

## Behind the waterfall - Interdisciplinary results from Holley Shelter and their implications for understanding human behavioral patterns at the end of the Middle Stone Age in southern Africa

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### ABSTRACT

Holley Shelter is a Middle (MSA) and Later Stone Age (LSA) site in KwaZulu-Natal, South Africa. The rock shelter is located at the intersection of three ecosystems, in a strip of the Savanna Biome between the Grassland and Indian Ocean Coastal Belt Biomes. Initial excavations in the 1950s by Gordon Cramb yielded large amounts of unifacial points and splintered pieces, as well as organic remains associated with MSA occupations. Our comparative techno-typological evaluation of this material in 2015 suggested the occupations may date to early MIS 3. We then initiated new excavations at the site using modern field methods and controlled sampling for lithic and organic material. Following the initial round of interdisciplinary analysis, we herein report the first absolute ages for Holley Shelter, a detailed technological analysis of new lithic material from the uppermost MSA layers at the site, and a preliminary study of the associated faunal remains. A set of 12 <sup>14</sup>C dates place these occupations within a constricted chronological period dated to ~36,000–34,000 cal. BP that overlaps with the so-called 'final MSA'. The hornfels-dominated lithic assemblages are characterized by diverse core technologies oriented toward the production of laminar products, which include bladelets and abundant splintered pieces. The zooarchaeological analysis documents an emphasis on open grasslands that provided the bulk of the animal prey exploited by the inhabitants of the shelter, with a preference for medium-sized antelopes. Three bone retouchers, a rare occurrence in southern African MSA contexts, were identified in the faunal assemblage. The archaeological deposits at Holley Shelter reflect short-term, potentially seasonal, and specialized occupations that could be influenced by its ecological position. The archaeological material exhibits marked discrepancies with other well-dated final MSA assemblages such as those from Sibhudu, Umbeli Belli, Sibebe and Border Cave. This illustrates considerable variability and a complex spatio-temporal patterning of behavioral adaptations and cultural traditions at the end of the MSA in southern Africa.

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## 1. Introduction

The Middle Stone Age (MSA) of Africa corresponds to the period of the earliest expression of material culture by *Homo sapiens*, dating to roughly 300–30 ka. This archaeological record is key to understanding the evolution and long-term trajectories of cognitive capacities, material culture and behavioral adaptations in our species (McBrearty and Brooks, 2000; Scerri and Will, 2023). For more than three decades, southern Africa has played a key role in these discussions as the region harbors a high number of sites with deep stratigraphic sequences and excellent organic preservation that have yielded numerous early expressions of technological and cultural innovations and symbolic communication (e.g., Bader et al., 2022b; Henshilwood, 2012; Thackeray, 1992; Wadley, 2015). This comparatively rich and well-dated record allows for the construction of inter-regional sequences of different industries or technocomplexes and the study of patterns and causes of behavioral variability among groups of early modern humans on various temporal and spatial scales.

A period that has been a particular subject of debate regarding issues of cultural structure and technological variability – or a lack thereof – is the end of the MSA and its expressions during Marine Isotope Stage 3 (MIS 3; ca. 58–29 ka). The archaeology of MIS 3 was neglected for a long time (Conard et al., 2012; Mitchell, 2008; Wadley, 2015), likely due to a strong emphasis on the earlier Howiesons Poort and the Still Bay industries of MIS 4 (ca. 75–59 ka; according to Henshilwood, 2012; Jacobs et al., 2013; Jacobs and Roberts, 2008), and MIS 5 (Guérin et al., 2013; Tribolo et al., 2013). With the exception of the frequent occurrence of unifacial points (Cochrane, 2006; Villa et al., 2005), initial observations on MIS 3 archaeology and the end of the MSA highlighted a lack of diagnostic lithic markers or other indicators of sophisticated behaviors, presumably reflecting a pattern of unstructured variability. This situation has changed, as new excavations and detailed studies of relevant material culture provide a wealth of new findings from this period across the entire southern African region (i.e. Elands Bay Cave, the Doring River, Boomplaas, Ga-Mohana and Apollo 11 [Mackay et al., 2014b; Pazan, 2022; Porraz et al., 2016; Tribolo et al., 2016; Vogelsang et al., 2010; Pargeter et al., 2018; Wilkins, 2023; Wilkins et al., 2020; Will et al., 2015]). Such findings offer the opportunity to explore spatial variations of technological expressions. Additionally, recent studies have placed a regional focus on the province of KwaZulu-Natal (KZN), which boasts a rich MIS 3 record. These studies document the presence of sophisticated lithic and non-lithic technologies associated with clear intra- and inter-regional variability, as well as ample temporal changes at the key sites of Sibhudu (Bader et al., 2022c; Conard et al., 2012; Wadley, 2005b; Will et al., 2014; Will and Conard, 2018), Border Cave (Backwell et al., 2018; de la Peña et al., 2022; Timbrell et al., 2022; Villa et al., 2012) and Umbeli Belli (Bader et al., 2016, 2018, 2022c; Bader and Conard, 2023).

Based on these findings, several questions have emerged, particularly regarding the chrono-cultural structure of the MIS 3 record in southern Africa. Can the record be meaningfully divided into separate successive units – such as a post-Howiesons Poort/Sibudan, late MSA and final MSA – and if so, how are they to be defined? Lombard et al. (2022), for instance, refrain from using the term “Sibudan” for early MIS 3 industries and argue for a more generalized post-Howiesons Poort in the absence of broader technocomplex acceptance (but see e.g., Conard et al., 2012; Will et al., 2014). Towards the end of the MSA and before the LSA, an informal ‘final MSA’ has often been noted but remains poorly defined. Lombard et al. characterize this period as exhibiting a particularly “high regional variability” (2022: p. 173). In our synthesis of the southern Africa MSA (Bader et al., 2022b), we come to a similar conclusion and show that final MSA assemblages from the east of southern Africa are not comparable to those from other parts of the subcontinent. Recent work by Bader et al. (2022c) point out that MSA expressions between 40–30 ka in KZN are characterized by a strong investment in unifacial and bifacial shaping technology, basal thinning of

pointed tools, hollow-based points, segments and a characteristic type of platform core reduction. These observations are similar to those made for the final MSA at Sibebe in Eswatini dating to ~37–27 ka cal BP (Bader et al., 2022a; Price Williams, 1981), although this assemblage lacks hollow-based points and segments. Whether this marks a specific eastern final MSA technocomplex requires additional comparative assemblages from within and around the region. The so-far unique assemblage at Border Cave dated to ~44–42 ka - assigned by some to the Early LSA (e.g., d’Errico et al., 2012; Villa et al., 2012) - might actually illustrate this strong local variability at the end of the MSA rather than the onset of the LSA (Bader et al., 2022a). A similar argument has been made by Mitchell (2012) and de la Peña (2015). The Lubombo Mountains may mark the natural north-eastern border of this eastern expression of the final MSA. Westward of Umbeli Belli and Sibhudu, Umhlatuzana most likely provides similar expressions, including hollow-based points and bifacial technologies (Kaplan, 1989, 1990). New excavations at the site and reinvestigations of the old collections are currently underway to test this hypothesis (Sifogeorgaki et al., 2020; Schmid et al. in prep.).

On a more interpretative level, these patterns of similarity and variability towards the end of the MSA require explanations. What are the underlying causes for the spatio-temporal changes that we see in material culture and behavioral adaptations, particularly towards the end of the MSA in (eastern) southern Africa? Most influential in recent years, Mackay et al. (2014a) provided a model that relates modern rainfall zones and climatic oscillations to different degrees of cultural connectivity between groups. These would result in patterns of either coalescence or fragmentation of human populations and their material expressions. According to this model, interglacial stages, including MIS 3, mark periods of high fragmentation due to different climatic regimes and a disruption of communication networks that results in a higher degree of inter-regional variability. While this model explicitly links ecological and demographic variables, other models have proposed additional variables such as climatic stress during glacial stages leading to specific adaptations and subsistence strategies (McCall and Thomas, 2012), demographic pulses and potential population extinction (Powell et al., 2009; Scerri and Will, 2023), patterns and pathways of cultural transmission (Eerkens and Lipo, 2005; Henrich, 2001; Shennan, 2001) or differences in technological organization, mobility patterns and site function (Andrefsky, 1994; Bader et al., 2021; Kelly, 1983; Nash et al., 2013; Parkington, 1972; Shott, 1986) to explain the observed shifts in behavioral variability. What has become clear is that if we want to understand the drivers of patterns in our data, we need to improve our regional knowledge of the interaction between different environmental conditions, natural resources and techno-cultural expressions through time.

Following the exemplary work of Lyn Wadley at Sibhudu (de la Peña and Wadley, 2017; Wadley, 2005b, 2010, 2012; Wadley and Jacobs, 2004; Wadley and Mohapi, 2008; Wadley et al., 2004, 2008, 2011; Wadley and Langejans, 2014) and others, many of us (GB, AV, SER, NS, MW) have worked at a number of sites in KZN and along the east coast of South Africa. This includes work conducted further north in Mpumalanga and the Kingdom of Eswatini (Bader et al., 2020, 2021). The archaeology of MIS 3 and the end of the MSA has been central to much of this work as occupations dating to this period are frequently preserved in KZN. Recent excavations at Umbeli Belli (Bader et al., 2016, 2018), a comparative work on the final MSA assemblages from Sibhudu (Bader et al., 2022c), and the reexamination of Sibebe in the Highveld of Eswatini (Bader et al., 2022a) have all shed further light on the technical dynamics of the very end of the MSA. Important work on the final MSA and LSA transition has also been carried out at Border Cave (Backwell et al., 2018; d’Errico and Backwell, 2016; Timbrell et al., 2022; Wadley et al., 2020; Zwane and Bamford, 2021), Umhlatuzana (Lombard et al., 2010, Sifogeorgaki et al., 2020) and on specific technological aspects such as the regional signals of point morphology (Mohapi, 2009, 2012, 2013). Notwithstanding these efforts, there are still few well-documented sites and a lack of key data necessary to understand human behavioral

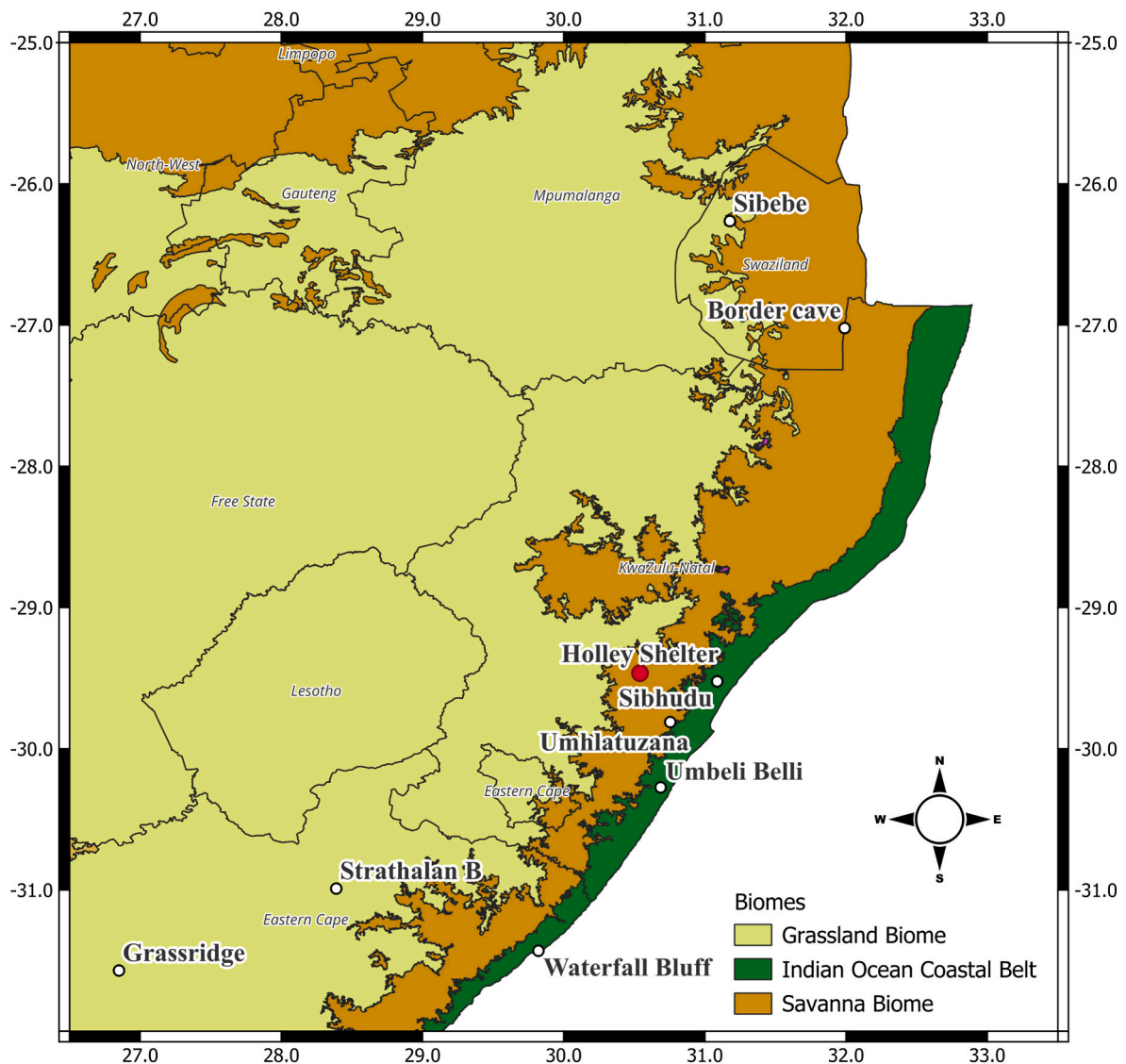
patterns during MIS 3, particularly considering the large area and diverse ecology of the region. As it stands, most well-known sites lie close to the coast and fall within the subtropical Indian Ocean Coastal Belt Biome. Regarding the archaeological record itself, the only sites in the broader region that have yielded both lithic artifacts and organic remains are Border Cave and Sibhudu. To improve our understanding of spatio-temporal variability and its underlying drivers during MIS 3, data from additional well-preserved sites are required, ideally from sites located in different geographical and ecological settings with organic preservation and high-resolution absolutely dated stratigraphic sequences.

Such conditions are found at the site of Holley Shelter. First excavated in the 1950s by G. Cramb, new fieldwork and a multidisciplinary research project at the site started in 2022 (Bader and Will, 2022). The site lies ca. 100 km inland from the modern coastline, and, to our knowledge, it is located in a different ecological zone to all other MSA sites in the region. It has organic preservation in well-stratified deposits, which allows for paleoenvironmental reconstructions and contextualization of lithic and chronometric data. While initially attributed to the post-Howiesons Poort or Sibudan around 58 ka due to similarities in the techno-typology of stone tools (Bader et al., 2015), here we show that occupations occurred much later, during MIS 3. In the following

sections, we present new results on chronometric ages, lithic assemblages and faunal remains excavated in 2022 and 2023. Based on a synthesis of these findings and contextualization within the existing regional data, we assess the spatio-temporal patterns of variability at the end of the MSA in southern Africa and discuss potential underlying causes.

## 2. The site of Holley Shelter and its ecological setting

Holley Shelter is a large rock shelter located on the property of Fountainhill Estate near the town of Wartburg (Figs. 1 and 2). According to Cramb (1952) the site was named after the former owner of the Farm, Mr. J. Hunt Holley. However, living descendants of the Holley family recently informed us that the correct owner by that time was Mr Geoffrey Holley. The site is situated within a sandstone cliff at the eastern extent of a gorge formed by backward waterfall erosion. At the base of the cliff, massive dolerite intrusions stopped this erosional process and led to the formation of the shelter. A waterfall flows in front of the rock shelter from the Hlambamasoka River, which joins the Umgeni River further west. On the back wall of the rock shelter faded rock paintings are preserved, including a rainbow directly over the main excavation area. On windy and sunny days, tiny drops of water are disturbed by the wind



**Fig. 1.** Location of Holley Shelter and other sites mentioned in the text within the meanwhile biome. Biomes are reproduced from Mucina and Rutherford 2006 and we express our gratitude to SANBI.



**Fig. 2.** The site of Holley Shelter. a) 3D model of the site generated with Agisoft metashape professional. b) View towards north on the two main trenches. Towards the front Cramb's main excavation area with our trench 10/52–11/52 at its base. In the back the northern trench covering squares 12/56–12/59. c) View from the northern extension of the shelter towards west. The waterfall from the top is feet by the Hlambamasoka stream.

in front of the shelter and a natural rainbow can sometimes be observed. The shelter itself is completely protected from the rain and wind, with direct sun only entering the shelter in the late afternoon. The view of the gorge and the atmosphere created by the waterfall are aesthetically pleasing today and might have been equally attractive for hunter-gatherers in the past.

Holley Shelter is situated about 770m above modern sea level, sitting at the intersection of three ecosystems in a strip of Savanna Biome (Fig. 1). This strip is situated between the Grassland Biome to the west and north, the sub-tropical Indian Ocean Coastal Belt Biome to the east and at the contact between the Ngongoni Veld and the KwaZulu-Natal Sandstone Sourveld in the Sub-Escarpment Savanna bioregion, a part of the Savanna Biome (Mucina and Rutherford, 2006). The Ngongoni Veld is characterized by dense and tall grassland dominated by *Aristida junciformis*, the wiry Ngongoni grass, which gives its name to the unit and is particularly appreciated by the medium to large ungulates thriving there, which include impalas *Aepyceros melampus* and Burchell's zebras *Equus burchellii*. The neighboring KwaZulu-Natal Sandstone Sourveld unit comprises a greater diversity of short grassland species, such as short shrubs and occasional *Protaceae* trees. Flat or rolling plateau tops and steep slopes that often form table mountains are common features of the landscape (Mucina and Rutherford, 2006). Holley Shelter is located in the summer rainfall zone with mean annual precipitations in the area ranging from 700 to 1200 mm. Frost is rare and the yearly temperatures vary between 0 °C and 38 °C (Mucina and Rutherford, 2006).

Recent agricultural activities in the area have impacted the indigenous vegetation originally described by early scientists and recognized by Mucina and Rutherford (2006). Mechanical cultivation and over-grazing have resulted in the development of secondary grasslands that have lost much of the diversity among the more palatable rangeland species (Greg Botha, pers. comm. 2023). Poor fire management coupled with increased CO<sub>2</sub> resulting from global warming have favored invasive woody species. The current property of Fountainhill Estate nonetheless

supports an extensive level of biodiversity. It is home to over 300 bird species, an extensive range of small and large mammals, numerous reptiles, amphibians and an extensive array of insects. Among the mammal and bird species identified from archaeological deposits reported in this paper (see Results), most taxa are still present there today, though in varying amounts. The modern environment has been further modified with numerous water storage dams constructed along the water drainage lines. These drainage lines feed the Hlambamasoka stream that flows at the site of Holley Shelter. This draining system ensures a steady trickle of water even in the dry winter periods and attenuates heavy flows during the wet seasons. Cultivated crop lands and timber plantations are situated above Holley Shelter, but protected conservation lands extend along water drainage lines and in fragile ecological areas.

Gordon Cramb was the first to excavate the site between 1951 and 1959 during several short campaigns. He published his results on recovered MSA and LSA material in two contributions to the South African Journal of Science (Cramb, 1952, 1961). Cramb excavated in two areas of the shelter, a smaller habitable zone at the southern entrance and a larger one in the northern area. For the latter, he used an imperial square grid system and painted the letters of the squares on the backwall of the shelter (Fig. 3). Cramb excavated in spits of 6-inch thickness (~15 cm) and each artifact was labeled with the square and depth below datum. He wrote initial reports on the stone tools and mentioned organic preservation even though he did not provide detailed descriptions of faunal or botanical remains. No reliable absolute chronometric ages were ever produced for the MSA or LSA occupations.

In 2015, Bader et al. (2015) published a reexamination of the MSA lithic material excavated by Cramb and proposed three distinct occupational horizons at the site based on differences in lithic techno-typology and raw material exploitation. The top 12 inches of deposits were characterized by blade production, an almost exclusive use of hornfels and large numbers of splintered pieces as the main tool category (Bader et al., 2015). The spits below, between inch 12 and 30,

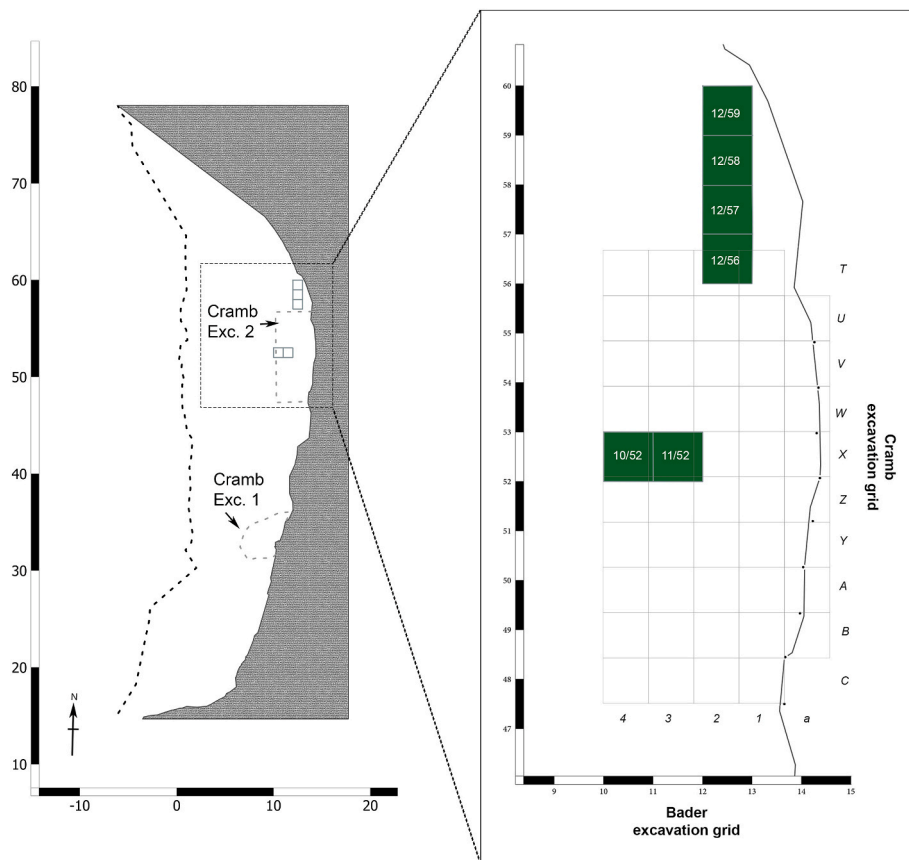


Fig. 3. Excavation plan of Holley Shelter. The dotted lines indicate Cramb's two main excavation areas. Green squares excavated by Bader and Will since 2022.

were characterized by large numbers of narrow shaped unifacial points, most of them made on thick blades, and points with faceted platforms similar to pieces described as Ndwedwe points in the ~58k layers at Sibhudu (Conard et al., 2012). Splintered pieces still occurred in large numbers and hornfels was the preferred raw material. The bottom of the excavation, inches 30 to 42, had generally low artifact densities. This unit shows a clear shift in raw material choice towards quartz, bipolar knapping was dominant over freehand percussion, and there are few retouched tools (Bader et al., 2015). While we recognized several significant differences in the assemblage composition, such as the unusually high component of splintered pieces, in the absence of absolute age control we proposed an age around 58 ka for the middle part of the sequence at Holley Shelter based on a techno-typological comparison with other sites in the broader region, such as Sibhudu.

The new research project and fieldwork at Holley Shelter applies modern field methods to obtain absolute chronometric ages and a controlled sample of lithic and organic material that can be studied using state-of-the-art methods by an interdisciplinary team to test our previous observations and provide a holistic view of human behavior and material culture in relation to paleoenvironmental change. Preliminary results were published in 2022, exactly 70 years after Cramb's first publication on Holley Shelter (Bader and Will, 2022). We started this work by concentrating on the larger area in the north of the shelter for several reasons. First, the grid marks still preserved on the shelter wall and the identification of Cramb's datum line allow us to directly correlate the results from our new excavations with data from the old collection. Second, this area shows the best potential to uncover a complete stratigraphic sequence of the MSA deposits. We opened two trenches with the first located at the bottom of Cramb's main excavation area. This includes squares 10/52 and 11/52 (Fig. 3). In this trench, we aimed to test whether Cramb reached bedrock in this area or not (see (Bader and Will, 2022)). The second trench covers the squares

12/56 and is situated at the northern border of Cramb's trench (Fig. 3).

In this contribution, we focus on the uppermost two MSA horizons in the northern section of Holley Shelter, which were excavated in 2022

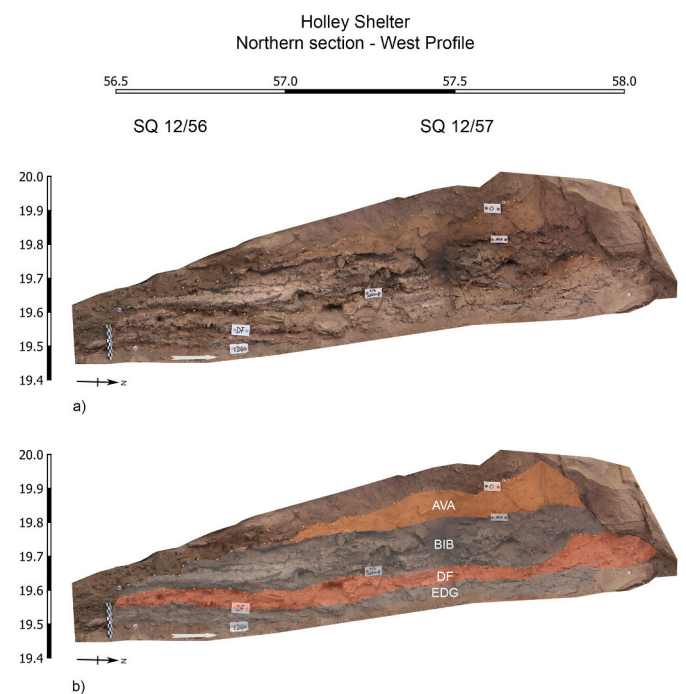


Fig. 4. Main stratigraphy of the northern trench. a) Original. b) Layers redrawn.

and 2023, and are named alphabetically from top to bottom: AVA (Avantasia) and BIB (Beast in Black) (Fig. 4). For a detailed description of our layer taxonomy and sediment description, we refer the reader to Bader and Will (2022). Both layers feature exclusively MSA material without any input of more recent time periods or modern disturbances. AVA and BIB encompass the upper 20–30 cm of intact deposits and correspond to Cramb's inches 0–12. Whilst AVA shows limited evidence of human presence and large amounts of microfauna likely accumulated by birds of prey, BIB is a massive hearth feature associated with intense human activity. Excellent preservation of organic material and spatial structures (i.e., hearth features) were observed in both layers. The two strata have provided lithic assemblages, micro- and macro-faunal remains, ochre, charcoal and other botanical materials such as seeds. In this paper, we provide new chronometric ages via C14 dating and a detailed analysis of the stone tools and macro-faunal remains.

### 3. Materials and methods

#### 3.1. Radiocarbon dating

A key aim of our new excavations was to provide a detailed absolute chronology for Holley Shelter. We took samples for radiocarbon and OSL dating in 2022 and 2023, though here we report only on the former results. A total of 2 charcoal samples for AVA and 10 for BIB were selected for AMS  $^{14}\text{C}$  dating at iThemba LABS, Johannesburg. These were selected during fieldwork from observed hearth features to ensure a direct connection to MSA human activities.

The charcoal was subjected to the standard acid-base-acid (ABA) pretreatment protocol (Olssen, 1986) to remove contaminants. The first acid reaction is with 1N HCl (acid), followed by a 1 h treatment with 1N NaOH (base) with care being taken to remove the charcoal if it appears it will dissolve completely. The remaining NaOH is neutralized with 1N HCl for 10 min (acid). All of the acid-base-acid steps take place at 70 °C. The remaining charcoal is washed with deionized water to neutrality, and the sample is placed in a drying oven at 70 °C. A ca. 5 mg aliquot of the charcoal is then weighed in a vacuum tube with excess CuO and Ag, and the sample is combusted at 900 °C in a muffle furnace. The evolved  $\text{CO}_2$  is distilled cryogenically, and subject to graphitization using an Fe catalyst in the presence of excess hydrogen (Vogel et al., 1984). This analysis was performed on the Tandem accelerator at iThemba LABS, Johannesburg, using coal as background and oxalic acid II as a standard. All calculations followed the protocol of Zoppi (2010).

#### 3.2. Lithic analysis

For the lithic analysis, we included all stone artifacts recovered from layers AVA and BIB, which comprise 681 artifacts >2 cm and 1069 pieces of small debitage <2 cm. The >2 cm artifacts were analyzed using the combined approach of lithic attribute analysis (Andrefsky, 1994; Kuhn, 1991; Marwick, 2008; Scerri et al., 2015) and *chaîne opératoire* (Boëda et al., 1990; Shott, 2003; Soressi and Geneste, 2011). This methodology is similar to the previous research published on Umbeli Belli (Bader et al., 2018), Sibhudu (Bader et al., 2022c; Will and Conard, 2020) and Sibebe (Bader et al., 2022a), and our previous examination of Cramb's material (Bader et al., 2015). For artifacts <2 cm, we recorded information on raw material type and quantified pieces with specific features, namely retouch flakes and splinters (see below). Retouch flakes are directly linked to secondary edge modification on tools and have been previously described elsewhere (Conard et al., 2012; Porraz, 2005).

Like Cramb's assemblage, our material contains numerous splintered pieces. To explore if these pieces were produced and/or used at the site, we documented all flakes related to the splintered edges. Villa et al. (2005) recognized such flakes in the late MSA assemblages from Sibhudu and described a shattered platform as a key characteristic. In the Holley Shelter material, we discovered several of these flakes that we

call 'splinters' and we defined two additional features on these artifacts. The first feature is the common presence of pronounced ripple lines on the ventral face, mirroring the rippled surface of the negatives on the splintered pieces. Ripple lines are frequently observed in bipolar technology (e.g., Jeske and Lurie, 1993). The second attribute is a distal hinge fracture, which correlates well with our observation that many of the negatives on the splintered pieces, especially the larger ones, terminate in a hinge (e.g., Fig. 7a–c, d, e, f). We considered only those pieces exhibiting at least two of the three criteria, (I) shattered platform, (II) ventral ripple lines and (III) distal hinge fracture. Based on these criteria, we quantified splinters from all artifact size categories in the AVA and BIB assemblages.

#### 3.3. Faunal analysis

A preliminary appraisal of the faunal assemblage from stratigraphic units AVA and BIB was conducted on-site during the 2023 field campaign. As a first step, identifiable material was separated from the non-identifiable fraction. Subsequently, we conducted detailed taxonomic and anatomical attribution analysis using the extensive collections of modern mammalian, reptilian and avian skeletal material housed at the Ditsong National Museum of Natural History in Pretoria. When possible, bone and dental specimens were assigned to family, genus and species. The non-identifiable bovid remains were attributed to a class size following Brain (1974). The taxonomic nomenclature follows Skinner and Chimimba (2005) for the mammals, and Sinclair et al. (2011) for the birds, unless stated otherwise.

The material presented here includes 693 faunal remains from AVA, 278 from BIB, and 145 from BIB Hearth. While humans clearly accumulated the lithic artifacts, understanding the origin of the faunal remains requires analysis of the taphonomic signal of the faunal assemblage by stratigraphic layer. Here, we have considered the faunal material associated with the combustion feature in BIB ("BIB Hearth") separately from the material retrieved from the surrounding sediment in that unit (BIB). The sample comprises faunal specimens larger than 2 cm whose exact position was measured with a total station during the excavation (N = 186). It also comprises specimens that were retrieved during sorting of the excavated sediments (N = 930). Due to time constraints, an estimated 368 faunal specimens from AVA (N = 205), BIB and BIB Hearth (N = 163) have not yet been analyzed; these include mostly non-identifiable bone fragments. As all identifiable specimens of macrofauna are included in this study, we suspect that the inclusion of these additional faunal remains would not drastically alter the interpretations of this study. Furthermore, the sample presented here is large enough to offer key insights into the accumulation processes of the animal remains in units AVA and BIB.

For each faunal specimen, the skeletal element and skeletal portion were recorded. Age estimates are proposed for some of the mammalian remains using the degree of epiphyseal fusion for long bones and use-wear on tooth occlusal surfaces. The age of the bird specimens was assessed by analyzing their surface texture and morphology, according to the methodology proposed by Watanabe and Matsuoka (2013). The color of the external (e.g., cortical) and internal (e.g., medullar) surfaces was recorded as this can be indicative of burning. Following Stiner et al. (1995), and Clark and Ligouis (2010), we used the following colors: unburnt (light brown/beige), dark brown, black (carbonized), grey, and white (calcined). Using the method developed by Villa and Mahieu (1991), fracture edges of long bone fragments were characterized as green, dry or recent. We selected a subsample of 202 remains to be investigated microscopically using an Olympus SZX7 that provides magnifications up to 56×. The presence/absence and characteristics of bone surface modifications caused by various abiotic and biotic agents were recorded. The degree of cortical surface that is visible was estimated as it influences, for instance, interpretations based on the frequency of cutmarks. Bone modifications considered include weathering (following Behrensmeier, [1978]), manganese coating, root etching,

water abrasion, and trampling marks. Pits, scores, notches, furrows, grooves, crenulated edges, acid etching inflicted by non-human predators (e.g., mammalian carnivores and raptors) and gnawing marks inflicted by rodents and invertebrates were recorded. Finally, the presence/absence of anthropogenic marks were noted. Their anatomical location and orientation were reported on bone templates using the software Gimp. Anthropogenic modifications include cutmarks, percussion marks and evidence of retouching activity were documented. The attribution of bone surface modifications to specific taphonomic agents and processes is based on the abundant literature available (including but not limited to [Armstrong and Avery \[2014\]](#); [Backwell et al. \[2012\]](#); [Brain \[1981\]](#), [d'Errico et al., 2012](#); [Domínguez-Rodrigo et al. \[2009\]](#), [Fernandez-Jalvo and Andrews \[2016\]](#), and [Shipman and Rose \[1983\]](#)) and on one of the authors' experience (AV). When relevant, chi-square tests were performed using PAST software to evaluate the significance of specific taxonomic or taphonomic differences observed between two samples.

## 4. Results

### 4.1. Dating

The results of AMS  $^{14}\text{C}$  dating, including calibrated results using OxCal4.4 and the SHCal20 calibration curve, are provided in [Table 1](#). The majority of the ages clusters in a narrow corridor between 36,000 and 34,000 cal BP ( $n = 11$ ) at the end of MIS 3. One sample towards the bottom of layer BIB (IT-C-4145) is slightly older with a mean age of about  $\sim 37,500$  cal BP and a maximum age of  $\sim 39,000$  cal BP. The mean ages of AVA are slightly younger compared to BIB and thus in correct stratigraphic order, but both assemblages have a consistent mean of about  $\sim 35,000$  cal BP.

With samples  $>30,000$  years in age it may be preferable to undertake a more stringent protocol like ABOx-SC ([Bird et al., 1999](#)) because the ABA/graphitization protocol may neither adequately decontaminate the charcoal of younger material nor prevent contamination occurring in the sample processing. An argument that has been used to support the accuracy of ABA results  $>30,000$  years is the consistency between multiple analyses on the assumption that it is unlikely that multiple samples will have the same level of recent contamination. This requires the analysis of many samples, which is the strategy that has been used at Holley Shelter, but there is also a suggestion that consistency is not necessarily a valid argument ([Wood et al., 2012](#)). The contamination that the ABOx-SC protocol avoids is at least partially from the graphitization process, and the background results obtained in this analysis, that had the same graphitization process, were all statistically distinct and substantially older than the results reported here. We rely on the consistency of the radiocarbon dates and the difference from background to suggest that they are all finite and provide an accurate estimate of the timing of human occupation. We will subject additional

samples to the more rigorous protocols to verify this position in the future.

### 4.2. Stone artifacts

Layers AVA and BIB represent the top 30 cm of deposits at Holley Shelter. In order to correlate the new results with those from Cramb's material ([Bader et al., 2015](#)), we draw comparisons with the assemblages from Cramb's inches 0–6 and 6–12 ([Bader et al., 2015](#); [Cramb, 1961](#)) where appropriate. Since AVA and BIB are roughly the same age, we will discuss the results by grouping both layers together unless stated otherwise.

#### 4.2.1. Raw material

The Holley Shelter lithic material is dominated by hornfels, a black metamorphic rock typically forming at the contact zone between sedimentary rocks such as shale and intrusive rocks such as dolerite ([Cairncross, 2011](#)). In total, 70.7% of all artifacts  $>2$  cm in AVA and 63.4% in BIB are made on hornfels ([Table 2](#)). Hornfels has an even higher proportion among retouched tools, showing a preferential selection of this raw material ([Table 3](#)). Cores were made almost exclusively on this material. The provenance of the hornfels used at Holley Shelter needs to be confirmed but the presence of both river-rolled cortex (25.9%) and slab cortex (37%) indicates the use of both primary and secondary sources. Cramb notes in 1952 that "judging from the water-worn cortex of specimens from the Middle Stone Age assemblage, indurated shale (HF) was gathered from water-courses which lie in the deep gorges westward towards the Umgeni River" ([Cramb, 1952:183](#)). Primary sources may well occur in the neighboring gorges as the entire geological area around Wartburg and Pietermaritzburg is scattered with shale and dolerite (see [Bader et al., 2015](#) and [Fig. 1](#)) but modern agriculture on the plains and thick bush in the gorges render surveys challenging and remain a target for future research.

The second most common raw material in our new assemblage is local Natal sandstone which is a noted discrepancy with the legacy museum collection. A total of 16.3% of the artifacts in AVA and 26.9% in BIB were made from this material. In our collection work from 2015, we identified only three pieces of sandstone in the inches 0–12. The relatively high number of sandstone artifacts in the new assemblage indicates that Cramb likely failed to recognize the anthropogenic nature of artifacts from this coarse-grained material and did not curate them. The MSA knappers used sandstone predominantly to produce blanks, which amount to 26.2% of the assemblage, and only rarely modified these further ([Table 3](#)). Dolerite was knapped at Holley Shelter, like at other important sites in the region including Sibhudu, but here represents only 11.4% of the assemblage in AVA and 5.4% in BIB. These numbers are also higher than in Cramb's assemblage (2.1% in inch 0–6 and 1% in inch 6–12). Cortical pieces from the new assemblage point exclusively towards secondary sources from the river. In fact, a dolerite intrusion

**Table 1**  
AMS radiocarbon dating results on charcoal. Calibration with OxCal4.4, SHCal20.

AMS C14 dating results on charcoal. Calibration with OxCal4.4, SHCal20											
LabCode	SampleCode	Layer	Abtrag	Find ID	Square	z-value	Feature	Age (uncal)	Error	Age cal BP	Probability
IT-C-4133	118SQ12	AVA	9	118	12/57	19.98	Hearth 1	30730	370	35909–34435	95.40%
IT-C-4138	120SQ12	AVA	9	120	12/57	20	Hearth 1	30300	520	35901–33829	95.40%
IT-C-4140	240SQ12	BIB	2	240	12/57	19.9	Hearth 1	29200	1500	38060–30807	95.40%
IT-C-4123	241SQ12	BIB	2	241	12/57	19.91	Hearth 1	30330	330	35365–34220	95.40%
IT-C-4126	364SQ12	BIB	5	364	12/57	19.74	Hearth 2	31380	470	36650–34704	95.40%
IT-C-4131	386SQ12	BIB	6	386	12/57	19.71	Hearth 2	30050	330	35230–33950	95.40%
IT-C-4128	388SQ12	BIB	6	388	12/57	19.72	Hearth 2	30640	360	35761–34361	95.40%
IT-C-4129	390SQ12	BIB	6	390	12/57	19.76	Hearth 2	29880	330	35115–33725	95.40%
IT-C-4127	463SQ12	BIB	8	463	12/57	19.76	Hearth 2	30980	350	36080–34631	95.40%
IT-C-4142	492SQ12	BIB	9	492	12/57	19.72	Hearth 2	31750	370	36855–35339	95.40%
IT-C-4145	518SQ12	BIB	10	518	12/57	19.72	Hearth 2	32710	590	39152–36084	95.40%
IT-C-4141	609SQ12	BIB	12	609	12/57	19.69	Hearth 2	30980	350	36080–34631	95.40%

**Table 2**

Raw material distribution of artifacts &gt;2 cm in layer AVA and BIB at Holley Shelter.

Layer	Hornfels		Dolerite		Quartz		Quartzite		Natal Sandstone		indet		Total n
	n	%	n	%	n	%	n	%	n	%	n	%	
AVA	87	70.7	14	11.4	2	1.6	0	0	20	16.3	0	0	123
BIB	354	63.4	30	5.4	14	2.5	5	0.9	150	26.9	5	0.9	558
<b>Total n</b>	<b>441</b>		<b>44</b>		<b>16</b>		<b>5</b>		<b>170</b>		<b>5</b>		<b>681</b>

**Table 3**

Raw material distribution per type of blank at Holley Shelter.

Type of artifact	Hornfels		Dolerite		Quartz		Quartzite		Natal Sandstone		indet		Total n
	n	%	n	%	n	%	n	%	n	%	n	%	
Blank	347	63.1	42	7.6	10	1.8	3	0.5	144	26.2	4	0.7	550
Tool	69	89.6	1	1.3	2	2.6	1	1.3	4	5.2	0	0.0	77
Core	16	84.2	1	5.3	1	5.3	0	0.0	1	5.3	0	0.0	19
Debris	9	25.7	0	0.0	3	8.6	1	2.9	21	60.0	1	2.9	35

below the waterfall at the bottom of the gorge provides an ideal source of this material. Several dolerite flakes have been found within a second shelter behind the waterfall that does not otherwise preserve archaeological deposits. Other materials like quartz or quartzite occur only in very small quantities (Table 2). Hence, we can confirm that the Holley Shelter legacy assemblages of the upper sequence are dominated by hornfels, but the new assemblages show that the inhabitants also made intense use of local Natal sandstone to produce larger unretouched flakes.

#### 4.2.2. Blank production

We recovered a total of 608 blanks greater than 2 cm in size which we divided by type into flakes, blades, bladelets, and points from AVA and BIB. This taxonomy follows standard definitions used in previous contributions (Bader et al., 2018; Bader and Will, 2022). Whereas flakes are on average similar in length and width, blades have parallel edges and are at least twice as long as they are wide. The cut off size in width that differentiates blades from bladelets is traditionally put at 12 mm. Points refer to flakes with convergent distal ends. Flakes represent most of the blanks at Holley Shelter (Table 4) although, like in the Cramb assemblages, blades occur in high numbers. In total ~20% of all blanks are blades, the majority of which (83.6%) are knapped on hornfels. Platform preparation occurs frequently on blades (Table 5), whereas most flakes have unprepared, plain platforms, pointing towards more intense preparation of platforms for blade production. The average size of hornfels blades are 49.6 mm in length, 20.4 mm in width, and 6.2 mm in thickness. Bladelets were also found in relatively high numbers (7.7% of all blanks). Like blades, the majority of bladelets were knapped on hornfels (95.7%).

Since the distinction between blades and bladelets is heuristic and might have no intrinsic meaning for the prehistoric knappers, we decided to study the assemblage with an emphasis on laminar/elongated products as a whole and include metrics for pieces <2 cm. In doing so, we measured the width of 129 laminar products, including broken pieces identified based on the shape of edges and cross-sections. A histogram of widths for these laminar products (Fig. 5) illustrates that instead of conforming to a unimodal normal distribution there are at

**Table 4**

Blank type numbers and percentages in layer AVA and BIB at Holley Shelter.

Layer	Flake		Blade		Bladelet		Point		Total n
	n	%	n	%	n	%	n	%	
AVA	73	68.2	23	21.5	10	9.3	1	0.9	107
BIB	354	70.7	93	18.6	37	7.4	17	3.4	501
<b>Total n</b>	<b>427</b>		<b>116</b>		<b>47</b>		<b>18</b>		<b>608</b>

least two distinct peaks, between 6–12 mm and 16–20 mm, with a noticeable underrepresentation of pieces with widths of 12–16 mm. Testing for normal distribution of the data (Shapiro-Wilks test;  $p < 0.001$ ) provides statistical support for the significance of this patterning. Phrased in typological terms, these data suggest the intentional manufacture of bladelets and blades. This was not observed in previous studies of the Cramb assemblage. Nearly all laminar products, regardless of size, are made on hornfels. In contrast, Natal sandstone, quartz and quartzite were almost exclusively used for flake production with only a few blades ( $n = 9$ ) made on dolerite.

#### 4.2.3. Cores

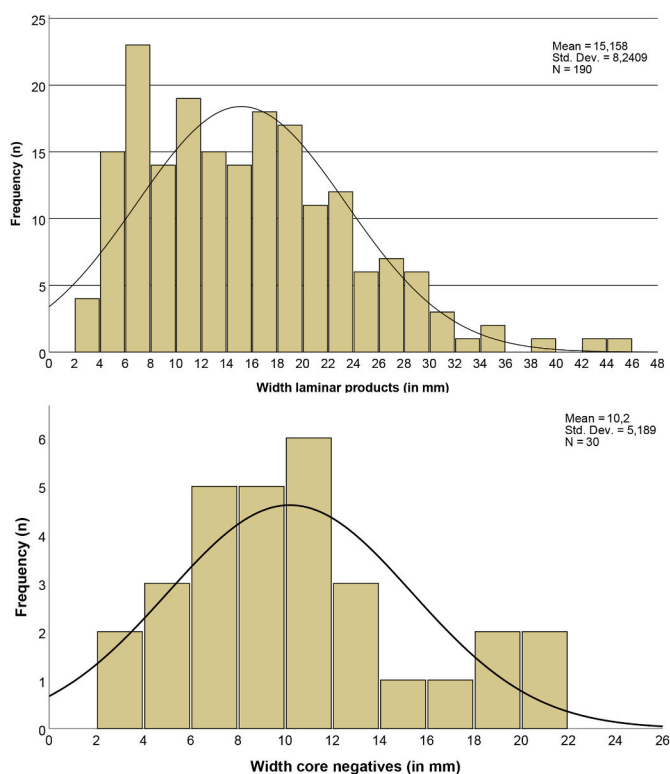
In total, 19 cores were identified within the AVA and BIB assemblages. Except for one example made of Natal sandstone in AVA, and one each of dolerite and quartz in layer BIB, all cores were produced on hornfels. Out of the 16 hornfels cores, 13 exhibit scars <12 mm in width pointing again towards the production of bladelets at the site, at least in the final stages of core reduction. Typically, knappers used thick, elongated blanks (blades) and the already existing ridges on their dorsal or lateral side to remove small bladelets. These cores can either be described as “bladelet core on flake/blade” (Fig. 6a and b) or “burin cores” (Fig. 6c and d). Bladelet cores on flakes exhibit bladelet removal scars on the dorsal surface and in one case on the ventral face. These bladelet removals were initiated on the distal end of the blank, typically on a breaking surface. Elsewhere in South Africa (e.g., at Bushman Rock Shelter [Porraz et al., 2015]) and in other parts of the world comparable cores were described as Kostienki ends (Efimienko, 1958) or Nahr Ibrahim cores (Solecki and Solecki, 1970; see also Frick, 2013 for further discussion). At Holley Shelter, a major difference is that the distal platform from which the bladelet removals were initiated remains unafaceted.

Alike the bladelet cores on flake sub-assemblage, burin cores with laminar removal scars from Holley Shelter were also frequently observed. Besides these two most common core categories only two semi-circumferential platform cores, similar to those described from the Cramb assemblage (Bader et al., 2015), were found. These cores occur in high numbers in the upper two spits (inches 0–6 and 6–12) of the Cramb excavation. Their near absence in our assemblage raises questions about the spatial organization of activity areas in the shelter (see discussion below). Some of the cores from the old assemblage overlap in technology with the new material, as they were made on large flakes as well as on blades. It is also worth mentioning that in 2015 we counted burins amongst the tools, a position from which we now refrain.

Table 6 provides an overview of all cores, regardless of raw material, while Table 7 details only cores made from hornfels and Table 8 details specimens according to the end products removed from the cores.

**Table 5**  
Platform types per blank type at Holley Shelter. Data from AVA and BIB combined.

Hornfels platforms (Only complete pieces and proximal fragments)								
Type of blank	Faceted coarse %	Faceted fine %	Dihedral %	step flaking %	Plain %	Cortical %	crushed %	Total n
Flake	5.4	2.0	2.0	1.4	61.2	2.0	25.9	147
Blade	28.8	6.8	3.4	3.4	37.3	0.0	20.3	59
Bladelet	0.0	0.0	0.0	0.0	76.2	0.0	23.8	21
Point	27.3	18.2	0.0	0.0	54.5	0.0	0.0	11
Total n	28	9	5	4	134	3	55	
Natal Sandstone platforms (only complete pieces and proximal fragments)								
Flake	0.0	0.0	0.0	0.0	97.1	2.9	0.0	102
Blade	0.0	0.0	0.0	0.0	100.0	0.0	0.0	3
Bladelet	0.0	0.0	0.0	0.0	0.0	0.0	100.0	1
Point	0.0	0.0	0.0	0.0	100.0	0.0	0.0	1
Total n	0	0	0	0	103	3	1	



**Fig. 5.** Histogram showing the width distribution of laminar products (top) and core negatives. Created with SPSS institutional license.

Table 9 provides further information on the average width and length of removal negatives on the discarded cores. The mean value for negative width is 10.2 mm and for length is 30.4 mm, which clearly overlap with (a) the overall laminar signal and (b) the metrics of all laminar products clustering within the separate ranges of bladelets and blades. Represented as a histogram in Fig. 5, this data reveals a strong peak in widths between ca 6–12 mm and a smaller one between 18 and 22 mm – as well as a conspicuous underrepresentation of scar widths between 12 and 18 mm – which match the blank data presented above (Fig. 5). The near absence of cores other than bladelet cores combined with the observation of generally low amounts of small flaking debitage suggests that large laminar blanks were knapped elsewhere inside or outside the shelter, transported to the area near our excavation, and further transformed there into either bladelet cores or tools before finally being discarded (see section below).

#### 4.2.4. Splintered pieces

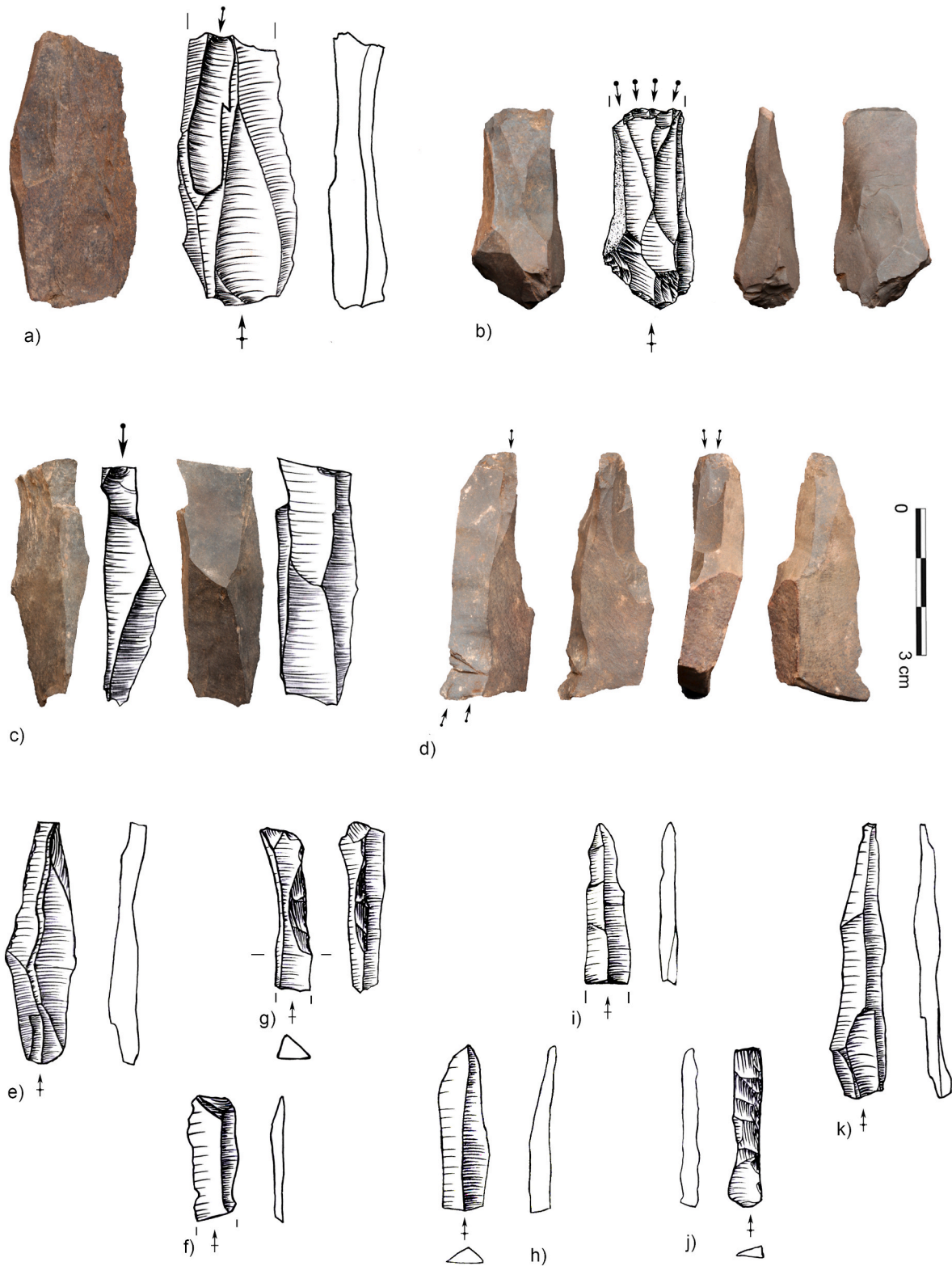
In total, 40 splintered pieces were identified and account for over

50% of all tools in AVA and BIB (Table 10). With the exception of one quartz example, all splintered pieces are made on hornfels. The same observation was made for Cramb's assemblage (Bader et al., 2015). These artifacts are currently under investigation by M. Denys at the Traceolab in Liège, Belgium. They will be discussed in a separate contribution dealing with aspects of use wear and functionality, and the ongoing discussion on whether these pieces should be classified as tools or cores. For this technological analysis, we counted the splinters (Fig. 8) that resulted from bipolar percussion mode on splintered pieces. The results are provided in Table 11. In total, 7.9% of the blank sub-assemblage in AVA and 5.3% in BIB (total n = 73; excluding micro debitage <0.5 mm) were recognized as splinters, all of which were made from hornfels. This implies that whatever action produced the splintered pieces, it took place frequently at the site.

#### 4.2.5. Tools

We document a relatively high percentage of tools in Layers AVA (9.8%) and BIB (11.6%), which includes retouched tools and splintered pieces. Bader et al. (2015) calculated that 23.5% of the lithic assemblage of inch 0–6 and 24.4% of inch 6–12 of the Cramb's assemblages constitutes retouched pieces. However, that study used a size cut-off of 3 cm to produce results comparable with those from the Sibhudu team (Conard et al., 2012; Conard and Will, 2015; Will et al., 2014). If we apply the same 3 cm cut-off size to the artifact assemblage from the new excavations at Holley Shelter, AVA reaches comparable tool percentages of 17.1% and BIB of 22.6%. The observation thus remains consistent that the upper layers in Holley Shelter provide large numbers of secondarily modified pieces which are not the result of a biased sampling strategy by Cramb. Counting AVA and BIB together, Table 3 indicates that 89.6% of the tools are made on hornfels whereas other materials such as Natal sandstone, dolerite, quartz and quartzite remained mostly unretouched.

Regarding other tool types, unifacial points are especially common in BIB (n = 12), whereas only one was found in AVA. Almost all unifacial points (n = 11) were made on a blade. Retouch is often invasive (see Bader et al., 2016) and affects exclusively the dorsal face of the piece. Several of these pieces (n = 4; Fig. 9 a – e) can be assigned to the Ndwedwe tool category defined by Conard et al. (2012) and similar forms were also found in the Cramb assemblage (Bader et al., 2015). Other retouched tools can best be described as retouched blades or flakes. We checked for retouch flakes across all size categories (excluding micro debitage), and found that only hornfels, dolerite and sandstone materials were used. As expected from the tool signal, most of the retouch flakes are made of hornfels (n = 56 or 5.8% of all hornfels flakes). Only one example of a dolerite retouched flake and one of sandstone were found. For hornfels tools, we can thus confirm that they were retouched or resharpened to a certain degree at the site. Compared to other assemblages in the region, like Sibhudu and Umbeli Belli, where percentages for retouch and shaping flakes are provided and indicate intense on-site retouch activities (Bader et al., 2018; Bader et al., 2022c; Conard et al., 2012) the numbers from Holley Shelter are low. For



**Fig. 6.** Laminar cores and products from Layer BIB. a, b) Bladelet core on flake (Kostienki/Nahr Ibrahim cores). c, d) Burin bladelet cores. e, f, h, k) Bladelets. g, j) Burin (spall) bladelets.

example, the Sibudan assemblage (layers BSP-BM) at Sibhudu yielded between 10% and 24% retouch flakes and the final MSA assemblages at Umbeli Belli included up to 28% shaping flakes.

In sum, the new tool assemblage from Holley Shelter reveals the same technological signal as the previously studied material recovered from the top two spits of the Cramb assemblage (Bader et al., 2015).

Additionally, this new study shows that, to a certain degree, tool manufacture and splintered piece production took place at the site as reflected by the presence of splinters and retouch flakes.

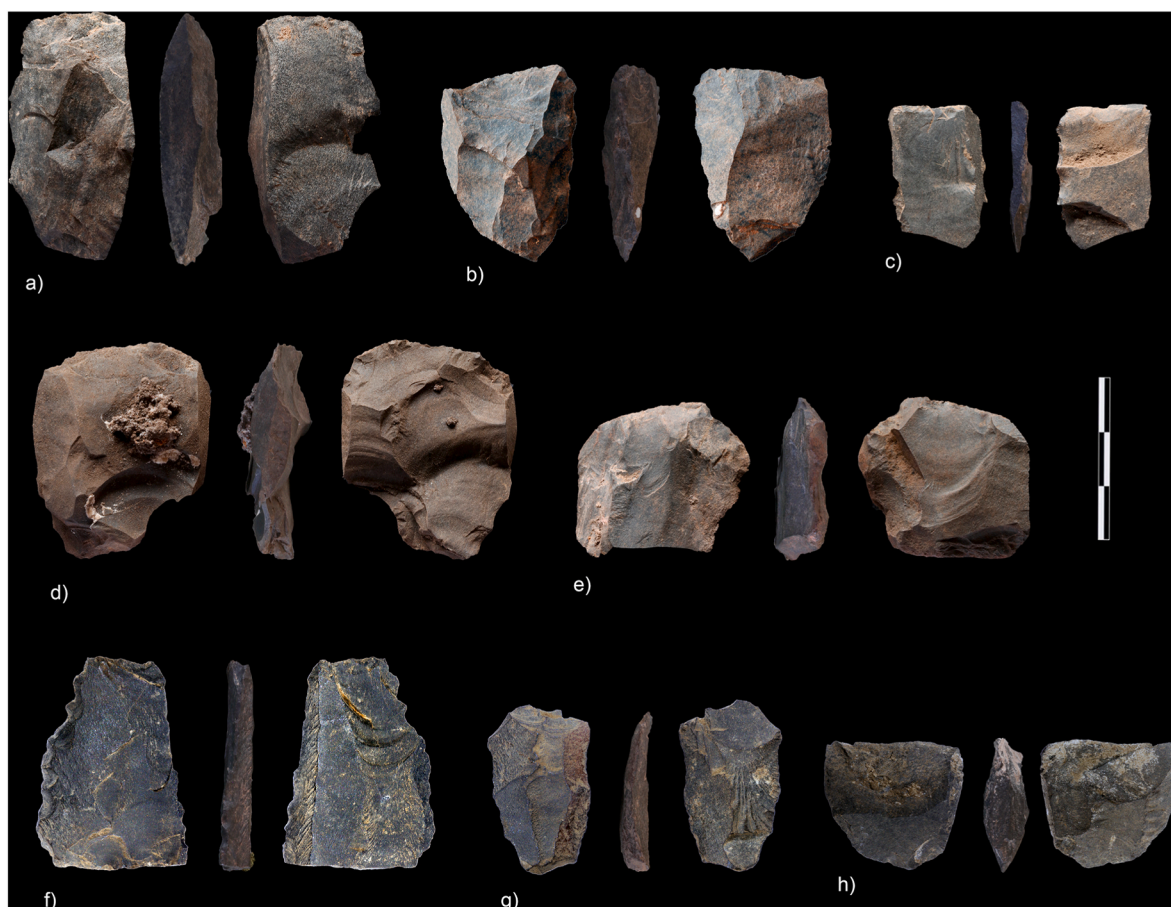


Fig. 7. Splintered pieces from AVA and BIB. All hornfels.

**Table 6**  
Core types at Holley Shelter.

Type of Core								
Layer	Platform Narrow sided n	Platform semi circumf. n	Platform indet n	Bladelet core on flake n	Flake core on flake n	Burin n	Bipolar n	Total n
AVA	0	1	0	1	1	0	1	4
BIB	0	1	1	3	0	6	4	15

**Table 7**  
Number of cores types in hornfels at Holley Shelter.

Hornfels cores					
Layer	Bladelet core on flake n	Flake core on flake n	Burin n	Bipolar n	Platform core n
AVA	1	1	0	1	0
BIB	3	0	6	3	1
<b>Total</b>	<b>4</b>	<b>1</b>	<b>6</b>	<b>4</b>	<b>1</b>

**Table 8**  
Numbers of cores classified according to removal scar type at Holley Shelter.

Cores classified by endproduct				
Layer	Flake n	Blade n	Bladelet n	Point n
AVA	2	0	2	0
BIB	4	0	11	0

**Table 9**  
Metrics for width and length of core removal negatives at Holley Shelter for all cores of AVA & BIB.

	Width of removal negatives	Length of removal negatives
N	30	17
Min	2	15
Max	21	49
Sum	306	517
Mean	<b>10.2</b>	<b>30.41</b>
Std. error	0.95	2.42
Stand. dev	5.19	9.98
Median	9.5	30
25 prcntil	6.75	23
75 prcntil	12.25	37.50
Skewness	0.59	0.33
Kurtosis	-0.13	-0.55
Coeff. var	50.87	32.80

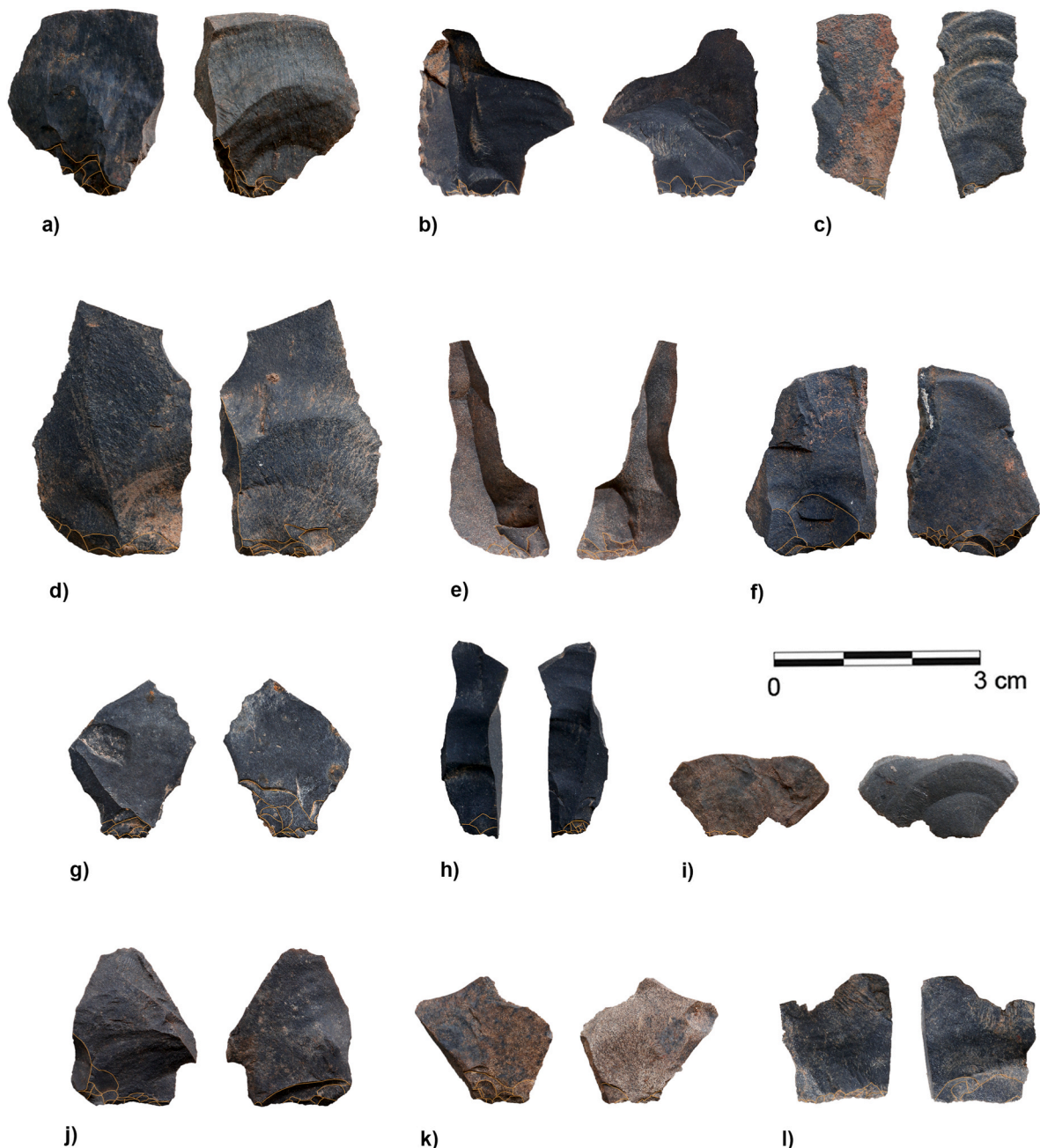
**Table 10**  
Typological tool categories at Holley Shelter.

Tools type	Layer		Total n
	AVA	BIB	
Backed knife	0	1	1
NBT	0	1	1
Point unifacial	1	12	13
Retouched blade	1	9	10
Retouched flake	2	6	8
Retouched point	0	2	2
Scraper convergent	0	1	1
Scraper end	1	0	1
Scraper round	0	1	1
Segment	1	0	1
Splintered piece	7	33	40
Total n	13	66	79

#### 4.3. Faunal remains

##### 4.3.1. Taxonomic composition of the faunal spectra in AVA and BIB and BIB hearth

Various proportions of the faunal samples could be identified to genus and/or species (Table 12) including: 278 faunal remains in AVA (40% of the sample from this stratigraphic unit), 64 in BIB (23%) and 14 in BIB Hearth (10%). The difference between AVA and BIB Hearth is statistically significant ( $\chi^2 = 42.213$ ;  $p$  value  $< 0.01$ ). The difference in proportions of identifiable material between AVA and BIB on the one hand, and BIB and BIB Hearth on the other, are consistent with increasing rates of fragmentation between these units. The percentage of the initial bone length preserved was recorded for 876 remains (496 in AVA, 272 in BIB, and 125 in BIB hearth). These data confirm that fragmentation is more intense in BIB Hearth than in BIB and AVA. In AVA, 213 specimens (43%) preserve less than 25% of their initial length,



**Fig. 8.** Splinters from AVA and BIB showing the characteristic splintered edge on the base, a distal hinge termination and ventral ripple lines. All hornfels.

**Table 11**  
Percentage of splinters at Holley Shelter.

Layer	blanks >2 cm (n)	blanks < 2 cm (n)	blanks total	Splinters >2 cm (n)	Splinters <2 cm (n)	Splinters total n	Splinters total %
AVA	78	200	278	9	13	22	7.9
BIB	320	641	961	27	24	51	5.3



**Fig. 9.** Formal tools from AVA and BIB. a, b, c, e, g, h, i) Unifacial points. d) Stemmed backed knife. f) retouched blade.

while 110 (22%) are complete or near-complete (where 100% of the initial length is preserved). In BIB, 144 elements (53%) preserve less than 25% of their initial length, while 49 (18%) are complete. In BIB Hearth, 82 specimens (66%) preserve less than 25% of their initial length, while 22 (18%) are complete. Complete elements are mostly phalanges, sesamoids, tarsals and carpals.

The same taxonomic families, genera and species are observed in the three units considered, although they are present in different frequencies. Small mammals include hyraxes, leporids and mongooses, which we did not attempt to identify beyond family level (Table 1). One of the co-authors (EG), manager of Fountainhill, kindly provided a list of species observed on the estate since 1994. These yearly recensions mention the presence of the rock hyrax *Procavia capensis*, the scrub hare

*Lepus saxatilis*, the banded mongoose *Mungos mungo*, the large grey mongoose *Herpestes ichneumon*, the slender mongoose *Galerella sanguinea*, the water mongoose *Atilax paludinosus*, and the white-tailed mongoose *Ichneumia albicauda*. According to Skinner and Chimimba (2005), the modern ranges of the following additional taxa are consistent with the location of Holley Shelter: Smith's red rock rabbit *Pronolagus rupestris*, the Natal red rock rabbit *Pronolagus crassicaudatus*, the tree hyrax *Dendrohyrax arboreus*, the dwarf mongoose *Helogale parvula*, and the Cape grey mongoose *Galerella pulverulenta*. The herpestid sample from Holley Shelter (n = 7) comprises two isolated teeth, a proximal humerus, three fragmentary calcanei and one complete calcaneum. The dimensions and morphology of this last specimen resemble those of *Galerella pulverulenta*, which would be found at the easternmost border

Table 12

List of taxa identified from the MSA deposits at Holley Shelter from the 2022 and 2023 excavation. Data in NISP and MNI.

ORDER	Family	Species	Vernacular name	AVA	BIB	BIB Hearth
HYRACOIDAE	Procaviidae	<i>Procavia/Dendrohyrax</i> sp.	Hyrax	58/8	11/3	4/2
LAGOMORPHA	Leporidae	<i>Lepus/Pronolagus</i> sp.	Hare/Rabbit	178/9	40/6	3/2
PRIMATES	Cercopithecidae	<i>Papio ursinus</i>	Chacma baboon	7/1	–	–
CARNIVORA	Herpestidae	Gen. et sp. indet.	Mongoose	4/1	3/2	–
			Small carnivore	–	2/-	–
PERISSODACTYLA	Equidae	<i>Equus</i> sp.	Zebra	1/1	3/1	2/1
ARTIODACTYLA	Suidae	<i>Phacocoerus africanus</i>	Warthog	–	1/1	–
		Gen. et sp. indet.	–	1/1	3/-	2/1
	Bovidae	<i>Syncerus africanus</i>	Buffalo	–	2/1	–
		<i>Damaliscus pygargus</i>	Blesbok/bontebok	15/2	2/2	2/1
		<i>Damaliscus</i> sp.	–	4/-	2/-	1/1
		<i>Pelea capreolus</i>	Grey rhebuk	1/1	1/1	–
		Bovids I	–	–	2/-	–
		Bovids I/II	–	3/-	7/-	5
		Bovids II	–	36/-	23/-	38/-
		Bovids II/III	–	11/-	17/-	16/-
		Bovids III	–	3/-	7/-	3/-
		Bovids IV	–	2/-	–	1/1
	Indet. family	Ungulates I/II	–	2/-	1/-	–/-
		Ungulates II	–	2/-	5/	3/-
		Ungulates II/III	–	3/-	13/-	7/-
		Ungulates III	–	2/-	2/-	3/-
		Ungulates III/IV	–	–	9/-	4/-
		Ungulates IV	–	–	1/-	–/-
Pelecaniformes	Threskiornithidae	<i>Geronticus calvus</i>	Southern bald ibis	14/6	2/1	2/2
Galliformes	Phasianidae	<i>Francolinus</i> sp.	Francolin	1/1	1/1	–
Columbiformes	Columbidae	Gen. et sp. indet.	Dove/pigeon	3	–	–
Passeriformes			Small passerine	5	1/1	1/1
			Medium passerine	21	1/1	–

of its modern range at Holley Shelter (Skinner and Chimimba, 2005). Besides small mammals, the presence of baboon remains in unit AVA is noteworthy. Seven specimens, all of them complete and sub-complete phalanges, are attributed to the chacma baboon *Papio ursinus*.

Ungulates identified at Holley Shelter thus far include equids, suids and bovids. The few equid remains (n = 6) are attributed to an unidentified zebra, *Equus* sp. Today, plains zebras *Equus quagga* are roaming the estate but the presence of the mountain zebra *Equus zebra* in the Pleistocene cannot be excluded. One molar fragment presents the typical occlusal surface of the worn dentition of the warthog *Phacocoerus africanus*. An additional six suid remains, including five phalanges, one carpal bone and a distal metapodial, could not be attributed to either the warthog or the bushpig *Potamochoerus larvatus*. A distal phalanx and an upper third molar retrieved from the sediments of BIB belong to the African buffalo *Syncerus africanus* (following Dusseldorp and Reynard, 2022); a cluster of five large long bones likely belonging to this species, and possibly to the same adult individual, was also collected from BIB. The presence of a tooth, a phalanx and long bones could suggest that at least the limbs and the skull of the same carcass were brought back to the rock shelter. Other large (class IV) bovid remains are rare in the assemblage (Table 12). With 19 identified remains, the blesbok/bontebok *Damaliscus pygargus* dominates the bovid sample. Remains that fall into the same size category (class size II) are also the most abundant (Table 12). Today, only the subspecies *Damaliscus pygargus phillipsi* (blesbok) occurs in KwaZulu-Natal, where it was reintroduced after becoming extinct due to intensive hunting. The second subspecies *D. p. pygargus* (bontebok) almost went extinct in the 19th century and is now restricted to a few protected areas with a population of less than 3000 individuals (Skinner and Chimimba, 2005). The remains from Holley Shelter could belong to either of these subspecies, which likely had a wide distribution across southern Africa until historical times. The specimens referred to *Damaliscus* sp. were too fragmentary to securely exclude an attribution to the slightly larger member of the genus, the Tsessebee *Damaliscus lunatus*, which is rare in the southern African region but was documented in northern KZN at the beginning of the 20th century (Skinner and Chimimba, 2005). Finally, two specimens are attributed to the grey rhebok *Pelea capreolus*.

Small amphibians were noted during sorting of the fine fraction, but reptiles and fish seem absent; not a single piece of tortoise shell or fish bone was collected. This contrasts with birds, which are well represented at Holley Shelter. Of particular interest, we would like to highlight the occurrence of the southern bald ibis *Geronticus calvus*, represented in the assemblage by 18 remains. The presence of 12 complete ulnare bones and four complete quadrate bones allows us to confidently identify these remains to *Geronticus calvus* rather than other members of the family, which include the glossy ibis *Plegadis falcinellus* and the hadeda ibis *Bostrychia hadedash*. We can also exclude the African sacred ibis *Threskiornis aethiopicus*, which was, until the 20th century, a winter visitor to the interior of southern Africa breeding only on offshore islands (Stark and Sclater, 1906). In recent times, it has taken advantage of extending farmland and other human modifications and now breeds regularly in the region (e.g., Sinclair et al., 2011). At Holley Shelter, at least two of the ibis ulnare bones belong to unfledged individuals. Besides ibises, francolins and pigeons are present. Francolins include several species found in KZN today and we did not attempt taxonomic identification of these specimens beyond genus level. Pigeons are represented in the area by the speckled pigeon *Columba guinea* and the African olive pigeon *Columba arquatrix*. The three pigeon specimens from AVA - a distal humerus, proximal coracoid and partial carpometacarpus - could belong to either of these taxa.

Small rodents are particularly abundant at Holley Shelter, with tens of thousands of cranial and post-cranial remains collected during the sorting of fine sediments from AVA, BIB and BIB Hearth. A detailed analysis of this material is ongoing under the lead of one co-author (SER).

As mentioned above, small mammals, ungulates and birds are present in the three units AVA, BIB and BIB Hearth, but their respective abundance varies markedly. Small mammals and birds are particularly abundant in unit AVA where they largely dominate the faunal spectrum. Neonate and juvenile individuals are also well represented in that unit: in the leporid sample, the MNI of nine includes two neonates, five juveniles and two adults; in the hyrax sample, the MNI of eight includes two neonates, one juvenile and five adults. The remains of southern bald ibises include at least three juveniles and four adults. While the

identified bovid sample from AVA comprises the remains of adult individuals only, the sample of non-identifiable bovid size class II includes 58% neonate (n = 16) and juvenile (n = 5) specimens.

#### 4.3.2. Abiotic and non-anthropogenic biotic modifications

Table 13 summarizes the information on the main bone surface modifications recorded on the sub-sample analyzed microscopically (n = 202). In this sub-sample, weathering had a limited effect on bone surfaces, with no visible differences between stratigraphic units and features. Most of the specimens (>70%) fall into stage 1, as defined by Behrensmeyer (1978). The occurrence of six remains from AVA, four from BIB, and one from BIB Hearth that show the deep cracks and exfoliation characteristic of weathering stage 4 does, however, indicate different rate of burial for some faunal specimens.

While weathering and root etching (see Table 13) are limited, bone surfaces are often poorly preserved because they have suffered from dissolution and/or corrosion. This modification occurs as pitting, with pits of different sizes, located both on the cortical and the medullar surfaces of bones. It was observed on ca. 50% of the sub-sample analyzed microscopically, with no apparent difference between stratigraphic units. It is unclear what might have caused bone dissolution at Holley Shelter; similar damage attributed to cave corrosion is documented for instance by Fernández-Jalvo and Andrews (2016). The humidity of the rock shelter due to the presence of the waterfall, and possible acidity of the soil related to fire activities, might be causal factors to consider despite the generally dry nature of Holley Shelter deposits.

Another common type of bone surface modifications observed at Holley Shelter is gastric acid etching produced by digestion of the faunal specimens (Table 13). Almost a third (29%) of the sample for which this information was recorded indicate some degree of acid etching. Evidence of digestion varies from light to heavy gastric acid etching. Here, there are clear differences between stratigraphic units. Most of the acid-etched specimens (n = 58) come from AVA, while a few only come from BIB (n = 12) and a single specimen from BIB Hearth. In AVA, BIB and BIB Hearth, the digested bones include the remains of neonate, juvenile and adult leporids and hyraxes, birds, including southern ibises, herpestids and baboons.

There is limited evidence for medium to large mammalian carnivore damage. Specimens with pits and punctures identified in AVA, BIB and BIB Hearth belong to small birds and small mammals – taxa which would have been destroyed if gnawed by large predators. Therefore, we exclude hyenas and/or leopards as contributing significantly to the faunal assemblage.

Pits, punctures and/or scores typical of damage caused by consumption by birds of prey were observed on 21 remains from AVA. The scores, in particular, are identical to those produced by the claws of

large, diurnal birds of prey as documented by Armstrong and Avery (2014). Five remains from BIB show tiny pits or punctures. In BIB however, no scores were observed and these small pits and punctures could result from small mammalian carnivores, such as mongooses, rather than birds of prey. The distinction between bone surface modifications produced by mammalian carnivores and birds of prey is not straightforward, but we suggest that the combination of pits, punctures, scores and acid etching observed on the material from unit AVA at Holley Shelter is most similar to avian damage.

#### 4.3.3. Evidence for anthropogenic modifications on the faunal remains

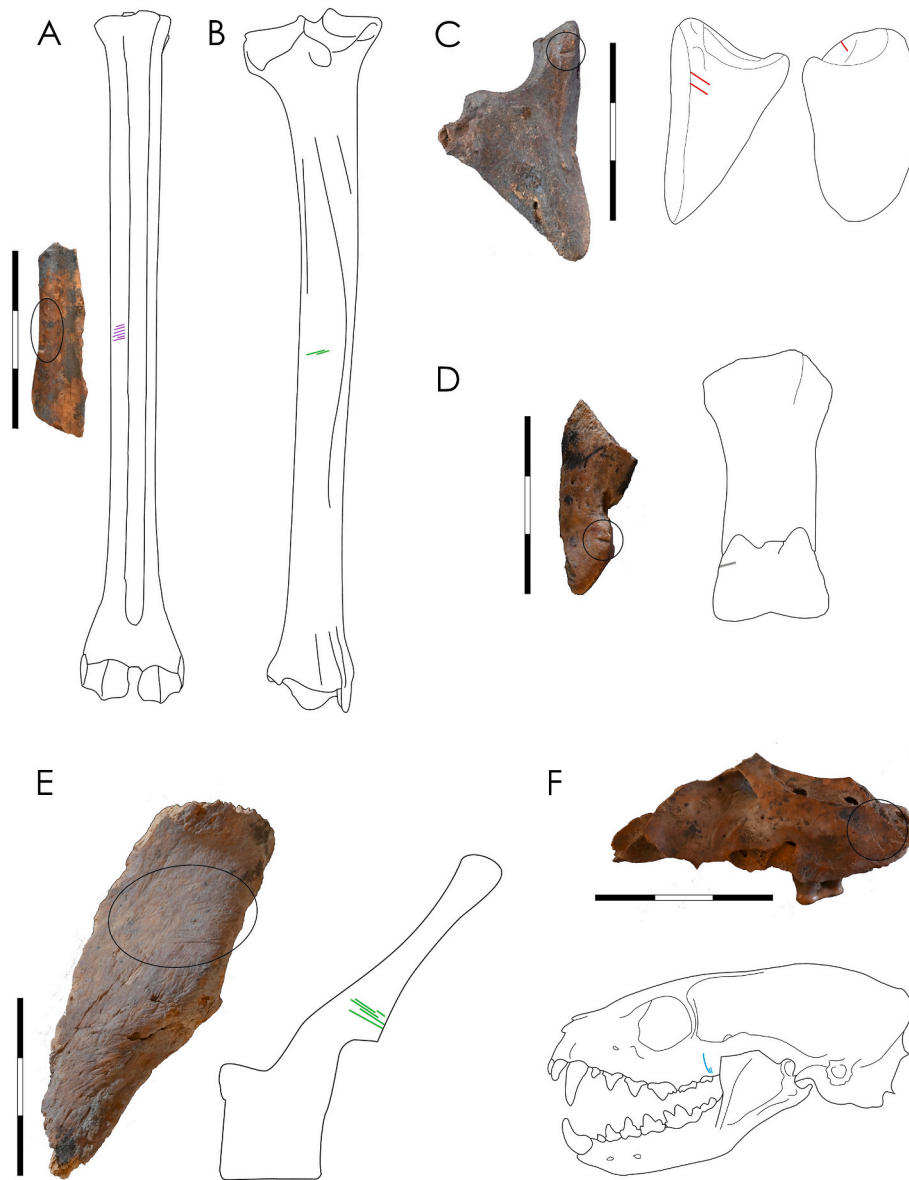
As pointed out above, dissolution and acid etching obscured some bone surfaces and, when combined with the high fragmentation rate of the faunal remains, this may result in an underrepresentation of butchery marks. However, within the sub-sample analyzed microscopically for bone surface modifications we identified 26 cut-marked remains, including five from AVA, 13 from BIB, and eight from BIB Hearth (Table 13). Interestingly, three of the cut-marked remains from AVA are distal phalanges of, respectively, a grey rhebok, a blesbok/bontebok, and a non-identifiable medium-sized ungulate. The fourth cut-mark specimen in AVA is an intermediate phalanx that belongs to a juvenile ungulate; the fifth cut-marked bone is the humerus shaft of a neonate of a non-identifiable small mammal. The location, length and orientation of the cut-marks on the second and third phalanges (Fig. 10) are consistent with those documented experimentally during the disarticulation of the limbs of red deer (Costamagno et al., 2019).

The cut-marked remains from BIB comprise several skeletal portions of medium and large ungulates, a fragmentary herpestid skull, and non-identifiable mammal flat and long bone fragments (Fig. 10). Within the ungulate sample cut-marks were observed on a rib shaft fragment, the spinous process of a thoracic vertebra, a proximal phalanx, a posterior fragment of the tibia shaft, a posterior fragment of metatarsal shaft, and a long bone (humerus/femur) shaft fragment. The anatomical location and orientation of the cut-marks on the thoracic vertebra, the posterior tibia and the long bone shaft fragment are consistent with defleshing. The cut-marks on the posterior metatarsal shaft are short, parallel and slightly oblique compared to the axis of the bone; they are similar to cut-marks produced experimentally during removal of the tendons of red deer (Costamagno et al., 2019). The single cut-mark on the proximal phalanx could also be related to tendon extraction but we cannot exclude other activities, including skinning or disarticulation. The cut-marks observed on the herpestid skull fragment are short, parallel and perpendicular to the zygomatic arch (Fig. 10). Comparison with experimental data on carnivore butchery (Crezzini et al., 2014; Val and Mallye, 2011) allows us to relate these cut-marks to skinning of this small carnivore.

**Table 13**

Summary of the main bone surface modifications observed on a sub-sample of 202 remains from AVA, BIB and BIB Hearth. The data is presented in numbers of remains and percentages of the number of remains in each given category, unless the sample sizes are smaller than 10 and percentages are meaningless. Small mam. = small mammals (i.e. leporids, hyraxes and small carnivores); small carn. = small carnivores (herpestids); diss. = dissolution; weath. >2 = weathering stages 3 or 4; cut-m. = cut-marks. The values in bold indicate the most frequent type of damage for each taxonomic grouping.

	Diss.	Weath. >2	Root etching	Trampling	Acid etching	Scores	Pits/Punctures	Cut-m.	N
AVA									
Small mam.	7 (18%)	2 (5%)	2 (5%)	2 (5%)	<b>25 (62.5%)</b>	–	6 (15%)	–	40
Ungulates	9 (26%)	4 (11%)	2 (6%)	4 (11%)	–	–	–	4 (11%)	35
Birds	–	–	–	2	<b>6</b>	1	2	–	9
Non-ident.	<b>15 (50%)</b>	6 (20%)	–	3 (10%)	3 (10%)	–	1 (3%)	1 (3%)	30
BIB									
Small carn.	–	–	–	–	1	–	–	1	3
Ungulates	<b>22 (85%)</b>	2 (8%)	1 (4%)	6 (23%)	–	–	1 (4%)	4 (15%)	26
Birds	–	–	–	1	1	–	<b>2</b>	–	4
Non-ident.	<b>8 (57%)</b>	6 (43%)	–	3 (21%)	1 (7%)	–	–	4 (28%)	14
BIB Hearth									
Birds	–	–	–	–	–	–	1	–	1
Ungulates	<b>15 (79%)</b>	3 (16%)	4 (21%)	10 (53%)	–	–	–	5 (26%)	19
Non-ident.	<b>9 (47%)</b>	–	1 (5%)	5 (26%)	–	–	–	–	19



**Fig. 10.** Anatomical position of some cut-marks identified on faunal remains from the Holley Shelter assemblage. Color code reads as follows: red cut-marks are interpreted as disarticulation marks, purple ones as tendon removal, blue ones as skinning, green ones as defleshing, and grey ones as undiagnostic. A) Bovid metatarsal (posterior view). B) bovid tibia (posterior view). C) Bovid third phalanx (picture: medial view; drawings: medial and dorsal views). D) Bovid first phalanx (palmar view). E) Bovid thoracic vertebra (lateral view). F) Mongoose skull (lateral view). The vectorized bones and skull are from [archaeozoo.org](https://archaeozoo.org).

The cut-marked specimens from BIB Hearth include seven medium bovids (class size II) and non-identifiable ungulate bones, and one non-identifiable mammal bone. The bovid remains comprise two rib fragments, a metapodial shaft fragment, and a possible radius shaft fragment. The non-identifiable ungulate remains comprise the spinous process of a vertebra, one long bone shaft fragment and one flat bone fragment.

We documented the breakage patterns (fresh/dry) for 355 edges of long bone fragments. These include 177 from AVA, 93 from BIB, and 85 from BIB Hearth. While we need to exert caution due to small sample sizes, it is worth noting the marked differences between stratigraphic units (Table 13). In particular, most long bones were broken in a green state in BIB Hearth, while most long bones from AVA were broken when already dry. In BIB, dry and fresh breakage patterns are almost equally distributed. The difference between the frequency of fresh breaks between AVA and BIB Hearth is statistically significant ( $\chi^2 = 22.89$ ;  $p$  value  $< 0.01$ ).

Table 14 below is a simplified presentation of the color-codes

attributed to all faunal remains to document burning patterns. It includes specimens for which one color only was detected. It excludes 32 specimens that presented two colors (for instance, dark brown and grey; unburnt and black) and it combines color information for both the outer and inner surfaces of bones, which explains the high numbers. The distribution of burning color-codes is similar between AVA and BIB, and, unsurprisingly, differs significantly in BIB Hearth. While the majority of

**Table 14**

Color-codes associated with burning for faunal remains from Holley Shelter. Data in number of specimens and percentage of samples considered.

	AVA	BIB	BIB Hearth
<b>unburnt</b>	<b>721 (69%)</b>	<b>404 (79%)</b>	<b>133 (59%)</b>
dark brown	275 (26%)	67 (13%)	35 (15%)
black	29 (3%)	15 (3%)	27 (12%)
grey	19 (2%)	21 (4%)	17 (8%)
white	2 (>1%)	2 (>1%)	14 (6%)
Total	1046	509	226

remains from all units are unburnt, burning has mostly affected the remains retrieved from BIB Hearth. Black, grey and white bones in particular, which are associated with prolonged and/or direct exposure to fire, are common in BIB Hearth ( $n = 58$  or 25% of the sample), while they are rare in AVA and BIB (see Table 14). Dark brown bones are distinct from clearly unburnt bones, but it is unclear whether their color is the result of burning or could relate to soil staining, for example.

The discovery of three bone retouchers in the faunal assemblage from Holley Shelter deserves a special mention here (Fig. 11). During inspection of bone surface modifications, we identified a concentration of pits and sub-parallel, oblique scores on three shaft fragments of ungulate long bones (specimens 585a, 816, and 702.52). We attribute these modifications to the use of the bones in the context of lithic retouching activities. Two specimens come from the sediments of BIB Hearth, while a third comes from the surrounding sediments of BIB. The three retouchers come from the same square. Specimen 585a is a shaft fragment of a long bone (possibly a tibia) of a large bovid (class size III). It measures 72 cm in length and the maximum cortical thickness is 7 mm. The bone is unburnt and no cut-marks were observed. The proximal edge seems to have been broken while fresh. Specimen 816 is the proximal, anterior portion of a large (class size III) ungulate tibia, which measures 67 cm in length for a cortical thickness of 7 mm, and it shows both proximal and distal broken edges characteristic of green fracture. No cut-marks were observed on this specimen and the bone is unburnt. Specimen 702.52 is a small fragment of class II bovid metacarpal shaft that was retrieved during sorting. It measures 27 mm in length and the maximum cortical thickness is 3 mm. The angle, shape and texture of the broken distal edges are characteristic of a green fracture. Some post-depositional corrosion has affected the morphology of the proximal edge (see Fig. 11) and it is therefore difficult to characterize the breakage pattern. There are no other butchery marks on the specimen, which is also unburnt.

#### 4.4. Ochre

In addition to evidence from the stone tools and faunal remains, we identified a rich assemblage of earth mineral pigments (Fig. 12), commonly referred to as ochre. A total of 690g of ochre fragments were found during the sieving process of Layer AVA and BIB. Overall, 53

pieces were piece-plotted because of their size ( $>2$  cm) or due to signs of secondary modification. Eleven stone artifacts, all from layer BIB, exhibit ochre stains. Four of those pieces are retouched tools. One of these tools (Fig. 13) can best be described as a backed knife with a proximal tang. The right lateral edge is backed steeply, whereas the opposing left lateral edge is sharp. The proximal tang is also backed steeply and provides ochre residues. No detailed analysis of the ochre assemblage has taken place to date but detailed studies incorporating provenance and functional analysis will be conducted in the near future.

#### 4.5. Spatial distribution and site use patterns

In his original excavations, Cramb (1961) noted the absence of any clear stratigraphy in the larger excavation area at Holley shelter and described the deposits as a “confused mass of ash and dust” (Cramb, 1961, p. 45). For this reason, he decided to excavate the “larger habitable area” of the site in artificial spits of 6-inch thickness. Regarding potential spatial structure preserved at the site, Cramb’s field notes, gratefully transcribed by Val Ward from the Natal Museum in the 1990s, clearly indicate distinct squares and spits with larger concentrations of artifacts associated with anthropogenic hearth features, whereas other areas – without identified hearths – had limited evidence for human activity. We conclude that Cramb had a decent understanding of the site’s stratigraphy despite publishing only a simplified version.

Our new excavations confirm some of Cramb’s observations. Layer AVA at the top of the sequence is characterized by relatively low numbers of artifacts but large amounts of microfauna and small mammals, most likely accumulated by birds of prey. The micromammal assemblage is currently undergoing detailed taxonomic and taphonomic analysis (by SER) and suggests that several diurnal and/or nocturnal birds of prey occupied the rock shelter simultaneously or alternatively. Two large diurnal birds of prey in particular occur in the area today and prey on animals similar to those retrieved from layer AVA: the martial eagle *Polemaetus bellicosus* and the crown eagle *Stephanoetus coronatus* (Boshoff and Avery, 1990; Boshoff et al., 1994). While a comprehensive taphonomic analysis of the complete faunal assemblage from Holley Shelter is pending, we suspect that crowned eagles are the most likely accumulators of the macrofaunal remains in AVA. Crowned eagles are still nesting on the farm today and spotted regularly. They feed mostly



Fig. 11. Bone retouchers from units BIB and BIB Hearth at Holley Shelter. The scale is 2 cm.

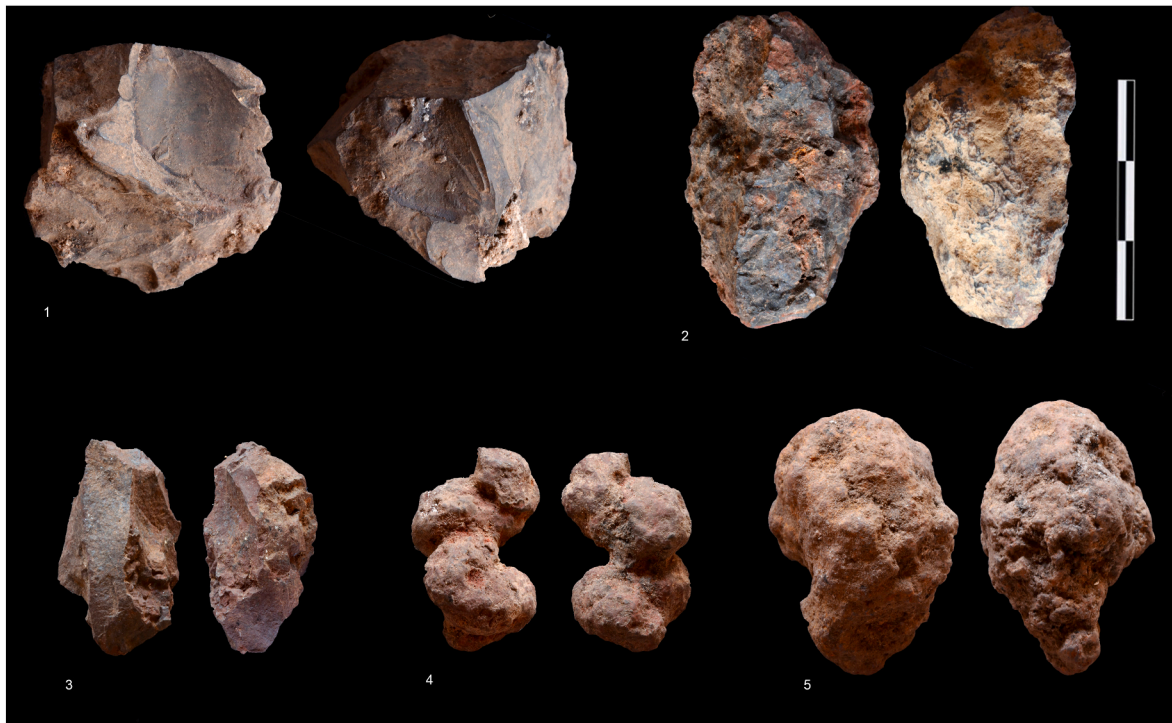


Fig. 12. Ochre finds from AVA and BIB. Numbers 1 and 3 show evidence of knapping.



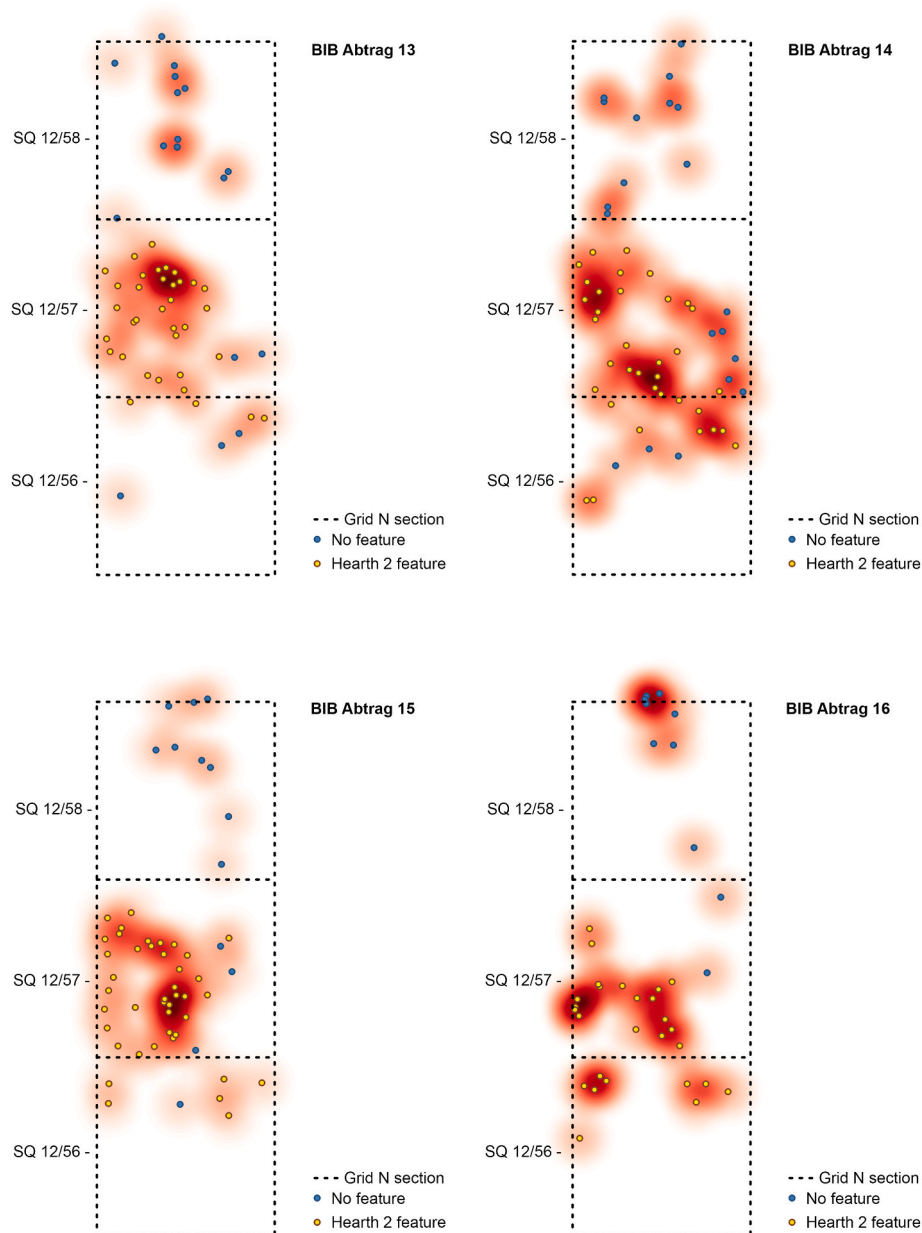
Fig. 13. Stemmed backed knife from layer BIB at Holley Shelter. Left = original. Right = visibility of red ochre stains enhanced using aDStretch and YBK filter.

on mammals and, to a much lesser extent, birds and reptiles, with locally marked preferences for hyraxes (both adults and juveniles), small wild bovids (mostly neonates and juveniles), mongooses, leporids, and ibises (Boshoff et al., 1994). At Holley Shelter, the macrofaunal assemblage from AVA is consistent with the preferred prey of crowned eagles locally, i.e. on Fountainhill Estate (Tammy Caine, pers. comm. 2024). The bone surface modifications (light to moderate acid etching, scores, pits and punctures) and fragmentation intensity in these deposits are similar to those documented for other species of diurnal birds of prey (Armstrong and Avery, 2014; Bocheński et al., 1997). Local experts who regularly survey the estate for conservancy purposes categorically

exclude Holley Shelter as a suitable nesting site for martial eagles (Tammy Caine, pers. comm. 2024). The geographic situation of the cliff at Holley Shelter, at the end of a densely wooded gorge, is particularly well-suited for crown eagles, which thrive in forested habitats (e.g., Boshoff et al., 1994).

The underlying layer BIB is characterized by massive amounts of ash and charcoal, which result from several intertwined hearths. The higher frequency of stone tools, the more frequent presence of cut-marked faunal remains, and the evidence for fresh breakage and burning all indicate a higher input of human activity compared to AVA. The average find density of lithics in BIB ( $2465 \text{ n/m}^3$ ) is about twice as high as in AVA ( $1203 \text{ n/m}^3$ ), whereas the weight of microfauna in AVA is more than five times higher than in BIB (AVA =  $1250 \text{ g/m}^2$ ; BIB =  $224 \text{ g/m}^3$ ). Within layer BIB, the hearths are associated with comparatively rich find accumulations as shown in Fig. 14, suggesting the formation and preservation of discrete activity zones within a general background of non-anthropogenic sedimentation. Geoarchaeological investigations currently underway will help to clarify the nature of these hearth features. In particular, these studies will investigate whether the aforementioned hearths are *in situ* fireplaces or rather episodes of hearth raking and ash dumping, such as at Sibhudu Cave (Goldberg et al., 2009).

Another observation made on Crumbs lithic assemblage was the surprisingly low number of small debitage, which total only 15% of the collection. This was previously interpreted as the result of a biased sampling strategy (Bader et al., 2015). Our new excavations revealed a slightly different situation. About 40% of all pieces in AVA and BIB are small debitage (<2 cm). This is still a relatively low value compared to other contemporary MSA assemblages in the region. Comparative values for the frequencies of small debitage include: >90% in the Sibhudu layers at Sibhudu (Will et al., 2014), 73% in the final MSA layer GH7 at Umbeli Belli (Bader et al., 2018), and 61% in the final MSA Stratum 5 at Sibebe in Eswatini (Bader et al., 2022a). Holley Shelter thus exhibits much less small debitage than other MIS 3 assemblages from the same region – particularly when compared to rich palimpsests and residential sites. This suggests differences in regard to on-site knapping and site function between Holley Shelter and other sites. These observations fit



**Fig. 14.** Density plot of Abtrag 13, 14, 15 and 16 in layer BIB. Yellow dots indicate finds from the Hearth feature, blue dot outside the hearth. Heat map clearly indicates higher find densities within the hearth.

with our findings regarding on-site lithic reduction sequences and their emphasis on distal stages at Holley Shelter as exemplified by the abundant amounts of discarded tools (e.g., frequent splintered pieces) and the evidence for retouching and resharpening, particularly on the most frequent material type which is hornfels. The small and heavily reduced cores recovered also suggest the specific production of small blades and bladelets, some by recycling or re-purposing other blanks as cores (burins).

## 5. Discussion

Our new multidisciplinary findings from Holley Shelter allow us to address several questions that remained open following previous work at the site and touch upon issues regarding behavioral variability towards the end of the MSA in southern Africa. Firstly, our data provide new insights into the occupation history, site function and chronological position of Holley Shelter itself. These results also concern the quality of

past excavations by Cramb and the validity of our previous interpretations of the 1950s assemblages. Secondly, we can integrate our new data on the lithic assemblages and behavioral patterns at the site during late MIS 3 with those from other sites in the region such as Sibhudu, Umbeli Belli and Umhlatuzana, as well as sites located further away like Grassridge, Waterfall Bluff and Strathalan B, to gain a better understanding of spatio-temporal patterns and the regional chrono-cultural sequence. Finally, the combination of lithic, faunal and contextual data allows us to explore the underlying drivers of behavioral patterns seen at Holley Shelter and the end of the MSA in southern Africa broadly. Crucially, the preservation of organic remains (*i.e.* microfauna, macrofauna, and charcoal) alongside a rich assemblage of cultural artifacts at Holley Shelter allows us to propose preliminary reconstructions of the palaeohabitats at the site during the final MSA and to discuss the nature of human interaction with local environments and associated resources.

### 5.1. Occupation history and site function of Holley Shelter during the final MSA

As a result of our new excavations, we can confidently state that Cramb conducted a reasonable excavation at Holley shelter, despite having never been trained as a professional archaeologist and especially given the general state of archaeological research in the 1950s. In terms of stratigraphy and stone tool technology, we can confirm nearly all observations made by Bader et al. (2015) on the legacy assemblage from the top of the sequence (Crambs inches 0–12), including a very high percentage of retouched tools and splintered pieces and a focus on laminar blanks. The admirable manner in which the 1950s artifacts were curated and labeled supported the valid reconstruction of the general stratigraphic succession at the site and the spatial distribution of on-site activities even 70 years after the initial excavations.

With the data presented herein, we can propose further-reaching interpretations on site function and the occupation history of Holley Shelter compared to previous work. The first chronometric ages for the site demonstrate that occupations took place over a narrow timeframe between ~36–34 ka cal BP towards the end of MIS 3 and the end of the MSA, more generally. The clustering and coherence of the twelve C14 ages underlines the stratigraphic integrity of the site and make the upper deposits at Holley Shelter one of the best-dated Late Pleistocene MSA occupations in southern Africa. Unlike Crambs published field observations, our new excavations reveal finely laminated sedimentary deposits accumulated through various anthropogenic and geogenic inputs. However, our new observations do confirm the finding from the previous excavations that evidence for human presence at the site is concentrated in distinct zones, mostly around hearth features. Other areas of the site explored in both Crambs and our excavation contain limited numbers of artifacts (Fig. 14). Instead of large palimpsests of archaeological assemblages and a seemingly random distribution of anthropogenic finds and features, we observe discrete zones of find densities and activities within and across strata. This suggests that discrete pulses of human presence were characteristic for Holley Shelter.

The occupation history, site function and the nature of the artifact distribution at Holley Shelter appear different from those of nearby sites. Contemporaneous archaeological units at Umbeli Belli (Bader et al., 2018), Sibhudu (Bader et al., 2022c; Wadley, 2005b) and Sibebe (Bader et al., 2022a) are characterized by high artifact densities with large numbers of small debitage and shaping flakes. Combined with the evidence for mostly complete lithic reduction sequences, the lithic assemblages from these sites point towards intense and frequent site occupations, suggesting these locals may have functioned as residential sites. Layers AVA and BIB at Holley Shelter have comparatively low numbers of artifacts in general, more fragmented reduction chains and significantly lower amounts of small debitage. The strong dominance of hornfels and high percentages of secondary modified tools – including splintered pieces in particular – combined with low numbers of retouched flakes is also specific to Holley Shelter. The local hunter-gatherers brought many blanks and retouched tools in finished stages to the site and either discarded them or occasionally re-sharpened and re-cycled them (e.g., as bladelet cores). Furthermore, we can now show that in addition to hornfels, local Natal sandstone was frequently knapped at the site. This was previously overlooked by Cramb, however sandstone artifacts are notoriously difficult to identify even in modern excavations (see e.g., Will, 2021). The frequent choice of sandstone to produce (mostly unretouched) flake blanks is an interesting aspect of the raw material economy of the knappers at Holley Shelter. It indicates an opportunistic, ad-hoc knapping strategy to supplement the higher-quality, non-local hornfels.

The lithic assemblages, find densities, and spatial distributions at Holley Shelter point towards multiple pulses of short-term occupation. The faunal assemblage adds to this picture by suggesting ephemeral occupations in AVA with only limited anthropogenic accumulation. Stratigraphic unit BIB, and in particular the feature BIB Hearth, show

clear signs of human impact on the recovered faunal remains – including the occasional use of bones as retouchers. Overall, the faunal assemblage from Holley Shelter primarily documents the hunting, transport and butchery of complete carcasses of medium-sized bovids, including neonates and juveniles. Interestingly, the cut-marks observed on the mongoose skull document additional butchery activities, namely the skinning of a small carnivore. While this does not preclude the consumption of this animal for its meat, a few examples in the archaeological record of South Africa illustrate non-nutritional functions associated with herpestids (Parkington and Fisher, 2006).

The animal species identified in the faunal samples from AVA and BIB document a predominance of open grasslands around Holley Shelter during MIS 3. The ungulate assemblage is dominated by medium to large grazers, including the blesbok/bontebok, zebra, warthog and buffalo (Skinner and Chimimba, 2005). Bald ibises also inhabit open grasslands where, as obligate cliff nesters, they favor rocky areas, valleys and canyons in the proximity of water (Pavia et al., 2017; Sinclair et al., 2011). The occurrence of unfledged birds in the bald ibis sample indicates the presence of a breeding colony at the site. The grey rhebok, while predominantly a browser, occupies rocky cliffs and favors the open grassy slopes in mountainous areas (Skinner and Chimimba, 2005). Hunter-gatherers at Holley Shelter seem to have selected locally available prey. While the ungulate prey spectrum is typical of cohorts occurring in open grasslands, it is interesting to note the absence of black wildebeests in the assemblage. Black wildebeests are large grazers, often found in association with zebras and smaller grazing antelopes such as blesboks and bonteboks. Historically they thrived in the open grasslands of the central southern African plateau, where Holley Shelter was located. Black wildebeests do not occur on the Fountainhill Estate today, but several herds of blue wildebeests are present. We are of course aware of the possible effect the small assemblage size, the limitations of specific identification (there are several non-identified bovids class size III in the assemblage), and of the possibility of human choice deliberately excluding this prey item. We would like, however, to propose an additional hypothesis to explain why this taxon was not detected in the faunal assemblage. Black wildebeests are restricted in their movements today due to human presence and modern agriculture, but Skinner and Chimimba (2005) indicate that past populations likely experienced local movements or even migration in the search for better grazing grounds. The presence of blesbok/bontebok neonates in the largely anthropogenic layer BIB could point towards a summer occupations of Holley Shelter. We propose that the absence of wildebeests in the faunal assemblage likely reflects their absence in the environment during the summer when they might have migrated northwards into the sub-Escarpment Grassland. Their presence is noted at two sites within this biome during MIS 3, Grassridge Rockshelter and Strathalan B (see below).

The numerous splintered pieces further allude to a specific site function. These pieces have been identified in several other MSA assemblages, such as the Howiesons Poort (Langejans, 2012) and Sibhudu assemblages (Conard and Will, 2015) of Sibhudu and in several layers at Umhlatuzana (Kaplan, 1989). To the best of our knowledge, however, there are no other MSA sites in southern Africa where these pieces are the most distinct feature and exceed (by far) all other tool categories. In a functional study, Langejans (2012) showed that the Howiesons Poort specimens from Sibhudu are related to animal processing. Currently all splintered pieces from AVA and BIB at Holley Shelter are being analyzed for use wear and residues. This work should reveal the function(s) of the pieces, inform discussions on their use as tools and/or as cores, and add significant details to our understanding of site function at Holley Shelter at the times when these artifacts were particularly abundant.

The high amount of ochre found in AVA and BIB at Holley Shelter provides further evidence for multidimensional use of the site beyond a singular function, such as an occasional hunting camp. The MSA inhabitants predominantly collected red ochre, which sometimes bears secondary modifications in the form of rubbing or scraping.

Furthermore, we have observed macroscopic traces on several stone artifacts (Fig. 13). This conforms with Wadley's observations at Sibhudu (Wadley, 2005a; Wadley et al., 2004) that ochre might have played a practical role as a loading agent for adhesives used for the hafting of various domestic and hunting tools. Ochre can have multiple other functional purposes as well, including use as sunscreen (Hodgskiss, 2020; Summers et al., 2014), mosquito repellent (Rifkin, 2015) and for tanning hides (Rifkin, 2011). Ochre is known to have symbolic value in traditional societies (e.g., for gender differentiation [Tönjes, 1996] or as a placeholder for blood and a connection to the ancestors [Forrester, 2020]). Geometrically engraved ochre pieces from MSA contexts (e.g., Blombos Cave [Henshilwood et al., 2009] or Klein Kliphuis [Mackay and Welz, 2008]) strongly imply a symbolic value for this material in the past. The painted stone slab from Apollo 11 in Namibia (Wendt, 1976) further implies that the tradition of rock painting in southern Africa has its roots in the MSA. Numerous faded rock paintings were found at Holley Shelter indicating that the place attracted people wishing to perpetuate their stories, rituals and experiences on the walls, at least during more recent times.

Based on the currently available evidence, Holley Shelter constituted an attractive place for hunter-gatherers during the MSA and was repeatedly visited during late MIS 3 for the carrying out of multiple activities. With the current data we can exclude interpretations of Holley Shelter as a central residential gathering site or long-term base camp for a large group of people or year-round occupation. In direct comparison to other MSA shelter sites in KZN, Holley Shelter appears to reflect rather short-term and potentially seasonal and special-purpose occupations that could be influenced by its particular ecological position (see below). Ongoing studies on the function of the splintered pieces, micromorphology and additional spatial analyses, alongside ongoing detailed examination of the microfaunal remains, will be crucial to further refine our interpretations of the site occupation history and function.

## 5.2. Holley Shelter in the regional context of the end of the MSA in southern Africa

One of the key achievements of our new excavations at Holley Shelter is absolute chronometric dating of the site using AMS  $^{14}\text{C}$  dating. In combination with the excavation of a controlled sample of lithic and faunal material, this allows Holley Shelter to be integrated into the regional context of late MIS 3 archaeology in southern Africa and the opportunity to re-evaluate previous interpretations based on the legacy collections. At the time of the reexamination of the Cramb assemblage in 2015, no absolute ages were available. Based on a techno-typological comparison with other, well dated sites in the region such as Sibhudu (Conard and Will, 2015; Will et al., 2014) we suggested that the assemblages at Holley Shelter belong to an early phase of MIS 3. We considered the high numbers of unifacial points, showing strong similarities with the Ndwedwe tools of Sibhudu (Conard et al., 2012) as well as platform cores and similarities in raw material economy with Sibhudu to be characteristic of the assemblage. The unexpectedly high number of splintered pieces in the upper layers was interpreted as a sign of regional, site-specific adaptation. Our new excavations with a set of twelve finite radiocarbon ages show that we were wrong, and Cramb was correct when he assumed that the assemblage from Holley Shelter represent a "final expression of the Middle Stone Age in the area" (Cramb, 1952, p. 186). The ages of Layers AVA and BIB at  $\sim 36\text{--}34$  ka cal BP overlap with other final MSA assemblages in the wider region, including Umbeli Belli (Bader et al., 2018; Bader et al., 2022c), Umhlatuzana (Kaplan, 1990; Sifogeorgaki et al., 2020), Sibhudu (Wadley, 2005b) and Sibebe (Bader et al., 2022a; Price Williams, 1981).

The evidence from both lithic and faunal remains from Holley Shelter presented herein differs significantly from the final MSA assemblages of Sibhudu, Umbeli Belli, and Sibebe. Recent research has demonstrated that lithic assemblages from Sibhudu dated to  $\sim 38$  ka and from Umbeli Belli dated to  $\sim 29$  ka are largely similar (Bader et al.,

2022c). A contribution on the updated OSL chronology for Umbeli Belli is currently in preparation (Tribolo et al., in prep.), and provides new ages for the final MSA occupation at this site of between 43–33 ka. These new ages position these layers as contemporaneous with layers Co–Es at Sibhudu and layers AVA and BIB at Holley Shelter. The final MSA assemblages from Sibhudu and Umbeli Belli are characterized by an intense focus on bifacial and unifacial shaping technology, basal thinning of pointed tools, a distinct platform core reduction strategy described as "final MSA cores" and the presence of hollow based points and segments (Bader et al., 2022c). Blade and bladelet production occur at both sites but is not a defining feature. The final MSA assemblage from Stratum 5 at Sibebe in Eswatini, dating to between  $\sim 37\text{--}27$  ka cal BP, provides the same features but in the absence of hollow-based points and segments (Bader et al., 2022a). The assemblages from AVA and BIB at Holley Shelter share few features with these sites. Blank production is much more oriented towards laminar products, whereas bifacial tools, shaping debitage and hollow based points are absent. Unlike the numerous, often triangular points with basal thinning at Umbeli Belli, Sibhudu and Sibebe, the points from Holley Shelter are made on thick, elongated blades with faceted platforms. The characteristic and abundant splintered pieces at Holley Shelter occur only in small numbers at other sites. Furthermore, Holley Shelter exhibits a very distinct core technology to produce bladelets not detected at the comparative sites, which instead include burins and other core on flake reduction systems.

Broadening our comparative framework to the south, another site with contemporaneous occupation to Holley Shelter is Grassridge Rockshelter, located in the interior grassland of the Eastern Cape Province. The MSA assemblages of the site were dated to between 27.8–28.6 and 39.4–42.4 ka cal BP (Ames et al., 2020). The description of the lithic technology remains provisional and information on core technology is missing (Collins and Ames, 2023; Opperman, 1988). The lithic assemblage at Grassridge seems to be characterized by unretouched blades and points with plain platforms and a small component of retouched pieces (<2%) (Collins, 2013). Similar to Holley Shelter, no hollow based points or bifacial tools have been reported. While Holley Shelter is characterized by high tool components and large numbers of splintered pieces (which are not evident at Grassridge), these two assemblages may share more similarities in comparison with the coastal sites of KZN. Further west, Strathalan B cave is situated in the grassland of the Drakensberg foothills of the Eastern Cape and was dated to between 26281–27270 and 33125–34327 cal. BP (Opperman, 1996; Opperman and Heydenrych, 1990). The MSA lithic assemblages appear to be very similar to those described from Grassridge. Hornfels is the most frequent raw material and flakes and blades with plain platforms are most common. Again the proportion of retouched pieces is low and no bifacial technology or hollow based points were observed. Flakes and blades were retouched exclusively on the dorsal side. Furthermore, Opperman (1996) describes multi-platform and single platform cores as dominant. Again, these observations overlap in several aspects with the material from Holley Shelter with the exception of the high tool component and the frequent splintered pieces mentioned above. Waterfall Bluff on the eastern Pondoland coast may further increase the resolution of the final MSA chrono-cultural sequence as it features a well-dated sequence for the late Pleistocene and Holocene (Fisher et al., 2020). Unfortunately, there is currently no information on the lithic material from the relevant MIS 3 layers. In conclusion, the inland sites of the savanna and grassland biomes, with the exception of Sibebe, seem to share several similarities with each other, whereas sites in the Coastal Forest Biome closer to the Indian Ocean differ strongly.

Importantly, the new findings from Holley Shelter allow us to go beyond comparisons of lithic technology and include behavioral patterns obtained from faunal remains. With the notable exception of Sibhudu Cave (Collins, 2016; Collins, 2013), faunal remains are not preserved in the MIS 3 assemblages of the aforementioned contemporaneous sites within the region (i.e., Umbeli Belli, Umhlatuzana and Sibebe). In order to draw comparisons with the material described

herein, we need to enlarge the scope and include several sites in the broader region that preserve sub-contemporaneous faunal assemblages: Strathalan B (Opperman, 1996; Opperman and Heydenrych, 1990), Grassridge Rockshelter (Opperman, 1988), and Border Cave (Klein, 1977; Stratford et al., 2022). Table 15 and Fig. 15 provide a comparison between the ungulate taxa identified from the different assemblages. For this comparison, we have only included MNI values for taxa identified to species, genus or family (e.g., Alcelaphini) and excluded MNI values for non-identifiable bovids and ungulates due to the heterogeneity of information published. We made one exception for Grassridge, which has a small sample size with limited taxonomic identifications. In that case only, we included the small (class I), and small-medium (class II) bovid individuals as separate taxa. At Sibhudu, Strathalan B, Grassridge and Border Cave, hunter-gatherers have primarily focused on locally available and abundant resources. Furthermore, the ecological setting seems a key element in explaining the composition of the faunal spectra. The differences observed between faunal assemblages seem to firstly reflect distinct ecological conditions and, to a lesser degree, differences in site function(s). It is therefore unsurprising that the faunal assemblage with a taxonomic composition most similar to that of Holley Shelter comes from Strathalan B (Opperman, 1996; Opperman and Heydenrych, 1990), a site located at the foothill of the Drakensberg Mountains, in the

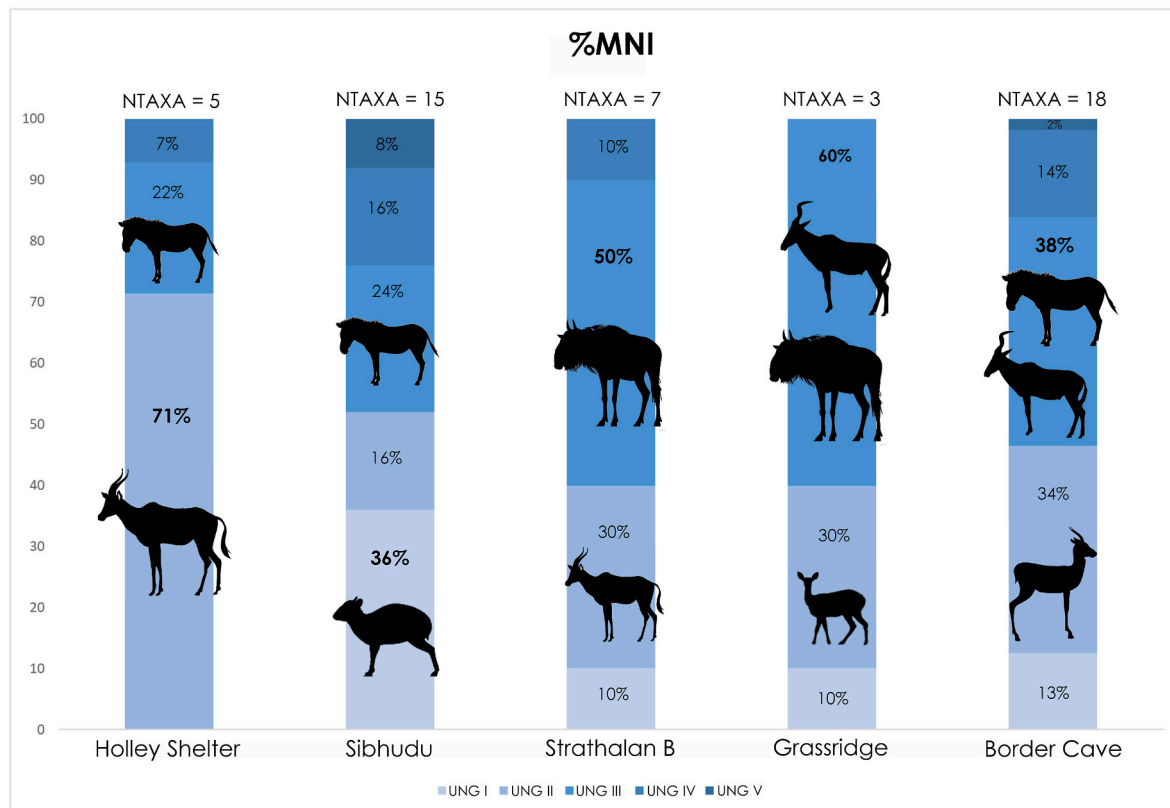
sub-escarpment grassland. There, humans have focused on medium to large ungulates associated with open grasslands. The analysis of the faunal remains retrieved from ongoing excavations at another locality in the sub-Escarpment grassland, Grassridge Rockshelter (Ames et al., 2020; Collins et al., 2017) is under way, and there are available data on the collections made by Opperman (1988). While the sample is small, it is interestingly dominated by large bovids (class size III) associated with open grasslands, including hartebeest or/and wildebeest. Opperman also suggested the possibility of a seasonal occupation at Grassridge, consistent with the migration of these ungulates in the area. As mentioned above, the faunal assemblage from Holley Shelter is dominated by smaller grazers, in particular blesboks/bonteboks, while larger alcelaphines are absent. Like Strathalan B, Grassridge provides evidence for the occurrence of abundant wildebeest and hartebeests in the region during MIS 3. Further work is required on larger faunal assemblages to investigate the possibility that migratory movements of large alcelaphines were perhaps paralleled, in this region, by the seasonal movements of people.

Sibhudu Cave, while only ~70 km away from Holley Shelter, is located in the subtropical Indian Ocean Coastal Belt Biome and the heavily forested habitat surrounding the site largely explains the hunters' preference for small ungulates thriving in this habitat,

Table 15

Ungulate taxa identified from the late/final MSA (MIS3) deposits at Holley Shelter (this study), Sibhudu Cave (Collins, 2016), Grassridge (Opperman, 1988), Strathalan B (J.Brink in Opperman, 1996), and Border Cave (Klein, 1977). The data is presented in MNI. When several stratigraphic units were assigned to the final MSA, we combined the MNI values for those units (e.g. units SWA and VBP at Strathalan B; units 2BS and 2WA at Border Cave; units GS, VGS, KGS at Grassridge).

Species	Vernacular name	Holley Shelter	Sibhudu	Grassridge	Strathalan B	Border Cave
<i>Loxodonta africana</i>	African elephant	–	1	–	–	–
<i>Hippopotamus amphibius</i>	Hippopotamus	–	1	–	–	–
Rhinocerotidae gen. et sp. indet.	Rhinoceros	–	–	–	–	1?
EQUIDS						
<i>Equus cf. capensis</i>	Giant Cape horse	–	–	–	–	1
<i>Equus quagga</i>	Plains zebra	–	4	–	–	–
<i>Equus cf. burchelli</i>	Burchell's zebra	–	–	–	–	5
<i>Equus sp.</i>	Zebra	3	–	–	1	–
SUIDS						
<i>Phacocoerus africanus</i>	Warthog	1	2	–	–	3
<i>Potamochoerus porcus</i>	Bushpig	–	–	–	–	1
Suidae indet.		1	–	–	–	5
BOVIDS						
BOVIDS IV						
<i>Syncerus africanus</i>	Buffalo	1	2	–	–	5
<i>Tragelaphus oryx</i>	Eland	–	1	–	1	2
<i>Megalotragus priscus</i>	Giant hartebeest	–	1	–	–	–
BOVIDS III						
Alcelaphine indet.	Hartebeest/Wildebeest	–	1	6	–	–
<i>Alcelaphus buselaphus/Damaliscus lunatus</i>	Hartebeest/Bastard Hartebeest	–	–	–	–	7
<i>Kobus ellipsiprurnus</i>	Waterbuck	–	1	–	–	–
<i>Hippotragus spp.</i>	Sable/Roan antelope	–	–	–	1	3
<i>Connochaetes gnou</i>	Black wildebeest	–	–	–	3	–
<i>Connochaetes taurinus</i>	Blue wildebeest	–	–	–	–	3
<i>Tragelaphus strepsiceros</i>	Greater kudu	–	–	–	–	2
<i>Tragelaphus angasi</i>	Nyala	–	–	–	–	1
BOVIDS II						
<i>Damaliscus pygargus</i>	Blesbok/bontebok	5	–	–	2	–
<i>Damaliscus sp.</i>		1	–	–	–	–
<i>Aepyceros melampus</i>	Impala	–	–	–	–	2
<i>Antidorcas marsupialis</i>	Springbok	–	–	–	1	–
<i>Antidorcas bondi</i>	Bond's springbok	–	–	–	–	6
<i>Redunca cf. arundinum</i>	Southern reedbuck	–	1	1	–	–
<i>Redunca fulvorufula</i>	Mountain reedbuck	–	–	–	–	2
<i>Redunca sp.</i>		–	1	–	–	–
<i>Pelea capreolus</i>	Grey rhebuk	2	–	–	–	–
	Bovid II indet.	–	–	2	–	–
BOVIDS I						
<i>Raphicercus campestris</i>	Steenbok	–	2	–	–	3
<i>Ourebia ourebi</i>	Oribi	–	–	–	–	2
<i>Oreotragus oreotragus</i>	Klipspringer	–	1	–	1	2
<i>Cephalophus natalensis</i>	Red duiker	–	1	–	–	–
<i>Philantomba monticola</i>	Blue duiker	–	5	–	–	–
	Bovid I indet.	–	–	1	–	–



**Fig. 15.** Distribution of ungulates according to class sizes in the MIS 3 faunal assemblages from Holley Shelter (this study), Sibhudu Cave (Collins, 2016), Grassridge (Opperman, 1988), Strathalan B (J. Brink in Opperman, 1996) and Border Cave (Klein, 1977). The data is presented in percentages of the MNI. The number of taxa (NTAXA) is the number of ungulate taxa identified from those assemblages (same references).

specifically the blue duiker. Collins (2016) suggests that in parallel to an acquisition strategy targeting these small forest-dwellers, a distinct hunting strategy was employed focused on larger grazing ungulates associated with more open habitats found further inland. The noticeable presence of hippopotamus remains at Sibhudu documents the development of marshy areas (Collins, 2016), likely associated with the uThongati River, during MIS 3. The development of two distinct hunting strategies, the clear anthropogenic origin of most faunal remains (Collins, 2013), combined with geoarchaeological and lithic signals from the MIS 3 occupations at Sibhudu, point towards repeated and somewhat more intensive occupations of the site compared to Holley Shelter.

At Border Cave, two sub-contemporaneous faunal assemblages were retrieved, respectively, from previous excavations and analyzed by R. Klein (1977), and ongoing excavations (Backwell et al., 2023; Backwell et al., 2018) analyzed by Stratford et al. (2022). The latter sample only comprises 13 remains and we will therefore base our comparison on the much larger sample described by Klein (1977). The faunal assemblage collected from the distinct stratigraphic units attributed to the MSA 3 is larger than at the other sites, which likely explains the greater taxonomic richness and diversity (18 ungulate taxa identified). At Border Cave, the rocky environment of the site and its location within the wooded habitats of the Lebombo Mountains is illustrated by the presence of several small and mostly solitary bovids, including the oribi, klipspringer, steenbok and mountain reedbeek. Grazing taxa including the extinct springbok *Antidorcas bondi*, alongside the large water-dependent African buffalo which are also well represented (Table 15).

To sum up, Holley Shelter cannot be assigned to the classic “Eastern Final MSA” that was proposed recently (Bader et al., 2022c) in terms of lithic technology and typology. Holley Shelter also differs drastically from and postdates the so-called Early LSA assemblages at Border Cave

(Beaumont et al., 1978; Villa et al., 2012), therefore adding another landmark supporting the late persistence of MSA technologies in southern Africa together with Strathalan B (Opperman, 1996), Rose Cottage Cave (Clark, 1997a, b), Umbeli Belli (Bader et al., 2016; Bader et al., 2018; Bader et al., 2022c; Blessing et al., 2022), Sibhudu (Wadley, 2005b), Umhlatuzana (Kaplan, 1989, 1990; Sifogeorgaki et al., 2020) and Sibebe (Bader et al., 2022a, Price Williams, 1981). The lithic and faunal remains from Holley Shelter highlight the marked variability of cultural expressions and behavioral strategies in the time between roughly 40–30 ka. These findings cast doubt on using a single “final MSA” label for all assemblages falling into this timeframe for southern Africa (e.g., Lombard et al., 2012, 2022), let alone for its eastern part. We note here, however, that Lombard et al. (2012: 15) did emphasize a ‘high regional variability’ and informal designation of their final unit of the MSA. The comparatively high resolution and quantity of data available for late MIS 3 in eastern South Africa due to the last two decades of focused research allows for a more nuanced assessment of this behavioral patterning, both in space and time, and the continued construction of a robust regional chrono-stratigraphy. At the current stage, Holley Shelter constitutes an outlier in the region, like Border Cave. Based purely on descriptive terms and a strong splitting taxonomy, one could see these sites as representing a “Holley complex” and/or “Border Cave complex”, distinct from or as a sub-unit of the eastern final MSA. Similar to the Sibhudu complex, however, this would require additional data, investigation of potential functional and site use differences (see below), and confirmation from other nearby well excavated and securely dated localities. Whatever taxonomy, interpretation and naming one may prefer, continuing with a single ‘final MSA’ label masks internal variability and does not adequately capture the characteristic signal of marked local and regional differentiation in material culture and behavioral adaptations of the late MIS 3 archaeological record in southern Africa before the onset of the LSA.

### 5.3. Understanding patterns of behavioral variability at the end of the MSA in southern Africa

The increased quantity, quality and resolution of data on behavioral patterns at the end of the MSA in eastern southern Africa allows for a discussion of the potential factors driving this variability. Here we focus particularly on Holley Shelter and its marked differences to sites such as Sibhudu and Umbeli Belli that together can be grouped into a coherent behavioral signature. Basic temporal or geographical factors cannot account for the observed differences, as Holley Shelter dates within the same time range and is less than 80 km to the west and northwest of the aforementioned sites and thus well within the ethnographically recorded annual range of residential moves of known hunter-gatherer groups such as the G/wi or Dobe!Kung (Kelly, 1983). Various other factors could contribute to the observed patterns, including site use and mobility patterns, resource availability and environmental factors, demographic differences or patterns in cultural connectivity. With the currently available data, we can preliminarily test for the influence of site use, mobility and paleoenvironmental setting. Ongoing studies of the micromammal, phytolith, and botanical assemblages of Holley Shelter alongside functional studies of splintered pieces and geoarchaeological analyses focused on site use will allow us to test the following hypotheses further in the near future.

One of the key differences between Holley Shelter and sites such as Sibhudu and Umbeli Belli appears to lie in their site function, with Holley Shelter exhibiting shorter-term and more episodic and discrete occupations. Why might Holley Shelter reflect different occupation patterns to most other MSA localities in KZN? Today, Holley Shelter lies in a unique situation in the hinterland of KZN at the intersection of three ecosystems in a strip of Savanna Biome between a Grassland Biome to the west and north and the sub-tropical Indian Ocean Coastal Belt Biome to the east. Whilst the coastal plains of KZN in which Sibhudu and Umbeli Belli lie are characterized by their short distance to the ocean, higher average temperatures and fully humid conditions (Bader et al., 2022c; Conradie, 2012), the higher elevations in the area around Holley Shelter results in a more seasonal climate with dry and cold winters. Temperatures below 0 °C occasionally occur during Austral winter in the area. The pollen derived climate model by Chevalier and Chase (2015) implies relatively stable mean annual temperatures of about 1 °C colder than today for the later part of MIS 3 in KZN. Based on the available plant and water resources, the area around Holley Shelter was likely an attractive place for hunter-gatherers and animals during the wetter and hot summer months, providing ideal grazing ground for the numerous ungulates identified in the hunting spectrum of the site. During the dry and cold winter months the seasonal Hlambamasoka flow, located today directly above Holley Shelter and creating its waterfall, would have almost certainly dried out and the numerous water catchments and drainage lines on today's Fountainhill Estate would have reduced to a trickle. Nevertheless, the Umgeni River and several tributaries are only 2–3 km away from the site and those would have flowed throughout the year. In general, arid conditions are no hindrance for hunter gatherers to survive, as indicated by multiple ethnographic but also archaeological studies (Kelly, 1995; Lee, 1968; Schoville et al., 2022; Woodburn, 1968). Hunter-gatherers also prepare for and react to periods of harsh conditions that bring along subsistence and reproductive risk via the formation of exchange networks and social bonds or migration (Kelly, 1995; Wadley, 1996; Wiessner, 1977; Wiessner, 1982). The proximity of Holley Shelter to other areas with more stable conditions, such as the coastal forest, thus might have resulted in more short-term and seasonal use of the site and longer stays and more intensive occupations eastwards in warmer and more stable climatic and ecological conditions.

The analysis of the faunal material provides some evidence for such a scenario, with assemblages from the most anthropogenic units (BIB and BIB Hearth) giving some insight into the season of occupation of the rock shelter by human groups. This requires caution, due to the small sizes of the samples considered and to the difficulty inherent in identifying

taxonomically the remains of neonate individuals. Comparatively high numbers of juvenile bones from e.g., blesbok indicate summer occupations according to the reproductive profile of these species. We also note the identification of two remains of a neonate zebra in BIB, alongside several neonate remains belonging to medium bovids similar in size to blesbok/bontebok in BIB and BIB Hearth. Both zebras and blesboks/bonteboks have their birth peaks during the summer months (Skinner and Chimimba, 2005), and this could indicate that the rock shelter was primarily visited during the warmer and rainiest months of the year.

Drawing on further insights of hunter-gatherer mobility and occupation patterns from ethnography, land-use strategies lie on a spectrum from logistical (collector) to residential (forager) mobility structured by various environmental, subsistence, material, demographic and social variables (see Binford, 1979, 1980; Kelly, 1983, 1995; Bamforth, 1991; Tryon and Faith, 2016; Clark and Barton, 2017). As outlined above, Holley Shelter features discrete intra-site activity zones with low densities of anthropogenic material within otherwise geogenic sediments, suggesting few and short stays by a low amount of people rather than intense and continuous occupations by large groups. Also considering the pronounced seasonality of environments and availability of plant and animal resources around the site, the AVA and BIB occupations could be an indication of logistical mobility in which temporary camps are set up apart from residential locations for the acquisition of specific resources or the performance of specific activities. Such an organization of mobility, bringing resources to people, would encompass special purpose locations and rather short-term (from seasonal to overnight) occupations that could be reflected in the lithic and faunal assemblages. Concerning lithic technology, ethnographic observations and modelling approaches provide the expectation of small and low-density assemblages that are highly curated, featuring high proportions of retouch (e.g., Barton and Riel-Salvatore, 2014; Tryon and Faith, 2016; Clark and Barton, 2017; Schoville et al., 2022) but also anticipatory caching of raw materials at the sites (i.e., provisioning of place; Kuhn, 1992, 1995). The stone tool assemblages from AVA and BIB fit such a picture of high logistical mobility and low sedentariness quite well (e.g., see Strategy 3 in Schoville et al., 2022, Fig. 1): comparatively low number and density of lithics, high proportion of retouched tools and fragmented reduction sequences with an emphasis on the final stages such as tool resharpening and recycling of objects such as transforming blades into burin cores for bladelet production. While there is no obvious evidence for caching of raw materials at Holley Shelter, the occupants did have access to the sandstone shelter walls and large blocks of roof spalling on the surface, which they repeatedly flaked while at the location.

Factors other than subsistence, mobility and environmental circumstances likely influenced the activities carried out at Holley Shelter and left their mark on the specific techno-typological signals of the lithic assemblages. Pronounced differences in core reduction and tool manufacture based on learned behaviors and potentially shared norms (Tos-tevin, 2012) may imply reduced cultural connectivity with groups to the east and stronger affiliations to the west and south, such as the Drakensberg area. Unfortunately, the lack of fine-grained technological data for these regions during late MIS 3 hinders an assessment of this factor at the moment. Studies of other kinds of material culture including styles of bead making or their isotopic signatures would be additional – though currently absent – sources to follow this line of interpretation (Miller and Wang, 2022; Stewart et al., 2020). In their study of strontium isotope analyses of ostrich eggshell beads, Stewart et al. (2020) identified the existence of macroscale, trans-biome social networks over many hundreds of square kilometers in Lesotho that stretch back to the later MSA at ~33 ka, matching with the new ages from Holley Shelter. Other basic demographic factors such as group size are difficult to estimate in the Pleistocene (Faith and Tryon, 2016; French, 2016). Yet, the frequent and often rich assemblages during MIS 3 in the eastern part of southern Africa suggest rather high population sizes that support frequent cultural innovations and create higher degrees of variability in material culture following basic theories of cultural transmission and

mathematical modelling (Cavalli-Sforza and Feldman, 1981; Eerkens and Lipo, 2005; Henrich, 2001; Powell et al., 2009; Shennan, 2001). Some or all these factors may have contributed to making the end of the MSA in the eastern part of southern Africa a dynamic hub for technological tinkering and cultural experimentation before the onset and proliferation of Later Stone Age technologies.

## 6. Conclusion

New excavations at Holley Shelter highlight the role of this site in understanding the behavioral patterns and material culture of hunter-gatherers during the later stages of the MSA. Organic preservation at the site combined with high spatial and temporal stratigraphic integrity offer an excellent opportunity to integrate results from inorganic materials such as lithics and ochre with those obtained from the analysis of faunal and botanical remains. We provide the first absolute chronology for the human occupation at the site: 12 AMS C14-ages date the uppermost horizons of Holley Shelter to ~36–34 ka cal BP, a phase associated with the final MSA in southern Africa. The deposits reveal discrete and diverse activity areas consistent with short-term and potentially seasonal occupations of the site. Zooarchaeological analyses document the acquisition and butchery of medium-sized bovinds, including juveniles; ungulate long bones were also selected to be used as retouchers. Together with the presence of the southern bald ibis, the ungulate assemblage indicates open grassland conditions, which might suggest a greater extension of the Grassland biome during MIS 3 than today. The lithic assemblages show characteristic features including the manufacture of laminar products with frequent bladelets made on burins as well as cores on flakes, and abundant splintered pieces. Direct comparisons with other well dated sites from this period including Umbeli Belli, Sibhudu, Umhlatuzana, and Sibebe revealed major differences in lithic techno-typology, while the faunal spectrum seems closest to sites located further east in the foothills of the Drakensberg, in particular Strathalan B and Grassridge. These findings illustrate the high degree of behavioral variability in late MIS 3, document a complex spatio-temporal patterning of cultural traditions at the end of the MSA and raise doubts on the use of a single label of ‘final MSA’ for assemblages within this timeframe.

## Author contribution

Gregor Bader designed the study, performed the lithic technological analysis and wrote the manuscript together with Aurore Val and Manuel Will. Bader further contributed tables and figures about the site and the lithic assemblage.

Aurore Val wrote the manuscript together with Gregor Bader and Manuel Will, conducted the faunal analysis and provided figures and tables about the faunal remains.

Edwin Gevers helped with the ecological background of the study area and wrote this section of the manuscript.

Sara Rhodes helped writing the manuscript, did repeated proof reading and added information on the meaning of the results from the faunal analysis.

Nina Stahl assisted with the artifact sampling process and lithic technological analysis, edited figures, finalized tables and contributed to the final text version of the manuscript.

Stephan Woodborne conducted the AMS 14C dating of the charcoal from Holley Shelter, wrote the section on the dating results and helped with the overall organization of the paper.

Manuel Will helped in designing the study, ran the statistical data analyses and wrote the manuscript together with Gregor Bader and Aurore Val.

## Declaration of competing interest

The authors declare that they have no known competing financial

interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.

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