



Compositional analysis of c13th century AD Mapungubwe ceramics in South Africa: regional, local and household connections

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Abstract

The 13th century AD in southern Africa is a period associated with the emergence of class-based society and the establishment of Mapungubwe as the capital of a regional state. This study reports on ceramics excavated from four households at Bosbokpoort, a small Mapungubwe settlement situated approximately 95 km from Mapungubwe. By combining traditional stylistic analysis with chemical (pXRF) and mineralogical techniques (optical petrology), the research explores how pottery production and use reflected both regional Mapungubwe influences and local practices at the household level. The ceramic assemblage was predominantly characteristic of the Mapungubwe ceramic style, along with sherds from the Eiland ceramic facies. Mineralogical analysis indicated that the majority of the Mapungubwe ceramics at Bosbokpoort were made locally, with some produced elsewhere in the Limpopo River valley. The clay utilized in the manufacture of the Eiland ceramics were sourced from regions further to the south, where most Eiland communities occur. This approach highlights the active role of local communities in negotiating their identities and relationships within the larger Mapungubwe sociopolitical landscape.

Keywords Mapungubwe · African Iron Age · Ceramics · PXRF · Optical petrology

Introduction

The thirteenth century is a seminal period in the southern African past as it saw the emergence of a political elite over much of what is today eastern Botswana, western Zimbabwe and northern South Africa. This period – locally referred to as the Middle Iron Age – sees the emergence of class distinction closely tied to long distance trade between communities of the African interior and the larger Indian Ocean World (cf. Robertshaw et al. 2010). This trade laid the foundation for the development of an elite social class in which imported goods were integrated within a pre-existing prestige goods system based on cattle ownership. One of the earliest elite settlements was Mapungubwe, located at the

confluence of the Shashe and Limpopo Rivers in far northern South Africa (Huffman 2000; Chirikure et al. 2013).

At Mapungubwe, class distinction is evidenced in a spatial configuration whereby elites physically and symbolically separated themselves from the rest of the community. The settlement's high-status living area was situated on an inaccessible hilltop, while the rest of the community lived around the base of the hill. The Mapungubwe hilltop also served as a burial ground for elites, who were interred with gold, ceramics, and imported glass beads (Schofield 1937; Steyn 2007). A notable aspect of this period is the spread of Mapungubwe's influence into new territories resulting in a hierarchical system of settlements (Huffman and Hanisch 1987). From its heartland in the Shashe-Limpopo Confluence Area (SLCA), Mapungubwe's elite drew on a vast and varied hinterland for tribute in the form of labour, crops and livestock, and received goods such as gold, ivory, and cotton (Antonites 2019a, b). These components were necessary to sustain trade in exotic goods from the Indian Ocean on which Mapungubwe's political power partly rested (Ashley and Antonites 2020). At the same time, participation in this trade gave hinterland communities access to goods that

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were restricted to elite segments of society within the SLCA heartland (Antonites 2019b).

This regional system of interaction between communities is seen in the distribution of a shared Mapungubwe ceramic style. Throughout the region, ceramics executed in the Mapungubwe style (Huffman 2007) were used in quotidian practices such as food preparation, serving and storage (Antonites and Ashley 2016; Antonites 2019b; Ashley and Antonites 2020) as well as important events such as burials (Fouché 1937; Schofield 1937) and rainmaking rituals (Schoeman 2006). However, the use and application of a shared style did not take place thoughtlessly but represented a deliberate choice to align with the larger constellation of the Mapungubwe polity and a sense of shared, mutual belonging. Earlier approaches to the role of ceramics in identity construction have often framed stylistic adoption in centrifugal terms, suggesting that the SLCA core imposed its identity and power on surrounding regions. Previously, we (Antonites and Ashley 2016; Ashley and Antonites 2020) have argued that ceramic choices are not passive echoes of subjugation but are acts that speak as much to local iterations of identity and lived experience, as they do to interactions with the SLCA politique. This approach feeds into a recognition that the archaeology of everyday life is just as influential as grand narratives, and that actions in the home or domestic arena ‘act back’ against meta-processes and structures as well as meekly reflecting them (Robin 2020). “[T]he seemingly banal actions of daily life are not trivial at all but are a nexus of activities and interactions that give shape and meaning to the world and give people the ability to shape their world and make it meaningful.Daily life does not just acquiesce to the changes thrust upon it but has a truly transformative potential” (Robin 2020, p. 375). Moreover, following de Certeau (1984) and others, Robin argues that it is only in the rejection of grand narratives, which smooth the messiness of lived experience, are the complexity of past society can be appreciated (Robin 2020, p. 383).

To investigate this process, analysis needs to be conducted at various spatial scales. As such, we have previously carried out excavations at small settlements outside the Mapungubwe heartland (Antonites and Ashley 2016; Ashley and Antonites 2020), which would have occupied the lower end of the Mapungubwe settlement hierarchy (cf. Huffman and Hanisch 1987). Notwithstanding this presumption of low status, the archaeology showed access to imported and elite-associated goods alongside ubiquitous Mapungubwe ceramics. This suggests that hinterland communities were constellating around local economies and value systems, far removed from the tightly controlled dynamics in the SLCA. At the same time, they were conceptually aligned with the idea – the ‘imagined

community’ (Anderson 2006) – of Mapungubwe, as expressed through the repeated and regular use of a shared ceramic style.

However, these interpretations have, to date, been based on stylistic and object distribution rather than quantitative data on ceramic provenance or manufacturing evidence. Consequently, the current paper represents work undertaken to test whether these conceptual models can be substantiated through technological and compositional analysis of ceramics from households on the 13th century settlement known as Bosbokpoort. While traditional archaeological approaches to ceramics in southern Africa have tended to emphasise large-scale spatial patterns, studies in ceramic ethnoarchaeology (Krause 1985; Lindahl and Matenga 1995; Fowler 2008; Thebe and Sadr 2017; Fredriksen and Lindahl 2023) have highlighted the importance of the household as a primary arena for craft learning and the transmission of ceramic traditions. As such, there is a recognized need for research that specifically investigates intra-site variations in ceramic assemblages to gain a finer-grained understanding of social practices and interactions within communities. It is with this in mind that ceramics excavated from four households on Bosbokpoort were characterised through a combination of a traditional stylistic analysis, chemical analyses using pXRF coupled with a mineralogical analysis through optical petrography. These methods have been shown to offer insights into past social organization and interactions (Forster et al. 2011; Frahm 2018), and here they are employed as complementary techniques to explore how multiple households interacted with one another and how various sites were connected within the Mapungubwe world.

Ceramics and technology in 13th century Southern Africa

Mapungubwe ceramics date between the narrow range of c. AD 1220 and 1300. These assemblages are characterised predominantly by recurved jars and to a lesser extent bellied jars (vessels with a globular body and vertical neck profile), with a significant uniformity in decorative motifs, mostly either downturned triangles or diagonal hatching on the lower neck or shoulder area. Arcades and bands of cross-hatching are also common decorative themes (cf. Meyer 1980; Antonites 2019b).

While we continue to recognise the merit and value of stylistic-typological approaches, additional interpretive and analytical methods are needed. To delve into the scales of engagement at the household or everyday level discussed above. Since the 1990s, approaches have expanded beyond a narrow focus on style typologies to encompass a wider range of topics that explore the social,

technological, and symbolic dimensions of pottery production and use (Lindahl and Matenga 1995; Calabrese 2000, 2007; Huffman 2002; Jacobson 2005; Pikirayi and Lindahl 2013). An increasing number of studies have explored how chemical and mineralogical analysis can complement traditional typological approaches by highlighting social relationships that may not be apparent from stylistic analysis alone (Jacobson et al. 1991; Lindahl and Matenga 1995; Jacobson 2005; Wilmsen et al. 2009; Lindahl and Pikirayi 2010; Pikirayi and Lindahl 2013; Fredriksen and Lindahl 2023).

An important early example that highlighted the interplay between style typologies and geochemical data in southern Africa, was research conducted on ceramics from the 13th century Limpopo Valley and Soutpansberg Mountains of northern South Africa (Jacobson et al. 1991). Here, researchers identified two main geochemical groups of pottery that corresponded to regions north and south of the Soutpansberg. This north-south division was also reflected in the stylistic data – with Mapungubwe ceramics corresponding to the northern geochemical group and Eiland ceramics to the southern group. In contrast to Mapungubwe ceramics, Eiland ceramics are identifiable by their finely executed herringbone and arcade motifs, crosshatching, and the use of graphite and ochre burnish on the rims and necks of long-necked jars (Evers 1974; Klapwijk and Evers 1987; Huffman 2007). This congruence between style and geographic origins strongly suggests that, in this case at least, visual styles were spatially anchored. Eiland communities were organised around central cattle byres (kraals), typically taken as evidence for the importance of cattle – both economically, and socially (cf. Loubser 1991). Eiland society existed as independent chiefdoms, and unlike Mapungubwe society north of the Soutpansberg, did not develop an elite social class nor any of the political centralisation that accompanied it. The study also found that there was a small but consistent number of vessels that moved across the Soutpansberg-divide, suggestive of interaction and contact between groups. The additional observation that some Mapungubwe vessels (i.e. a northern style) found on southern sites were made with local clays, suggests southern communities were perhaps emulating their more powerful, socially complex northern neighbours (Jacobson et al. 1991, p. 23).

In a more recent study, Wilmsen et al. (2009) focused on ceramic sourcing in Botswana, and demonstrated how the integration of stylistic and geochemical data can reveal complex social interactions and patterns of mobility. The petrographic analysis of ceramics and clay samples showed movement over significant distances (400–600 km), thereby revealing connections between communities which were not apparent from visual style alone. The study also identified

the long-distance transportation of clays from geological deposits to the sites where pots were made, thereby adding an additional layer of complexity to the understanding of pottery production and exchange networks in the southern African Iron Age.

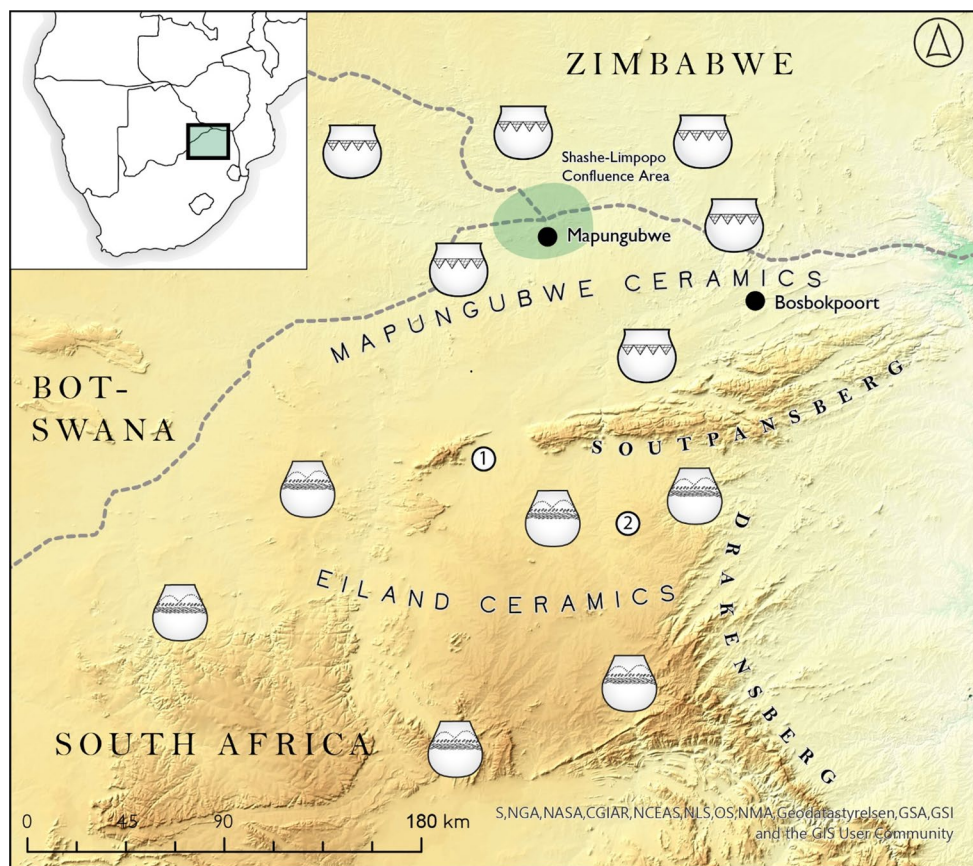
Site context

Bosbokpoort (N -22.499222° , E 30.23745°) is located in the Maremani Nature Reserve, Limpopo Province, approximately 95 km east of Mapungubwe (Fig. 1). The site was first identified in 2018 during a survey of the reserve by the University of Pretoria's Department of Anthropology and Archaeology (Fletcher 2021). It was subsequently excavated between 2019 and 2021 by Alexander Antonites and Ceri Ashley. The site is located on a plateau of the east-west running Ha-Tshirundu hills and overlooks the Nzhelele River 300 m to the south (Fig. 2). From the Bosbokpoort site, the river flows in an easterly direction, passing through the Ha-Tshirundu Hills at Bosbokpoort Gorge, before mouthing into the Limpopo River 20 km to the northeast. Approximately 35 km to the south, the east-west running Soutpansberg Mountains rise up steeply to approximately 1 000 m above the surrounding landscape forming a significant barrier to movement (Fig. 1).

The archaeological deposits of Bosbokpoort extend over roughly 8 000 m² (0.8 ha) and are very shallowly stratified with a single Mapungubwe occupation horizon across the site. It lacks any stone walling that typically identifies higher status settlements. Visible features include a cattle byre (kraal) in the centre of the settlement, surrounded by household areas identified by stone grain-bin foundations.

Excavations within the domestic areas of Bosbokpoort exposed floors constructed as compacted gravel platforms, approximately 10–20 cm thick, placed directly on the natural pre-settlement surface. The floor surfaces were plastered with a clay mixture, but these were poorly preserved. Although no superstructure survived, circular arrangements of postholes indicate the location of wattle and daub huts, likely of the cone and cylinder variety. In this domestic area of the site, spatially discrete floors associated with grain bin foundations were taken to define four household areas that form the sampling pool for this study. The site represents a single, relatively short-lived occupation of, likely no more than a single generation. Stratification of deposits are minimal with no evidence of rebuilding episodes, and across the site, features and deposits rest on the same sterile soil horizon. Therefore, the households represent near contemporary samples, thus allowing an examination of intra and inter-household patterning. Ceramics used in the study were collected from the floors, small middens adjacent to floors, and deposits associated with grain bins.

Fig. 1 Location of Bosbokpoort in relation to Mapungubwe, the Shashe Limpopo Confluence Area and the relative distribution of Mapungubwe and Eiland ceramics in the region. (1) Indicates the general location of the sedimentary-volcanic Blouberg Formation; (2) is the general location of the ultramafic Bandolierskop Complex, a possible source of peridotite



The site's spatial features and size suggest that it was the residence of a ward headman (Huffman 1986, 2021; Huffman and Hanisch 1987) – i.e. a leader with local authority over a number of separate homesteads or villages (Huffman 1986). It is part of a settlement system in which political power is manifested in a hierarchy of courts, ranging from family heads to paramount chiefs or even kings. At the foundational level is the family or homestead head, who has authority over members of his settlement. The ward headman, in turn, is the senior who would judge and resolve disputes between family heads.

Geological setting

Several prominent geological formations are present in the vicinity of Bosbokpoort (Fig. 2). On a regional scale, the geological formations fall within the Central Zone (CZ) of the Limpopo Mobile Belt (LMB) (Light 1982). The local CZ lithology is part of the Karoo Supergroup; however, other nearby lithologies include Sand River Gneiss, the Beitbridge Complex, and the Musina Suite (Brandl 1981). The Karoo Supergroup are basal sedimentary sequences that consists of various sedimentary units and argillaceous rock, which generally occupy flat ground with limited exposure (Brandl 1981). The archaeological site is located on Tshipise

Sandstone of the Clarens Sandstone Formation (Brandl 1981). The Clarens Sandstone Formation – one of the many sedimentary sequences of the Karoo Supergroup – covers large parts of the Limpopo River valley (Brandl 1981, pp. 18–23). It consists of two main units: Tshipise Sandstone and Red Rocks Sandstone. The Tshipise member is a very fine to fine, pink or red argillaceous sandstone, mottled by irregular patches of fine cream-coloured sandstone, while the Red Rocks is whitish or cream-coloured, fine-grained equigranular rock that locally exhibits large-scale crossbedding (Brandl 1981, pp. 21–22).

The Soutpansberg Mountains to the south, consist of gneissic material of granitic composition. This granitic Baviaanskloof gneiss belongs to the Bandolierskop Formation (Jacobson et al. 1991). The Bandolierskop Complex contains ultramafic, mafic and pelitic rock units. The ultramafic rocks are massive, weakly foliated rocks that once probably belonged to a continuous basal layer. The mafic rocks include mafic granulites that are medium-grained, black and white mottled rock composed of plagioclase, augite, orthopyroxene and green to brown hornblende. The pelitic units are largely composed of plagioclase, quartz, biotite, garnet, cordierite, K-feldspar, spinel and kyanite and bands of leucocratic anatectic material (Brandl 1986, pp.7).

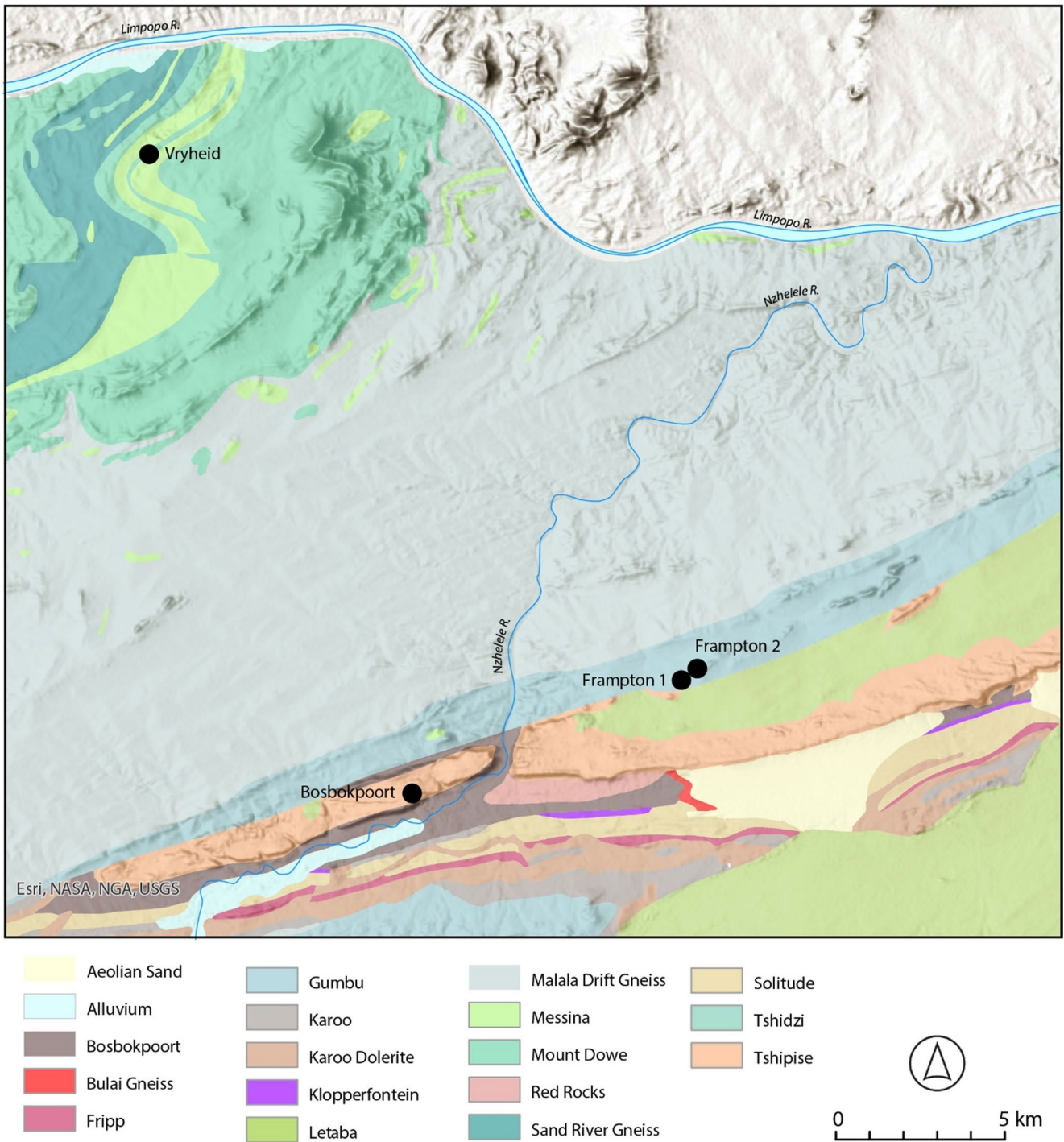


Fig. 2 Map of lithography of area around Bosbokpoort. Geological data from (Brandl 1981, 1986). Descriptions of lithography in Online Resource 2

Materials and methods

The ceramics analysis was performed in three stages: an initial stylistic analysis, followed by chemical and mineralogical analyses. The entire ceramic assemblage from the households was analysed using stylistic attributes. For

chemical and mineralogical analysis, random stratified sampling was used, in which vessel type served as the primary stratum and individual ceramics were randomly selected from household assemblages within each shape category.

A total of 353 vessels were recorded and analysed from the four households. The stylistic analysis was based on the

multidimensional approach outlined by Huffman (1980), widely regarded as a standard typological method for southern African ceramics. The method used three dimensions or attributes to identify types. The dimensions include the profile (shape), design layout and motif categories (Huffman 2007).

A total of 169 vessels were selected for the pXRF analysis through random stratified sampling using households and vessel shapes as sampling strata. Because pXRF has lower sensitivity, it has a more limited elemental detection range compared to destructive analytical techniques, and is susceptible to grain size effects and surface irregularities (Hunt and Speakman 2015). As a result, it was not used to generate a comparative dataset of absolute elemental concentrations, but instead, it was employed in this study as a semi-quantitative method to identify compositional trends within the dataset and to screen samples for subsequent petrographic analysis.

The analytical instrument used, was a Niton™ XL3t XRF Analyzer and all the samples were analysed using the Cu/Zn mining option within the “Soils and Minerals” mode. Because pXRF measurements can be affected by factors such as surface morphology, grain size, and matrix mineralogy (Forster et al. 2011; Frahm 2018), three separate measurements of 90 seconds each were taken at different locations on every sample, and the mean of these readings was used to represent the bulk composition (cf. Forster et al. 2011: 397). The built-in elemental range filter was run for 30 seconds on each setting. The “high filter” is optimized for heavy elements from barium (Ba) up to silver (Ag). The “main filter” is optimized for transition elements and from manganese (Mn) through to Bismuth (Bi) and the “low filter” for titanium (Ti) through to chromium (Cr). The total range elements and chemical forms measured are Mg, MgO, Al, Al₂O₃, SiO₂, P, S, K, K₂O, Ca, CaO, Ti, TiO₂, V, Cr, Cr₂O₃, Mn, MnO, Fe, Fe₂O₃, Ni, NiO, Cu, CuO, Zn, Rb, Sr, Nb, Ba, Bal. However, of these elements, the low-energy fluorescence of those lighter than Ti (especially Mg, Al, Si, P, S) is strongly attenuated in air, and as a result, their instrumental detection limits are comparatively high. Consequently, only relatively high concentrations registered above background values, with sub-threshold values reported as ‘< LOD’ (Online Resource 1). The certified reference material SARM 69 was used as an analytical standard (Table 1). SARM 69 is derived from archaeological ceramics for chemical analyses of ceramic materials (Jacobsen et al. 2002). The reference was run at the start of an analytical run as a control sample.

Each sherd was cut to expose a fresh interior section using a Struers Discoplan-TS and polished to a flat surface with a Struers LaboPol-25. The polished cross-section reduces surface contamination and minimises grain-size/

topography effects (cf. Forster et al. 2011; Frahm 2018). The polished cross-section was placed flush on the pXRF window for analysis. For each sherd, three 90 s measurements were acquired on different positions of the polished section, and the mean was used to represent bulk composition. This method prevented an offset in the reading caused by any large mineral inclusions imbedded within the fabric (cf. Forster et al. 2011; Bergman and Lindahl 2016). The final measurement for all the samples was determined by calculating the mean of all three readings. JMP® Pro, Version 18 was used to explore the data. To prepare the dataset for multivariate analysis, all elemental concentrations were standardized using z-score normalization (subtracting the mean and dividing by the standard deviation for each element). PCA was conducted on the standardized dataset and the eigenvalues calculated. Because the oxide values – except for SiO₂ – were nearly perfectly correlated ($|r| \approx 1$) with their corresponding elemental concentrations, they were excluded from the PCA to ensure a positive definite correlation matrix. The resulting eigenvalues indicated that the first eight principal components collectively accounted for 86% of the total variance. These PCA scores of the eight principal components were used in a hierarchical cluster analysis using Ward’s method for linkage and Euclidean distance as the dissimilarity measure. The resulting dendrogram was evaluated to determine the optimal number of clusters. Based on visual inspection of the dendrogram structure and the distribution of samples in PCA space, a two-cluster solution was selected as the most interpretable partition of the dataset.

The pXRF results were used to select a subset of 25 vessels for petrographic analysis that represent both the main compositional clusters and identified outliers. Selection was also stratified to include vessels from all four household contexts. Sherds selected for petrographic analysis was mounted onto a glass slide using an epoxy resin and

Table 1 Certified values of reference sample SARM 69 (Jacobsen 2005) and results of replicate analysis

Constituent	Certified Value	Replicate Value Mean	Unit	% Difference
SiO ₂	66.60	53.815	%	-19.2%
Al ₂ O ₃	14.40	4.27	%	-70.4%
Fe ₂ O ₃	7.18	3.535	%	-50.8%
CaO	2.37	0.95	%	-59.9%
K ₂ O	1.96	0.95	%	-51.5%
MgO	1.85	0.00015	%	~99.99%
MnO	0.129	0.0895	%	-30.6%
TiO ₂	0.777	0.745	%	-4.1%
Ba	518	87	mg/kg	-83.2%
Cr	223	122	mg/kg	-45.3%
Zn	68	28.5	mg/kg	-58.1%
Ni	53	0.635	mg/kg	~98.8%

hardener. The samples were placed in an oven at a standard temperature of 40 °C and left overnight. Each slide was then attached to the Struers Discoplan-TS through an air vacuum where the bulk of the sherd was sliced off. The same machine was then used to polish the thin section down until a thickness of 1–2 mm was reached. The thin section was further polished by hand to a thickness of 30 µm, to allow for the minerals' optical properties to be projected under the polarizing microscope.

The analysis of the ceramic thin sections focused on three components: mineral inclusions, voids and the clay matrix (cf. Peterson and Betancourt 2009; Santacreu 2014). A Nikon Eclipse 50i POL polarizing microscope was used for the analysis of the thin sections. Each mineral was identified according to its morphological characteristics in both plane polarized light (PPL) and crossed polarized light (XPL). In plane polarized light (PPL) the characteristics included the mineral's crystal habit/shape, relief, cleavage and pleochroism. In crossed polars (XPL) attention was given to the mineral's birefringence and extinction angles (Deer et al. 2013; MacKenzie et al. 2017). The Udden Wentworth chart was used for all grain size measurements.

Results

Diagnostic sherds were used to identify a combined minimum number of 353 vessels from the four sampled households (Table 2). Household 3 had the highest number of recorded vessels ($n=159$) and Household 1 the lowest ($n=10$), though this is likely influenced by excavation size and volume of excavated deposits.

Seventy vessels contained information on all three dimensions of shape, decoration and placement of decoration. This resulted in a total of 14 vessel types (undecorated vessels were not considered) (Fig. 3; Table 3). Types 1 to 10 are typical of the Mapungubwe facies, while Types 11 to 14 represent seven vessels that have attributes that are regarded as typical of the Eiland facies (Huffman 2007; Antonites 2019b). This is not entirely unexpected as Eiland ceramics have been recorded in low numbers at other Mapungubwe sites (e.g. Meyer 1980; Loubser 1989; Antonites 2019b).

Table 2 Minimum number of ceramic vessels (MNV) from each household

Household	Vessels (MNV)	%
Household 1	10	2.8
Household 2	116	32.9
Household 3	159	45.0
Household 4	68	19.3
Total	353	100%

Two types – 1 and 6 – account for almost half of the entire assemblage (49%; $n=18$), with the remaining types represented in smaller proportions. Type 1 – recurved jars with bands of incised decoration on the shoulder (typically downturned triangles – was the most dominant type in all four households accounting for 25% of the entire assemblage (Fig. 4). Type 1 is also the most common stylistic type in other Mapungubwe assemblages (Meyer 1980; Huffman 2007; Antonites 2019b). The second most common vessel type was Type 6 – open bowls with incised band of decoration on the rim – accounting for 24% ($n=16$) of the assemblage. Bowls of this type are a common type and not diagnostic of a particular facies. However, the most common decoration were variations of triangles which are the common decorative element in Mapungubwe assemblages (Meyer 1980).

Type 1 was the only type found in all four households (Table 4). The other Types were absent from at least one household. Type 2 vessels were only found in Household 1 and Household 3. Type 3 appeared in Household 3 and Household 4. Type 4 was unique to Household 3. Type 5 was only found in Household 1 and Household 3. Type 6 vessels found in all except Household 1, while Type 7 was only found in Household 2. Type 8 was found in Households 2, 3, and 4. Type 9 was found in Household 3 and 4. Type 10 appeared only in Household 3.

Types 11 to 14 were the vessels identified as being of the Eiland facies. These vessels were only found in Household 2 and 3 – the two households that also had the largest ceramic samples. Here they occur in very low numbers and comprise less than 2% of the respective household assemblages.

pXRF analysis

The pXRF analysis indicated that SiO₂, Al₂O₃ (Al), Fe₂O₃T (Fe), CaO (Ca), K₂O (K), MgO (Mg), TiO₂ (Ti), and MnO (Mn) occur at percent levels and therefore major constituents (≥ 1.0 wt%; = 10,000 mg/kg). All other reported analytes (P, S, V, Cr, Ni, Cu, Zn, Rb, Sr, Nb, Ba) occur at minor/trace (< 1 wt%) levels (Online Resource 1).

PCA of the normalized pXRF data revealed that the first two principal components accounted for 35.7% and 13.4% of the total variance respectively (Fig. 5). Hierarchical clustering identified two main clusters. Cluster 1 was the largest grouping and accounted for 153 (91%) of the 169 samples while cluster 2 had 16 samples (9%) (Fig. 6). Cluster 1 spans a wide range along both PC1 and PC2 and was mostly influenced by positive loadings on Mg, Cr, Ni, P, Zn, Fe, and Mn and negatively loaded Cu. Cluster 2 is characterized by consistently low PC1 scores and by positive values for Ca and Al.

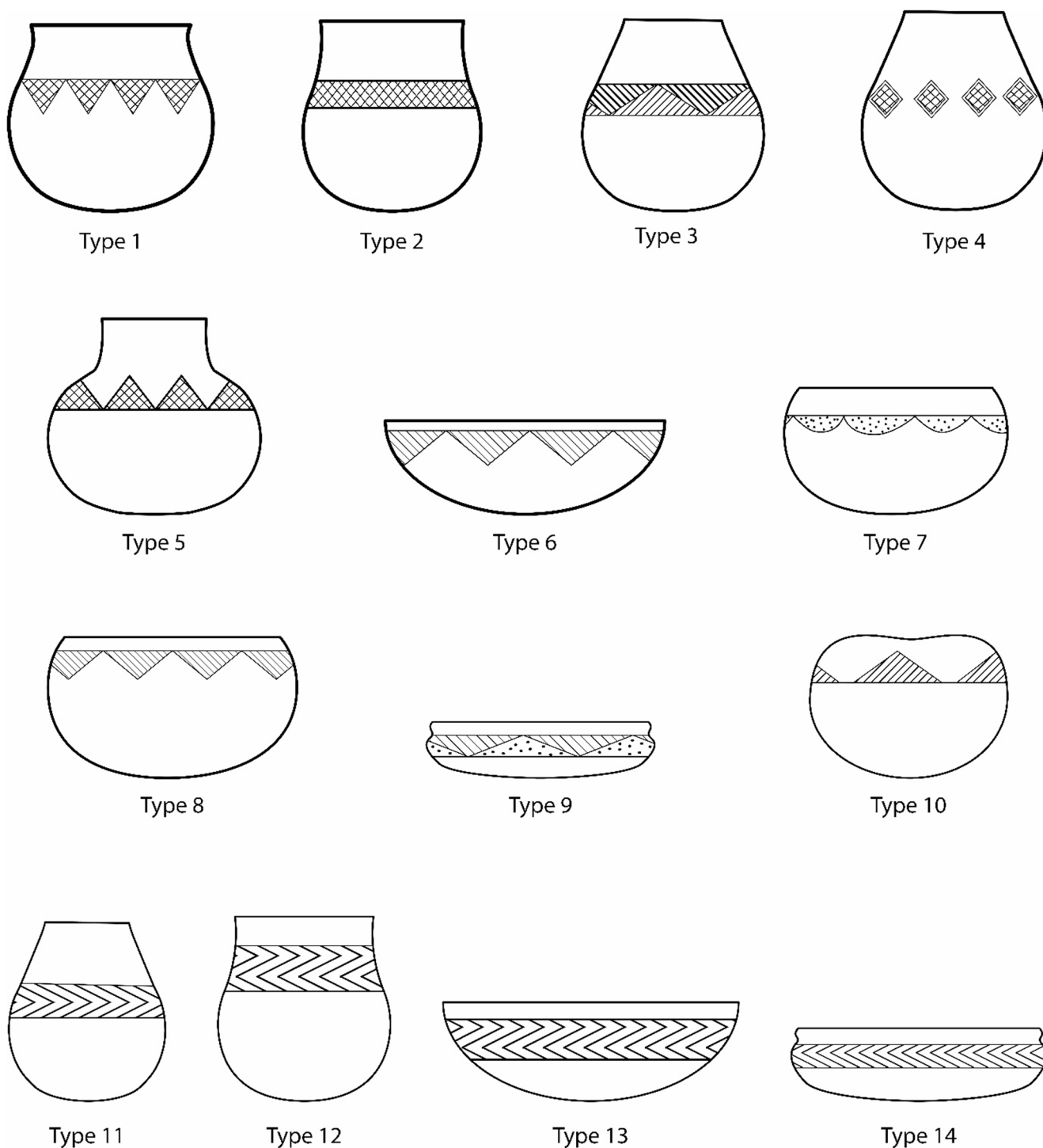


Fig. 3 Schematic representation of stylistic types recorded within the assemblage. Types 1–10 are Mapungubwe, Types 11–14 are Eiland. Not to scale

The three Eiland samples — C27, C414, and C436 — were examined in isolation within the broader PCA results. All three samples fell within Cluster 1 (Fig. 5) but did display some internal variation. There is closer compositional affinity between C27 and C414 when compared to the C436. Of the three, C27 had higher elevated

concentrations of Sr, Zn, Cr, and Fe, which generally aligns with the central tendency of Cluster 1. In contrast, sample C414 shows negative loadings for metals like Ni and Cu but higher values for Mg and P. Sample C436 is distinct with positive loadings for Ba and Nb and negative scores for Sr and Rb.

Table 3 Description of Bosbokpoort stylistic types

Type	Description	Style facies
Type 1	Recurved jar with incised decoration on the shoulder	Mapungubwe
Type 2	Recurved long-necked jar with incised decoration on the shoulder	Mapungubwe
Type 3	Long-necked jar with incised decoration on the	Mapungubwe
Type 4	Long-necked jar with a band of incised and punctate decoration on the neck	Mapungubwe
Type 5	Straight neck jar with band of incised decoration on shoulder-neck area	Mapungubwe
Type 6	Open bowl with incised decoration on rim to body	Mapungubwe
Type 7	Closed bowl with punctuates on the shoulder	Mapungubwe
Type 8	Closed bowl with incision on the rim	Mapungubwe
Type 9	Necked bowl with incised decoration on body	Mapungubwe
Type 10	Incurvate bowl filled with incised decoration on rim	Mapungubwe
Type 11	Long-necked jar with incised herringbone decoration on the shoulder	Eiland
Type 12	Recurved jar with bands of incised herringbone decoration on the neck	Eiland
Type 13	Open bowl with incised herringbone decoration on the neck	Eiland
Type 14	Necked bowl with incised herringbone decoration on the neck	Eiland

The large degree of variation observed within Cluster 1 suggests a compositional variability which could mask the presence of subgroups. Unfortunately, the analytical

limitations of pXRF does not allow for clear differentiation of these potential subclusters. Nevertheless, the pXRF results provides important insight into the broad compositional trends across households.

Petrographic analysis

Out of the 25 samples selected for petrographic analysis (Online Resource 3), 22 are from Mapungubwe types, while three were from Eiland types. A total of nine fabric groups were identified (Tables 5, 6 and 7; Fig. 7). The petrographic analysis of the Mapungubwe vessels revealed that the majority belonged to petro-fabric groups 1–4 with groups 5 and 6 regarded as atypical. Each of the three Eiland vessels had distinct fabrics and were placed in their own groups.

The majority of fabrics were similar in their overall mineral composition of quartz, feldspar and micaceous minerals (Table 7) with variation in the rock fragments and added tempers. The rock fragments are often sedimentary ‘clasts’ that formed part of the clay source that was used for ceramic production (Quinn 2022). Tempers and tempering as used here, refer to all aplastic inclusions that was intentionally added to the clay paste (cf. Quinn 2022).

Petro-fabric groups 1–6 were associated with Mapungubwe ceramics:

Petro-fabric 1 consist of a fine to very coarse grained sand and is primarily composed of quartz (10–20%) and feldspars, including plagioclase (20%), K-feldspar (5%),

Fig. 4 Distribution of vessel types across the households

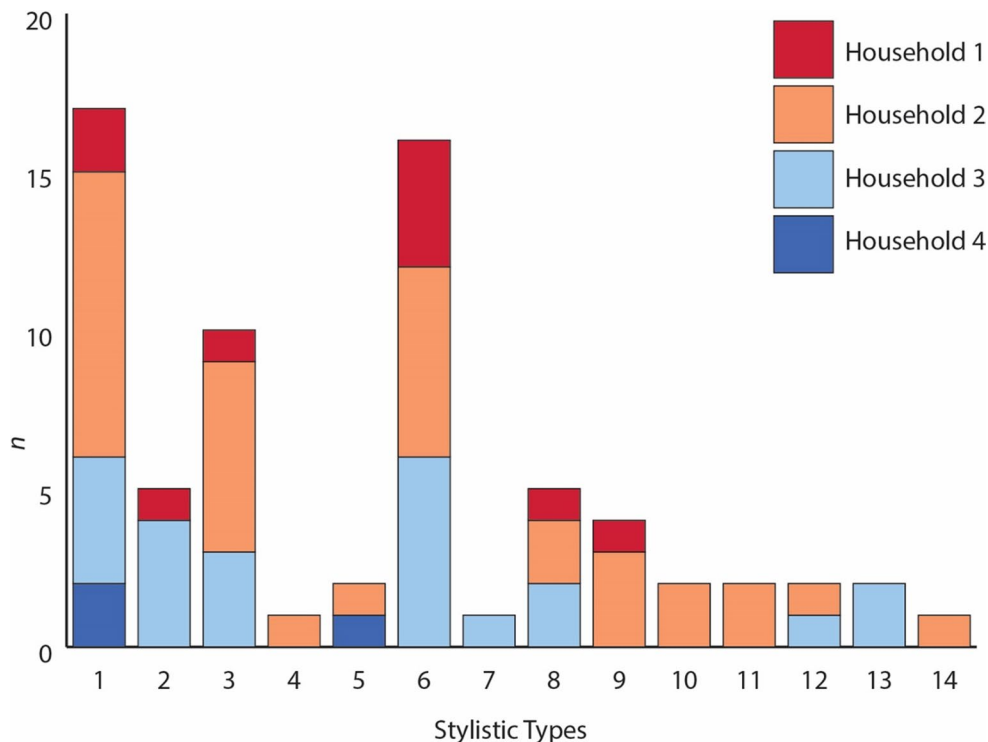
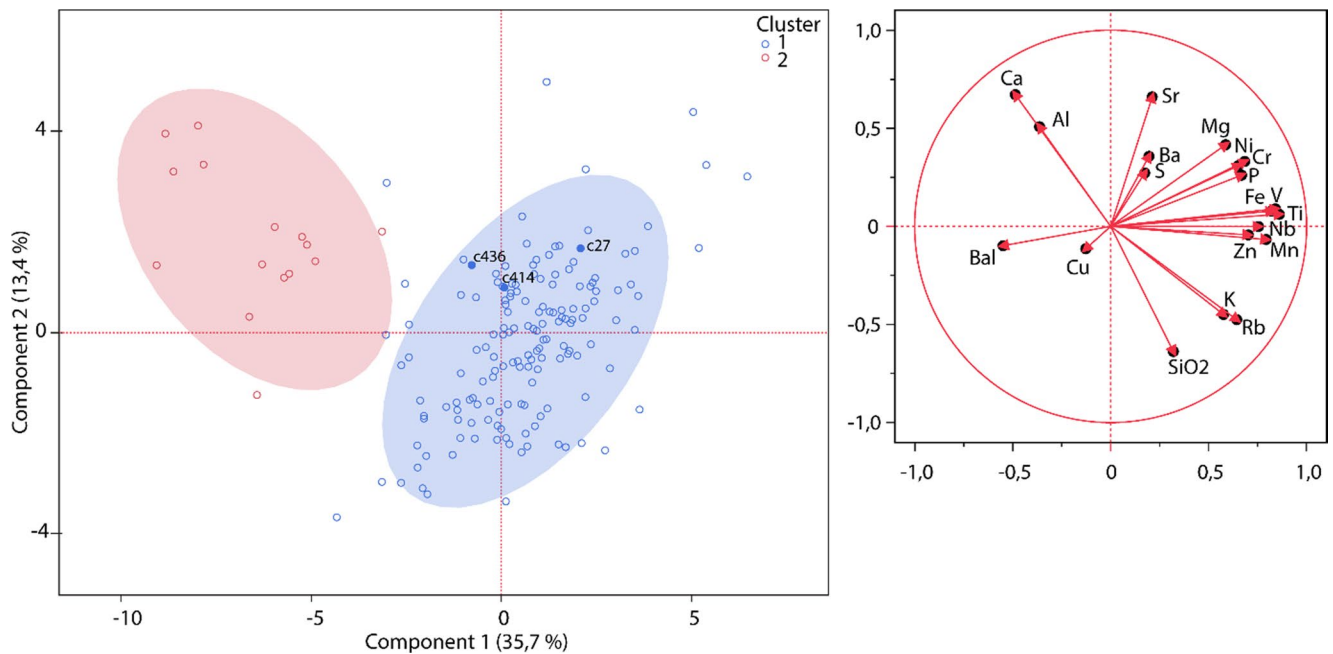


Table 4 Stylistic types per household sample

Type	Household 1		Household 2		Household 3		Household 4	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Type 1	2	2.90	4	5.80	9	13.04	2	2.90
Type 2	–	–	4	5.80	–	–	1	1.45
Type 3	–	–	3	4.35	5	7.25	1	1.45
Type 4	–	–	–	–	1	1.45	–	–
Type 5	1	1.45	–	–	1	1.45	–	–
Type 6	–	–	6	8.70	6	8.70	4	5.80
Type 7	–	–	1	1.45	–	–	–	–
Type 8	–	–	2	2.90	2	2.90	1	1.45
Type 9	–	–	–	–	3	4.35	1	1.45
Type 10	–	–	–	–	2	2.90	–	–
-Type 11	–	–	–	–	2	2.90	–	–
Type 12	–	–	1	1.45	1	1.45	–	–
Type 13	–	–	2	2.90	–	–	–	–
Type 14	–	–	–	–	1	1.45	–	–
Total	3	4.35	23	33.33	33	47.83	10	14.49

**Fig. 5** PCA of compositional data. Left: Scores plot with 90% confidence ellipses for each cluster; Eiland samples are labeled and highlighted in bold. Right: Loadings plot indicating the contributions of elemental variables to the first two principal components

and orthoclase (10%). Majority of the quartz grains exhibit angular to subrounded shapes. Additionally, this group also contained micaceous minerals, such as biotite (3%) and muscovite (3%). Most samples in this group were tempered with grog and rock fragments (3%), including granite, metamorphic rocks and polycrystalline quartz.

Petro-fabric 2 is very similar to that of group 1, with some variations in the frequency of certain minerals and tempers added. This group also consist of a fine to coarse grained sand, consisting of quartz and similar feldspar minerals, but with fewer quantities of micaceous minerals present. This group consist of high quantities of argillaceous

inclusions (1–5%) and some Alkali basalt fragments (1%). Argillaceous inclusions can be divided into four categories: Argillaceous rock fragments (ARF), grog, clay pellets and clay temper (Whitbread 1986). The majority of the argillaceous inclusions identified within the samples of group 2 had irregular shapes, diffused boundaries and neutral densities (see Fig. 7). These characteristics are suggestive of clay pellets (cf. Whitbread 1986).

Petro-fabric 3 consist of a fine-grained sand, composed of quartz (10–20%), plagioclase (2%), K-feldspar (1%) and orthoclase (1%). The quartz grains were predominantly subrounded in shape. The majority of the samples also

Fig. 6 Distribution of elemental clusters per household

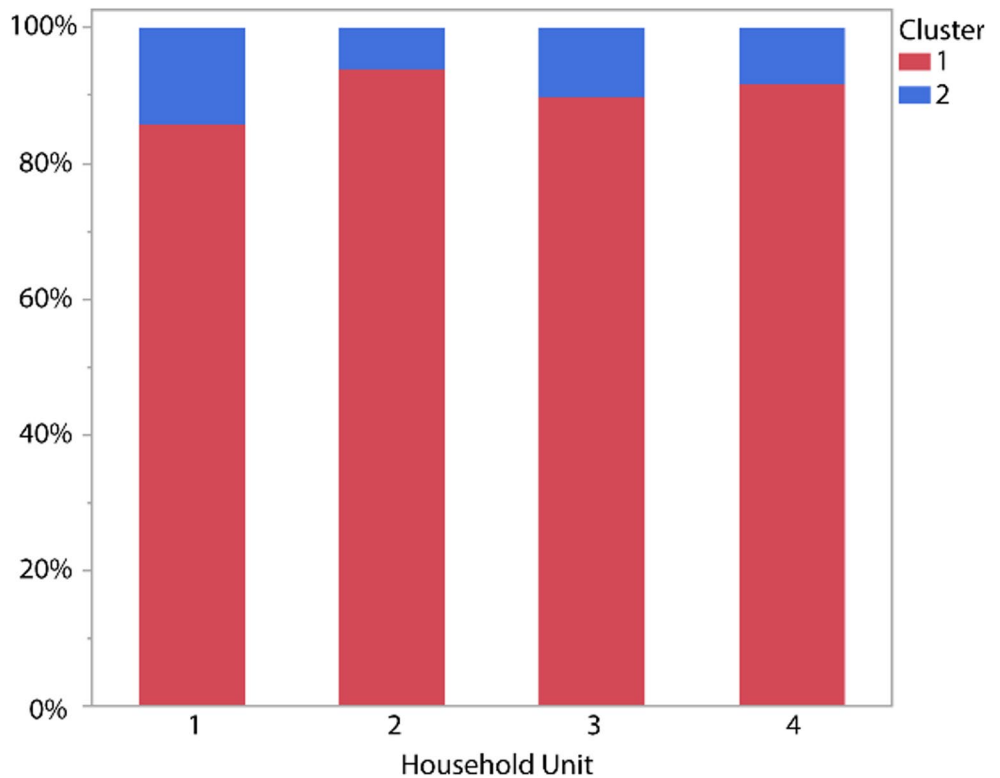


Table 5 Major-element oxides (wt%) obtained through pXRF for petro-fabric samples

Petro-fabric group	Sample	MgO	Al2O3	SiO2	K2O	CaO	TiO2	Cr2O3	MnO	Fe2O3
1	C76	2.13	8.26	65.75	0.69	2.66	1.50	0.04	0.17	7.24
	C118	1.60	6.15	61.09	0.48	3.72	1.46	0.06	0.12	6.89
	C7	0.33	6.26	67.10	0.59	1.69	1.10	0.04	0.08	5.60
	C11	0.36	10.63	54.47	0.29	7.02	0.58	0.02	0.05	2.51
	C28	2.43	11.05	60.34	0.41	4.97	0.92	0.05	0.08	4.78
	C36	1.23	9.59	59.73	0.34	4.68	0.84	0.02	0.05	4.28
	C214	0.97	13.20	56.37	0.27	9.51	0.52	0.03	0.06	3.27
2	C72	1.18	7.53	61.54	0.57	4.25	0.90	0.03	0.11	5.37
	C121	0.86	10.22	59.72	0.27	4.63	0.67	0.02	0.04	3.25
	C285	1.40	6.89	62.04	0.59	2.43	1.33	0.05	0.15	6.54
	C63	1.44	6.64	66.23	0.35	6.52	0.93	0.03	0.03	4.20
	C50	1.10	8.27	63.68	0.33	7.33	0.76	0.02	0.04	3.53
3	C297	0.83	10.19	57.91	0.55	5.89	0.58	0.02	0.06	3.06
	C249	1.76	7.66	69.51	0.64	2.32	1.76	0.07	0.11	7.53
	C114	2.29	7.70	63.25	0.54	5.28	1.25	0.04	0.19	7.19
4	C301	1.86	6.40	66.06	0.59	4.27	1.25	0.04	0.22	6.14
	C89	1.70	7.17	63.36	0.55	3.10	1.33	0.05	0.13	7.44
5	C17	0.69	11.70	53.15	0.31	11.04	0.46	0.02	0.06	2.96
	C158	0.00	9.61	61.27	0.25	2.06	1.69	0.06	0.10	10.41
	C300	2.86	4.64	44.56	0.62	3.22	1.45	0.07	0.15	7.71
6	C293	2.18	11.71	55.70	0.17	3.53	0.89	0.11	0.09	12.73
7	C180	0.44	5.37	69.16	0.63	1.21	0.88	0.03	0.03	4.02
8	C27	2.23	7.52	63.68	0.52	4.52	1.35	0.05	0.15	7.03
9	C414	1.17	6.36	61.03	0.58	4.71	1.15	0.04	0.10	6.62
	C436	0.20	8.90	60.24	0.36	1.82	1.11	0.04	0.09	7.33

Table 6 Distribution of petro-fabric groups per household

Household	Petro-fabric group	<i>n</i>	% (per household)
1	Group 1	2	50.00
	Group 2	2	50.00
2	Group 1	1	16.66
	Group 2	2	33.33
	Group 3	1	16.66
	Group 4	1	16.66
	Group 6	1	16.66
3	Group 1	3	30.00
	Group 3	1	10.00
	Group 4	2	20.00
	Group 5	1	10.00
	Group 7	1	10.00
	Group 8	1	10.00
4	Group 1	2	40.00
	Group 2	1	20.00
	Group 3	1	20.00
	Group 4	1	20.00
Total		25	100

contained muscovite (1%), clinopyroxene (1%), grog (2%) and alkali basalt fragments (2–3%), consisting of olivine, augite and plagioclase feldspar. One of the samples also contained some sandstone fragments.

Petro-fabric 4 is a medium sand to silt grained fabric that is composed of quartz (10–20%), Plagioclase (5%), K-feldspars (3%), orthoclase (2%), micaceous minerals such as biotite (1%), muscovite (1–2%), amphibole and high quantities of orthopyroxene (20%). The quartz grains were angular to subrounded in shape. Grog is frequently present within this group. Two of the samples (2%) also contained Alkali basalt fragments.

Petro-fabric 5 is a medium grained sand, composed of quartz (5%), weathered plagioclase feldspars (1%), orthopyroxene (2%), clinopyroxene (5%), olivine (1%) and a few alkali basalt fragments (1%). The quartz grains were angular to subrounded in shape.

Petro-fabric 6 consist of a very fine sand, composed of quartz (5%), high amounts of fine-grained plagioclase feldspars (30%), grog (3%), alkali basalt fragments (3%) and sandstone fragments (3%). The quartz grains are very rounded, suggestive of an alluvial sediment that was transported over a longer distance.

Petro fabrics 7, 8 and 9 were identified only within the Eiland samples (Table 7):

Petro-fabric 7 is a fine-grained sand, composed of subrounded quartz grains (5%), plagioclase feldspar (5%), biotite (2%), orthopyroxene (1%), grog (1%), argillaceous inclusions (clay pellets) (1%) and tholeiitic basalt (3%). The tholeiitic basalt consists of plagioclase feldspars, clinopyroxenes, few olivine minerals and iron ore.

Petro-fabric 8 is mineralogically similar to fabric 7. It is also a fine grained sand that consist of subrounded to rounded quartz grains (5%), plagioclase feldspar (5%), orthopyroxene (1%) clinopyroxene (1%), grog (1%) and tholeiitic basalt (4%). However, this fabric does not contain any argillaceous inclusions. Most of the feldspars are weathered and covered in sericite. The quartz in fabric 8 were more rounded and finer grained. This suggest an alluvial sedimentary clay that was likely carried over a longer distance compared to that of fabric 7.

Petro-fabric 9 identified within the Eiland sample C436 is very distinct from fabric 7 and 8. Fabric 9 consist of a medium grained sand, composed of angular to subrounded quartz grains (10%), K-feldspars (7%), clinopyroxene fragments (5%), amphibole (2%), and serpentinized dunite minerals (1%).

Bosbokpoort ceramic manufacture

Clay pellets were observed in several samples. These often form when a dry clay was used that was not well hydrated and kneaded (Eramo 2020). Basalt was used as a tempering agent in all the households except Household 1. The use of basalt could be due to its ability to form glass at relatively low temperatures, resulting in hard and durable pottery (Rye 1981). Grog was also frequently used as a temper (Table 7).

In terms of manufacturing technique, most of the Mapungubwe vessels that were analysed, were manufactured using a coiling technique. There were exceptions, however, with two a-typical fabric types (5 and 6) and five Mapungubwe vessels not identified to type, manufactured using the pinching – also known as pulling – technique (cf. Lindahl and Pikirayi 2010). Most of the vessels from each fabric were partially oxidized and some unoxidized, suggestive of open bonfires used for firing, with temperatures ranging between 600 and 940 °C (Quinn 2022). All three Eiland samples were manufactured using the coiling method and were partially oxidized.

Geological source of the petro-fabrics

Based on the mineralogical composition and grain sizes, petro-fabric groups 1–4 were likely manufactured from a sedimentary type of rock such as sandstone or shale. The geology in the immediate surrounds of Bosbokpoort consists largely of sandstone of the Tshipise Sandstone member while also occurs locally (Van Rooyen 2002). While no locally documented sources of clay in the vicinity of the site are known today, the local geology provides a strong indication that most of the Bosbokpoort ceramic vessels were made from clays originating from riverbeds and streams near the site.

Table 7 Petro-fabric group composition

Petro fabric type/group	Frequency in assemblage	Grain size	Quartz	Quartz shape	Feldspar type		Mica		Pyroxenes		Amphibole	Olivine	Crog	Argillaceous inclusions	Rock frag.	Alkali Basalt	Theoleitic basalt	Serpentinized Dumite	Sandstone fragments
					Plagioclase	K-Feldspar	Orthoclase	Biotite	Muscovite	Orthopyroxene									
%	n																		
1. Quartz - feldspar - mica	32	8	Fine to very coarse-grained sand (4.14 mm-0.41 mm)	10-20%	Angular to subrounded	1-20%	2-5%	2-10%	1-2%	1-3%	1-7%	1%	1-3%	1-2%	1-3%	1-3%			
2. Quartz - feldspar - mica - argillaceous fragments	20	5	Fine to coarse grained sand (2.55 mm-0.41 mm)	5-20%	Angular to subrounded	5-10%	1-3%	1-3%	1%	1%	2%	1-2%	1%	1-5%	2-5%	1%			
3. Quartz - feldspar-Alkali basalt	12	3	Fine Sand (0.87 mm-0.50 mm)	20%	Subrounded	2%	1%	1%	1%	1%	1%	1%	2%	3%	2%	2-3%		<1%	
4. Quartz - feldspar - orthopyroxene	16	4	Medium Sand to Silt/Clay (1.2 mm-0.3 mm)	10-20%	Angular to subrounded	1-5%	1-3%	1-2%	1%	1-2%	1-20%	1%	1-5%	1%	<1%	2%			
5. Quartz - Clinopyroxene-Olivine	4	1	Medium Sand (1.26 mm-0.97 mm)	5%	Angular to subrounded	1%		1%	1%		2%		1%			1%			
6. Pyroxene-feldspar - sedimentary conglomerates	4	1	very Fine Sand (0.47 mm-0.28 mm)	20%	Rounded	30%							3%			3%			
7. Quartz - tholeiitic basalt - argillaceous rock fragments	4	1	Fine Sand (0.5-1 mm)	5%	Rounded to subrounded	5%		2%			1%		1%	1%	1%	1%	3%		
8. Quartz-feldspar-tholeiitic basalt	4	1	Fine Sand (0.6-0.9 mm)	5%	subrounded	5%					1%		1%				4%		
9. Quartz - feldspar - serpentized dumite	4	1	Medium Sand (1.47 mm-0.62 mm)	10%	Angular to subangular	7%							5% (Fragments)		1%		1%		

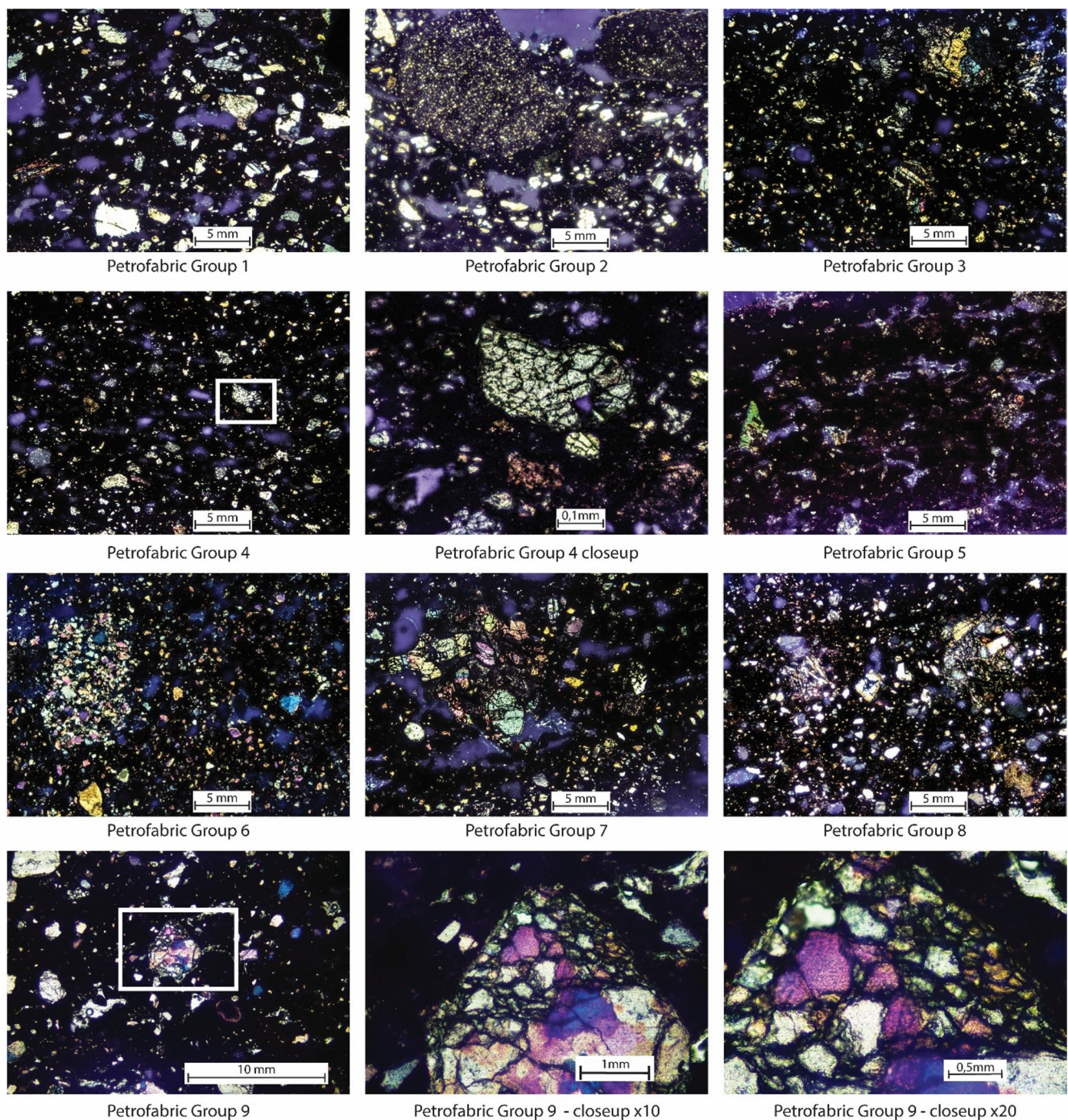


Fig. 7 Micrographs of Petro-fabric groups

A likely source for such clays would be the nearby Nzjelele River (300 m from the site) whose mineral composition consists of quartz, feldspar and mica minerals (Ramadolela 2023). The proximity of the Nzjelele River as a source is also consistent with ethnoarchaeological studies that indicate potters frequently use clay sources no further than 7 km, and in many cases no further than 1 km, to obtain their clay (Arnold 1985). There are, however,

examples from southern Africa where potters would travel much greater distances to access a preferred source so this cannot be ruled out completely (Wilmsen et al. 2009, 2016; Fowler 2011, 2015; Thebe 2017).

The atypical fabric types 5 and 6, indicate that some vessels were manufactured from clays that do not occur within the local geology of Bosbokpoort. Based on the weathered feldspar and clinopyroxene, the source of petro-fabric 5 was

likely a weathered granitic rock. Granitoid gneisses occur in the wider region of Bosbokpoort and various similarities can be drawn between petro-fabric group 5 and Singlele Gneiss – a pink granitoid gneiss formation from the Beit Bridge Complex (Brandl 1981). This formation is ± 15 km northwest of Bosbokpoort and is in the vicinity of another Mapungubwe settlement known as Vryheid (MNR 04) also excavated by two of the authors (AA and CA).

This congruence could indicate vessels that was manufactured at the site Vryheid and transported to Bosbokpoort or alternatively, a case where a Bosbokpoort potter used clay from the vicinity of the Vryheid settlement. While either scenario remains speculative given the currently available data, future mineralogical and chemical investigations of the Vryheid ceramic assemblage may shed light on possible interaction between the two sites.

This mineral composition of petro-fabric 6 suggests that the clay likely derived from a basaltic rock. The closest occurrence of such material is the Letaba Formation, located approximately 5km from Bosbokpoort at its nearest point. Once again, this could point to possible connections with other Mapungubwe sites - in this case, the two small sites Frampton 1 and 2 which are located ± 8 km northeast of Bosbokpoort (Fig. 2).

Eiland clay sources

Despite the small sample size, Eiland ceramics displayed a great degree of variability and includes fabrics groups that includes tholeiitic basalt fragments and potentially serpentized dunite. This suggest that, despite their stylistic similarity, the vessels are likely not from the same source. Unfortunately, without clay samples from the source, it is impossible to precisely pinpoint the location of the communities that manufactured these Eiland vessels. However, possible sources can be narrowed down to somewhere within the known distribution range of Eiland ceramics- i.e. the area between the Soutpansberg in the north the Magaliesberg Mountains in the south (± 200 km), and bounded in the east by the Drakensberg Escarpment and in the west by the margins of the Kalahari Desert (± 250 km).

Petro-fabric types 7 and 8 consist of a fine-grained matrix with sand- and clay-sized particles and were therefore manufactured from a sedimentary rock such as sandstone. The most likely source for petro-fabrics 7 and 8 is the Blouberg Formation, located approximately 130 km west of Bosbokpoort (Fig. 1), immediately west of the Soutpansberg and near the northern extent limit of Eiland sites (Brandl 1986). The Blouberg Formation is a sedimentary-volcanic assemblage, located within the Waterberg group where fine sand is abundant within its sediments (Brandl 1986). The sediments from this

geological formation include conglomerates, feldspathic grit, arkose, and sandstone (Brandl 1986).

The mineralogical composition of petro-fabric type 9 on the other hand, points to a clay derived from an ultramafic rock due to the presence of serpentized dunite – an end member of an end member of the peridotite group. Peridotites commonly occur within the Bandolierskop Complex south of the Soutpansberg (Fig. 1), which consists of ultramafic and mafic rocks, magnetite quartzite, metaquartzite, metapelite, marble and calc-silicate rocks (Brandl 1986). It is therefore likely that the clay used for petro-fabric 9 was sourced from deposits associated with the Bandolierskop Complex.

Distribution of petro-groups at Bosbokpoort

The most typical fabric type was petro-fabric 1, which was the only fabric present in all four households, albeit in differing proportions. Household 1 consisted of petro-fabric groups 1 (50%) and 2 (50%). In Household 2, petro-fabric groups 2, 3 and 4 (81%) dominated. Household 2 was the only household that contained the atypical fabric group 6. In Household 3, petro-fabric group 1 (30%) was the most common, followed by fabric group 4 (20%). Household 3 also contained atypical fabric group 5. The samples from Household 4 were mostly from fabric group 1 (40%). Fabric groups 7–9 were the Eiland vessels and were only found in Household 3.

Households 2 and 3 showed the highest diversity in petro-fabrics, with five and seven types respectively. However, they also constituted the largest samples in the study. Consequently, to assess the whether the distribution of petro-fabric groups across households were meaningful rather than a result of sampling bias, a chi-square test of independence was performed. The test yielded no statistically significant association between household and the distribution of petro-fabric group ($\chi^2 = 16.14$, $df=24$, $p=0.883$). This suggests that the inter-household variation in the petro-fabrics are likely due to differences in sample size. As a result, no meaningful conclusions around the frequency of petro-groups at a household level can be drawn at this stage but does highlight the importance of sample size to capture the range of potential variability at a site level.

Ceramics and networks of interactions

In this paper, our intention has been to examine the ceramic technology of Bosbokpoort through the lens of local, regional, and supra-regional connections, as a means of further explore how hinterland societies- especially small-scale ones- articulated with the Mapungubwe core in the SLCA. Unlike other technological studies on this period that have

focused on long-distance ceramic movement and trade, our results indicate that ceramic distribution at Bosbokpoort constellates around and not necessarily at long distance ones. Ultimately this supports our premise that the idea of unequal and top-down hierarchical relations between the core and periphery of the Mapungubwe state needs to be dismantled, and that recognition should be given to the likelihood that local spheres of activity and influence defined and demarcated everyday social lives and economies across the hinterland. The evidence of petro-fabric groups 5 and 6 which potentially indicate clay sources from the vicinity of other Mapungubwe period sites (Vryheid and Frampton 1 and 2) offer a glance at how such inter-site connections might have been looked. Because the Mapungubwe period is tightly demarcated to around 70 years, there is a strong likelihood that other Mapungubwe period sites and households would have been aware of each other in this landscape. More work on ceramics from those sites is likely to enhance our understanding of how this peripheral landscape emerged and sustained itself through connections and shared experiences.

The evidence of petro-fabric 7, 8 and 9- associated with ceramics stylistically identified as Eiland- adds to this picture of regional entanglement beyond the SLCA. Although likely sourced from farther afield than the fabrics 5 and 6, they nevertheless originate from the hinterlands and peripheries of the Mapungubwe world. At a basic level, and in line with previous studies on Eiland ceramic distribution, this serves as a reminder that political boundaries are materially porous, and relations exist both across and within maps of stylistic uniformity.

One interpretation for such ceramic mobility, developed from local ethnographies, is that non-local ceramics represent marriage alliances (Jacobson et al. 1991; Jacobson 2005). Some ethnographic sources state that with a marriage, a new bride brings pots from her original home as dowry (Van Warmelo and Phophi 1967, p. 1067). While this would result in a pattern of non-local ceramics akin to the Bosbokpoort samples, several factors would speak against this interpretation. For one, the sample size of Eiland ceramics in the Bosbokpoort households is very small (only 7 vessels), which makes it difficult to draw definitive conclusions about the reasons for their presence. In addition, the diversity of fabric groups within this small sample suggests that these vessels may have come from multiple sources within the wider Eiland distribution area, and therefore less likely to be from a single bride's maternal home. Despite this lack of certainty, it is nevertheless clear that Eiland ceramics were being brought to Bosbokpoort, reinforcing the picture of regional fluidity of motion and contact.

One of the other ambitions of this study, was to ascertain how individual households interacted at a site level. As

presented above, the overwhelming majority of the samples analysed came from petro-fabric groups 1–4, which are highly likely to have been sourced locally to the site, probably from the nearby Nzhelele River. While it may not be entirely possible to definitively assert intra-site consistency, the presence of ceramics from other nearby Mapungubwe sites suggests a strong local expression of Mapungubwe identity – one that is connected to the broader polity yet distinctly articulated through local coherence and a shared worldview.

Conclusion

The Bosbokpoort ceramics highlight the importance of combining stylistic analysis with archaeometric techniques to better understand ceramic production and distribution. This approach has shown that Mapungubwe-style vessels made from non-local clays reflect a complex network of interactions and exchanges between different communities within the Mapungubwe world-, including, crucially, local or semi-local networks among hinterland communities at Bosbokpoort, Vryheid and Frampton, as well as longer-distance connections with different Eiland communities to the south. The widespread distribution of Mapungubwe-style ceramics across a vast region, from the heartland in the SLCA to areas like Bosbokpoort, suggests a deliberate effort to create a shared visual language. The act of choosing to make and use Mapungubwe-style pottery was an active choice and not a passive reflection of geographic proximity. This choice reflects a conscious alignment with the 'idea of Mapungubwe'. Even when produced locally, the widespread distribution of the Mapungubwe style points to a regional interaction system involving the movement of people, ideas, and possibly even raw materials, which facilitated the transmission of stylistic knowledge and fostered a sense of shared cultural identity. Therefore, the local manufacture of ceramics reflecting the Mapungubwe style does not contradict the existence of a regional system. Instead, it reveals the complex interplay between local practices and regional influences in shaping the material culture of communities such as Bosbokpoort. The adoption of a shared visual language demonstrates a connection to a wider sociopolitical entity, while local production highlights the agency and adaptability of these communities. This interplay emphasizes that stylistic homogeneity does not necessarily imply centralised control or an absence of local identity. Rather, it reflects the deliberate and active participation of communities in a broader cultural sphere, negotiating their place within it through the production and use of material culture. Ultimately, further research- including the analysis of larger samples from Mapungubwe and Eiland sites across the region -will shed more light on the complex interactions that constituted the Mapungubwe world.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s12520-025-02320-5>.

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Author contributions JH analysed the ceramics sample for her unpublished MA dissertation research. A.A. and A.L. contributed to the interpretation and statistical investigation of the data. A.A. and C.A. excavated the site and were the principal contributors to the discussion and conclusion sections. A.A. prepared Figs. 1, 2, 3 and 4. Both A.A. and J.H. prepared Figs. 5, 6, 7 and 8. All authors reviewed the manuscript before submission.

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Data availability No datasets were generated or analysed during the current study.

Code availability Not applicable.

Declarations

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. It reflects the paper reflects the authors' own research and analysis in a truthful and complete manner.

Competing interests The authors declare no competing interests.

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