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Spatio-temporal distribution and consumption of local earthenwares from 19th-20th century Amedeka, Southeastern Ghana☆

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ABSTRACT

In this paper, we present preliminary results of a combined typological analysis, ethnographic data, and Neutron Activation Analysis (NAA) of local earthenware from the later 19th-century site of Amedeka in southeastern Ghana. This preliminary geochemical study is the first study done on local earthenware from the site, and the goal is to examine geochemical variation within the Amedeka assemblage to determine if distinctive compositional groups could be identified and linked to possible areas of production within and beyond the region. Furthermore, we compared the data to previously characterized ceramic data from elsewhere in Ghana, reported by Ann Stahl and colleagues, in order to understand the scale of ceramic raw material procurement practices in Amedeka within the broader contexts of the late 19th and 20th centuries.

1. Introduction

Archaeologists have utilized archaeometric techniques like Neutron Activation Analysis (NAA) to determine the provenance of artifacts (Glascock and Neff, 2003; Glascock et al., 2004; Neff, 2000). In Ghana, a regional ceramic sequence based on elemental composition for the southeastern region and the Accra plains is yet to be established (Boachie-Ansah, 2009; Gblekpor, 2017; Ozanne, 1965, 1964; Shaw, 1961). Many archaeological analyses of 19th and 20th-century ceramics in Ghana have focused on documenting vessel forms, stylistic variabilities, production techniques, distribution, and functions (Nutor, 2022, 340). Despite the importance of NAA, its application in Ghana, particularly the hinterland regions, is limited. In the past two decades, few archaeological studies have used NAA to analyze local earthenwares to provide insights into ceramic production, exchange, and consumption, particularly during the Atlantic era (Stahl et al., 2008; Tandoh et al., 2010; Tandoh, 2008; Nyarko et al., 2011). There are still more questions to be asked about the local craft industries in the southeastern region of Ghana and how these industries were reorganized during ‘legitimate’ trade. This article discusses the results of a combined typological analysis and NAA of local earthenwares from the 19th and 20th-century site of Amedeka in the southeastern region of Ghana. The NAA was conducted at the Archaeometry Lab at the University of Missouri Research Reactor.

In the following section, we provide a brief background about Amedeka, the local pottery assemblage from the site, and the pottery industry in the southeastern region. Next, we discuss the methods and results of the NAA data used to source pottery from Amedeka. The statistical analysis of the NAA data distinguished three compositional groups that connected the Amedeka vessels to possible locations where Amedeka consumers acquired their vessels. The analysis also demonstrates that NAA, combined with typological analysis, is a useful tool for understanding local and regional pottery production, exchange, and consumer agencies.

2. Background: Amedeka in the 19th-20th century and local pottery industries in the southeastern region

The economic history of the 19th and 20th centuries is referred to by the Historians of Africa as “legitimate” trading era. This period was from 1807 until the 1884 Scramble of Africa, which launched significant parts of African countries into the official colonization by Europe. In sum, legitimate trade was the economic transition from the *trans*-Atlantic slave trade and slavery, which by this time was considered by Britain

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and other European countries as immoral with adverse economic impacts on Africa. However, the transition to legitimate trade stimulated massive production of botanical commodities such as palm oil, palm kernel oil, gum, and rubber in West Africa for overseas markets and the importation of mass-manufactured goods from other African and overseas markets (Chamberlin, 1979; Law, 2002; Oriji, 2011; Freund, 2016; Lynn, 1997). This non-slave commerce thrived on the illicit use of enslaved labor within certain interior African societies (e.g., Peki) and across the Atlantic, particularly in the early 19th century (Austin, 2005; Wilks, 1971; Nutor, 2024, 2022).

Legitimate trade on the coasts of West Africa came with socioeconomic adjustments for local people. An instance of this adjustment is that African elites who had erstwhile dominated the Atlantic trade were no longer dominating the legitimate trade because the trade, especially in oil palm production, was not capital intensive and was now accessible to a broader economic class. Some states negotiated this new trading era by providing the export market with native raw materials. In interior regions like Asante and Biafran region, enslaved people were still used as labor for the large-scale production and trade of Kola nuts and the growing commerce in palm oil, respectively, until the 1830s (Austin, 2005; Wilks, 1971; Kea, 1995, 137; Abrampah, 2018; Bredwa-Mensah, 2004; Northrup, 1976). In other states like the eastern littoral zones of Amedeka, export slavery continued alongside the growing commerce in palm oil until the 1830s (Lovejoy, 2011; Akyeampong, 2014; Shumway and Getz, 2017). Legitimate trade relied heavily on river transportation and available consumer and producer markets (Law, 1995) and the hinterland region of Amedeka served the vital role of connecting hinterland economies to trading firms along the coast.

Amedeka (Fig. 1) is approximately 55 miles northeast of the Atlantic coast and Ghana's capital, Accra, and lies along the Volta River, a trade route that linked hinterland agricultural economies to the European trading forts and castles on the Atlantic Coast in the 19th century. By the mid-19th century, palm oil exports from the southeastern region of Ghana to Britain and other global markets had dominated the Afro-European trade (Wilson, 1990, 269), leading to the rise of small-scale entrepreneurs and producers in hinterland palm oil production regions such as Akuapem, Krobo, and Shai in southeastern Ghana (Kea, 1995; Lynn, 1995; Maier, 2009). However, these production areas lacked access to transportation waterways, a strategic geographical feature enjoyed by Amedeka. Krobo palm oil producers, for instance, relied on Amedeka's river route, approximately 10 miles north in the distance, to transport their goods to the Atlantic coast. The area of Amedeka became a central trade and transportation hub in the hinterland regions for the Afro-European trade and settlers from other towns in Ghana. Local people's entanglement in the legitimate trade and the presence of multiple interested parties in the region introduced new trade opportunities and reorganization of local craft industries. These interactions increased the direct access to regional goods (e.g., local earthenwares) and imported goods (e.g., Japanese ceramics, beads, schnapps, cloth).

The increased demand for palm oil because of the economic transition expanded the local pottery industries in the southeastern region. Local palm oil producers and exporters in and around Amedeka relied heavily on local pottery vessels to prepare, store, and transport their products. Over the next two decades of the century, the pottery industries in the southeastern region became one of the important local craft industries with an increased demand for local earthenwares with relatively quick changes in vessel forms and shapes over time (Fig. 2).

The archaeological samples included here were excavated from four units at Amedeka: the River and Old Settlement areas. The River Area context represents the economic center where trade and exchange occurred before and during the 19th century. The River area features remnants of warehouses and retail stores, with archaeological contexts consisting of continuous layers of trash deposits that contain high densities of trade goods (e.g., ceramics, alcohol bottles), fauna, and botanical remains linked to regional and global trade. The Old Settlement Area is the early settlement of the Amedeka region. The archaeological

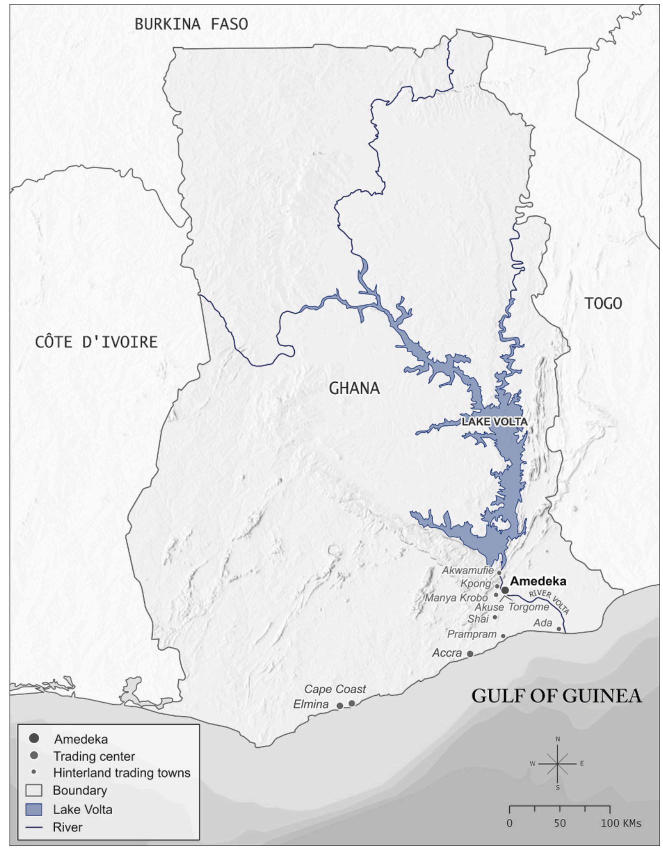

Fig. 1. Geographical location of Amedeka and Ghana in Sub-Saharan Africa. Map by Méch Frazier, Geographic Information Systems and Cartographic Specialist, Northwestern University Libraries. Image note: Map of Amedeka and Coastal and hinterland trading towns. Note. The Lake Volta was created post-damming of the Volta River in 1950 by the Volta River Authority to build the hydroelectric dam. The Lake Volta does not represent the waterscape of the late 19th century. Both the regional and European trade in the hinterland region was situated on River Volta.

deposits include relatively sparse quantities of imported ceramics, glass bottles, and beads and relatively high densities of local earthenwares, botanical, and faunal remains. The excavations comprised a 2 × 1 m unit (A18/U1) and a 2 m × 2.5 m trench (A18/T1) at two loci in the River area and two 1 m × 1 m and 1 m × 1.5 m units at two loci in the Old Settlement area (A64′18/U1 and AGK 18/U1) were excavated at arbitrary levels of 10 cm until reaching a sterile level.

Based on dateable European trade materials, the two contexts are contemporaneous with the late 19th and early 20th centuries. The typological analysis combined with data from ethnographic surveys suggests to us that the earthenwares consumed by Amedeka residents may not have been produced on-site. Instead, they may have been produced at production centers located nearby or possibly indicate that socioeconomic networks that may have stretched as far south as their Akan neighbors in the interior of Ghana. The typological analysis of some of the Amedeka earthenwares shows some stylistic similarities with late 19th-century Akan vessels (Boachie-Ansah, Personal Communication, September 2020). For example, Bowl Form 1 (see Fig. 2 and 5) and its variations are commonly carinated at the shoulder area and characterized by multiple bands of grooves at the neck between the carination and the rim. These carinated vessels are known to have Akan origin and are locally known as *nkwasen* (soup bowls) in Akan (Boachie-Ansah, 2007) or *kutu* in Dangme. Carination was also found in pre-19th-century Akan vessels but became frequent in later 19th-century coastal areas (DeCorse, 2001, 122).

To determine the relative provenance of the Amedeka vessels, we

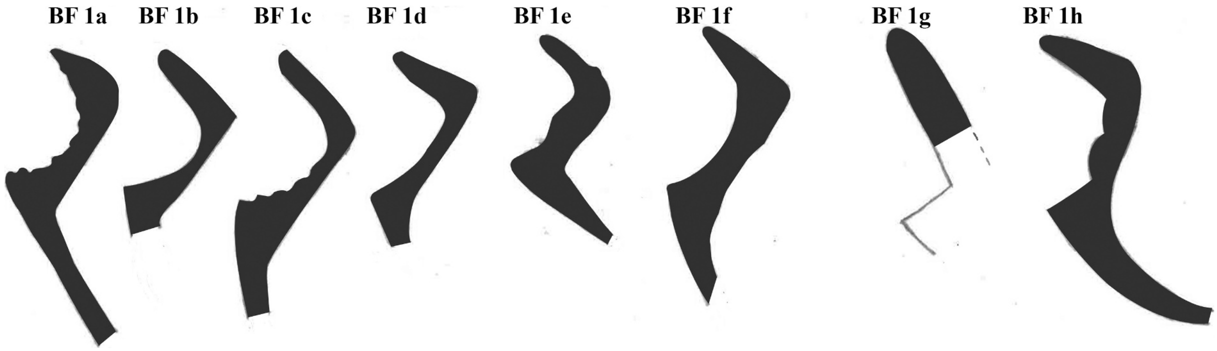

Fig. 2. Rim Profile Variations of Amedeka Bowl Form 1.

sampled and analyzed archaeological pottery from the excavated units, ethnographic pottery from nearby potting towns, and clays from both abandoned and currently used clay pits in proximity to Amedeka. The elemental signatures from the Amedeka pottery were then compared with NAA data from Banda, west-central Ghana.

Out of a total of 582 rim sherds identified from the Amedeka earthenware assemblage, vessel forms were reconstructed from 125 rim fragments (Table 1). Two primary vessel forms were identified using rim analysis. The first is the direct/slightly incurved, everted, and carinated bowls, known locally as *agba/ka*. Among the bowl forms, eight bowl varieties were determined. The second form is the flaring everted, hemispherical/globular jars (*ze/bue*). Five varieties of form, defined by rim profile variations, were determined for the jars (Crossland, 1989, 29–30). On a broad scale, the earthenwares varied in form, shape, and size. Bowls ranged from 10 cm to 36 cm, and jars ranged from 15 cm to 29 cm.

The Amedeka vessels, especially the jars, exhibit a wide range of variations in their shapes. Through the typological analysis, we observed changes in jar sizes over time. By the turn of the 19th century, there was a high demand and preference for large-sized everted rim jars, with rim diameters ranging from 25 cm to 29 cm. This specific vessel type, which we categorized as Jar Form 1 (Fig. 3), was found in relatively high frequencies across the site and accounts for 70 % of all jar forms. The outer profile of the rim curved smoothly at the rim-neck joint, while the inner profile of the rim curved sharply to join the globular-shaped body and a rounded base. The vessels were well-fired and unburnished on both the outer and inner surfaces. It is possible that these jars constituted an integral part of Amedeka's palm oil production and transportation industries and were used to transport the finished products to the Atlantic coast and possibly across the Atlantic to overseas markets.

By the early decades of the 20th century, a change in jar size occurred as medium-sized Jar Form 1, with rim diameters ranging from 16 cm to 18 cm, became popular. This shift can be attributed to broader socioeconomic changes that led to a transition in the trade from palm oil to cocoa and rubber (Dumett, 1971; Linneweh, 2019), resulting in a decline in the high demand for palm oil. The new jar sizes exhibited a high frequency of heterogeneously sorted coarse inclusions. In addition to the decline in palm oil demand, these heterogeneous coarse inclusions may be associated with the evolving socioeconomic roles of local

Fig. 3. Example of Jar Form 1 recovered from Amedeka. Image by J. Marley.

potters. In the southeastern region, pottery has been a domain of women, and this continues to be the case. Traditionally, the knowledge of pottery production was passed down within families, usually from the matriarch to other women in the family. Women in Amedeka were often seen as the key negotiators of taste and styles within the household. As Amedeka became more entangled in the global trade, women's roles within the household began to expand beyond traditional household tasks. They started to engage in the production and trade of palm kernel oil, which was a highly sought-after export by the late 19th century. It is during these times that we observe an increase in the presence of heterogeneously sorted medium-coarse wares, possibly for the production and transportation of palm kernel oil. As the roles of women were changing during this period, potters, primarily women, reduced labor inputs for raw material processing to meet high demands for vessels and to provide additional time to engage in other economic activities.

Changes in household economies and their effects on regional pottery industries indicate active social interactions between potters and consumers within a shared network (Haour, 2013; Roddick and Stahl, 2016). Our goal is where Amedeka consumers acquired their vessels to meet evolving domestic economic needs. Oral accounts from Amedeka

Table 1
Quantity and Percentage Distribution of Pottery Assemblage from Amedeka.

Context	Body	%	Rims	%	Neck	%	Base	%	Carination	%	Colander	%	Unknown	%	Lid	%	Handle	%
River Area (A18/T1)	1467	46	246	8	75	2	12	0.4	0	0	4	0.1	23	1	0	0	0	0
River Area (A18/U1)	763	24	330	10	65	2	17	1	31	1	5	0.2	8	0.2	2	0.1	2	0.1
Old Settlement (AGK18/U1)	18	1	6	0	3	0.1	0	0	0	0	0	0	0	0	0	0	0	0
Old Settlement (A6418/U1)	117	4	1	0	3	0.1	2	0.1	0	0	0	0.0	3	0.1	0	0	0	0
TOTAL	**2365**	**74**	**583**	**18**	**146**	**5**	**31**	**1**	**31**	**1**	**9**	**0.3**	**34**	**1**	**2**	**0.1**	**2**	**0.1**

elders suggest that the community lacked a local production industry. This account is supported by the absence of pottery production markers, such as wasters, old clay pits, and open firing spaces observed during ethnographic and reconnaissance surveys on the site. Only two families in Amedeka engage in pottery production, having begun this practice in the last twenty years. In the broader southeastern region, pottery making is a specialized activity carried out primarily by women, who produce three main categories of vessels: cooking, storage, and serving vessels. Given Amedeka's proximity to six historical pottery-producing towns in the southeastern region (Fig. 4), consumers in the 19th century likely had a variety of choices regarding where they acquired their vessels.

Elderly Amedeka residents recall that the archaeological vessels from the site share some stylistic similarities with vessels from neighboring potting communities, such as the Shai-Doryumu area, Okwenya, Dodowa, and possibly, the Accra plains (Boachie-Ansah, 2009; Bredwa-Mensah, 1996; Gblekpor, 2017). In comparison to vessels from the Shai-Doryumu area (Quarcoo and Johnson, 1968; Gblekpor, 2017; Anquandah, 1980; 1982; 1990; Ozanne, 1965), those found in Amedeka exhibit greater variability in shape and style (Fig. 5a–Fig. 5b).

If local people in Amedeka did not produce the pottery they consumed, then two possible scenarios could explain their pottery acquisition and consumption strategies. Firstly, local people may have acquired different pottery forms from different production centers in other regions. It is also likely that consumers acquired their vessels from peddlers who resold wares from various production centers. Secondly, distant ceramic traditions may have influenced some vessel forms or shapes while most, if not all, vessels may have been produced within the southeastern region. To test these hypotheses, we analyzed pottery and clay samples from Amedeka using NAA between 2021 and 2022 at the University of Missouri Research Reactor (MURR).

3. Materials and methods

3.1. Geological clay sample

We collected four clay and one temper sample from the southeastern region, targeting abandoned and currently used clay pits located in Okwenya, Torgome, Doryumu, and Aku Creek (see Fig. 4). The objective is to calculate the likelihood that any of the Amedeka ceramic compositional groups are linked to the local clay deposits, which will help identify potential production areas. While the southeastern region is geologically diverse, it is also connected with water bodies, which may result in the clays having similar geochemical signatures. The southeastern region is bounded on the northeast by sandy and pebbly beds, calcareous, basic, acidic ortho and paragenesis, schist, and migmatites, which are rich in garnet, hornblende, and biotite. There are quartzites, basalts, sandstones to the west, granitoid, phyllite, conglomerate, basic intrusive to the southwest, metamorphosed lava, and pyroclastic rock to the west, suggesting geological diversity in the eastern and southeastern regions (Fig. 6). The southeastern region is also bordered by Lake Volta and the Volta River, which transports and mixes geological materials and sediments from adjoining waterways, sediments, and geological

Fig. 5a. Examples of Bowl Form 1 recovered from Amedeka. Image by J. Marley.

Fig. 4. Map of pottery production towns near Amedeka and areas from which we collected clay samples. Map created by Bashara Abubakari, Applications Specialist, Center for Remote Sensing and Geographic Information Services, University of Ghana.

Fig. 5b. Example of Bowl Form 2 recovered from Amedeka. Image by J. Marley.

contexts and deposits them downstream. These activities, in addition to the clay tempering, can make it difficult to identify specific raw materials used to produce the archaeological ceramics (Rice, 1996, 168–72; Neff et al., 1988). The Neutron Activation Analysis can identify the bulk composition or geochemical groups that might be associated with ceramic raw material sources and different distributions within a site (Costin, 2001, 306).

3.2. Archaeological pottery samples

Our samples consist of 41 archaeological rim sherds from the 2018 excavations in Amedeka as well as one ethnographic bowl from Okwenya potting town. The decision to analyze only rim sherds was determined by the nature of the Amedeka assemblage. The pottery assemblage is highly fragmented, and using body sherds could result in the redundant sampling of the same vessels. Two factors contribute to the fragmented conditions of the assemblage. First, Amedeka is an active site, currently inhabited by communities that use the space for daily business activities. These activities often interfere with the archaeological record and its remains. Second, the excavated contexts were community middens, continuously used over a long period. The fragmentations of the potsherds may reflect local disposal practices where vessels were possibly crushed before discard. The minimum number of vessels (MNV) identified two forms: jars and bowls. Our samples (n = 41) were recovered from the River and Old Settlement areas and are representative of bowls (n = 29) and jars (n = 12) (Table 2).

3.3. Sample preparation and analytical procedures

3.3.1. NAA experimental procedure

The samples were prepared by D. Kuma, and the statistical report was prepared by B.L. MacDonald using procedures standard at MURR (Glascock, 1992; Neff, 2000; Hector Neff, 1992; Glascock and Neff, 2003). A small piece of each specimen (~2 cm × ~2 cm) was clipped, and all exterior surfaces burred with a diamond-burr Dremel tool. Each piece was washed in deionized water and ground to a fine powder in an agate mortar and pestle. Two analytical samples were prepared from each ceramic and clay specimen. Portions of approximately 150 mg were weighed into clean high-density polyethylene vials used for short irradiations. The short-duration samples were irradiated alongside standard reference materials via a pneumatic tube system for 10 s at a flux of 8×10^{13}n cm^{-2} s^{-1}. These samples were allowed to decay for 25 min. At that time, the gamma-ray emissions were measured for 12 min using a hyper-pure germanium detector to detect elements that produce

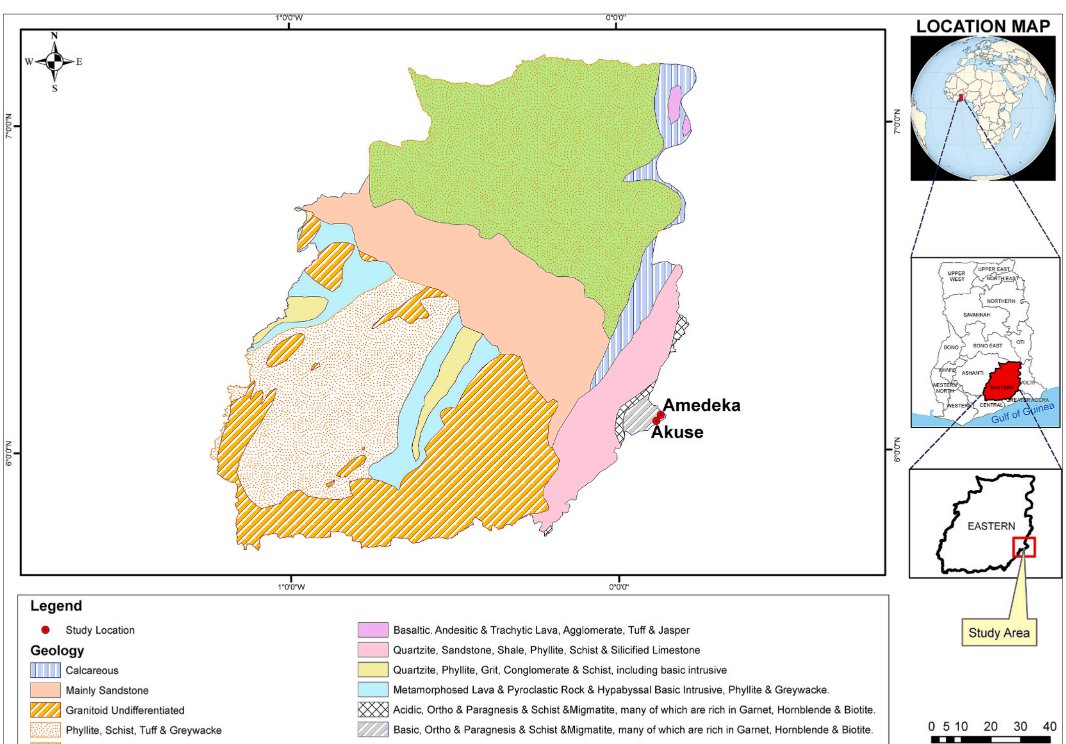

Fig. 6. Geological Map of Eastern and Southeastern regions of Ghana. Map by Bashara Abubakari.

Table 2
Counts of pottery and clay samples analyzed in the paper and corresponding geochemical and unassigned groups.

Form	Group 1	Group 2	Group 3	Unassigned	Clay	Total
Bowl 1	5	4	1			10
Bowl 2	5			1		6
Bowl 3		5				5
Bowl 4		1				1
Bowl 5	1	1	2			4
Bowl 6	1					1
Bowl 7			1			1
Bowl 8				1		1
Bowl-Ethnographic						1
Jar 1	5	1				6
Jar 2	1					1
Jar 3	1	2				3
Jar 4		1				1
Jar 5	1					1
Clay					4	4
Temper					1	1
Total	20	15	4	2	5	47

short-lived radioisotopes for aluminum (Al), barium (Ba), calcium (Ca), dysprosium (Dy), potassium (K), manganese (Mn), sodium (Na), titanium (Ti), and vanadium (V). The second portion of each sample was weighed to 200 mg in clean high-purity quartz vials for long irradiations. Quartz encapsulated samples were subjected to a 24-hour irradiation at a neutron flux of 6×10^{13} n cm^{-2} s^{-1}. These samples were measured for 2000 s after seven to ten days to measure medium-lived radioisotopes arsenic (As), lanthanum (La), lutetium (Lu), neodymium (Nd), samarium (Sm), uranium (U), and ytterbium (Yb), and then again after two to three weeks for 8200 s to measure the long-lived radioisotopes cerium (Ce), cobalt (Co), chromium (Cr), cesium (Cs), europium (Eu), iron (Fe), hafnium (Hf), nickel (Ni), rubidium (Rb), antimony (Sb), scandium (Sc), strontium (Sr), tantalum (Ta), terbium (Tb), thorium (Th), zinc (Zn), and zirconium (Zr). The spectral data were calculated to elemental concentrations by comparator method using NIST standard reference materials (NIST SRM-1633b, SRM-688, SRM-278).

3.3.2. Statistical interpretation of chemical data

The NAA procedure produced elemental concentration values for 33 elements in most of the ceramic and clay samples. Statistical analysis was subsequently carried out on base-10 logarithms of concentrations using all elements. The use of log concentrations rather than raw data compensates for differences in magnitude between the major elements, such as aluminum, on one hand, and trace elements, such as the rare earth or lanthanide elements (REEs). Transformation to base-10 logarithms also yields a more normal distribution for many trace elements.

3.3.3. Identifying compositional groups in archaeological materials

The interpretation of compositional data obtained from the analysis of archaeological materials is discussed in detail elsewhere (Baxter and Buck, 2000; Bieber et al., 1976; Glascock, 1992; Glascock and MacDonald, 2023; Neff, 2000; Bishop and Hector, 1989). Here, we applied standard multivariate analyses used in provenance studies to identify distinct chemical groups and outliers within the dataset, including bivariate analysis, cluster analysis (CA), and principal component analysis (PCA), with results detailed in Section 4.0. Based on the provenance postulate of Weigand et al. (1977, 15–34) and the criterion of abundance (Bishop et al., 1992), different chemical groups within a ceramic assemblage may be assumed to represent geographically restricted production zones or sources of raw materials collectively used by a potting community. Patterns evident in the statistical analysis are also informed by geological and sedimentological characteristics (Steponaitis et al., 1996), as well as the local presence or absence of raw materials. The ubiquity of ceramic raw materials usually makes it impossible to sample all potential "sources" intensively enough to create groups of knowns to which unknowns can be compared; therefore, it is more conceptually useful to consider ceramic compositional groups to represent zones of production rather than "sources" of raw materials.

4. Analytical results

Element concentration data on the 47 pottery and four clay samples were analyzed by PCA on the $\log^{10}$ transformed data set, using all available elements. The first four principal components contributed to 79.47 % of the variance (Table 3). The first 28 principal components explain 100 % of the assemblage of the 47 samples. The scoring coefficients for each element are representative of that variable's contribution to each principal component. PCA results indicated that the elements Th (0.323), K (0.248), and La (0.205) positively drive the variance for PC1, while Ca (−0.445), Sr (−0.369), and Na (−0.347) negatively drive the variance. The elements K (0.560), Ba (0.297), and Sr (0.232) positively drive the variance for PC2, while Ni (−0.269), Co (−0.242), Sc (−0.208), Cr (−0.208) and Ti (−0.204) negatively drive the variance (Fig. 7).

Based on the initial PCA, our analyses revealed three compositional groups. The majority of the pottery samples were categorized in Group 1 (n = 20) and Group 2 (n = 15), and a smaller number fell into Group 3 (n = 4) with two outliers (see Table 2 & Fig. 7). Group 1 consists of an equal distribution of bowls and jars, with Bowl Forms 1 and 2, as well as Jar Form 1, which is the most common vessel type in this group. Group 2 is primarily composed of Bowl Form 3 (Fig. 8). In contrast, Group 3 is made up of only three specimens, which include two vessels related to Bowl Form 5 (Fig. 9) and one related to Bowl Form 1.

The PCA suggests that the elements that "pull" the Amedeka G2 cluster away from the other two clusters are the presence of higher Th, K, and La. That same group also contains the only examples of grog-tempered wares. The ethnographic ceramic from the Okwenya market and the temper samples from Torgome did not show any correlation with the main ceramic groups. The clay samples were compared against the ceramic compositional groups using the Mahalanobis Distance

Table 3
Percentage variation and cumulative variation for each of the 28 principal components.

PC	% var.	% cum.
PC 1	53.74	53.74
PC 2	12.90	66.64
PC 3	7.71	74.35
PC 4	5.12	79.47
PC 5	4.19	83.66
PC 6	3.88	87.53
PC 7	3.22	90.76
PC 8	2.24	93.00
PC 9	1.73	94.73
PC 10	1.37	96.10
PC 11	1.14	97.24
PC 12	0.82	98.06
PC 13	0.57	98.63
PC 14	0.36	98.99
PC	% var.	% cum.
PC 15	0.28	99.27
PC 16	0.21	99.48
PC 17	0.12	99.60
PC 18	0.10	99.70
PC 19	0.08	99.78
PC 20	0.06	99.84
PC 21	0.04	99.89
PC 22	0.04	99.92
PC 23	0.03	99.95
PC 24	0.02	99.97
PC 25	0.01	99.98
PC 26	0.01	99.99
PC 27	0.01	100.00
PC 28	0.00	100.00

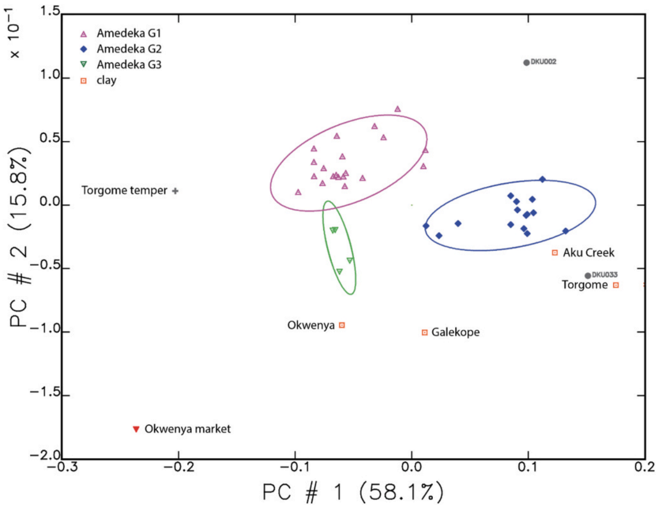

Fig. 7. Scatterplot of PC1 (58.1%) versus PC2 (15.8%) showing the distribution of the 47 clay specimens included in this study. Ellipses are drawn at 90% confidence. Clay samples, temper, and outliers (DKU002, DKU033) samples are individually marked.

Fig. 8. Example of Bowl Form 3 recovered from Amedeka. Image by J. Marley.

equation. The membership probability scores demonstrate that the Okwenya clay has a 14.57 % probability of membership with Amedeka G3, while the Aku Creek clay has a 3.72 % probability of affiliation with Amedeka G2. The Galekope clay has a 2.32 % probability of affiliation with Amedeka G3. The clay from Torgome has a <1 % probability match to any group.

4.1. Comparison to previously characterized ceramics from Ghana – Banda

We compared the Amedeka geochemical data to data from Banda, west-central Ghana (Stahl et al., 2008), where geochemical compositional groups have been identified and archived in the MURR's ceramic database.

The existing comparative dataset in the MURR database contained over 600 samples from previously reported data. To facilitate a refined comparison, a new PCA was calculated using the Amedeka and Stahl datasets (Fig. 10). The scatterplot in Fig. 10 shows a comparison of the Amekeda ceramic groups and clays projected against the three main compositional groups reported in Stahl et al. (2008). The Amedeka ceramic and clay samples were tested against the Stahl reference groups using Mahalanobis distance (see Appendix). The Amedeka G1 and G3 specimens have poor correlates to any of the Stahl groups. However, the

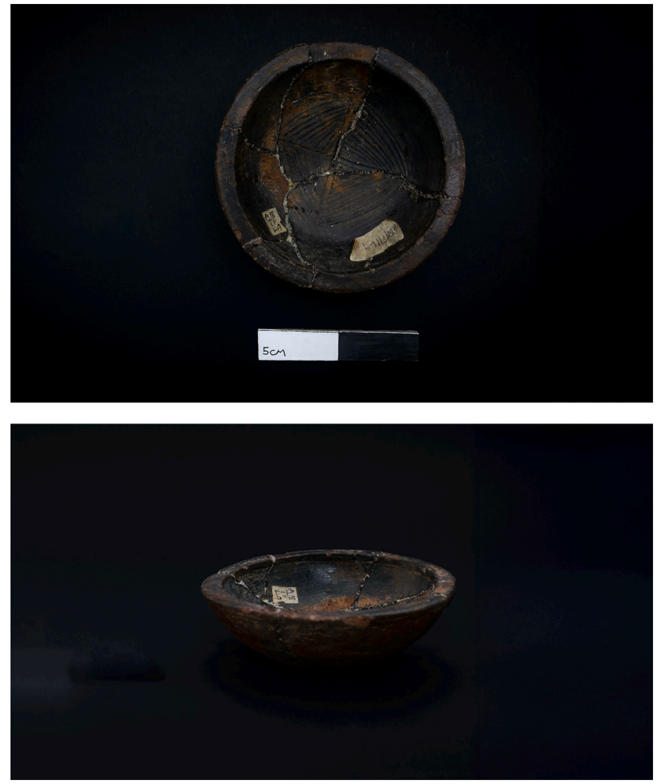

Fig. 9. Example of Bowl Form 5 recovered from Amedeka. Image by J. Marley.

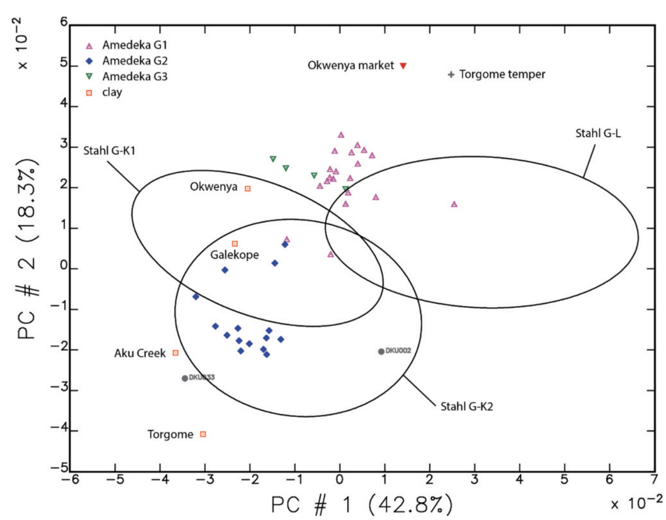

Fig. 10. Scatterplot of PC1 (42.8%) versus PC2 (18.3%) showing the distribution of the Amedeka pottery samples and clays, projected against previously defined compositional groups (Stahl et al. 2008). The Stahl reference groups are presented as 90% confidence ellipses.

majority of the Amedeka G2 samples have moderate to high probability scores for affiliation to Stahl G-K2 (~20–80 %), suggesting that these two groups are compositionally similar. The Aku Creek clay also has a moderate probability score for Stahl G-K2 (53 %), while the Torgome clay has a low score of 12 % affiliation to Stahl G-K2 (~12 %). The Okwenya and Galekope clays have a < 1 % score for any of the Stahl groups.

5. Discussion

Our analysis provides some preliminary insights into patterns of pottery production and consumption in Amedeka and the southeastern region. The compositional groups indicate that the vessels consumed in Amedeka were produced locally but suggest a more dispersed production involving multiple potters. Group 1, the largest geochemical group, displays a pattern of variation in vessel forms with similar geochemical composition. This corresponds with patterns of general production where multiple potters use chemically similar clays or raw materials from the same source to produce a variety of vessels for more extensive markets or consumer bases. This pattern explains our observations regarding the reduction in sizes of Jar Form 1 from 29 cm in the early 19th century to 18 cm in the 20th century and the presence of heterogeneously sorted coarse inclusions in the latter.

By the early decades of the 20th century, consumer and trade interests began to pivot towards other agricultural products like palm kernel oil, cocoa, and rubber. Potters made economic trade-offs to streamline their labor requirements and organization of pottery production and other household tasks, thus leading to the reduction in jar sizes and sorting of inclusions. This included spending less time on raw material preparation and using similar tools or bodily "sequence of gestures" (Logan and Cruz, 2014, 218) to perform related tasks, allowing potters additional time to engage in other lucrative activities presented through the kernel oil trade. Similar patterns were observed in Banda by Amanda Logan and Maria Dores Cruz (2014), who observed the interdependence between tools used to perform daily domestic tasks and other economic activities. They theorize this phenomenon as 'gendered taskscapes' organized by shared tools, embodied practices, and operational chains. They argue that new economic demands impact access to household labor and gendered division of labor (Logan and Cruz, 212–213), which requires women to make trade-offs or find shared tools and techniques to perform a given task. They observed that women in Banda use similar tools and bodily motions to produce both pots and food. For example, potters prepare their clay using similar tools, bodily motions, and techniques as those used in preparing foods like *fufu* and *Tuo Zaafi*.

Group 2 specimens show higher concentrations of Th, K, and La. This group is primarily represented by Bowl Form 3 and Jar Form 3 (Fig. 11). Additionally, it contains grog-tempered vessels and has strong compositional similarities with the Stahl Group-K2. We present two possible scenarios that could explain the observed patterns. First, it is possible that potters in the southeastern region used raw materials from sources similar to those in Group 1 to produce all other vessel forms except Bowl Form 3 and Jar Form 3. These specific forms were manufactured using mixed clays from distinct sources, potentially acquired or transported from other regions. This practice of mixing clays could have resulted in the distinct geochemical signature found in Group 2. The second scenario, which is the most plausible explanation, involves the use of grog as a tempering agent. Potters often add grog to clay to improve workability or firing properties. In the case of the Amedeka vessels, it is probable that some potters tempered their wares with grog as a manufacturing strategy to distinguish their wares from those produced in other potting centers (Rosselló, 2010). This practice of tempering the clay with grog can influence the chemical signature of the final vessels.

Fig. 11. Example of Jar Form 3 recovered from Amedeka. Image by J. Marley.

Since none of the clay specimens have high membership probability scores with any of the three Amedeka geochemical groups, it is challenging to confidently argue that the raw materials were sourced from any of the local clays. When tested against the pottery compositional groups using the Mahalanobis Distance equation, only the Okwenya clay showed a relatively high probability membership at 14.57 % with Amedeka Group 3. This group consists of only four samples, dominated by Bowl Form 5, but it also includes the only specimen of Bowl Form 7. There are two possible scenarios for these observations. First, it could be that our clay samples did not capture all of the geochemical variation in the area; therefore, our Group 3 does not reflect all possible distinct clay sources.

The second scenario explores the possibility of specialized production or selective consumption. In this context, specialized production refers to manufacturers who produce specific types of vessels for consumers. The range of vessel forms represented in Group 3 contrasts with those in Groups 1 and 2. Notably, no jar forms are present in Group 3. Based on typological analysis, ethnographic, and geochemical data, the production of Bowl Form 5 was a specialized production where particular potting centers devoted their craft to producing these vessels. It is also possible that Amedeka consumers engaged in the selective consumption of Bowl Form 5. These bowls are direct-rimmed shallow bowls with sloping bodies and slightly rounded bases. According to oral accounts from Amedeka elders, these vessels originated from the nearby Okwenya area and are used to serve traditional medicines or herbs. This also confirms what we observed from the geochemical data. Okwenya is about 14 km west of Amedeka, so in terms of distance, this potting town provides relatively easy access for consumers to travel to acquire their vessels compared to the Shai-Doryumu area or even the Accra plains that are between 20 km to 40 km from Amedeka.

The two unassigned samples are not significantly different from those in Group 2; they appear to be outliers of this group rather than representing a distinct compositional group. Analyzing a relatively larger sample set will broaden the range of variations and allow us to identify compositional groups that are not present in the current samples.

Our analysis also provides the first geochemical data regarding raw material sources in Amedeka. Our data point to some strong patterns of compositional similarity across the southeastern and west-central regions of Ghana. The ceramic assemblage from Amedeka has three distinct compositional groups. The comparison to the clays collected for the Amedeka study has shown that the Okwenya clay has a low-moderate affiliation with the G3 ceramics, and the Aku Creek clay has a low 3.7 % affiliation with Amedeka G2, and the Galekope has a 2 % affiliation with G3. These scores are relatively low and may be viewed as false positives in some cases.

Comparison to the Stahl reference groups indicates strong compositional similarities between Amedeka G2 and Stahl G-K2. Stahl characterized G-K2 as the dominant group produced in the general area east of the Banda hills, based on the firmly provenanced clays from Bui village (Stahl et al., 2008, 5) and clays from south of Bungasi, the Tombe river, among others. The compositional signatures of the clays from east of the Banda hills are influenced by the Tarkwaian rocks of the Permian formation (including phyllite and sandstone units) that extend from the Tombe River in the south to the Volta River in the North. With regard to Stahl G-K2, the ceramics in this group included wares from the Iron Age III phase of Makala Kataa, Volta phase sherds, all ceramics from Banda 27, and half of the samples from Banda 13 (Stahl et al., 2008, 14). Overall, the Stahl G-K2 samples correlate with the Ngre Phase contexts in a range of vessel forms. This compositional type was abandoned during the Kuulo Phase but reappeared in the Makala Phase II contexts. Stahl suggests that G-K2 sources were continuously exploited by eastern potters in their study area, although were not widely distributed in comparison to other compositional groups.

There are some potential explanations for the compositional similarities between the Amedeka Group 2 and Stahl Group K2 that are worth considering. One possibility is the long-distance movement of ceramics through interregional trade networks or the itinerant movement of people along the Black Volta and River Volta. In the 19th century, when Amedeka became the hinterland center of legitimate trade, the region attracted people from diverse ethnic and economic backgrounds. These processes possibly created actively shared exchange networks between potters in Banda and consumers in Amedeka. Several exchange mechanisms may have played out. In this paper, we discuss two such mechanisms of exchange that the people of Amedeka engaged in on a local and regional level. These are direct access to ceramic producers (restricted distribution) and indirect access (general distribution) to ceramic producers.

In the case of direct access or restricted distribution, the access to and distribution of the wares was organized by African and European merchants who had direct access to a wide network of pottery producers, for example, Banda pottery producers. The direct access by merchants would have restricted who had access to the wares in regional circulation. Other economic activities also influenced these forms of exchange. Historical documents (ADM.7/1/32 1898) suggest that African and European merchants established trading factories and store branches at Amedeka, where they played significant roles in the direct acquisition and sale of manufactured goods (Ocansey, 1881, 5). Many of these merchants owned launches or steam launches, which made the transportation of goods over long distances faster (Dumett, 1983, 673). Regionally produced goods, such as farm products, came exclusively from Manya Krobo; fish originated partly from the Volta River; salt was sourced from Ada and occasionally Keta; and other trade items, including textiles, came from Accra and Tema (Addo, 1988, 9–10; Wilson, 1991). Goods like pottery were obtained from producers in neighboring regions of the southeastern Volta Basin, particularly the Shai-Doryumu area. Some of these vessels were also acquired through distant pottery networks in Vume and Banda, located in the present-day Volta and west-central regions. To limit direct access to goods and their redistribution, S.T. Addo (1988, 10) found that European trade firms reduced competition with local traders and, at times, their African merchant competitors by monopolizing the sale and redistribution of certain goods. However, African merchants like the Ocansey firm posed fierce competition against some of the European firms. They dominated most inter- and intra-regional retail networks, which included redistributing local fish, salt, pottery, and some imported goods to local traders and retailers in central and northern Ghana (Dumett, 1983, 672–74).

The second exchange mechanism involves indirect access to producers or the general distribution of vessels, likely explored by local, small-scale traders who redistribute these goods at the intraregional level. Here, local traders refer to individual and small-scale retailers who obtained their goods from African and European merchants for retail in village markets, roadside selling points, stalls, and house-to-house hawking. Many local traders, primarily women, acquired from these merchants a wide variety of goods such as palm oil, food crops, local pottery, and other imported commodities such as ceramics, drugs, canned food, perfumes, cooking utensils, hardware, footwear, and textiles from merchants (ADM.11, 1, 1098. , 1911). They redistributed these goods to petty traders at small shops and at open markets in Kpong, Akuse, and Agomenya during market days (Huber, 1963).

In tracking the interregional networks along the River Volta and other trade connections, we cannot deny the existence of alternative exchange mechanisms utilized by individuals who independently acquired and redistributed goods. Oral accounts and historical documents indicate that certain individuals, local traders, and canoeists established connections that bypassed administrative authorities. They obtained goods directly from producers or middlemen to distribute within their network of retailers. These practices created tensions with colonial authorities, particularly because they often evaded customs charges by using smaller canoes. H. J. Bevin (1956, 78) observed that colonial authorities were concerned about smaller canoes that were used to smuggle goods, including weapons, into interior regions that were not under British jurisdiction, such as Asante. This allowed these goods to evade customs control. On the Volta River, canoes could travel further into areas that were inaccessible to larger steamers and vessels. Local people exploited these regulatory gaps, taking advantage of an unequal colonial economy. These actions affected the profit margins of many of the European trading firms (Dumett, 1983, 683).

Another factor that could explain the compositional similarities between the Amedeka Group 2 and Stahl Group K2 is the drainage basin of the Black Volta River and its tributaries, which may have contributed to the compositional similarity of all or most clay pits along its river course. It is reasonable to infer that the drainage of the Black Volta and its alluvial deposits flowing southward into the River Volta accounts for the widespread use of similar raw materials on a localized scale (Stahl et al., 2008, 4). Finally, the recycling of raw materials, as indicated by the use of grog temper in Amedeka G2, could also account for the compositional similarities. It is important to note that interconnected waterways and other factors, such as mixing clays and tempers, can lead to significant elemental redistribution, potentially masking the geochemical composition of the ceramic fabrics. To identify variations in ceramic recipes more effectively, complementary analytical techniques can be useful (Speakman and Hector, 2005; Stahl et al., 2008). In future analyses, the authors plan to augment the INAA data by incorporating insights from Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS). This approach will help ascertain the impact of grog tempers on the chemical composition of the Amedeka G2 compositional group and offer further insights into variations in fabric recipes used by potters in the southeastern region.

6. Conclusion

This study marks an initial step toward enhancing our understanding of the local pottery economies in Amedeka during the 19th and 20th centuries, highlighting a complex interplay between production organization, raw material selection, and the broader trade networks. Our analysis identified three compositional groups within the Amedeka samples, offering insights into potential raw material sources and production areas. The comparative analysis with datasets from Banda shows compositionally similar pottery between the two regions, particularly for Amedeka Group 2. This suggests a significant influence of interregional trade networks and shared geological resources among pottery communities in southeastern and west-central Ghana, enhancing our understanding of sociocultural and economic connections between the regions.

We have demonstrated that, although the vessels consumed in Amedeka were not produced on-site, consumers had access to multiple networks of potters from which they acquired specific vessel forms to satisfy their taste preferences. The membership probability scores between the Amedeka groups and clays, along with the stylistic similarities to Akan vessels discussed in the paper, emphasize the extent of exchange mechanisms and strategies employed by potters, traders, and consumers in response to socioeconomic changes, such as shifts in agricultural priorities and economic demands in the 19th and 20th centuries.

The insights derived from the geochemical analysis suggest some directions for further analysis. One possibility is to expand the Amedeka database to explore the specialized production and selective consumption of Bowl Form 5 in Group 3. Additionally, this study also offers an example that highlights the value of legacy comparative databases, illustrating the importance of interoperability within and between NAA laboratories for the scholarly reuse of compositional data (Boulanger, 2017).

CRediT authorship contribution statement

R.Dela Kuma: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Brandi L. MacDonald:** Writing – review & editing, Validation, Software, Resources, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jasrep.2025.105248.

Data availability

Data attached as a supplementary file.

References

Abrampah, D.A., 2018. Frederikssted: Archaeology of a Former Danish Plantation at Dodowa, Ghana. Dissertation, LaTrobe University, Australia.

Addo, S.T., 1988. Traditional Markets in the Development Process in Manya Krobo in Ghana, 1700–1970. Singapore Journal of Tropical Geography 9 (1), 1–17. https://doi.org/10.1111/j.1467-9493.1988.tb00192.x.

ADM.11/1/1098. 1911. "Akuse Native Affairs." Public Records and Archives Administration Department, Accra.

ADM.7/1/32. 1898. "Gold Coast Colony. Blue Book for Imports and Exports for the Year 1898." Public Records and Archives Administration Department, Accra.

Akyeampong, E., 2014. Commerce, Credit, and Mobility in Late Nineteenth-Century Gold Coast: Changing Dynamics in Euro-African Trade. In: *Africa's Development in Historical Perspective*. Cambridge University Press, pp. 231–263. https://doi.org/10.1017/CBO9781139644594.010.

Anquandah, J., 1980. Traditional potting and the pottery trade in Shai (Ghana) an ethno-archaeological Study. In: Proceedings of a Conference of the West African Aggrey Society. Freetown, Sierra Leone: Sierra Leone chapter of the West. African Aggrey Society.

Anquandah, J., 1982. Archaeological reconnaissance and excavation in the Shai Hills, Ghana. Nyame Akuma 15–17.

Anquandah, J., 1990. A preliminary report on archaeological investigation at Adwuku Hill, Shai, Ghana. Archaeology of Ghana No. 3: 33–37. Archaeology of Ghana 3, 33–37.

Austin, G., 2005. *Labour, Land and Capital in Ghana: From Slavery to Free Labour in Asante, 1807-1956*. University of Rochester Press. https://muse.jhu.edu/book/85473.

Baxter, M., Buck, C.E., 2000. Data Handling and Statistical Analysis. In: *Modern Analytical Methods in Art and Archaeology*. John Wiley and Sons, New York, pp. 681–746.

Bevin, H.J., 1956. The Gold Coast Economy about 1880. Transactions of the Gold Coast & Togoland Historical Society 2 (2), 73–86. https://www.jstor.org/stable/41406609.

Bieber, A.M., Brooks, D.W., Harbottle, G., Sayre, E.V., 1976. Application of multivariate techniques to analytical data on aegean ceramics. Archaeometry 18 (1), 59–74.

Bishop, R.L., Rands, R.L., Holley, G.R., 1992. Ceramic compositional analysis in archaeological perspective. In: *Advances in Archaeological Method and Theory*. Academic Press, New York.

Boachie-Ansah, J., 2007. Traditions and changes in pottery from Mount Mary Training College and Adjikpo-Yokunya, Eastern Region, Ghana. Traditions and Changes in Pottery from Mount Mary Training College and Adjikpo-Yokunya, Eastern Region, Ghana 48 (1), 83–107.

Boachie-Ansah, J., 2009. Archaeological investigation at the Danish plantation site of Brockman, Ghana. Afrique: Archéologie and Arts 5, 149–172. https://journals.openedition.org/aaa/857.

Bishop, R. L., and Hector N. 1989. "Compositional Data Analysis in Archaeology." In Archaeological Chemistry IV, 220:57–86. Advances in Chemistry 220. American Chemical Society. https://doi.org/10.1021/ba-1988-0220.ch004.

Boulanger, M., 2017. "Recycling Data: Working with Published and Unpublished Ceramic-Compositional Data." In The Oxford Handbook of Archaeological Ceramic Analysis, 73–84. https://doi.org/10.1093/oxfordhb/9780199681532.013.6.

Bredwa-Mensah, Y., 1996. The production and use patterns of Ga pottery in the lower Densu Valley, Western Accra plains, Ghana. In: Papers from the Institute of Archaeology 7. https://doi.org/10.5334/pia.95.

Bredwa-Mensah, Y., 2004. Global encounters: Slavery and slave lifeways on nineteenth century Danish plantations on the Gold Coast, Ghana. Journal of African Archaeology 2 (2), 203–227. https://doi.org/10.3213/1612-1651-10028.

Chamberlin, C., 1979. Bulk exports, trade tiers, regulation, and development: An economic approach to the study of West Africa's 'Legitimate Trade.'. The Journal of Economic History 39 (2), 419–438. http://www.jstor.org/stable/2118946.

Costin, C. L. 2001. "Craft Production Systems." In Archaeology at the Millennium: A Sourcebook, edited by Gary M. Feinman and T. Douglas Price, 273–327. Boston, MA: Springer US. https://doi.org/10.1007/978-0-387-72611-3_8.

Crossland, L.B., 1989. *Pottery from the Begho-B2 Site, Ghana*. University of Calgary Press, Calgary.

DeCorse, C.R., 2001. *An Archaeology of Elmina: Africans and Europeans on the Gold Coast, 1400-1900*. Smithsonian Institution Press, Washington, DC.

Dumett, R.E., 1971. The rubber trade of the gold coast and Asante in the nineteenth century: African innovation and market responsiveness. The Journal of African History 12 (1), 79–101. http://www.jstor.org/stable/180568.

Dumett, R.E., 1983. African merchants of the gold coast, 1860–1905–dynamics of indigenous entrepreneurship. *Comparative Studies in Society and History* 25 (4), 661–693. http://www.jstor.org/stable/178669.

Freund, B., 2016. *The Making of Contemporary Africa: The Development of African Society since 1800*, Third edition. Lynne Rienner Publishers, Boulder, Colorado.

Gblekpor, W.N., 2017. The weapons of our warfare are not carnal: An archaeological and ethno- historical study of anti-colonial identity in Krobo, Ghana. The University of Texas at Austin. Unpublished Dissertation.

Glascock, M.D., 1992. Characterization of archaeological ceramics at MURR by neutron activation analysis and multivariate statistics. *Chemical Characterization of Ceramic Pastes Archaeology* 11–26.

Glascock, M., Neff, D.H., Vaughn, K.J., 2004. Instrumental neutron activation analysis and multivariate statistics for pottery provenance. *Hyperfine Interactions* 154 (1), 95–105. https://doi.org/10.1023/B:HYPE.0000032025.37390.41.

Glascock, M.D., Neff, H., 2003. Neutron activation analysis and provenance research in archaeology. *Measurement Science and Technology* 14 (9), 1516. https://doi.org/10.1088/0957-0233/14/9/304.

Glascock, M., MacDonald, B., 2023. Multivariate analysis in archaeology. *Handbook of Archaeological Sciences* 1183–92, 2. https://doi.org/10.1002/9781119592112.ch58.

Haour, A., 2013. Outsiders and Strangers: An Archaeology of Liminality in West Africa. OUP, Oxford.

Huber, H., 1963. *The Krobo: Traditional Social and Religious Life of a West African People*. St. Paul's Press.

Kea, R.A., 1995. Plantations and Labour in the South-East Gold Coast from the Late Eighteenth to the Mid Nineteenth Century. In: *From Slave Trade to "legitimate" Commerce: the Commercial Transition in Nineteenth-Century West Africa*. Cambridge University Press, pp. 57–77.

Law, R (Ed.), 1995. *From Slave Trade to "Legitimate" Commerce: The Commercial Transition in Nineteenth-Century West Africa*. African Studies. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9780511523861.

Law, R (Ed.), 2002. *From Slave Trade to "Legitimate" Commerce: The Commercial Transition in Nineteenth-Century West Africa*. Cambridge University Press.

Linneweh, B., 2019. Global Trading Companies in the Commodity Chain of Rubber between 1890 and the 1920s. Business History 65 (5), 863–879. https://doi.org/10.1080/00076791.2019.1693544.

Logan, A., Dores Cruz, M., 2014. Gendered taskscapes: Food, farming, and craft production in Banda, Ghana in the eighteenth to twenty-first centuries. *African Archaeological Review* 31 (June), 203–231. https://doi.org/10.1007/s10437-014-9155-6.

Lovejoy, P.E., 2011. Transformations in Slavery: A History of Slavery in Africa, 3rd ed. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9781139014946.

Lynn, M., 1995. The West African Palm Oil Trade in the Nineteenth Century and the 'Crisis of Adaptation.'. In: Law, R. (Ed.), *From Slave Trade to "legitimate" Commerce: the Commercial Transition in Nineteenth-Century West Africa*. Cambridge University

Press, African Studies. Cambridge, pp. 57–77. https://doi.org/10.1017/CBO9780511523861.003.

Rosselló, J. G., 2010. "Análisis traceológico de la cerámica: modelado y espacio social durante el postalayótico (V-I A.C.) en la Península de Santa Ponça (Calvià, Mallorca)." *TDX (Tesis Doctorals en Xarxa)*. Universitat de les Illes Balears Ph.D. Thesis.

Lynn, Martin, 1997. *Commerce and Economic Change in West Africa: The Palm Oil Trade in the Nineteenth Century*. Cambridge University Press. https://doi.org/10.1017/CBO9780511582035.

Maier, D., 2009. Precolonial palm oil production and gender division of labor in nineteenth-century gold coast and Togoland. *African Economic History* 37, 1–32. http://www.jstor.org/stable/41756120.

Neff, H., 2000. Neutron activation analysis for provenance determination in archaeology. In: Ciliberto, E., Spoto, G. (Eds.), *Modern Analytical Methods in Art and Archaeology*. John Wiley and Sons, New York, pp. 81–134.

Neff, H., 1992. *Chemical Characterization of Ceramic Pastes in Archaeology*. Monograph in World Archaeology 1. Prehistory Press, Madison, WI.

Neff, H., Ronald, L.B., Sayre 1988, E.V.. A Simulation Approach to the Problem of Tempering in Compositional Studies of Archaeological Ceramics. http://repository.si.edu/xmlui/handle/10088/43029.

Northrup, D., 1976. The Compatibility of the slave and palm oil trades in the bight of Biafra. *The Journal of African History* 17 (3), 353–364. http://www.jstor.org/stable/180699.

Nutor, B.K. 2022. "The Landscapes of Transatlantic Contacts and Slavery at Peki in Eastern Ghana, c.1600-1900." Unpublished Dissertation, The University of Texas at Austin.

Nutor, B.K., 2024. Power, status, and the archaeology of the atlantic experience in Peki, Ghana. *Journal of Field Archaeology* 276–290. https://www.tandfonline.com/doi/full/10.1080/00934690.2024.2440832.

Nyarko, B. J. B., Dampare, S.B., Serfor-Armah, Y., Tandoh, J.B., and Bredwa-Mensah, Y., 2011. "Chemical Characterization of Ancient Pottery From Ghana Using Neutron Activation Analysis: Slavery and Trade Perspective," September. https://www.osti.gov/etdeweb/biblio/21538508.

Ocansey, J.E., 1881. "African Trading, or, The Trials of William Narh Ocansey of Addah, West Coast of Africa, River Volta." James Looney, 11 Cable Street, Liverpool. http://ugspace.ug.edu.gh/handle/123456789/37814.

Oriji, J.N., 2011. Abolition of the slave trade and the geneses of legitimate commerce, christianity, and the new imperialism. In: Oriji, J.N. (Ed.), *Political Organization in Nigeria since the Late Stone Age: A History of the Igbo People*. Palgrave Macmillan US, New York, pp. 139–159. https://doi.org/10.1057/9780230116689_6.

Ozanne, P., 1964. Notes on the later prehistory of Accra. *Journal of the Historical Society of Nigeria* 3 (1), 3–23. https://www.jstor.org/stable/41856686.

Ozanne, P., 1965. "A Shai tradition in ritual pottery." *University of Ghana. Institute of African Studies*. Research Review 2 (1), 64–67. https://n2t.net/ark:/85335/m5vt1j239.

Quarcoo, A.K., Johnson, M., 1968. Shai pots: The pottery industry of the Shai people of Southern Ghana. *Baessler-Archiv. Neue Reihe* 16, 47–88.

Rice, P.M., 1996. Recent ceramic analysis: 2. Composition, production, and theory. *Journal of Archaeological Research* 4 (3), 165–202. https://doi.org/10.1007/BF02228880.

Roddick, A.P., Stahl, A.B., 2016. *Knowledge in Motion: Constellations of Learning Across Time and Place*. University of Arizona Press.

Shaw, T., 1961. *Excavation at Dawu: Report on an Excavation in a Mound at Dawu, Akuapim*. Ghana. T., Nelson.

Shumway, R., Getz, T.R., 2017. *Slavery and Its Legacy in Ghana and the Diaspora*. Bloomsbury Publishing Plc, BLOOMSBURY.

Speakman, R.J., Hector, N., 2005. The Application of Laser Ablation-ICP-MS to the Study of Archaeological Materials—an Introduction. In: Speakman, R.J., Neff, H. (Eds.), *Laser-Ablation ICP-MS in Archaeological Research*. [N.M: University of New Mexico Press, Albuquerque.

Stahl, A.B., Maria das Dores Cruz, Neff, H., Glascock, M.D., Speakman, R.J., Bretton, G., Leith, S., 2008. Ceramic production, consumption and exchange in the Banda Area, Ghana: Insights from compositional analyses. Journal of Anthropological Archaeology 27 (3), 363–381. https://doi.org/10.1016/j.jaa.2008.04.001.

Steponaitis, V.P., Blackman, J.M., Neff, H., 1996. Large-scale patterns in the chemical composition of Mississippian pottery. American Antiquity 61 (3), 555–572. https://doi.org/10.2307/281840.

Tandoh, B. J., 2008. "Characterization of Ancient Pottery from Greater Accra Region Using Nuclear Analytical Technique," June. https://www.osti.gov/etdeweb/biblio/22217373.

Tandoh, J.B., Nyarko, B.J.B., Dampare, S.B., Bredwa-Mensah, Y., Gyampo, O., Ahiamadjie, H., 2010. The use of INAA technique in provenance studies of ancient pottery from the greater Accra region of Ghana. *Journal of Radioanalytical and Nuclear Chemistry* 284 (3), 567–573. https://doi.org/10.1007/s10967-010-0507-7.

Weigand, P.C., Harbottle, G., Sayre, E.V., 1977. Turquoise Sources and source analysis: Mesoamerica and the southwestern U.S.A. In: Earle, T.K., Ericson, J.E. (Eds.), *Exchange Systems in Prehistory*. Academic Press, New York, NY, pp. 15–34.

Wilks, I., 1971. Asante policy towards the Hausa trade in the nineteenth century. In: *The Development of Indigenous Trade and Markets in West Africa*. Routledge.

Wilson, L.E., 1990. The 'Bloodless Conquest' in Southeastern Ghana: The Huza and territorial expansion of the Krobo in the 19th century. *The International Journal of African Historical Studies* 23 (2), 269–297. https://doi.org/10.2307/219338.

Wilson, L.E., 1991. The Krobo People of Ghana to 1892: A Political and Social History. In: Monographs in International Studies. Africa Series; No, 58. University, Center for International Studies, Athens, Ohio: Ohio.