Archaeological and Anthropological Sciences (2023) 15:34
https://doi.org/10.1007/s12520-023-01735-2

RESEARCH

# Shell disc beads and the development of class-based society at the K2-Mapungubwe settlement complex (South Africa)

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Received: 5 September 2022 / Accepted: 6 February 2023 / Published online: 28 February 2023


## Abstract

The K2-Mapungubwe settlement complex is widely regarded as the centre for the development of class-based society out of earlier ranked communities between c. AD 900 and AD 1300 in northern South Africa, southern Zimbabwe, and eastern Botswana. Beads made from ostrich eggs, the shells of Achatinidae snails, and freshwater bivalves formed an important part of the K2-Mapungubwe economy. Although thousands of shell beads have been excavated at the K2-Mapungubwe complex, this assemblage has never been analysed or even quantified in any meaningful manner. As such, only rough estimates of the distribution, use, and meaning of shell beads at these important sites were done. This article represents the first focussed research effort on this assemblage. The results demonstrate distinct spatial and chronological changes in the shell bead assemblage. Achatina beads are more common earlier in earlier phases, but after AD 1220, ostrich eggshell beads dominate. This could indicate access to new sources of raw materials. Our analysis took into account the spatial and social contexts of beads. This indicated that shell bead assemblage from the higher-status royal living areas remained morphologically constant over time, with a clear preference for smaller-sized beads. In contrast, beads from the lower-status areas could be grouped into distinct clusters of larger and smaller beads. The grouping of smaller bead on lower-status areas closely resembles elite assemblages. Smaller beads however become proportionally rarer outside elite areas over time. This may reflect changes in elite control and preferential access to shell beads. These results demonstrate how the use and manufacture of shell beads intersected with the socio-political changes that characterise the period. It also highlights the need for careful consideration of shell beads as a significant component of the political economy in the southern African Iron Age.

**Keywords** African Iron Age · African farming communities · Social complexity · Disc bead production · Craft production · Specialisation · Trade · Greefswald

## Introduction

Shell disc beads (SDB) are found in the archaeological record from across the globe since at least 60 kya through to recent times (e.g. Hartzell 1991; Allen et al. 1997; Mellars 2006; Bouzouggar et al. 2007; Texier et al. 2010; Villa et al. 2012; Balme and O'Connor 2017; Miller et al. 2018; Medchill et al. 2020; Gamble 2020; Spinapolice et al. 2022; Miller and Wang 2022; Kozuch 2022; Turgeon 2022). In southern Africa, shell beads are often discussed in the context of the region's mobile hunter-gatherer communities (e.g. Plug 1982; Wadley 1989; Hall and Smith 2000; Orton 2008); however, their use and manufacture by southern African Iron Age communities remain largely unexplored. Locally, the term 'Iron Age' refers to the archaeology associated with Bantu-speaking communities of the last 2000 years. In contrast to hunter-gatherer groups, these communities made extensive use of ceramics, lived in sedentary villages, planted crops, kept herds (cattle, sheep, and goats), and had a well-developed metallurgical industry. This paper will focus specifically on the K2-Mapungubwe settlement complex, which is widely regarded as the centre for the development of class-based society from earlier ranked communities in northern South Africa, southern Zimbabwe, and eastern Botswana during the c. AD 900–AD 1300 Middle Iron Age (MIA) (Fig. 1). K2 is the older settlement and was established around AD 1000 when communities associated with the Leopard's Kopje ceramic style settled in the area around the confluence of the Shashe-Limpopo

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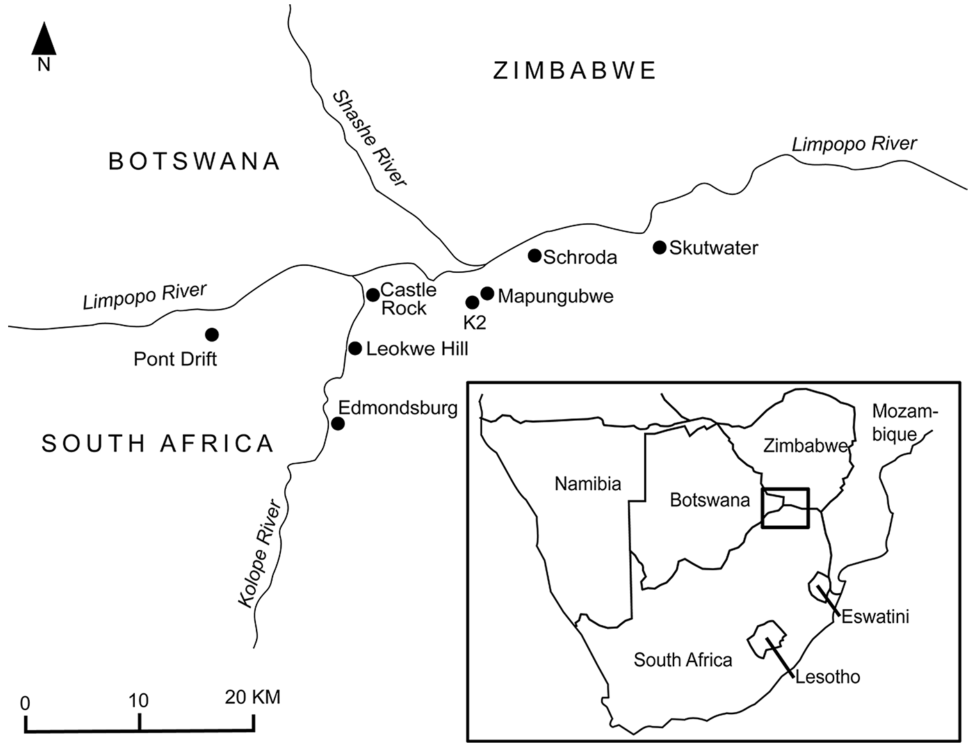



**Fig. 1** The Shashe-Limpopo confluence area with sites mentioned in the text with regional context provided as insert (bottom right; insert map scale 1: 40,000,000)

Rivers (Huffman 2007, p. 371). By AD 1050, the settlement had risen as the regional political centre and controlled long-distance trade. K2 was abandoned around AD 1220 in favour of Mapungubwe, a prominent hill approximately 2 km away. Here, social distinctions between elite and commoner groups became reified during the thirteenth century (Meyer 2000; Huffman 2009). Within the local archaeological context, the term 'elite' refers to a higher-status social class, likely tied by kin relations and who had privileged status, rights and duties, and preferential access to trade and high-status goods (e.g. Calabrese 2000, 2007; Huffman 2000, 2015). Elites resided in exclusive areas of district, provincial, and national capitals (Huffman 2000, p. 14). In these settlements, physical space was organised in such a way that it came to express the social distance between elites from the rest of the population who lacked the same access to wealth, prestige, and power. This latter part of the population is typically referred to as lower-status 'commoners', 'non-elites', and 'followers'. In the MIA of southern Africa, they typically lived in smaller homesteads and mainly tended to their agricultural fields and livestock. However, they were also the craftsmen and producers, miners, hunters, and traders that underpinned the wider MIA political economy (Antonites 2019a, 2019). It is this development of in situ class distinction out of an earlier ranked society that makes K2 and Mapungubwe important in understanding the development of social inequality in the region.

Excavations at both sites since the 1930s have produced a particularly diverse worked osseous assemblage (Voigt 1983; Antonites et al. 2016) which include disc beads manufactured from ostrich eggshell (*Struthio camelus*), shells from snails of the Achatinidae family (collectively referred to as Achatina in this paper) and from freshwater bivalves of the Unionidae family (here collectively referred to as Unionid). Unlike many of the trade items circulated during the MIA, shell disc beads were used by both commoners and elite alike (Fouché 1937; Tapela 2001; Calabrese 2007). Their manufacture and use therefore have bearing on the regional political economy of early social complexity in southern Africa. In this paper, we will explore how shell disc beads intersected with the social changes witnessed at K2 and Mapungubwe.

## The K2 and Mapungubwe settlement complexes

Although they are generally treated as two distinct archaeological sites, K2 and Mapungubwe can be seen as different spatial and temporal foci of a single community. Incorporating a contextual approach to shell beads at the sites therefore calls for a careful consideration of spatial and chronological information.

The Mapungubwe-K2 settlement complex (also known as the Greefswald sites in older publications, since it is located on the farm of that name) was brought to international attention in 1933, when it was reported that a 'grave of unknown origin, containing much gold work, found on the summit of a natural rock stronghold' in the Limpopo region of South

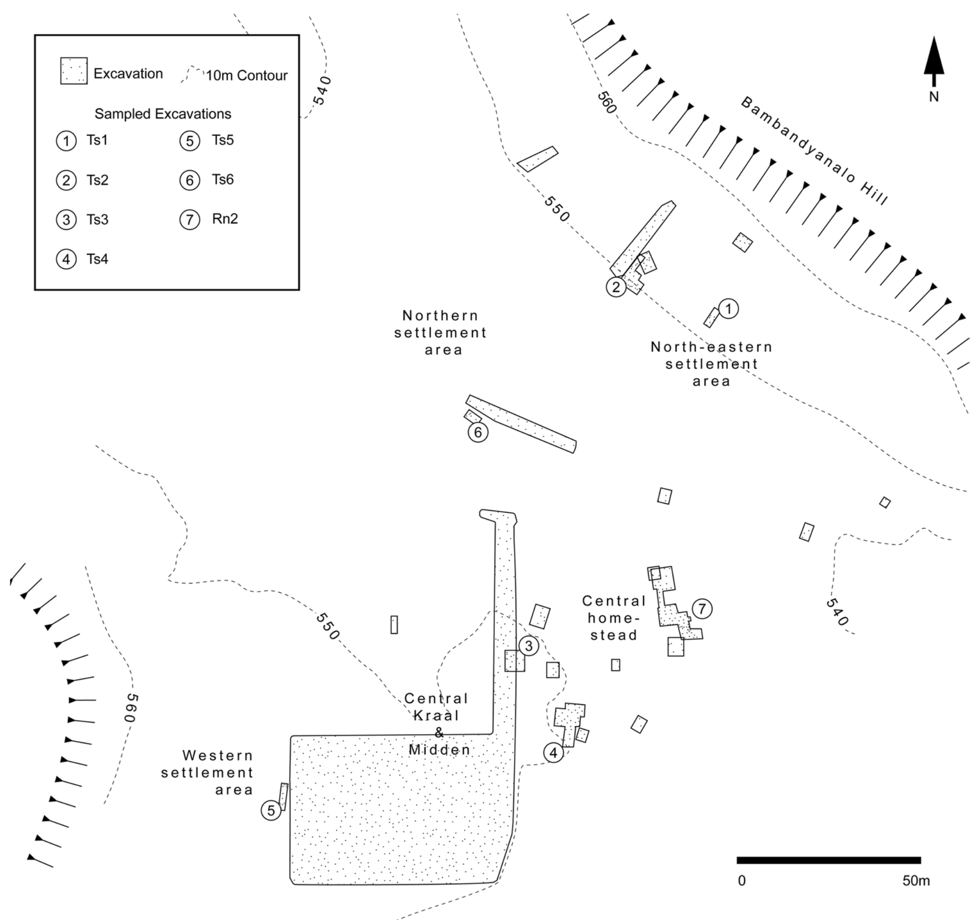
Africa (Paver 1933, p. 494). Since then, it has become one of the most researched archaeological sites in southern Africa. Meyer (2000, pp. 4–5) groups archaeological research at the site into four phases. Initial research conducted between 1933 and 1940 was largely aimed at descriptions of material culture assemblages (e.g. contributions in Schofield 1937) and linking the archaeology to the 'ancestry of indigenous groups' of the region (Meyer 2000, p. 4). These early excavations were typically large-scale and unfortunately, frequently suffered from poor documentation and what would today be regarded as crude methods. In the 1950s, a series of new excavations were conducted. These were on a much smaller scale than before but followed more rigorous methods with a greater appreciation of stratigraphic and chronological complexities (e.g. Sentker 1954, 1969). The 1970s saw excavations expanded into new areas as well as a reinvestigation of earlier evidence culminating in a comprehensive report (Eloff 1979b), which included contributions by several material specialists. The final phase of field research entailed mapping and focussed investigations to refine the sites' stratigraphy and chronology. This period was concluded with a final report published in 1998 (Meyer 1998). The site complex was declared a UNESCO World Heritage Site in 2003. Since then, activities at the site have been limited to the reburial and repatriation of human remains (Schoeman and Pikirayi 2011) and the stabilisation of old excavation trenches (Nienaber and Hutten 2006), while material culture studies have concentrated on the analysis of existing collections (e.g. Wood 2000; Steyn 2007; Antonites et al. 2016; Tiley-Nel 2018), and excavations have shifted to outlying settlements (e.g. Schoeman 2006a, b; Calabrese 2007; Huffman 2017; Antonites 2019b).

## Spatial context

K2 lies in a sheltered valley surrounded by sandstone cliffs (Fig. 2) and covers an area of approximately 5 ha (Fig. 2). It contains a large central midden, a central cattle kraal (open-air livestock enclosure), a large central homestead area with smaller adjacent middens, a north-eastern settlement area on the slope of Bambandyanalo Hill with adjacent middens at the base of the slope, a Western Settlement area, a Northern Homestead and an Eastern Peripheral Midden (also known as site K1).

The Mapungubwe complex, located 2 km northeast of K2, is a single habitation site that covered approximately 10 ha at the height of its influence. It contains several spatial components, the most prominent being Mapungubwe Hill (MK), a sandstone hill with a flat summit approximately 30

Fig. 2 Spatial layout of K2 with units sampled in this study indicated (adapted from Meyer 1998)



m high and 300 m long, with vertical cliffs that can only be accessed through specific routes. The hill is surrounded by a flat valley bottom that includes discrete spatial areas such as the Southern Terrace (MST), Mahobe settlement area, southern settlement area, northern slope settlement area, and an eastern slope element (Fig. 3).

## Historical context

The first signs of class distinction appear at K2 during the latter half of the twelfth century when a significant spatial rearrangement of the settlement takes place (Meyer 1998). Initially, the spatial layout of the early K2 village followed the traditional Iron Age pattern of a male assembly area and court located within the central cattle kraal (Huffman 1982, p. 143). As K2's political importance increased, so too did the size of the court and assembly area and the frequency of their use. As a result, the midden associated with the court activities expanded to the extent that it engulfed the kraal, which had to be moved to the outside of the village (Huffman 2007, p. 373). This move is significant since the central cattle kraal traditionally represented an assembly area for all inhabitants, irrespective of rank, with cattle binding people together through their use as a medium for social exchanges such as bridewealth (c.f. Kuper 1980). Relocating the kraal represented a change in fragmenting the common ground between the chief and his followers and the initial stirrings of class distinction between commoners and a ruling elite (Huffman 1996a).

By AD 1190, the community located at K2 largely abandoned the site and resettled at Mapungubwe (Meyer 1998; Vogel 2000; Huffman 2015b). Here, the spatial separation of elite and lower-status followers is fully realised as the hilltop became a restricted elite area with lower-status followers occupying the surrounding valley floor and neighbouring settlements (Meyer 1998; Carrion et al. 2000; Huffman 2007). The inaccessibility of

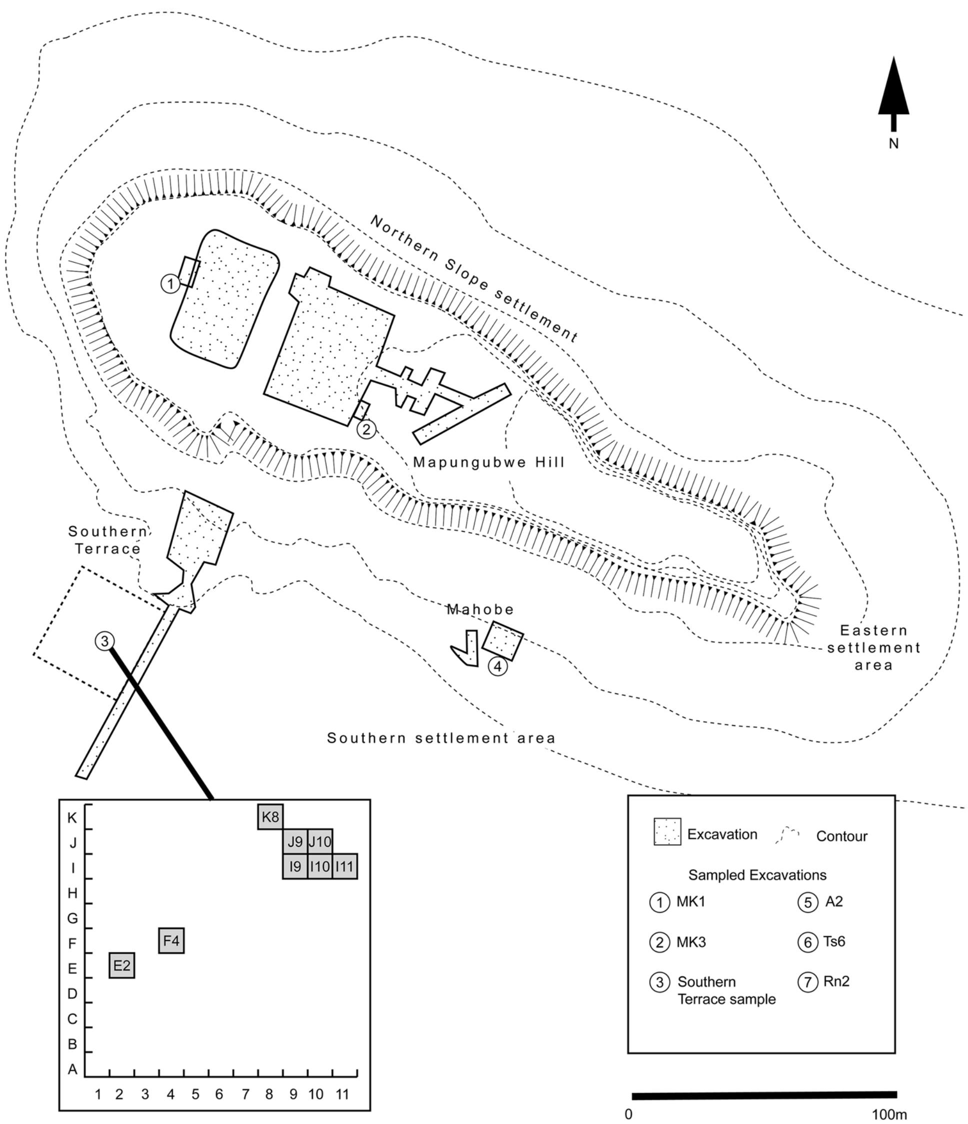



**Fig. 3** Spatial layout of Mapungubwe with units sampled in this study indicated (adapted from Meyer 1998)

the hill emphasised the spatial and ritual seclusion of the leader and signified his sacred leadership since the hill was previously a centre for rainmaking rituals (Schoeman 2006; Huffman 2007). This spatial divide marks the first time that the leadership physically separated themselves from the rest of the community, signalling the full materialisation of class distinction that had first emerged at K2 (Huffman 2000, 2007, 2009). Although Mapungubwe Hill was only occupied for roughly 70 years, from AD 1220 to AD 1290, it saw a substantial increase in population, settlement size and area under its control. Mapungubwe was largely abandoned around 1300 AD (Meyer 1998). The reasons for its decline remain unclear but are likely an interplay of socio-political and environmental factors (Tyson and Lindesay 1992; Huffman 95, 2000; Pikirayi 2002; Kim and Kusimba 2008).

In order to periodise the discussion of shell disc beads, we follow Meyer's (1998) four-phase settlement sequence for the K2-Mapungubwe settlement complex. Phase I represents an isolated Early Iron Age (c. AD 300 to AD 500) occupation in some areas of the site (Meyer 1998, p. 181) and is unrelated to the focus of this paper. The earliest MIA occupation is known as phase II and dates between AD 1030 and AD 1220. It is associated with the increase of K2's regional importance and, towards the end of this period, the initial stirrings of the commoner-elite divide (Meyer 1998, p. 181). The entire K2 occupation dates to this phase as well as does early strata at Mapungubwe Hill and the Southern Terrace.

Phase III of the settlement sequence dates from AD 1220 to AD 1250. Meyer (1998) identified two sub-phases: during the older phase III(a), occupation of K2 largely ceased and the settlement relocated to Mapungubwe where there is a concomitant increase in building activities—primarily on the Southern Terrace. The first housing structures are also erected on Mapungubwe Hill during the early part of phase III(a), but these were restricted to the western end of the hill. Huffman (Huffman 2009, p. 7) interpreted the remains of a particularly large residence in this area as the first king's house. During phase III(b), occupation of Mapungubwe intensified, and stonewalls and terraces were constructed on the Southern Terrace and Mapungubwe Hill (Meyer 1998; Meyer and Cloete 2010).

Settlement phase IV dates from AD 1250 to AD 1290 (Meyer 1998, p. 182). Stone-walled architecture constructed in phase III(b) continued to be used during the early part of phase IV but was eventually covered up by deposit on both Mapungubwe Hill and the Southern Terrace. Both Eloff (1979a) and Meyer (1998) describe a lack of any new, large-scale building projects during phase IV. The MIA settlement was largely abandoned by c. AD 1300, although sporadic occupation and re-use of the site occurred up until recent times.

## Shell disc beads in the southern African Iron Age

Several historical and ethnographic accounts mention that Bushman hunter-gatherers of the region produced and traded ostrich eggshell beads with neighbouring Bantu-speaking farmer groups, i.e. the descendants of archaeological Iron Age communities (Stow 1905, p. 139; Schapera 1930, p. 66; Marshall 1961). As such, it is frequently suggested that the beads found at Iron Age sites were manufactured by and obtained from neighbouring hunter-gatherer groups (e.g. Silberbauer 1981; Jacobson 1987a; Mazel 1987, p. 279). However, the historical association of SDB manufacture with hunter-gatherers does not preclude other groups in the archaeological record to have manufactured these as well (Schapera 1937, pp. 143–144; Mazel 1987, p. 276; Tapela 2001). Indeed, the MIA settlements of Schroda, Castle Rock, Edmondsburg, Skutwater, Pont Drift, Leokwe Hill, and Mutamba (Fig 1) all produced debris related to the manufacturing of SDB (Hanisch 1980; van Ewyk 1987; Calabrese 2007; Raath 2014; Antonites 2019a). Mutamba (Antonites 2019), Leokwe Hill, and Castle Rock (Calabrese 2007) produced evidence for low-intensity manufacture, while Schroda appeared to have produced SDB on a much larger scale (Hall and Smith 2000). Here, a cache of thousands of rough-drilled ostrich eggshell discs and strung roughouts ready for grinding was recovered, which could indicate more intensive production activities (Raath 2014). Hall and Smith (2000) observed that with the political and economic power becoming centralised by K2 and Mapungubwe elites, hunter-gatherers were increasingly marginalised in the MIA political economy and ceased to make beads altogether. The Schroda cache demonstrated that production had seemingly moved to lower-status farmer settlements, with hunter-gatherers merely acting as suppliers of ostrich eggshell, instead of the producers of finished items.

An important theme in southern African SDB research has been their role as markers of identity—particularly between herders and hunter-gatherers. Jacobson (1987b) was the first to suggest that SDB size could aid in distinguishing between hunter-gatherer (smaller beads) and herder (larger beads) assemblages—two groups that are difficult to distinguish from the lithic record alone. From this initial research, several complementary studies subsequently emerged that link shell bead size to either social, economic, and cultural identities, or as chronological indicators (Jacobson 1987; Smith and Jacobson 1995; Smith et al. 2001; Tapela 2001; Sadr et al. 2003). However, several critiques on the uncritical equation of bead size and identity have also emerged. In an extensive study on ostrich eggshell bead variability, Wilmsen (2015) investigated the morphology of ostrich eggshells, together with pre- and post-depositional factors that could affect the relative size and thickness of an ostrich eggshell bead. The relative size of a bead was the result of a complex interplay between multiple variables, such as 'an eggshell's original chemical structure, environmental influences pre- and post-bead fabrication, and a bead maker's original intent for the use to which the bead was to be put' (Wilmsen 2015, p. 89). Variability in bead dimensions can therefore be the result of several factors other than those that may relate to identity. From his archaeological and ethnographic evidence, Wilmsen (2015, p. 99) concludes that 'bead size, however measured, cannot serve as a criterion for relative dating nor as a stylistic marker for distinguishing herder and pre-herder or hunter-gatherer archaeological sites'. Caution should therefore be exercised when using beads (and other forms of material culture) as a simple *fossil directeur* for complex social categories.

Equally ambivalent is our understanding of the variety of ways SDBs were used during the MIA, since disc beads are mostly recovered as single, isolated items within archaeological deposits. The exception of this are burials, which allows for the recovery of items within their use context. Local examples indicate that SDBs were strung and worn as strings around the neck or as waistbands (Mosothwane and Steyn 2004; Antonites 2016). It is, however, likely incorrect to assume that all beads were worn as strings since historical examples show that they often formed part of decorative elements on composite objects such as waistbands, girdles, aprons, and skirts (Werner 1919; Van Warmelo 1932; Stayt 1968; Gitywa 1970; Tyrrell 1976). In contrast to the southern African ethnographic record, which almost exclusively refers to ostrich eggshell as a raw material for SDBs, archaeologists have also identified the use of Achatina and Unionid disc beads (e.g. Fouché 1937; Gardner 1963; Plug 1982; Miller et al. 2021). While shell beads are present in many Iron Age archaeological assemblages, few previous studies discuss the use of other raw materials such as Achatina and Unionid. Notable exceptions are Pont Drift (ninth–twelfth centuries) and Schroda (ninth–eleventh centuries) in the Limpopo Valley where Achatina discs dominated the assemblages (Hanisch 1980, p. 290). Hall and Smith (2000) speculated that this could indicate a difference in the value between beads manufactured from ostrich eggshell and Achatina, with the former being more highly valued. In their comparative study of SDB assemblages, Ward and Maggs (1988) identified several cases of misidentification of shell type in earlier studies and emphasised the need for greater accuracy in identifying SDB manufactured from ostrich eggshell, Achatinidae and Unionidae (Miller et al. 2018). The use of these shell types to make beads is therefore likely underrepresented in the literature.

It should be noted that elsewhere in the African archaeological record, other osseous materials were used to make disc beads opercula of the terrestrial gastropod *Revoilia guillainopsis* (e.g. Assefa et al. 2008) and various marine bivalves (e.g. Juma 2004; Flexner et al. 2008; Crowther et al. 2016). As yet, none of these have however been found on southern African MIA sites.

## Shell disc bead manufacturing activities

The manufacture of SDB has largely been reconstructed through both ethnographic and historical studies (e.g. Stow 1905; Bleek 1928; Schapera 1930; Fouché 1937; Forde 1934; Drury 1935; Silberbauer 1965, 1981; Tapela 2001; Wingfield 2003; Vanhaeren 2005; Hitchcock 2012), complemented by archaeological and experimental studies (Yellen 1977; Plug 1982; Jacobson 1987a; Bednarik 1997; Vuruku 1997; Tapela 2001; Wingfield 2003; Kandel and Conard 2005; Orton 2008). Although these studies exclusively focus on the manufacture of beads from ostrich eggshell, Miller et al. (2021) have demonstrated the applicability of these to Achatina beads. From these studies, a basic manufacturing sequence of four main activities can be identified: blank preparation, drilling/reaming, trimming, and grinding. The sequence of these tasks varies along at least two different pathways (Orton 2008). In Pathway 1, blanks were drilled and perforated before being trimmed into a disc, while in pathway 2, blanks were trimmed into a disc before being perforated.

### Blank preparation

This step entails breaking the shell into appropriate sizes in preparation of further manufacture.

These fragments were otherwise unmodified with no evidence of alteration (Kandel and Conard 2005, p. 1712). Bleek (1928, p. 9) observed the use of a stone to chip off fragments, while Drury (1935, p. 98) mentioned that crafters used their teeth to bite off smaller pieces.

### Drilling and perforation

Drilling the hole could be done by rapidly rubbing a drill between the hands. The drill could have been made from various materials, although stone and iron are the most popular reported ethnographically (Stow 1905; Schapera 1930; Drury 1935). Drilling could take place from either the inner or outer shell surface. From his experimental work, Bednarik (1997, p. 157) noted that both methods took an equal amount of time to complete, but that it was simply easier to drill from the inner surface due to the concave shape (Wingfield 2003, p. 57). The blank can also be drilled from both surfaces until the two holes meet. Drury reported that shell fragments were drilled to near completion, before the fragment was turned over and drilling continued from the opposite surface (Drury 1935, p. 98). Plug (1982, p. 60) observed a similar pattern in SDBs recovered from the archaeological deposits at Bushman Rock Shelter. Conversely, Bednarik (1997, p. 157) argued that bead blanks were unlikely to have been drilled from both surfaces as he found it very difficult to get the two holes to meet.

After drilling, blanks can be considered beads. Kandel and Conard (2005, p. 1712) distinguished between a 'bead' and a 'finished bead' whereby a bead referred to a perforated piece of shell in any stage of production, while a finished bead specifically represented the final product. This definition requires a clear description of what can be considered as complete. Some beads were worn despite the fact that they were only partially ground smooth, while Tapela (2001) noted ostrich eggshell beads with rougher edges on clothing; jewellery such as necklaces tended to consist of smooth and well-rounded beads. Similarly, Plug (1982, p. 61) noted a string of 145 trimmed, but not ground, ostrich eggshell beads recovered from a child's grave from Bushman Rock Shelter and suggested that 'trimmed but unground beads were also regarded as ornaments in their own right'.

### Trimming

This step involved the chipping away of small angular fragments from the bead—frequently using a stone or horn—until a roughly circular shape is achieved (Bleek 1928, p. 9; Schapera 1930, p. 66; Yellen 1977, p. 141; Tapela 2001, p. 63). Drury (1935, p. 98) also described the use of two stones, acting as a hammer and anvil to chip away at rough edges.

### Grinding

The rough edges of the beads were ground smooth with a stone. Several methods have been described. In some examples, a string of disc beads was placed on a hard surface and ground with a stone, presumably by rubbing the stone over the beads (Schapera 1930; Drury 1935; Yellen 1977; Wingfield 2003). Several studies describe the use of a grooved stone to shape beads (Bleek 1928; Forde 1934; Goodwin 1945; Silberbauer 1965; Wingfield 2003; Orton 2008). According to Orton (2008, p. 1769), 'one might either pull a string of beads through a groove or, perhaps more likely, rest the string on something and rub it longitudinally with the grooved stone while it is held taut'.

## The K2-Mapungubwe shell disc bead sample

For this study, a total of 6172 beads were analysed from phases II–IV and from both high-status and lower-status areas of the K2-Mapungubwe settlement complex. Only excavated material that retained contextual information relating to site of origin, context, or any other provenience information was sampled, which was often lacking for much of the early excavations.

The K2 sample ($n$ = 2488) was selected from excavations in the central midden and kraal area (TS3), central homestead area (Rn2 and TS4), north-eastern settlement area (TS1 and TS2), western settlement area (TS5) and northern settlement area (TS6). The excavation methods and contextual information for these units were retrieved from Eloff (1979) and Meyer (1994, 1998). The Mapungubwe sample was taken from MK1 and MK3 for the elite Hill area ($n$ = 1112; here collectively referred to as MK) and squares E2, F4, K8, I9, I10, I11, and J10 from the lower-status Southern Terrace area ($n$ = 2572; here collectively referred to as MST). The excavation methods and contextual information for these units were retrieved from Jones (1937), Eloff (1978, 1979b, 1980), and Meyer (1994, 1998; Meyer and Cloete 2010). Detailed layer and square descriptions of the sample are reported in Mouton (2021).

## Methods

### Identification of shell type

Identification of raw materials was done through direct comparison with ostrich eggshell, Achatinidae, and Unionidae reference samples housed in the University of Pretoria Archaeology laboratories. The characteristics of each shell type are set out below. The analysis was conducted with a stereo microscope with a magnification range from 6.5× to 45× and with lighting from above.

In some cases, delamination of the shell surface hampered accurate identification. Delamination of ostrich eggshell occurs when the outer layers are removed, exposing the inner (spongy) palisade layers. This can be the result of either the manufacturing process or from damage. A similar process occurs with Achatina and Unionid beads where the outer periostracum and prismatic surface layers are removed. Ostrich eggshell beads are identifiable by a smooth, glossy finish (cuticle) on the outer surface, while the inner surface (mammillary layer) appears grainy and rough (Fig. 4).

Ostrich eggs have a characteristic 'dimpled' or pitted exterior surface, which is usually easily identified on both large and small beads. In large beads, the convex (outer surface)-concave (inner surface) shape of the eggshell is often well-preserved. Delaminated ostrich eggshell beads can be distinguished from mollusc shell beads when the molluscs' nacre layers are absent. Ostrich eggshell that has been exposed to heat is easily identified as the outer

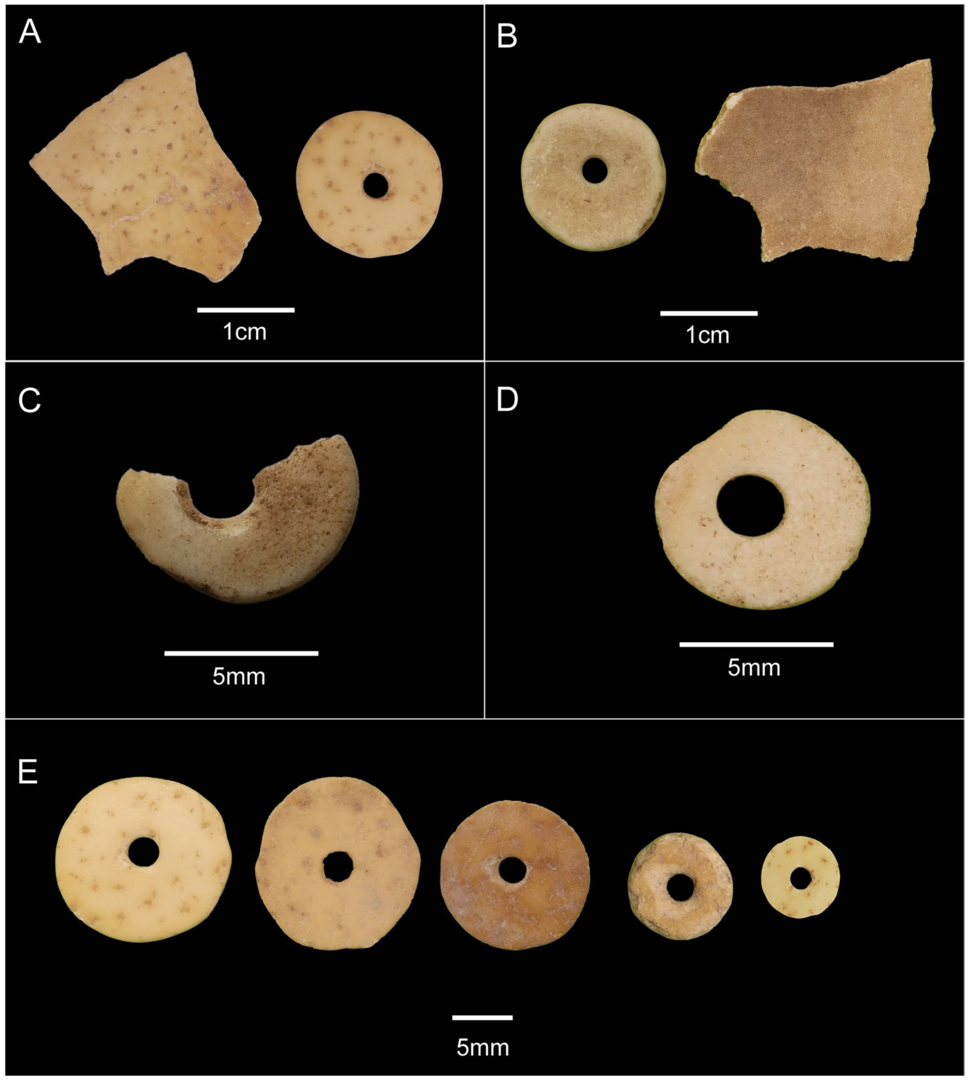



**Fig. 4** Ostrich eggshell beads with outer surface 'dimpled' outer surface (**A**), rough inner mammillary surface (**B**), partially delaminated inner mammillary surface exposing spongy palisade centre (**C**, **D**) and examples of sizes ranges (adapted from Mouton 2021)

and inner surface burns differently, with the inner surface often being lighter in colour. Additionally, when sufficiently exposed to heat (identified by a dark grey to black colouration), the inner mammillary layer often separates (delaminates), leaving a rough, broken surface (Janssen et al. 2011, p. 660; Craig et al. 2020, p. 3). Depending on the temperature it is exposed to, heated ostrich eggshell can be various shades of brown, grey, black, or white.

Achatina beads have a clear white colouration, often appearing semi-translucent (Fig. 5). Heated Achatina beads were found to have a light grey colour and retain characteristics unique to the shell type. Achatina, like other gastropod shell, consists of several types of foliated layers—the periostracum, prismatic, and nacreous layers (Taylor et al. 1969; Checa and Rodriquez-Navarro 2001; Lawfield et al. 2014). Distinguishing between Achatina and ostrich eggshell beads with the naked eye can be difficult, especially with worn, delaminated, or small beads (cf. Miller et al. 2018, p. 349). However, when viewed under a microscope with sufficient magnification, characteristics unique to Achatina become clear. Most obvious are the foliated nacre layers of Achatina shells when viewed from its side profile. Similarly, the crossed-lamellar nature of the nacre layers is visible from the bead shaft, or on the surface, once the prismatic layer has been removed. In some samples, the outer surface is partially preserved, in which case distinctive ridges can still be observed in parallel rows (Ward and Maggs 1988, p. 410; Miller et al. 2018, p. 361).

Unionid beads have a glossy, mother-of-pearl shine that is clearly visible with the naked eye when exposed to natural light (Fig. 6). The shell structure is similar to Achatina and consists of an arrangement of superimposed organic and inorganic layers (Checa 2000). When viewed in cross-section, these superimposed layers are clearly visible. Samples recovered from the archaeological record are often very fragile. When inadequately stored, the superimposed layers flake apart in beads, and flakes are often crushed into a fine powder.

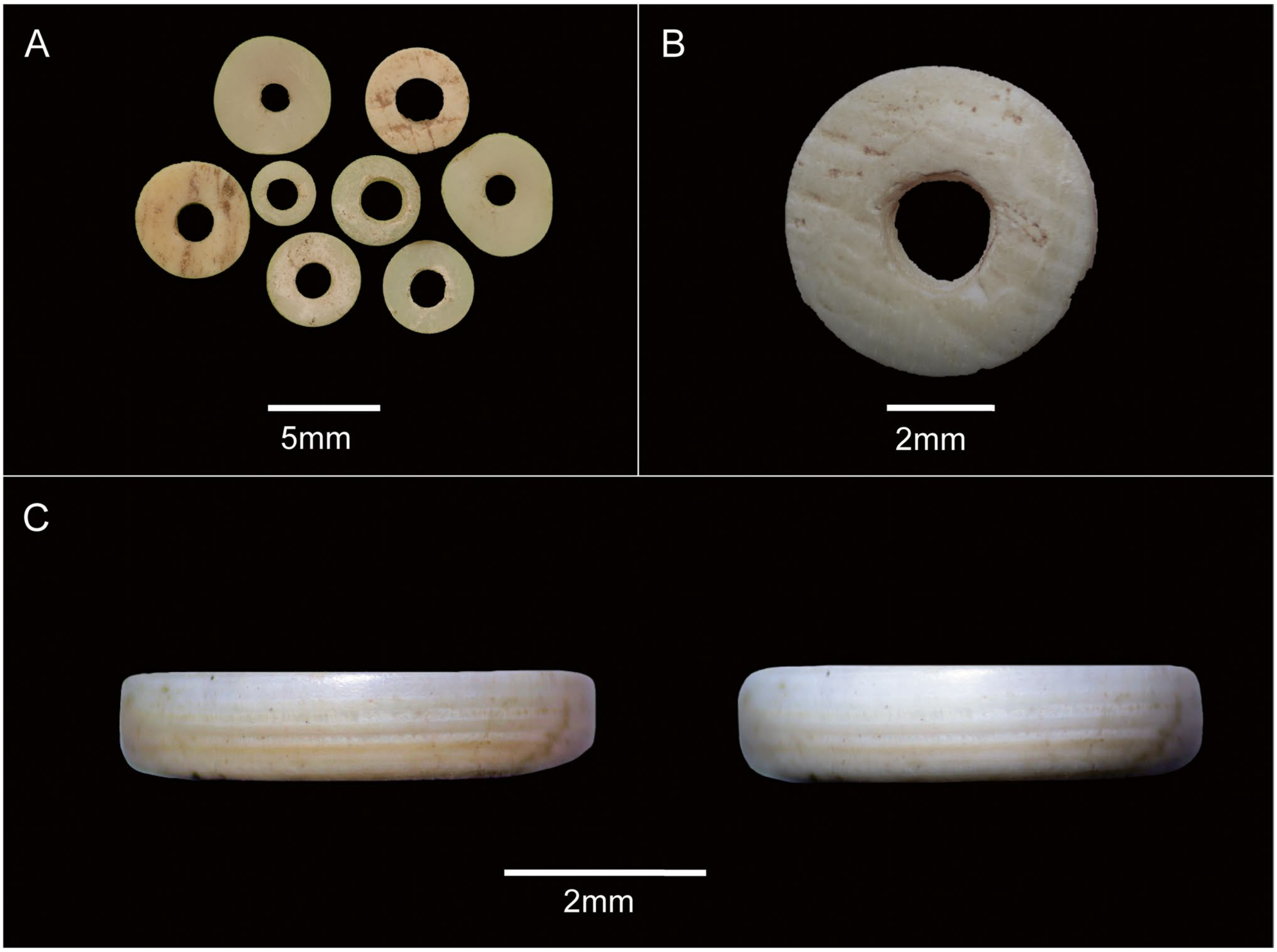



**Fig. 5** Achatina shell bead examples (**A**) with outer surface showing with distinctive ridges (**B**). **C** Side view of laminated nacreous layers (adapted from Mouton 2021)

## Description and analysis of shell disc bead morphology

Where possible, attempts were made to determine angularity (Fig. 7) and whether the bead was drilled from the inner surface, outer surface, or from both surfaces. This was not always possible, particularly with delaminated or damaged beads. In case of delamination, a determination was made between drilling from a single surface or from both surfaces. This was generally the case with Achatina beads, in which surface determination is usually more difficult.

The perforation shaft shape was also categorised as conical, biconical, or cylindrical, which are a function of the drilling process but could also be influenced by general wearing and use of the bead before entering the archaeological record (Fig. 8). The general bead shape was described by viewing the bead from the front and categorised as either circular, ovoid, or irregular.

Colour variations in SDBs were noted where present since experimental research has shown that the different colours are related to heat exposure (Craig et al. 2020). The colouration of heated beads was described for both sides of the bead. The colour groupings were grey, brown, black, white, and blue. Beads with variations of the same colour, or of different colours, were recorded as 'mixed'. These beads were likely exposed to different heat levels and were recorded as such.

Bead diameter, perforation, and thickness were recorded where possible. The maximum external diameter was used where beads were somewhat irregular, while the minimum was measured for the perforations. All dimensions were measured with a digital calliper (TWIN-CAL IP67) in millimetres (mm) to two decimal places with an error range of 0.02 mm per 100mm.

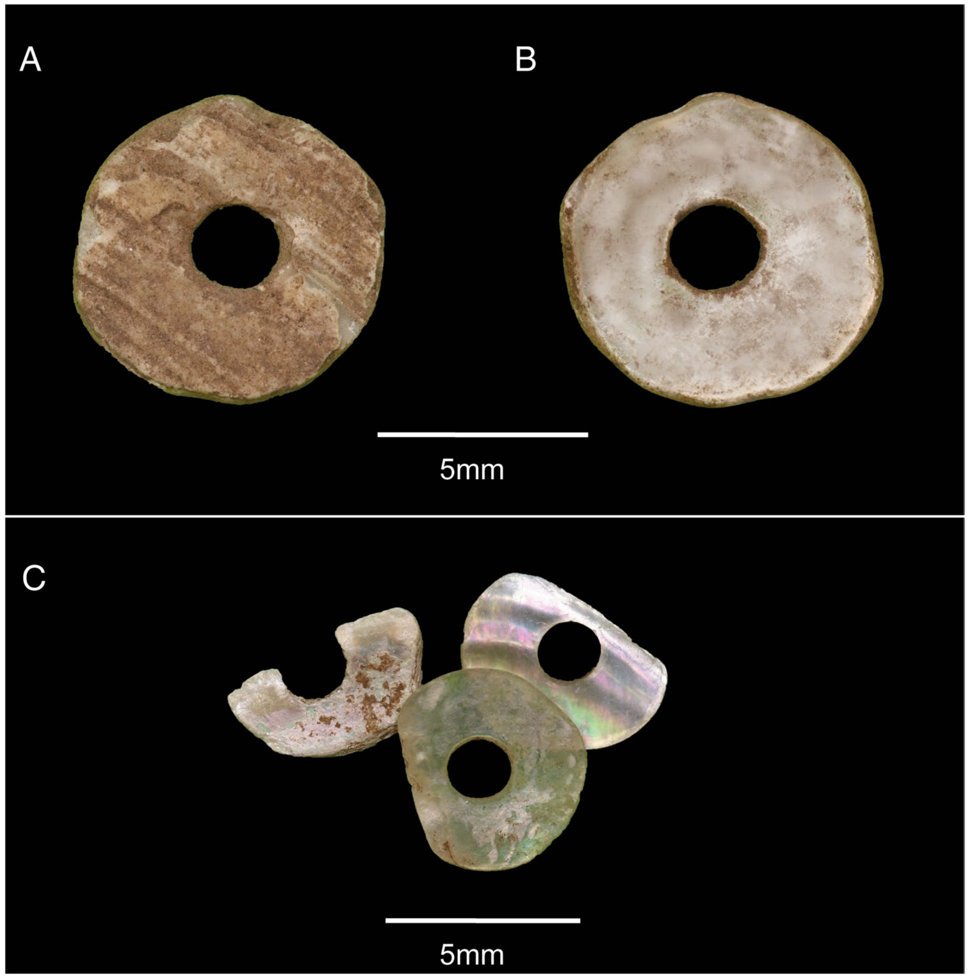



**Fig. 6** Unionid shell bead characteristics with **A** outer and **B** interior surfaces. **C** Laminar fragmentation of a single bead showing glossy, mother-of-pearl inner surface (adapted from Mouton 2021)

## Statistical methods

Statistical methods were applied using SAS JMP version 17. The sample was summarised using standard descriptive methods (mean standard deviation, minimum, maximum, range, coefficient of variation, and median). The distribution of bead sizes was explored through visual inspection of histograms and statistically through the Shapiro–Wilk test (*W*-test) for goodness of fit. Because visual inspection highlighted possible size intervals, the assemblage was further

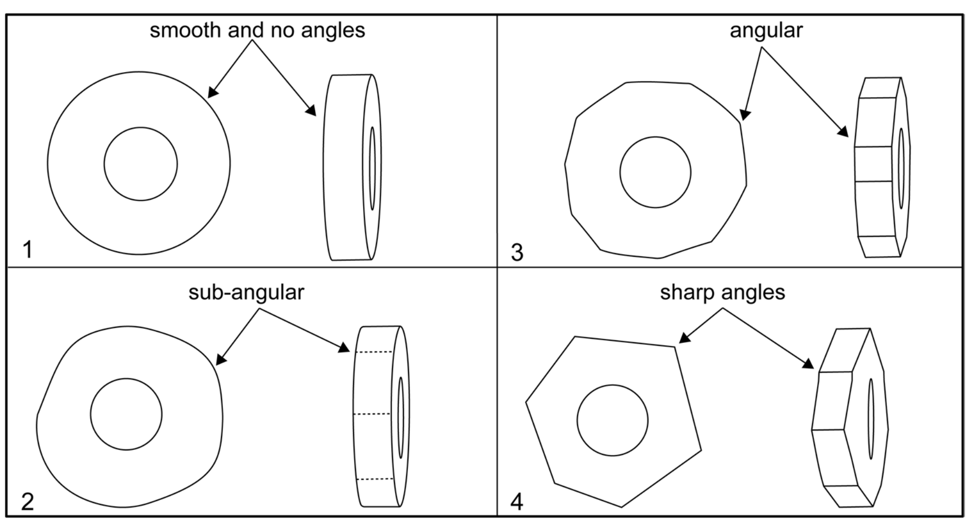



**Fig. 7** Disc bead edge categories: well rounded (1), rounded (2), angular (3), and very angular (4) (adapted from Mouton 2021)

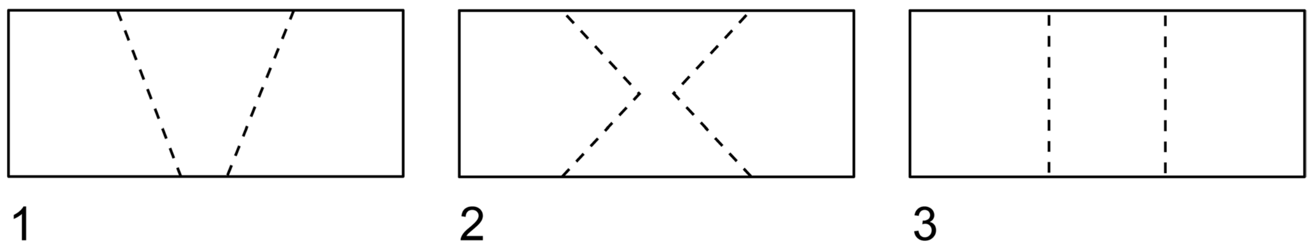



**Fig. 8** Cross-sections of conical (1), biconical (2), and cylindrical (3) shaft shapes (adapted from Mouton 2021)

explored though a K-means cluster analysis of the bead size variable. The objective of K-means is to divide observations into hypothetical clusters (*K*), the number of which are specified by the analyst, and defined by their mean. Every point is iteratively assigned to a cluster whose centroid is continuously updated based on the points assigned to that cluster and is repeated until no point changes cluster centroids (Wu 2012, p. 7). At that stage, a point is considered to be in a particular cluster if it is closer to that cluster's centroid than any other centroid (Piech 2013).

## Results

### Shell type

Beads from ostrich eggshell, Achatina, and Unionid shells were present throughout the K2-Mapungubwe MIA occupation sequence (Table 1). Unionid beads were only found in negligible numbers and were most common at K2 ($n$ = 72); only three were recovered from the Southern Terrace, and none were included in the Mapungubwe Hill sample. At a site level, ostrich eggshell dominated the phase III and phase IV samples from Mapungubwe Hill (95%; $n$ = 1053) and the Southern Terrace samples (97%; $n$ = 4513). In contrast, Achatina was more common at K2, with 70% ($n$ = 1733) made from these shells. While Achatina is significantly more prevalent at K2 than anywhere else, there is clear spatial variation in the proportional distribution of these beads in the sample. In particular, TS1 and TS2, located in the northeastern settlement area of K2, had roughly twice as many Achatina beads compared to ostrich eggshell, while the ratio for the rest of the site was relatively equal. Regardless, the pattern is one of much greater Achatina use at K2 and therefore phase II, with a marked decline in its use once the community had relocated to Mapungubwe by phase III (Fig. 9). These results are not likely to be influenced by misidentification since only four beads from the entire sample (< 0.001%) could not reliably be identified to species level (Table 1).

### Diameter

The overall diameter trends suggest an increase in mean bead size over time (Table 2). Initial inspection suggests that this is likely a factor of material type since Achatina beads, prevalent in phase II, tend to have smaller diameters ($\bar{x}$ = 4.4 mm) compared to ostrich eggshell beads, which are prevalent in phase III and IV at Mapungubwe Hill ($\bar{x}$ =

**Table 1** Distribution of shell beads for K2 and Mapungubwe Hill (MK) and Southern Terrace (MST)

| | | Site | | | |
|---|---|---|---|---|---|
| Material | | MST | K2 | MK | Total |
| Ostrich eggshell | *n* | 2513 | 682 | 1053 | 4248 |
| | % | 59% | 16% | 25% | |
| Achatina | *n* | 81 | 1733 | 58 | 1872 |
| | % | 4% | 93% | 3% | |
| Unionid | *n* | 3 | 72 | 0 | 75 |
| | % | 4% | 96% | 0% | |
| Unknown | *n* | 2 | 1 | 1 | 4 |
| | % | 50% | 25% | 25% | |
| Total | *n* | 2599 | 2488 | 1112 | 6199 |
| | % | 42% | 40% | 18% | |
| Sample Total % | | 42% | 40% | 18% | |

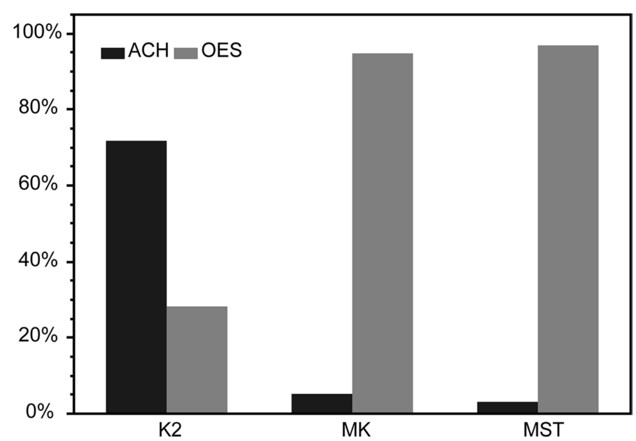



**Fig. 9** Shell by raw material distribution at K2 and Mapungubwe Hill (MK) and Southern Terrace (MST)

**Table 2** Summary of the diameter of Achatina beads at the K2-Mapungubwe settlement complex per occupation phase. CV, coefficient of variation

| Phase | *n* | Mean (mm) | Std dev (mm) | Min (mm) | Max (mm) | Range (mm) | CV | Median (mm) |
|---|---|---|---|---|---|---|---|---|
| Phase II | 1734 | 4.4 | 1.0 | 2.3 | 11 | 8.8 | 22.5 | 4.3 |
| Phase III | 71 | 4.3 | 1.1 | 2.6 | 6.9 | 4.3 | 25.1 | 4.1 |
| Phase IV | 50 | 4.3 | 1.1 | 3.0 | 7.7 | 4.8 | 24.4 | 4.1 |

**Table 3** Summary of ostrich eggshell disc bead diameter per occupation phase and per site. CV, coefficient of variation

| | Site | *N* | *n* | Mean (mm) | Std dev (mm) | Min (mm) | Max (mm | Range (mm) | Median (mm) | CV |
|---|---|---|---|---|---|---|---|---|---|---|
| Phase II | K2 | 682 | 676 | 4.8 | 1.1 | 2.5 | 10.5 | 8.0 | 4.6 | 24.0 |
| | MK | 92 | 92 | 5.8 | 1.3 | 4.0 | 10.7 | 6.7 | 5.5 | 22.1 |
| | MST | 86 | 85 | 5.4 | 0.7 | 3.9 | 8.2 | 4.3 | 5.2 | 13.7 |
| | Combined | 860 | 853 | 4.9 | 1.2 | 2.5 | 10.7 | 8.2 | 4.8 | 23.8 |
| Phase III | MK | 768 | 740 | 6.0 | 1.5 | 2.2 | 14.0 | 11.8 | 5.9 | 25.0 |
| | MST | 441 | 424 | 6.7 | 2.1 | 2.1 | 16.0 | 13.9 | 6.5 | 31.2 |
| | Combined | 1209 | 1164 | 6.3 | 1.8 | 2.1 | 16.0 | 13.9 | 6.1 | 28.3 |
| Phase IV | MK | 193 | 188 | 6.0 | 1.6 | 2.8 | 11.7 | 8.8 | 5.4 | 26.6 |
| | MST | 1986 | 1729 | 8.3 | 2.2 | 2.6 | 15.8 | 13.2 | 8.5 | 25.9 |
| | Combined | 2179 | 1917 | 8.1 | 2.2 | 2.6 | 15.8 | 13.2 | 8.3 | 27.5 |

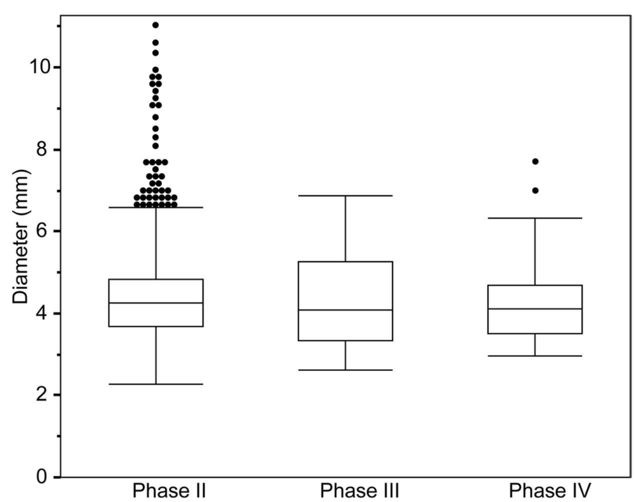
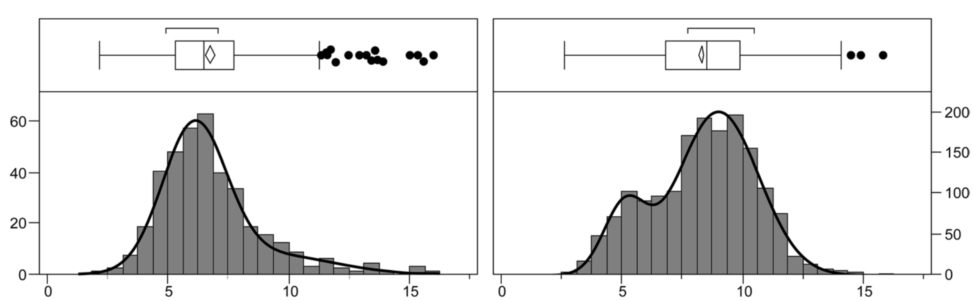



**Fig. 10** Achatina size distribution at the K2-Mapungubwe settlement complex per occupation phase

6 mm) and the Southern Terrace ($\bar{x}$ = 7.90 mm). To test the perceived link between bead material and diameter, a Welch *t*-test was conducted. The results ($t = 58.43$ $P < .0001$) confirmed that shell type has a highly significant impact on bead size. The substantial influence of shell type on size shows that any archaeological analysis of bead diameter size must first establish raw material type.

The increase in bead diameter was primarily driven by changes in the ostrich eggshell sample where there is an overall increase from 4.8 mm in phase II to 6.2 mm in phase III and 8 mm in phase IV (Table 3). In contrast, the Achatina sample demonstrates negligible variation over time. During phase II, Achatina beads had a 4.4 mm mean (SD 4.3 mm) and 8.8 mm range, which includes 31 outliers (3-sigma SD) (Fig. 10). This small group of outliers ranged between 6.9 and 11 mm and contrasts significantly with the rest of the Achatina assemblage, which is tightly spaced around the 4.2 mm median with an interquartile range of only 1.1 mm. The mean diameter of Achatina beads from phases III and IV both had a mean diameter of 4.3 mm and a standard deviation of 1 mm and are therefore essentially identical to

**Fig. 11** Distribution of Southern Terrace ostrich eggshell disc bead diameters with a normal two-mixed curve fitted



the phase II sample. Therefore, the overall trend is of little change in Achatina bead diameter between phases III and IV.

In the Hill sample, there is continuity in ostrich eggshell bead size between phase III ($\bar{x}$ = 6.0 mm; SD 1.4 mm) and phase IV ($\bar{x}$ = 5.9mm; SD 1.5 mm). In contrast, changes of ostrich eggshell disc bead sizes are observed on the Southern Terrace where there is an increase in mean diameter and variation from phase II ($\bar{x}$ = 5.4 mm) to phase IV ($\bar{x}$ = 8.3 mm).

Visual inspection and subsequent goodness of fit tests indicate that the ostrich eggshell bead sizes from the Southern Terrace potentially followed a bimodal distribution (Fig. 11), which could indicate two size groupings in both phases. Results from a Shapiro–Wilk test were performed and showed that the distribution of diameters departed significantly from normal (phase III $W = 0.91$, $p$-value < 0.001; phase IV $W = 0.98$, $p$-value < 0.001). A 1-dimension K-means cluster analysis was conducted in order to explore two hypothetical size groups in the data. This method separated the ostrich eggshell beads from each phase into a cluster of smaller and larger beads. In the phase III sample, the smaller beads cluster centred around a mean of 5.8 mm ($n$ = 312; SD = 1.1 mm), while the larger beads cluster had a 9.5 mm mean ($n$ = 112; SD = 1.9 mm). This clustering is essentially mirrored in phase IV, where the smaller diameter cluster had a 5.9 mm mean ($n$ = 626; SD 1.2 mm) and the larger beads had a 9.6 mm mean ($n$ = 1103; SD = 1.3 mm) (Table 4; Fig. 12).

**Table 4** Hypothetical K-means clusters of large and small ostrich eggshell disc beads from the Southern Terrace

| Cluster | Phase | Phase % | Mean | Std dev | CV |
|---|---|---|---|---|---|
| 1 Smaller beads | III | 74.33 | 5.78 | 1.07 | 18.45 |
| | IV | 36.67 | 5.98 | 1.20 | 20.07 |
| 2 Larger beads | III | 25.67 | 9.52 | 1.90 | 19.92 |
| | IV | 63.33 | 9.6 | 1.3 | 13.0 |

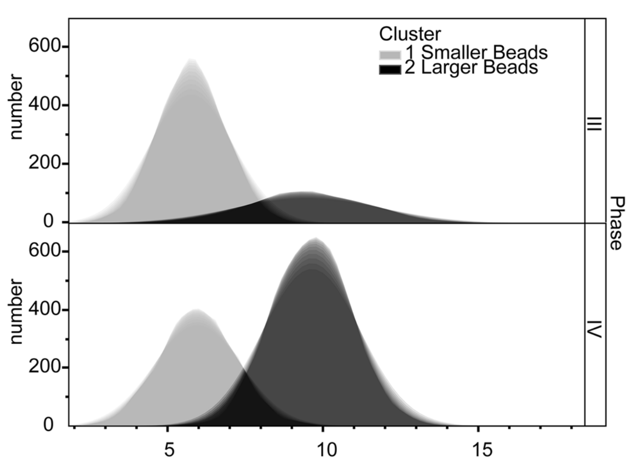



**Fig. 12** K-means hypothetical distribution of large and small ostrich eggshell disc bead cluster on the Southern Terrace in phase III and phase IV

## Shell disc bead drilling directions

Two distinct pathways of creating bead perforation were observed (Table 5). The first consists of beads that were drilled from a single direction, while the second pathway include beads drilled from only one surface. Tests indicate that there was a highly significant relationship between drilling direction and shell raw material (Pearsons $P$ > .0001). Achatina showed no preference for being drilled from both ($n$ = 635; 53%) sides, or a single side ($n$ = 570; 47%)—though it was largely impossible to determine from which side (inner/outer) this was. Ostrich eggshell beads, on the other hand, had a clear preference for being drilled from a single side ($n$ = 2751; 80%) instead of, drilling from both sides ($n$ = 684; 20%).

Chronologically, drilling preference for ostrich eggshell beads highlights a noteworthy trend (Table 6). While the ostrich eggshell samples from phases III and IV were predominantly drilled from a single side (81–90%), the phase II sample, which is predominantly from K2, had a much higher proportion of being drilled from both sides (38%). Therefore, during phase II, a small but noticeable proportion of ostrich eggshell beads followed the same manufacturing pathway as that of Achatina beads, which are also the more prevalent bead type during that phase (Fig. 13).

## Exposure to heat

Only 9% ($n$ = 236) of the beads from K2 had evidence of being exposed to heat (Table 7). These were dominated by variations of grey. Mapungubwe Hill had similarly low numbers of heated beads, with only 12% ($n$ = 135) with evidence of heat exposure. The sample from the Southern Terrace had comparatively higher counts of heated beads. More than half (57%; $n$ = 1473) of the analysed assemblage had evidence of

**Table 5** Drilling direction for Achatina and ostrich eggshell disc beads across all phases in the K2-Mapungubwe site complex

| | One sided | | Both surfaces | | Total |
|---|---|---|---|---|---|
| | *n* | % | *n* | % | *n* |
| Ostrich eggshell | 2751 | 80 | 684 | 20 | 3435 |
| Achatina | 635 | 53% | 570 | 47% | 1205 |
| All | 3386 | 73 | 1254 | 27 | 4640 |

**Table 6** Drilling direction for ostrich eggshell disc beads per occupation phase of the K2-Mapungubwe site complex

| Direction | Phase II | | Phase III | | Phase IV | | Total | |
|---|---|---|---|---|---|---|---|---|
| | *n* | % | *n* | % | *n* | % | *n* | % |
| Both sides | 239 | 34 | 92 | 10 | 353 | 19 | 684 | 20 |
| One sided | 469 | 66 | 824 | 90 | 1458 | 81 | 2751 | 80 |
| Total | 708 | | 916 | | 1811 | | 3435 | |

being heated. Some beads were only partially exposed with only sections of the beads showing colour changes, mostly as light brown patches. Several samples exhibited multiple colour combinations such as black, grey, and brown which is evidence for unequal exposure to heat. Uneven heat exposure and the mixture of heat-related colours indicate that these beads were likely exposed to indirect heat and not to direct fire (Collins and Steele 2017).

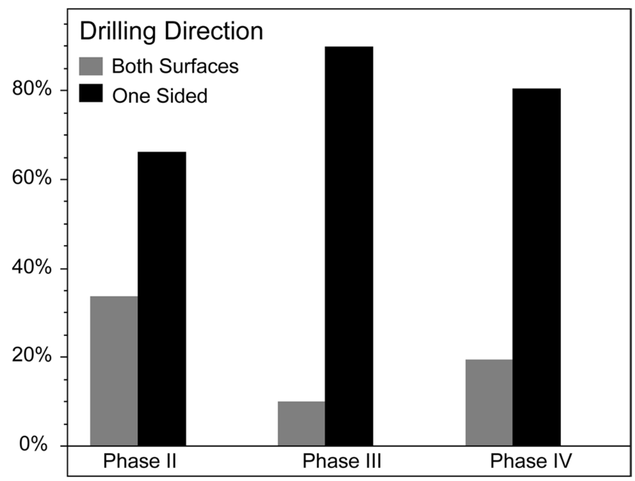



**Fig. 13** Drilling direction for ostrich eggshell disc beads per phase in the K2-Mapungubwe site complex

## Bead form variability

Analysis of edge angularity shows that the ostrich eggshell beads generally had a higher proportion of well-rounded edges (*n* = 3273; 77%), while Achatina was evenly distributed between the well-rounded and rounded categories. Angular and very angular edge types occurred in negligible numbers (*n* = 140; 2.5%) compared to more rounded types (Table 8).

All three sites were dominated by beads with a circular shape. The sample analysed from K2 had a noteworthy occurrence of 160 ovoid-shaped Achatina beads. These beads shared a uniform shape, size, and colour. Based on their uniformity, their design is clearly intentional and wholly unique to K2.

## Unionid beads

The Unionid bead samples were poorly preserved with most displaying flaking of the nacreous layers. For this reason, thickness and perforation were not measured. The degree of flaking means that the Unionid sample should not be considered as representative, and their presentation here

**Table 7** Occurrence of burning at the K2-Mapungubwe site complex

| Site | No burning | | Present | | Partial | |
|---|---|---|---|---|---|---|
| | *n* | % | *n* | % | *n* | % |
| MST | 1058 | 41 | 1436 | 56 | 63 | 2 |
| K2 | 2250 | 91 | 235 | 9 | 0 | 0 |
| MK | 975 | 88 | 133 | 12 | 1 | 0 |
| Total | 4283 | 70 | 1804 | 29 | 64 | 1 |

**Table 8** Angularity of disc beads per raw material type in the K2-Mapungubwe site complex

| | Achatina | | Unionid | | Ostrich eggshell | | Total | |
|---|---|---|---|---|---|---|---|---|
| | *n* | % | *n* | % | *n* | % | *n* | % |
| Very angular | 0 | 0 | 0 | 0 | 1 | 100 | 1 | 0 |
| Angular | 14 | 10 | 2 | 1 | 123 | 88 | 139 | 2 |
| Rounded | 921 | 51 | 41 | 2 | 844 | 48 | 1806 | 29 |
| Well-rounded | 931 | 22 | 31 | 2 | 3273 | 77 | 4235 | 69 |

serves only as generalised summary. The samples were predominantly circular with most bead edge categories ranging between well-rounded and rounded. The beads covered a wide range of diameter sizes. For the beads where drilling direction could be identified, the sample from K2 indicated that beads tended to be drilled from both surfaces.

## Discussion

The detailed analysis of the shell beads from the K2-Mapungubwe complex reveals several spatial and chronological differences. The majority of the SDBs from phase II (AD 1030–AD 1220) were manufactured from Achatina and, to a lesser extent, ostrich eggshell. In contrast, the beads associated with the height of Mapungubwe's socio-political dominance, from AD 1220 onwards, were largely made from ostrich eggshell with very low counts of other shell types. In addition to the chronological differences, spatial variation in the distribution of shell types is also evident. The majority of Achatina beads from K2 were from the north-eastern settlement units TS1 and TS2. The central homestead units of Rn2 and TS4 had equally distributed ratios of shell type (details of spatial differentiation contained in Mouton 2021). However, the glass bead assemblage suggests that Rn2 and TS4 likely date to late phase II or early phase III (Wood 2005), which only serves to further emphasise the clear departure away from Achatina to ostrich eggshell beads by around AD 1220.

The analysed sample also included beads recovered from five burials on K2 (TS2.G1, TS2.G2, TS2.G3, TS4.G1, TS5.G2), likely dating to phase III of the site sequence. Though the sample is limited, the beads that formed part of burial goods were predominantly Achatina (see also Antonites 2016), with the exception of burial TS2.G2 that had a near equal distribution of ostrich eggshell ($n$ = 21) and Achatina beads ($n$ = 24). Significantly, a small amount of Unionid beads were recovered from two burials (TS2.G1 and TS2.G2). Considering their negligible numbers from other contexts, their use in graves could relate to a distinct use-value hitherto unexplored.

### Manufacturing pathways

Throughout the occupation of the K2-Mapungubwe settlement complex, the preferred pathway for bead manufacture was one where bead blanks were drilled from a single side (either inside or outside—as this could not always be determined). However, the consistent presence of a proportion of Achatina, ostrich eggshell, and Unionid beads that were drilled from both sides at K2 suggests the presence of an additional production pathway at the site, in addition to the more common method of drilling only from one side. While it is the most evident in Achatina beads, a proportion of the ostrich eggshell sample is manufactured in this manner as well and still stands in marked contrast to its near complete absence at Mapungubwe. In addition, the southern African ethnographic literature as well as the archaeological record uniformly indicate single-facet drilling as the norm (Plug 1982, p. 60; Wingfield 2003, p. 57; Orton 2008, p. 1767; Wang et al. 2009, p. 3890). Wang et al. (2009, p. 3890) argued that the microstructure of the inner surface of ostrich eggs makes drilling from the inner surface easier, reducing the possibility of breakage. The outer surface, on the other hand, is too compact and 'slippery', making the drilling process from this surface difficult.

The presence of this unique pathway at K2 is therefore noteworthy since it likely represents a distinct producer community, archaeologically visible in their application of a distinct production method. The sudden near-absence of this method in the assemblage after AD 1220 suggests that the producer group associated with this pathway, either abandoned this technique, or was cut out of the production network after the social and economic transformations that accompanied the development of an increasingly centralised state economy during phase III (AD 1220–AD 1250). A renewed inspection of SDB from other MIA assemblages will be able to identify how widespread this bi-facet drilling pathway was, which could be either a hallmark of production at K2 itself or identifiable as a community of shared practice located somewhere on the larger landscape (for example hunter-gatherer groups or specific Iron Age settlements/communities). This highlights the value of identifying production details, which to date have not been captured for Iron Age SDB assemblages. It represents an important avenue for future research as it will potentially identify the contribution of bead production to the regional political economy.

The use of heat as a discrete production stage to change bead colour was also investigated. Although visually distinctive, black and/or brown heat-affected beads occurred in relatively low frequencies at both K2 and Mapungubwe Hill. A large percentage of the heated beads from K2 were recovered from contexts associated with household refuse that generally contained clear signs of burning such as charcoal, charred grains, and ash refuse as well as burnt hut rubble (Meyer 1998). Similarly, the heated beads recovered from MK1 on Mapungubwe Hill were concentrated in deposits with multiple burnt features that included the remains of burnt huts and a large refuse pit with ash. The number of heated beads drops significantly outside of these deposits. In addition, the large proportion of mixed colours suggests indirect exposure to heat. Therefore, it seems that in most cases, instances of bead discolouration are linked to depositional or post-depositional events, rather than a deliberate production step.

### Bead size distributions

Achatina beads from all three assemblages were relatively uniform throughout the 300-year period under consideration here, with all three stages displaying a mean of 4.3 mm and a standard deviation that only varied between 0.8 and 1 mm (outliers removed). However, ostrich eggshell beads demonstrate noticeable spatio-chronological variation in terms of size. The K2 (phase II) assemblage comprised of relatively small beads with a 4.6 mm mean and a narrow range of variation (1 mm SD). Spatially, this sample was also largely homogenous across the various settlement areas. However, several changes are discernible after AD 1220, when the occupation moves to Mapungubwe. Here, the ostrich eggshell bead assemblage from the elite hilltop area is characterised by large degrees of uniformity over time, with near identical means (5.9 mm and 6.0 mm, for phase III and IV respectively) and a standard deviation of 0.2 mm. The similarity in bead size between phase III and phase IV for the Hill implies that these two samples seen together, provide a trend for the elite bead assemblage as one with a mean of around 5.9 mm and a narrow range of variation around it (SD 1.3 mm).

In contrast to the homogenous elite pattern on Mapungubwe Hill, the lower-status Southern Terrace had much greater levels of variation and change over time, and is likely a reflection of the more diverse population who resided here. Analysis of the distribution revealed the probable presence of two clusters of large and smaller beads in each phase. K-means clustering suggests that the means and standard deviations of the respective small and large clusters are essentially similar for phase III and phase IV. Significantly, the smaller bead clusters for both phases are largely identical to the elite assemblage from the Hilltop in terms of size and dispersion. If the Hill assemblage of small, beads with little size variation is taken to represent an elite pattern, the presence of a similar component on the Southern Terrace assemblage implies access to the same beads as those consumed by elites. This could be the archaeological signature of higher-status households on the Southern Terrace. However, there is a noticeable change in the proportions of size clustersper phase. In the earlier phase III, beads from the small cluster account for nearly three-quarters of the sample (74%), while in phase IV, this pattern is reversed with around two-thirds being form the large beads cluster (64%). Therefore, elite-type smaller beads became rarer in lower-status areas over time, which could reflect the increasing monopolisation and control by Mapungubwe elites over the production economy and less choice for lower-status groups.

To compare how the Southern Terrace compares to other assemblages, the coefficient of variation can be used. This measure is frequently employed by archaeologists as a robust method to compare the variability of assemblages and determine the standardisation of artefacts (Eerkens and Bettinger 2001). The Southern Terrace sample as a whole had higher CV values than either Mapungubwe Hill or K2. However, this difference falls away if the Southern Terrace sample is split into the observed size clusters. This suggests that while there are differences in bead size over time and space, there is little difference in the variation of bead diameter of the sub-assemblages. The interpretation of this pattern is not immediately apparent and could be the result of several factors such as the influence of technology, technique, bead use, and preference. For example, alternative uses for beads—such as decorative elements on composite pieces or buttons—could also be reflected in the small but consistent groups of large outliers in every phase for both Achatina and ostrich eggshell.

### Bead crafting at the K2-Mapungubwe settlement complexes

K2 and Mapungubwe are generally regarded as centres of craft production for items made from wood, bone, and ivory (Voigt 1983; Plug and Voigt 1985; Plug 2000; Antonites et al. 2016), glass bead re-shaping (Gardner 1963; Wood 2000, 2005), hide and leather working (Voigt 1981, 1983; Antonites et al. 2016), metallurgy (Calabrese 2000; Miller 2001), and cotton spinning (Antonites 2019). The widely held assumption is that SDB would have formed part of the craft production repertoire, since beyond the raw material, little infrastructure and manufacturing technology are needed (cf. Yellen 1977). However, as this study has shown, there is a distinct lack of clear evidence related to the manufacture of shell beads at both sites. The absence of production debris is conspicuous when contrasted to its presence at contemporaneous sites. Yellen (1977, p. 142), in his ethnoarchaeological research on site formation processes, notes, for example, that '[a]t any stage of this process, a blank may be lost in the sand, break, or be discarded because of faulty workmanship. Thus, beads in various stages of manufacture are found on abandoned sites'. While the absence of production debris from early twentieth-century excavations could be explained by coarse sampling methods, they are also absent from more recent fine-grained excavations.

Bead angularity could be taken as an indicator for on-site bead manufacturing since it is assumed that these beads are 'unfinished'. However, several ethnographic and archaeological studies caution that angular beads were used as completed ornaments (Plug 1982, p. 61; Tapela 2001, p. 64). While the K2-Mapungubwe complex SDB assemblages contained examples of angular ostrich eggshell and Achatina beads, these examples all had well-worn and smoothed perforations and edges that suggest that they were in use before being deposited. Without clear evidence of manufacture, such as blanks and unfinished discs, it cannot be determined whether beads were manufactured at either K2 or Mapungubwe. If such evidence exists, it was not immediately apparent from the SDB assemblage alone. Either shell beads were manufactured elsewhere, or any evidence for on-site production was so ephemeral that it was not archaeologically visible.

Ethnographies collected in the nineteenth and twentieth centuries, stress the role of hunter-gatherers in producing shell beads for Bantu-speaking farmers and the potential role of bead production by these more mobile communities cannot be overlooked. However, as Hall and Smith (2000) pointed out, evidence for bead production is largely absent at hunter-gatherer sites of the region after AD 1100, and production of these items had likely shifted to Iron Age farming communities. Furthermore, there seems to be an overall decrease in the range of craft activities that took place at Mapungubwe in relation to the earlier K2 period, with a concomitant increase of these activities at lower-status settlements (Calabrese 2007).

Another explanation for the absence of bead manufacturing evidence may relate to the dramatic shift towards ostrich eggshell during the occupation of Mapungubwe. This could indicate greater availability of other shell types during the earlier occupation phase II, or that during this phase, there was little preference for beads from a specific shell type. At the same time, the predominance of ostrich eggshell beads at Mapungubwe could indicate that other shell types were scarcer during phase III and IV, possibly due to over-exploitation in the preceding 200 years. However, the presence of both Achatina and Unionid shells in the faunal assemblage from phases III and IV (Gardner 1963; Voigt 1983, 1998) seems to argue against this. Instead, it is likely that choice—at the producer and/or consumer side—played a role in shell type selection. Alternatively, it could indicate that new sources of ostrich eggshell as a raw material were opening up through Mapungubwe's increasingly expanding trade networks. Although ostriches do occur in the Limpopo Valley region, they prefer and are more abundant in open savannah and grassland regions such as the margins of the Kalahari Desert (Verlinden and Masogo 1997; Cooper et al. 2009). It may therefore be significant that by the early thirteenth century AD, elites with clear social and trade links to Mapungubwe—perhaps through kin relations—established regional dominance over this area and trade networks across the greater Kalahari region from the regional capital Bosutswe (Denbow et al. 2008). Hunter-gatherer groups occupied much of the more arid regions and formed an important part of this exchange network. Historical and ethnographic records indicate that these highly mobile communities traded, among other things, ostrich eggshells to sedentary farmer communities. A similar scenario in the thirteenth century may have existed, whereby Bosutswe could source ostrich eggshell or the final products from across its greater hinterland. Therefore, the change towards ostrich eggshell beads at Mapungubwe was likely related to its role in the expansion and redirection of regional trade.

## Conclusion

Analysis of the K2-Mapungubwe SDB assemblages shows some distinct spatial and chronological differences. Many of the observed differences could be explained as a result of shell type rather than cultural, economic, or social factors. This variation in shell use accentuates the significance of raw materials when comparing the SDB assemblages from multiple sites or periods. On a site level, the SDB assemblage from K2 displayed the least amount of standardisation, both in raw material and manufacturing techniques. There was also a noticeable difference in diameter size distributions between K2, the Hill, and the Southern Terrace. However, this too was likely due to the difference in shell type. Overall, Achatina beads were mostly dominated by small size ranges, while ostrich eggshell ones were larger. Conversely, the greater variability in diameter sizes on the lower-status Southern Terrace could indicate a diverse manufacturing and consuming community. However, the possibility exists that beads were not produced at K2 or Mapungubwe. No debris related to the manufacture of SDB could be located from either K2 or Mapungubwe, nor any publications presenting such evidence. Without clear manufacturing evidence, such as unfinished discs, it cannot be assumed that beads were manufactured here. If beads were traded onto the sites, the K2 community seemingly had less preference for specific raw material types compared to later periods at Mapungubwe. At Mapungubwe Hill, beads fell within a narrower range of small sizes and was almost exclusively made from ostrich eggshell. Although the lower status Southern Terrace demonstrates a similar preference for ostrich eggshell beads, there was greater variability in size distributions and the presence of a definable cluster of larger sized beads.

**Acknowledgements** Access to the Mapungubwe Collection was kindly provided by the University of Pretoria Museums, Office of the Registrar and assistance was provided by Dr Sian Tiley-Nel, head curator.

**Author contribution** MM analysed the shell bead sample for her unpublished MA dissertation research, developed and applied the methods for shell bead analysis used here, and reconstructed the archaeological context for the data sets (Mouton 2021). AA conducted a statistical investigation of the data and was the major contributor to the discussion and conclusion sections. Both AA and MM contributed to the manuscript text and figures. AA and MM reviewed the manuscript before submission.

**Funding** Open access funding provided by University of Pretoria. The research was supported by the National Research Foundation (South Africa), Grant 98801.

National Research Foundation,98801,98801

**Data availability** The datasets generated and analysed during the current study are curated by the Department of Anthropology and Archaeology, University of Pretoria, and consent for publication is available from the corresponding author on reasonable request.

**Code availability** Not applicable

## Declarations

**Competing interests** The authors declare no competing interests.

**Ethics approval** The research was conducted in an ethical manner, and all relevant permissions were obtained from the University of Pretoria, Department of Anthropology and Archaeology, to study the objects included in this research. No human or animal subjects formed part of this study. This material is the authors' own original work, which has not been previously published elsewhere. The paper reflects the authors' own research and analysis in a truthful and complete manner.

**Conflict of interest** The authors declare no competing interests.



## References

Allen J, Holdaway S, Fullagar R (1997) Identifying specialisation, production and exchange in the archaeological record: the case of shell bead manufacture on Motupore Island, Papua. Archaeol Ocean 32:13–38. https://doi.org/10.1002/j.1834-4453.1997.tb00367.x

Antonites A (2019a) Mapungubwe's hinterland: excavations, ceramics and other material culture from Mutamba in the Soutpansberg. South Afr Humanit 32:1–22

Antonites A (2019b) Fiber spinning during the Mapungubwe period of Southern Africa: regional specialism in the Hinterland. Afr Archaeol Rev 36:105–117. https://doi.org/10.1007/s10437-018-09323-9

Antonites A (2016) Zhizo and Leokwe period human remains and burial practices at Schroda. South Afr Archaeol Bull 71:14–26

Antonites AR, Bradfield J, Forssman T (2016) Technological, functional and contextual aspects of the K2 and Mapungubwe worked bone industries. Afr Archaeol Rev 33:437–463. https://doi.org/10.1007/s10437-016-9233-z

Assefa Z, Lam YM, Mienis HK (2008) Symbolic use of terrestrial gastropod opercula during the Middle Stone Age at Porc-Epic Cave, Ethiopia. Curr Anthropol 49:746–756. https://doi.org/10.1086/589509

Balme J, O'Connor S (2017) Traditions and change in scaphopod shell beads in Northern Australia from the Pleistocene to the recent past. In: Bar-Yosef Mayer DE, Bonsall C, Choyke AM (eds) Not just for show. Oxbow Books, Oxford, pp 7–18

Bednarik RG (1997) About Ostrich Eggshell Beads. Acta Archaeol 68:153–161

Bleek DF (1928) The Naron: a Bushman tribe of the central Kalahari. Cambridge University Press, Cambridge

Bouzouggar A, Barton N, Vanhaeren M et al (2007) 82,000-year-old shell beads from North Africa and implications for the origins of modern human behavior. Proc Natl Acad Sci 104:9964–9969. https://doi.org/10.1073/pnas.0703877104

Calabrese JA (2000) Metals, ideology and power: the manufacture and control of materialised ideology in the area of the Limpopo-Shashe confluence, c.AD 900 to 1300. Goodwin Ser 8:100. https://doi.org/10.2307/3858051

Calabrese JA (2007) The emergence of social and political complexity in the Shashi-Limpopo Valley of Southern Africa, AD 900 to 1300: ethnicity, class, and polity. Archaeopress, Oxford

Carrion JS, Scott L, Huffman T, Dreyer C (2000) Pollen analysis of Iron Age cow dung in southern Africa. Veg Hist Archaeobotany 9:239–249. https://doi.org/10.1007/BF01294638

Checa AG, Rodriquez-Navarro A (2001) Geometrical and crystallographic constraints determine the self-organization in of shell microstructure in Unionidae (Bivalvia: Mollusca. Proc R Soc B Biol Sci 268:771–778

Collins B, Steele TE (2017) An often-overlooked resource: ostrich (Struthio sp.) eggshell in the archaeological record. J Archaeol Sci Rep 13:121–131

Cooper RG, Mahrose KhMA, Horbańczuk JO et al (2009) The wild ostrich (Struthio camelus): a review. Trop Anim Health Prod 41:1669–1678. https://doi.org/10.1007/s11250-009-9364-1

Craig C, Collins B, Nowell A, Ames C (2020) The effects of heating ostrich eggshell on bead manufacturing: an experimental approach. J Archaeol Sci Rep 31:102287. https://doi.org/10.1016/j.jasrep.2020.102287

Crowther A, Faulkner P, Prendergast ME et al (2016) Coastal subsistence, maritime trade, and the colonization of small offshore islands in eastern African prehistory. J Isl Coast Archaeol 11:211–237. https://doi.org/10.1080/15564894.2016.1188334

d'Errico F, Backwell L, Villa P et al (2012) Early evidence of San material culture represented by organic artifacts from Border Cave, South Africa. Proc Natl Acad Sci 9:13214–13219

Denbow J, Smith J, Ndobochani NM et al (2008) Archaeological excavations at Bosutswe, Botswana: cultural chronology, paleo-ecology and economy. J Archaeol Sci 35:459–480. https://doi.org/10.1016/j.jas.2007.04.011

Drury J (1935) Preliminary report on anthropological research carried out by Mr. Drury of the South African Museum in South West Africa. Ann South Afr Mus 24:89–110

Eerkens JW, Bettinger RL (2001) Techniques for assessing standardization in artifact assemblages: can we scale material variability? Am Antiq 66:493–504. https://doi.org/10.2307/2694247

Eloff JF (1979a) Die Kulture van Greefswald: 'n argeologiese studie van die Ystertydperkkulture op die plaas Greefswald, vol 2. University of Pretoria, Pretoria

Eloff JF (1979b) Die Kulture van Greefswald: 'n argeologiese studie van die Ystertydperkkulture op die plaas Greefswald, vol 1. University of Pretoria, Pretoria

Eloff JF (1978) Greefswald 1977–1978 Opgrawingsverslag: Mapungubwe Suidelike Terras (MST). Universiteit van Pretoria, Pretoria

Eloff JF (1980) Greefswald-opgrawing 1980. Universiteit van Pretoria, Pretoria

Flexner JL, Fleisher JB, LaViolette A (2008) Bead grinders and early Swahili household economy: analysis of an assemblage from Tumbe, Pemba Island, Tanzania, 7th-10th centuries AD. J Afr Archaeol 6:161–181. https://doi.org/10.3213/1612-1651-10110

Forde CD (1934) Habitat, economy, and society: a geographical introduction to ethnology. Methuen, London

Fouché L (1937) Mapungubwe, ancient Bantu civilization on the Limpopo. University of Pretoria, Pretoria

Gamble LH (2020) The origin and use of shell bead money in California. J Anthropol Archaeol 60:101237. https://doi.org/10.1016/j.jaa.2020.101237

Gardner CGA (1963) Mapungubwe volume 2: report on excavations at Mapungubwe and Bambandyanalo in Northern Transvaal from 1935 to 1940. J.L. van Schaik, Pretoria

Gitywa VZ (1970) The arts and crafts of the Xhosa in the Ciskei: Past and Present. University of Fort Hare, MA

Goodwin AJH (1945) Some historical Bushman arrows. South Afr J Sci XLI:429–443

Hall S, Smith B (2000) Empowering places: rock shelters and ritual control in farmer-forager interactions in the Northern Province. Goodwin Ser 8:30–46. https://doi.org/10.2307/3858044

Hanisch EOM (1980) An archaeological interpretation of Certain Iron Age sites in the Limpopo. University of Pretoria, MA

Hartzell LL (1991) Archaeological evidence for stages of manufacture of Olivella shell beads in California. J Calif Gt Basin Anthropol 13:29–39

Hitchcock RK (2012) Ostrich eggshell jewelry manufacturing and use of ostrich products among San and Bakgalagadi in the Kalahari. Botsw Notes Rec 44:93–105

Huffman TN (1982) Archaeology and ethnohistory of the African Iron Age. Annu Rev Anthropol 11:133–150. https://doi.org/10.1146/annurev.an.11.100182.001025

Huffman TN (1996a) Snakes & crocodiles: power and symbolism in ancient Zimbabwe. Witwatersrand University Press

Huffman TN (1996) Archaeological evidence for climatic change during the last 2000 years in southern Africa. Quat Int 33:55–60. https://doi.org/10.1016/1040-6182(95)00095-X

Huffman TN (2000) Mapungubwe and the origins of the Zimbabwe culture. Goodwin Ser 8:14. https://doi.org/10.2307/3858043

Huffman TN (2007) Handbook to the Iron Age: the archaeology of pre-colonial farming societies in Southern Africa. University of KwaZulu-Natal Press

Huffman TN (2009) Mapungubwe and Great Zimbabwe: the origin and spread of social complexity in southern Africa. J Anthropol Archaeol 28:37–54. https://doi.org/10.1016/j.jaa.2008.10.004

Huffman TN (2015) Social complexity in Southern Africa. Afr Archaeol Rev 32:71–91. https://doi.org/10.1007/s10437-014-9166-3

Huffman TN (2015b) Mapela, Mapungubwe and the origins of states in southern Africa. South Afr Archaeol Bull 14

Huffman TN (2017) Origins of Mapungubwe Project: test excavations at Den Staat 14B and 14C. South Afr Humanit 185–245

Jacobson L (1987a) The size variability of ostrich eggshell beads from central Namibia and its relevance as a stylistic and temporal marker. South Afr Archaeol Bull 42:55–58

Jacobson L (1987b) More on ostrich eggshell bead size variability: the Geduld early herder assemblage. South Afr Archaeol Bull 42:174–175. https://doi.org/10.2307/3888746

Janssen JD, Mutch GW, Hayward JL (2011) Taphonomic effects of high temperature on avian eggshell. Palaios 26(658–664):118

Jones N (1937) The 1934 expedition. In: Fouche L (ed) Mapungubwe: ancient Bantu civilization on the Limpopo. Cambridge University Press, Cambridge, pp 9–31

Juma A (2004) Unguja Ukuu on Zanzibar : an archaeological study of early urbanism. Uppsala University

Kandel AW, Conard NJ (2005) Production sequences of ostrich eggshell beads and settlement dynamics in the Geelbek Dunes of the Western Cape. South Africa. J Archaeol Sci 32:1711–1721

Kim NC, Kusimba CM (2008) Pathways to social complexity and state formation in the southern Zambezian region. Afr Archaeol Rev 25:131–152. https://doi.org/10.1007/s10437-008-9031-3

Kozuch L (2022) Shell bead crafting at Greater Cahokia. North Am Archaeol 43:64–94. https://doi.org/10.1177/01976931211048205

Kuper A (1980) Symbolic dimensions of the Southern Bantu homestead. Africa 50:8–23. https://doi.org/10.2307/1158639

Lawfield AMW, Gingras MK, Pemberton G (2014) Microboring in a freshwater Fluvial Inionid bivalve substrate. Ichnos Int J Plant Anim Traces 21:193–204

Maggs T, Ward V (1988) The slipped disc. Ann Natal Mus 29:407–416

Marshall L (1961) Sharing, talking, and giving: relief of social tensions among !Kung Bushmen. Africa 31:231–249. https://doi.org/10.2307/1157263

Mazel AD (1987) People making history: the last ten thousand years of hunter-gatherer communities in the Thukela Basin. University of Cape Town, PhD

Medchill B, Loendorf C, Rodrigues T (2020) Indigenous disk beads in the southern southwest: contemporary, ethnographic, ethnohistorical, and archaeological evidence. KIVA 86:428–447. https://doi.org/10.1080/00231940.2020.1775425

Mellars P (2006) Going east: new genetic and archaeological perspectives on the modern human colonization of Eurasia. Science 313:796–800. https://doi.org/10.1126/science.1128402

Meyer A (1994) Stratigrafie van die Ystertydperkterreine op Greefswald. South Afr J Ethnol 17:137–160

Meyer A (1998) The archaeological sites of Greefswald: stratigraphy and chronology of the sites and a history of investigations. University of Pretoria

Meyer A (2000) K2 and Mapungubwe. Goodwin Ser 8:4. https://doi.org/10.2307/3858042

Meyer A, Cloete C (2010) Architectural traditions of Mapungubwe and Bambandyanalo (K2). J Transdiscipl Res South Afr 6:. https://doi.org/10.4102/td.v6i1.115

Miller D (2001) Metal assemblages from Greefswald areas K2, Mapungubwe hill and Mapungubwe southern terrace. The South African Archaeological Bulletin 56:83. https://doi.org/10.2307/3889031

Miller JM, Keller HM, Heckel C et al (2021) Approaches to land snail shell bead manufacture in the early Holocene of Malawi. Archaeol Anthropol Sci 13:37. https://doi.org/10.1007/s12520-021-01274-8

Miller JM, Sawchuk EA, Reedman ALR, Willoughby PR (2018) Land snail shell beads in the Sub-Saharan archaeological record: when, where, and why? Afr Archaeol Rev 35:347–378. https://doi.org/10.1007/s10437-018-9305-3

Miller JM, Wang YV (2022) Ostrich eggshell beads reveal 50,000-year-old social network in Africa. Nature 601:234–239. https://doi.org/10.1038/s41586-021-04227-2

Mosothwane MN, Steyn M (2004) Palaeodemography of Early Iron Age Toutswe communities in Botswana. South Afr Archaeol Bull 59:45. https://doi.org/10.2307/3889242

Mouton M (2021) The manufacture, use, and significance of shell disc beads from the 9th to 13th century CE in northern South Africa. University of Pretoria, MA

Nienaber W, Hutten M (2006) The 2003 Mapungubwe Stabilization Project. Unpublished report submitted to the Department of Environmental Affairs and Tourism, Pretoria

Orton J (2008) Later Stone Age ostrich eggshell bead manufacture in the Northern Cape, South Africa. J Archaeol Sci 35:1765–1775. https://doi.org/10.1016/j.jas.2007.11.014

Paver FR (1933) Mysterious grave on Mapungubwe Hill. Illus. Lond. News 494–495

Piech C (2013) K Means. https://stanford.edu/~cpiech/cs221/handouts/kmeans.html. Accessed 9 Dec 2022

Pikirayi I (2002) The Zimbabwe culture: origins and decline of southern Zambezian states. Rowman Altamira

Plug I (1982) Bone tools and shell, bone and ostrich eggshell beads from Bushman Rock Shelter (BRS). Eastern Transvaal. South Afr Archaeol Bull 37:57. https://doi.org/10.2307/3888676

Plug I (2000) Overview of the Iron Age fauna from the Limpopo valley. South Afr Archaeol Soc Goodwin Ser 10:117–126
Plug I, Voigt EA (1985) Archaeozoological studies of Iron Age communities in southern Africa. Adv World Archaeol 4:189–238
Raath A (2014) An archaeological investigation of Zhizo/Leokwe foodways at Schroda and Pont Drift, Limpopo Valley. Yale University, South Africa. Ph.D.
Sadr K, Smith A, Plug I et al (2003) Herders and foragers on Kasteelberg: interim report of excavations 1999–2002. South Afr Archaeol Bull 58:27. https://doi.org/10.2307/3889154
Schapera I (1930) The Khoisan peoples of South Africa: Bushmen and Hottentots. Routledge & Kegan Paul, London
Schapera I (1937) The Bantu-speaking peoples of Southern Africa. Routledge & K. Paul, London; Boston
Schoeman MH (2006a) Clouding power? Rain-control, space, landscapes and ideology in Shashe-Limpopo state formation. University of the Witwatersrand
Schoeman MH (2006) Imagining rain-places: rain-control and changing ritual landscapes in the Shashe-Limpopo confluence area. South Africa. South Afr Archaeol Bull 61:152. https://doi.org/10.2307/20474923
Schoeman MH, Pikirayi I (2011) Repatriating more than Mapungubwe human remains: archaeological material culture, a shared future and an artificially divided past. J Contemp Afr Stud 29:389–403. https://doi.org/10.1080/02589001.2011.600847
Schofield JF (1937) The pottery of the Mapungubwe district. In: Fouche L (ed) Mapungubwe: Ancient Bantu civilization on the Limpopo. Cambridge University Press, Cambridge, pp 32–62
Sentker HF (1954) Algemene argeologiese verslag oor die opgrawings te Mapungubwe Suidelike Terras (UP/AGL/D/1504/1/1. University of Pretoria, Pretoria
Sentker HF (1969) Mapungubwe 1953-1954. University of Pretoria
Silberbauer GB (1965) Report to the Government of Bechuanaland on the Bushman Survey. Bechuanaland Government, Gaberones
Silberbauer GB (1981) Hunter and habitat in the central Kalahari Desert. CUP Archive
Smith A, Jacobson L (1995) Excavations at Geduld and the appearance of early domestic stock in Namibia. South Afr Archaeol Bull 50:3–14. https://doi.org/10.2307/3889270
Smith AB, Halkett D, Hart T, Mutti B (2001) Spatial patterning, cultural identity and site integrity on open sites: evidence from Bloeddrift 23, a pre-colonial herder camp in the Richtersveld, Northern Cape Province, South Africa. South Afr Archaeol Bull 56:23–33
Spinapolice EE, Zerboni A, Meyer MC et al (2022) Back to Uluzzo – archaeological, palaeoenvironmental and chronological context of the Mid-Upper Palaeolithic sequence at Uluzzo C Rock Shelter (Apulia, southern Italy). J Quat Sci 37:217–234. https://doi.org/10.1002/jqs.3349
Stayt H (1968) The Bavenda. Frank Cass, London
Steyn M (2007) The Mapungubwe gold graves revisited. South Afr Archaeol Bull 62:140–146
Stow GW (1905) The native races of South Africa. Swan Sonnenschein, London
Tapela MC (2001) An archaeological examination of ostrich eggshell. Pula Botsw J Afr Stud 15:60–74
Taylor JD, Kennedy WJ, Hall A (1969) The shell structure and mineralogy of the Bivalvia. In: Introduction: Nuculacea-Trigoniaccea. Bulletin of the British Museum (Natural History), Zoology. pp 1–125
Texier P-J, Porraz G, Parkington J et al (2010) A Howiesons Poort tradition of engraving ostrich eggshell containers dated to 60,000 years ago at Diepkloof Rock Shelter, South Africa. Proc Natl Acad Sci 107:6180–6185. https://doi.org/10.1073/pnas.0913047107
Tiley-Nel SL (2018) Past imperfect: the contested early history of the Mapungubwe archive. University of Pretoria, Thesis
Turgeon L (2022) Shell beads and belts in 16th- and early 17th-century France and North America. Gradhiva Rev Anthropol Hist Arts 40–59. https://doi.org/10.4000/gradhiva.6194
Tyrrell B (1976) Tribal peoples of southern Africa. T.V. Bulpin, Cape Town
Tyson PD, Lindesay JA (1992) The climate of the last 2000 years in southern Africa. The Holocene 2:271–278. https://doi.org/10.1177/095968369200200310
van Ewyk JF (1987) The prehistory of an Iron Age site on Skutwater. University of Pretoria, MA
Vanhaeren M (2005) Speaking with beads: the evolutionary significance of personal ornaments. In: d'Errico F (ed) From tools to symbols: from early hominids to modern humans. Wits University Press, Johannesburg, pp 525–554
Van Warmelo NJ (1932) Contributions towards Venda history, religion and tribal rituals. Government Press, Pretoria
Verlinden A, Masogo R (1997) Satellite remote sensing of habitat suitability for ungulates and ostrich in the Kalahari of Botswana. J Arid Environ 35:563–574. https://doi.org/10.1006/jare.1996.0174
Villa P, Soriano S, Tsanova T et al (2012) Border cave and the beginning of the Later Stone Age in South Africa. Proc Natl Acad Sci 109:13208–13213. https://doi.org/10.1073/pnas.1202629109
Voigt EA (1983) Mapungubwe: an archaeozoological interpretation of an Iron Age Community. Transvaal Museum, Pretoria
Voigt EA (1981) The faunal remains from Schroda. In: Voigt EA (ed) Guide to archaeological sites in the northern and eastern Transvaal. Transvaal Museum, Pretoria, pp 55–62
Voigt EA (1998) Identification of terrestrial and freshwater mollusca from Greefswald. In: Meyer A (ed) The archaeological sites of Greefswald: stratigraphy and chronology of the sites and a history of investigations. University of Pretoria, Pretoria, pp 281–282
Vogel JC (2000) Radiocarbon dating of the Iron Age sequence in the Limpopo Valley. Goodwin Ser 8:51. https://doi.org/10.2307/3858046
Vuruku M (1997) The technology of ostrich eggshell bead production. Kenya Past Present 29:49–56
Wadley L (1989) Legacies from the Later Stone Age. Goodwin Ser 6:42–53. https://doi.org/10.2307/3858131
Wang C, Zhang Y, Gao X et al (2009) Archaeological study of ostrich eggshell beads collected from SDG site. Chin Sci Bull 54:3887–3895
Ward V, Maggs T (1988) The slipped disc: a guide to the identification of shell disc-beads. Ann Natal Mus 29:407–416. https://doi.org/10.10520/AJA03040798_373
Werner A (1919) Introductory sketch of the Bantu languages, by Alice Werner … Kegan Paul, Trench. Trubner and Co., London
Wilmsen EN (2015) Ostrich eggshells and their beads. South Afr Archaeol Bull 70:89–105
Wingfield C (2003) Ostrich eggshell beads and the environment, past and present. Oxf Univ Sch Archaeol Monogr 57:54–60
Wood M (2005) Glass beads and pre-European trade in the Shashe-Limpopo region. University of the Witwatersrand, MA
Wood M (2000) Making connections: relationships between international trade and glass beads from the Shashe-Limpopo area. Goodwin Ser 8:78. https://doi.org/10.2307/3858049
Wu J (2012) Cluster analysis and K-means clustering: an introduction. In: Wu J (ed) Advances in K-means clustering: a data mining thinking. Springer, Berlin, Heidelberg, pp 1–16
Yellen JE (1977) Archaeological approaches to the present: models for reconstructing the past. Academic Press, New York