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

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

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

1. Introduction

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

Presented here is a detailed description of the shelter's context. This includes the site's location on the landscape, but more important, its occupation sequence and stratigraphy. How these relate to the

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

2. Context and background

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

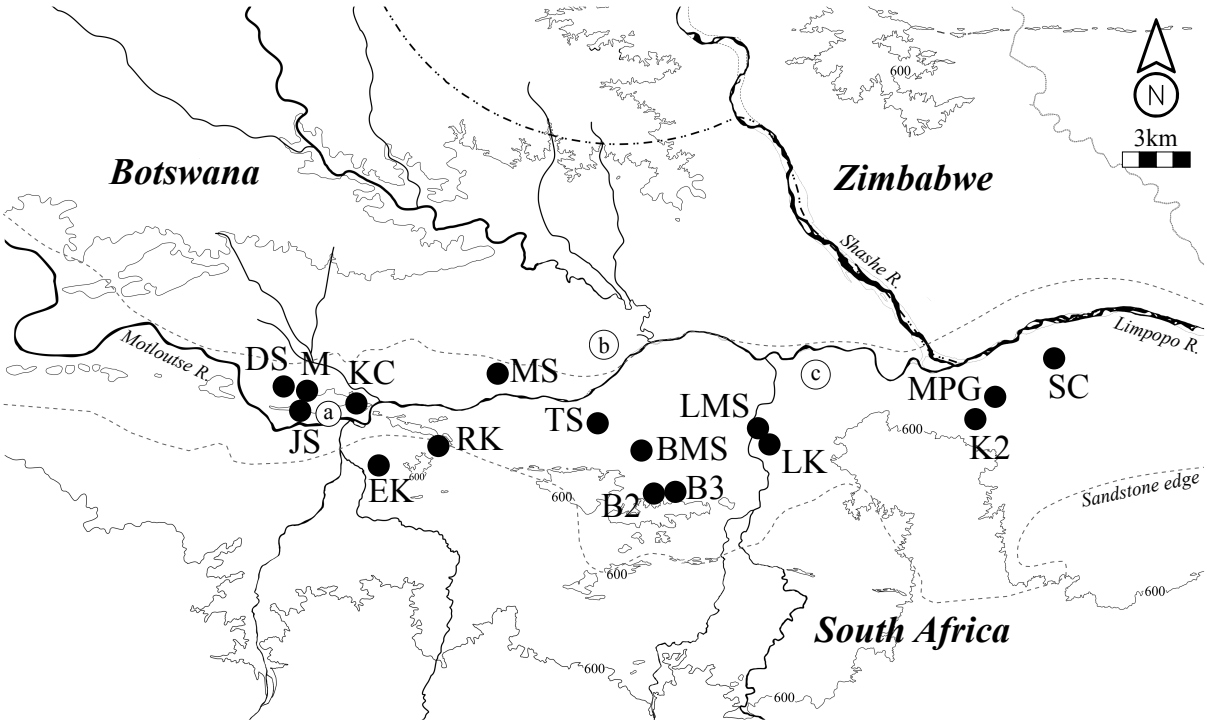

Figure 1. Map of the Little Muck Shelter landscape with the sandstone belt (dashed line) indicated and the seasonal wetlands (a-c). Key sites in the region: B2, Balerno Shelter 2; B3, Balerno Shelter 3; BMS, Balerno Main Shelter; DS, Dzombo Shelter; EK, Euphorbia Kop; JS, João Shelter; K2, Bambandyanalo;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

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

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

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

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

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

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

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

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

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

3. Materials and methods

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

Excavations were carried out in both the sheltered and open areas of the site to determine their

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

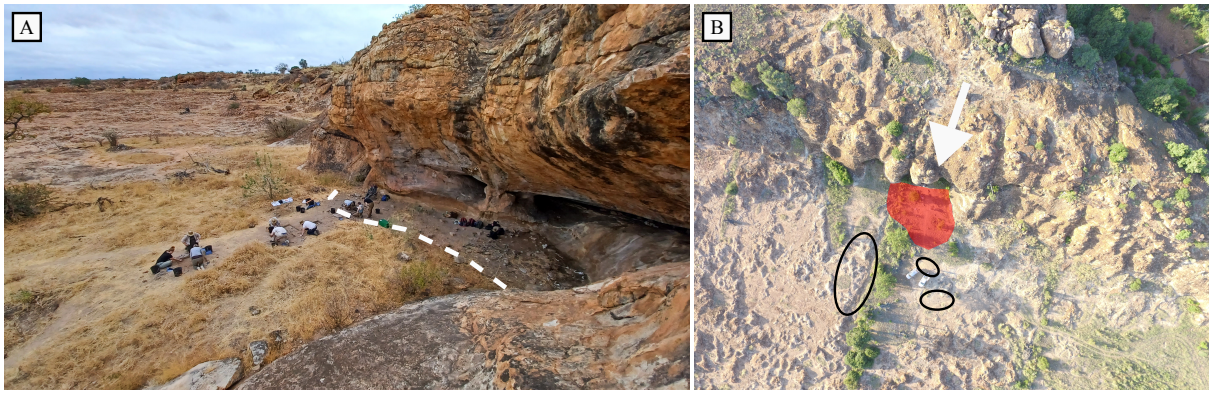

Figure 2. An image showing Little Muck Shelter spatial locations (a) with the dripline indicated by a dashed line, alongside an aerial view of the shelter (b) marked by a white arrow that shows the open area in front of the shelter (red) and the rock markings in black circles.

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

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

4. Results

Stratigraphic context

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

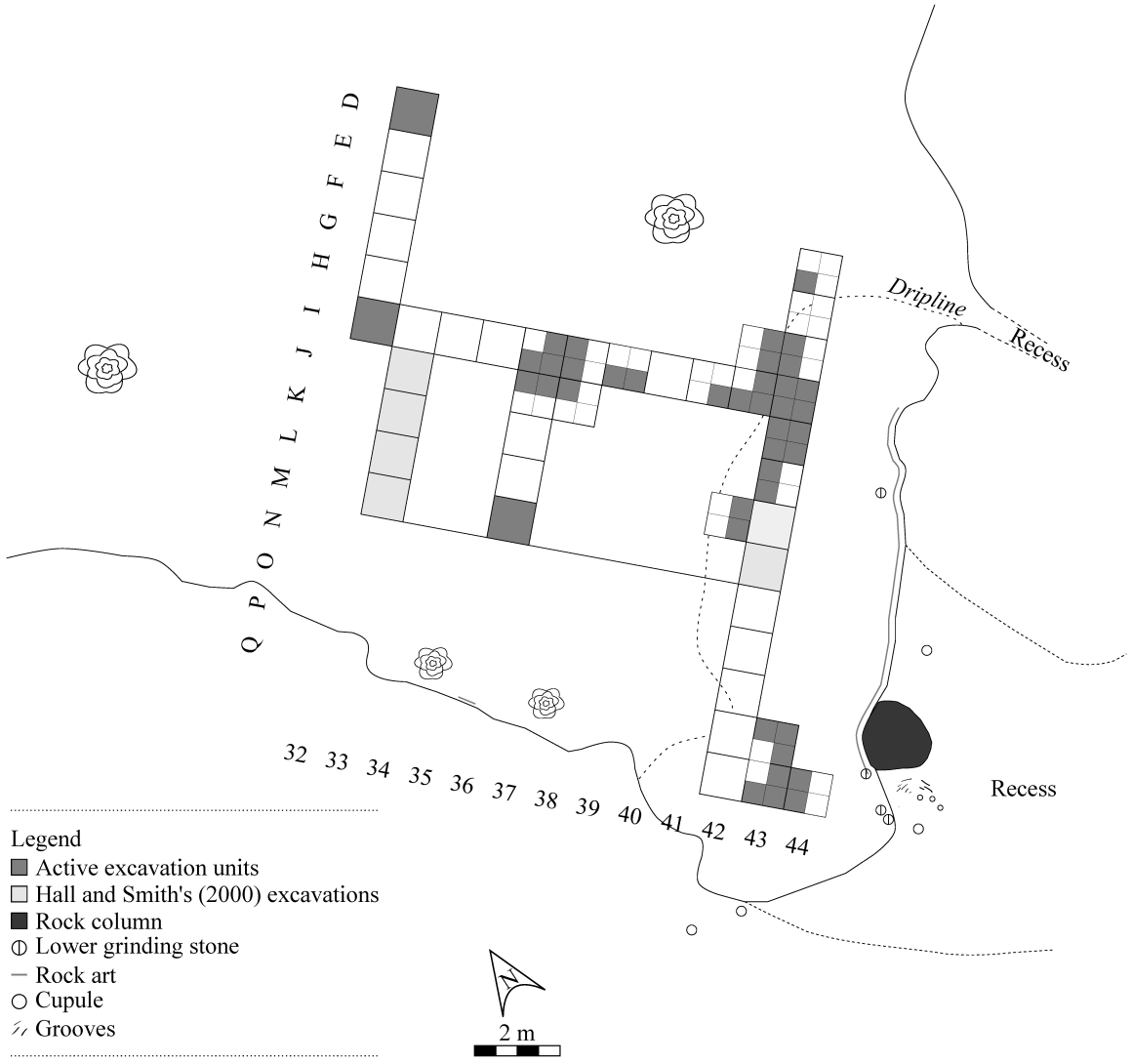

Figure 3. The excavation layout of Little Muck Shelter in dark grey with the Hall and Smith (2000) excavations in light grey (produced by Tim Forssman).

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

Below GB3 was PBG1. This unit represents a clear shift in terms of colour, compaction, grain coarseness, inclusions, and artefacts. The deposit was paler in colour than the above strata and exhibited a notable increase in artefact frequencies. However, from PBG1, there was a split in the stratigraphic sequence. In J42 quadrant B and I42 quadrant A, a different profile was identified compared to elsewhere (Fig. 4). Here PBG1+ followed PBG1. The ‘+’ was used to indicate an increase in artefact

densities with no other notable stratigraphic change. As such, PBG1+ appeared the same as PBG1 except for the frequency of artefacts. In this case, the stratum was predominantly composed of artefacts and shell remains. Why such a change took place may relate to different occupation intensities spread throughout the unit (in this case PBG1) with more activities or people at site in the early stages that was followed by less regular visits; a smaller population may also have been present in the shelter; or, it could relate to a shift in activities and activity areas. In any event, it seems to have been affected by highly localised winnowing of the deposit by a drip point along the shelter dripline, since it occurs only in a single quadrant (J42B) over four spits (18-21). The influence water has had on the deposit and assemblage will be elaborated on further when the chronology is discussed since it appears to be significant. As such, and supported by dates presented below, both PBG1 and PBG1+ can be seen as a single occupation phase.

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

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

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

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

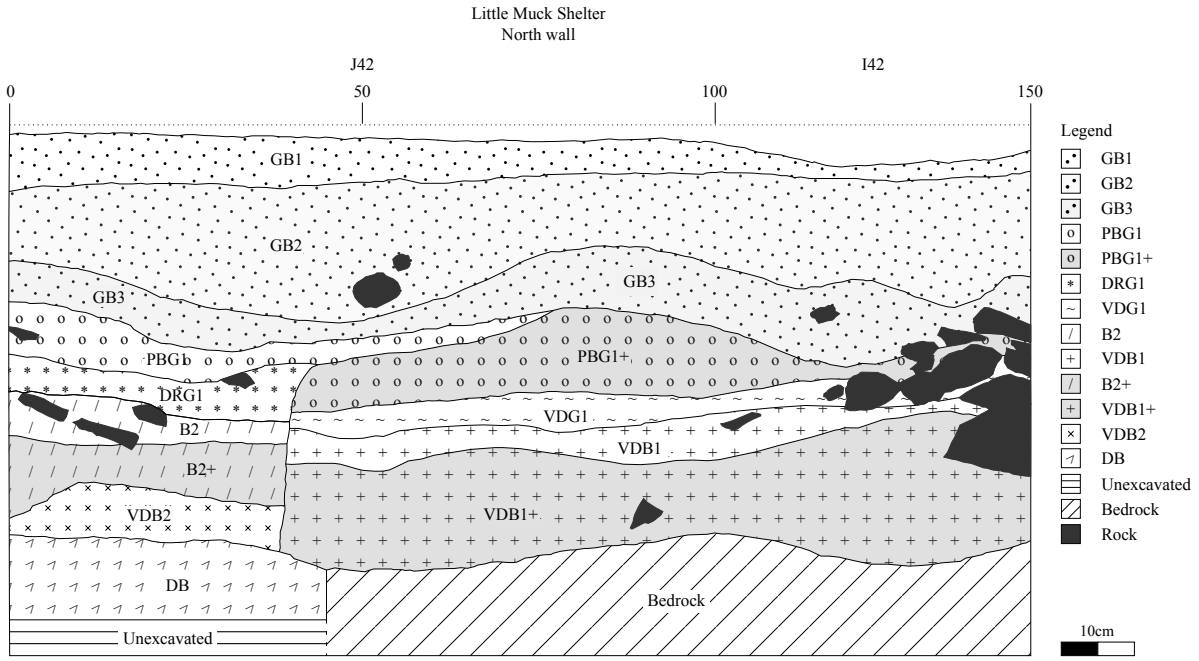

Figure 4. The divided stratigraphic sequence observed in the north wall of J42 (A & B) and I42 (A) (produced by Tim Forssman; from Forssman et al. 2023).

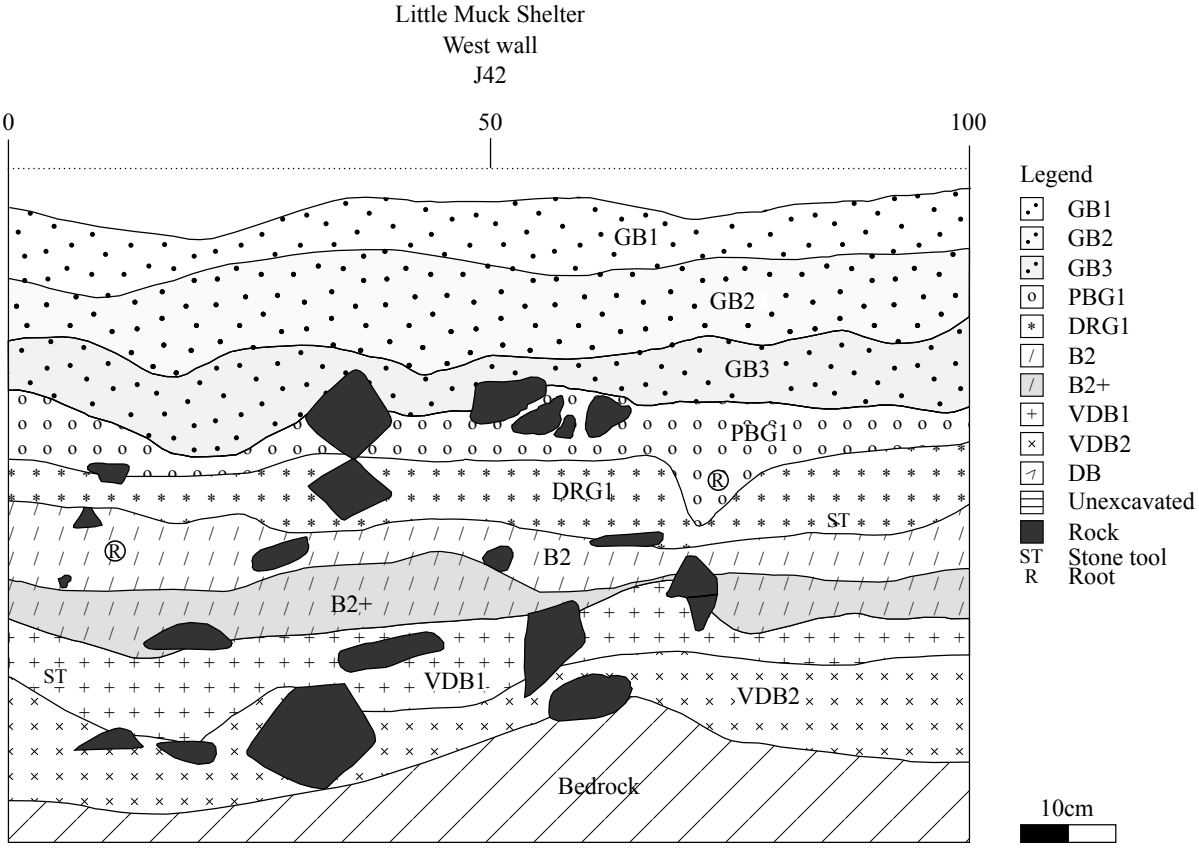

Figure 5. An unbroken sequence along the J42 west wall (C [0-50 cm] and A [50-100 cm]) (produced by Tim Forssman; from Forssman et al. 2023).

More common across the site are the PBG strata followed by DRG1 and DRG1+. DRG1+ has the same relationship as the two PBG stratum, regarding an increase in artefacts. Similarly, it was limited to I41C and I42B, C and D suggesting a drip point or a localised winnowing of the matrix. DRG1 is also

horizontally constrained to I42 to K42, but the presence of DRG1+ in I41C and a lack of excavation units next to J and K (i.e., J41 and K41) means that the full extent of these strata cannot yet be established.

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

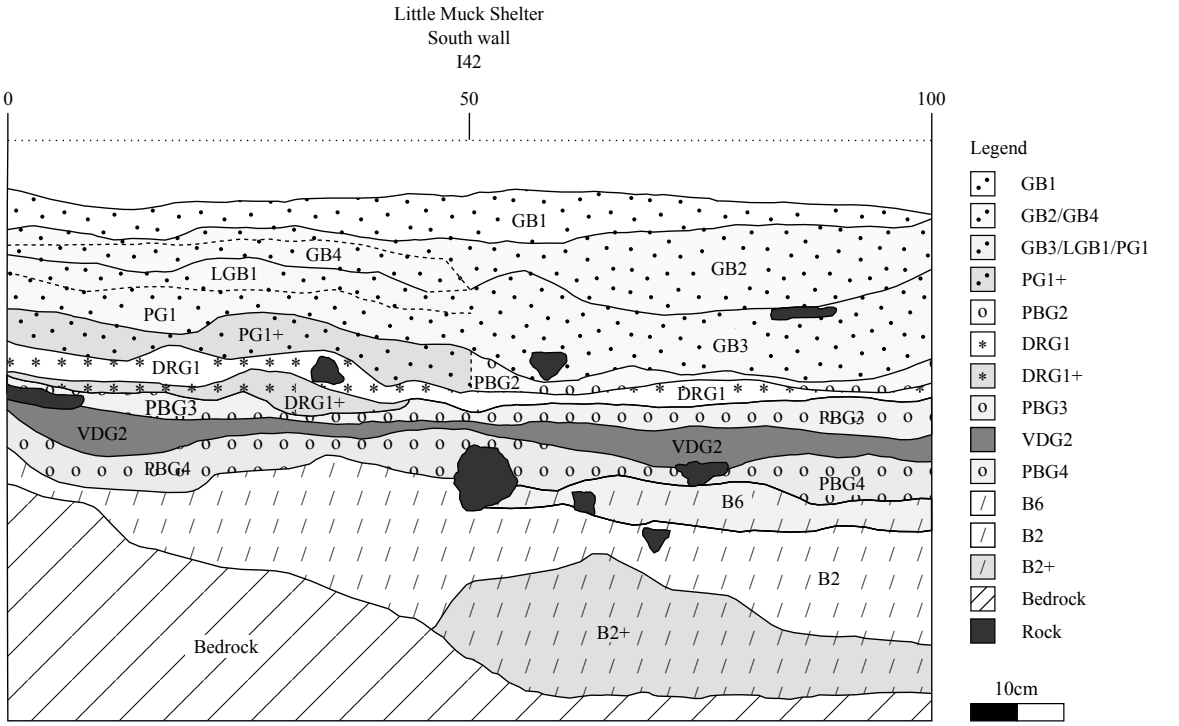

Figure 6. An unbroken sequence along the I42 south wall (D [0-50 cm] and C [50-100 cm]). See Table 1 for stratigraphic units indicated in the profile (produced by Tim Forssman).

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

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

the shelter by farmers, possibly during the Leopard's Kopje period, as it resembles those excavated by Schoeman (2006) in rain control sites of that age (investigations are ongoing).

Chronology

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

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

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

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

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

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

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

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

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

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

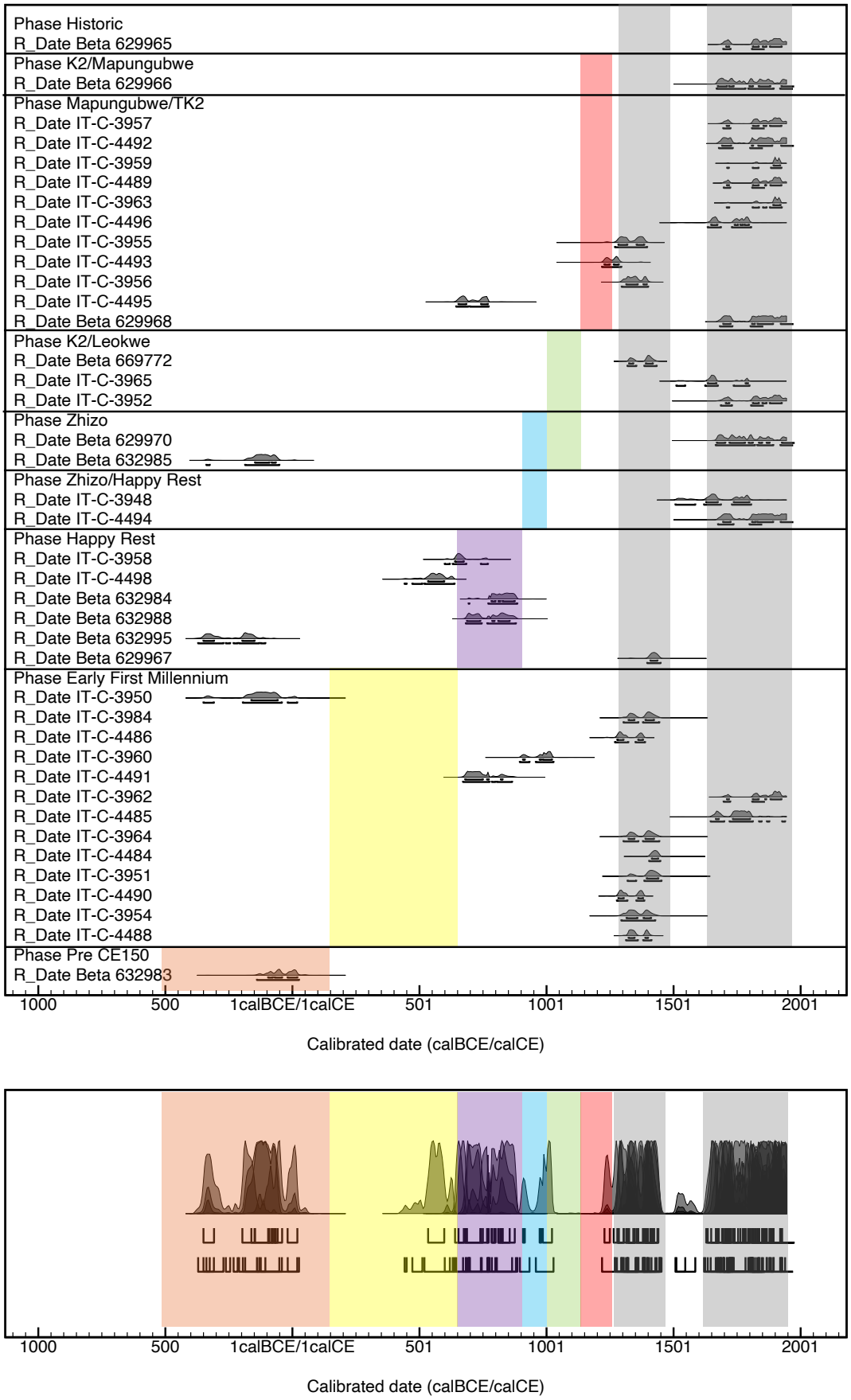

Figure 7. All calibrated dates in order of their stratigraphic appearance and organised following the expected relative chronology established by Forssman et al. (2023).

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

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

Cultural sequence

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

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

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

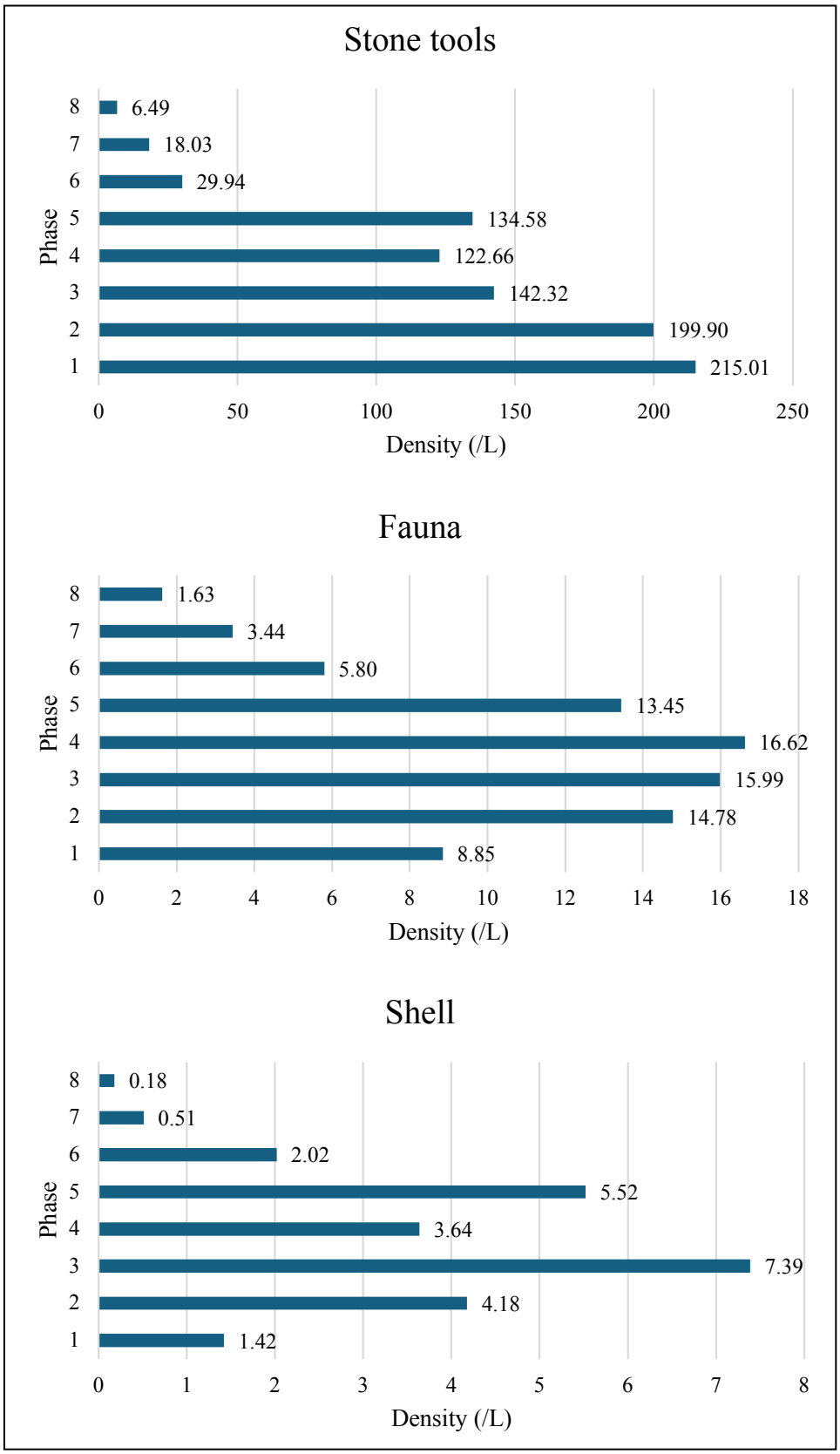

Figure 8. Stone tools (top), faunal remains (middle) and shell (bottom) densities from the pre-ceramic (phase 1) to historic (phase 8) periods.

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

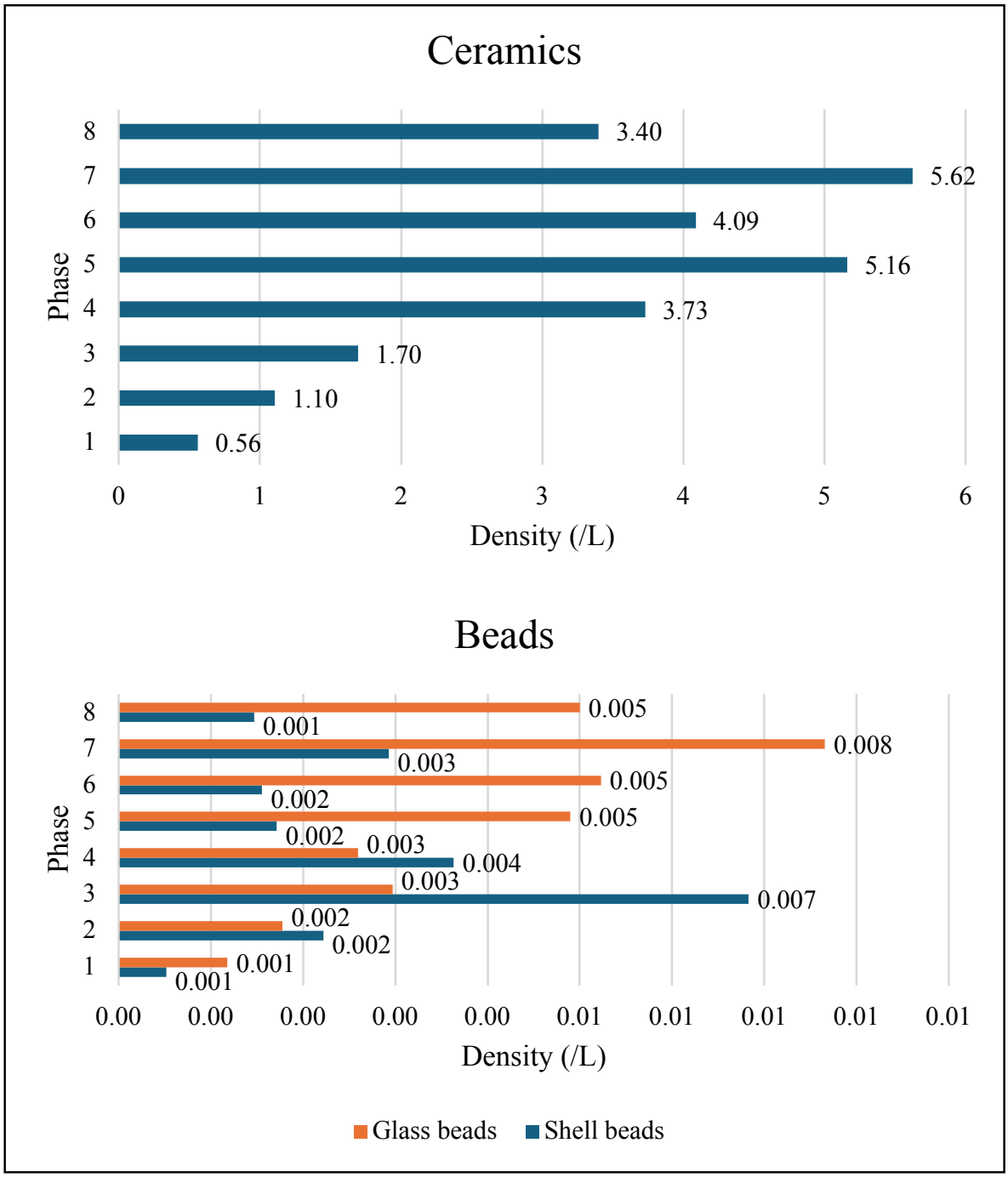

Figure 9. Ceramics (above) and beads (below), showing both glass (orange) and ostrich eggshell (blue) beads, from the pre-ceramic (phase 1) to historic (phase 8) periods.

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

5. Comparison to Hall and Smith's excavations

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

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

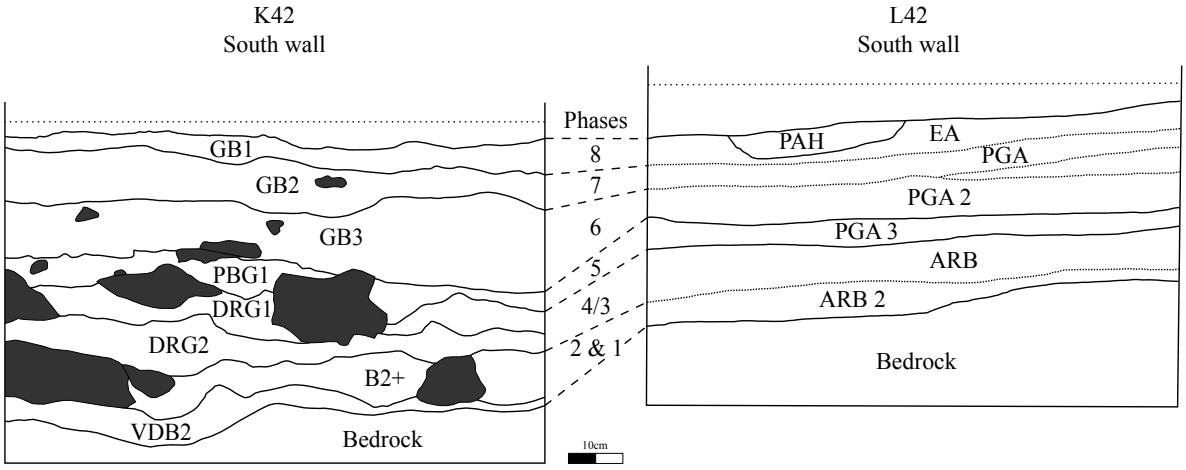

Figure 10. The south walls of K42 (left) and L42 (right) are shown with the suggested phases between them (rocks in K42 marked in dark grey). L42 redrawn from Hall and Smith (2000), which did not include a scale (produced by Tim Forssman).

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

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

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

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

6. Conclusions

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

cultural association with the strata reiterates the continued use of the shelter during the second millennium CE, when it was thought the site was abandoned by foragers. However, the nature of social relations during this time is not entirely clear and might in fact represent modalities across the region.

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

Acknowledgements
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