in the Upper Zeekoe Valley, South Africa. In: Hall, M., Avery, G., Avery, D.M., et al. (eds) Frontiers: Southern African Archaeology Today: 96-110. Oxford: BAR International Series 207.
Schapera, I. 1930. The Khoisan Peoples of South Africa: Bushmen and Hottentots. London: Routledge & Kegan Paul.
Skead, C.J. 1980. Historical Mammal Incidence in the Cape Province, Vol. 1: The Western and Northern Cape. Cape Town: Department of Nature and Environmental Conservation.
Skoglund, P., Thompson, J., Prendergast, M., et al. 2017. Reconstructing prehistoric African population structure. Cell, 171: 1-13. https://doi.org/10.1016/j.cell.2017.08.049
Sadr, K. 2015. Livestock first reached southern Africa in two separate events. PLoS One 10(8): e0134215.
Smith, A.B. 1989. The Near Eastern connection: Early to Mid-Holocene relations between North Africa and the Levant. In: Krzyzaniak, L. & Kobusiewicz, M. (eds) Late Prehistory of the Nile Basin and the Sahara. Studies in African Archaeology 2: 69-77. Poznan: Poznan Archaeological Museum.
Smith, A.B. 2006. Excavations at Kasteelberg and the Origins of the Khoekhoen in the Western Cape, South Africa. Oxford: BAR International Series 1537.
Smith, A.B. 2014. The Origins of Herding in Southern Africa: Debating the 'Neolithic' Model. Saarbrücken: Lambert Academic Publishing.
Smith, A.B. 2017. Why would southern African hunters be reluctant food producers? Hunter-Gatherer Research, 2(4): 415-435. https://doi.org/10.3828/hgr.2016.28
Smith, A.B. 2022. First People: The Lost History of the Khoisan. Cape Town: Jonathan Ball Publishers.
Smith, A.B. & Jacobson, L. 1995. Excavations at Geduld and the appearance of early domestic stock in Namibia. South African Archaeological Bulletin, 50: 3-14. https://www.jstor.org/stable/3889054
Snyman, L.D., Schultz, R.A. & van den Berg, H. 2011. Variability of yellow tulp (*Moraea pallida* Bak.) toxicity. Journal of the South African Veterinary Association, 82: 131-132. https://doi.org/10.4102/jsava.v82i2.48
Swart, S. 2010. Horses in the South African War, c.1899-1902. Society and Animals, 18: 348-366.
Thomas, D. & Shaw, D.A. 1991. The Kalahari Environment. Cambridge: Cambridge University Press.
Wallace, R. 1896. Farming Industries of Cape Colony. Cape Town: Juta.
Waterhouse, G. 1932. Simon van der Stel's Journal of his Expedition to Namaqualand, 1685-6. Dublin: Hodges, Figgis & Co.
Webley, L.E. 2001. The re-excavation of Spoegrivier Cave on the west coast of South Africa. Annals of the Eastern Cape Museums, 2: 19-49.