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Ceramic production, consumption and exchange in the Banda area, Ghana: Insights from compositional analyses

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ABSTRACT

Ceramic production, exchange and consumption in the Banda area, west central Ghana has been affected by historical developments ranging from recent competition with alternative vessels (made of metal and plastic) to political economic upheavals that altered community relationships within and outside the region. In this study, we explore spatial and temporal patterning in pottery production, exchange and consumption using a combination of analytical techniques. Instrumental neutron activation analysis (INAA) of a large sample (491 specimens) of archaeological and ethnographic pottery, clay and temper samples from sites across the Banda area has led to the identification of seven compositional groups whose differential distribution implies shifts in resource selection through the last thousand years. Laser ablation-ICP-MS analysis was used to explore the effects of distinctive tempering agents (crushed slag) on the bulk chemical signature of a subset of Banda ceramics, while petrographic analysis provides insight into the preparation of ceramic fabrics. We integrate insights from these diverse physical studies to investigate the dynamics of pottery production, exchange and consumption over the course of the last millennium in the Banda area and explore potential linkages with broader political economic transformations.

Ethnoarchaeological studies of African potting practices have contributed significantly to archaeological method and theory through investigations of technological style (Childs, 1991, p. 332; Lechtman, 1977), operational sequences (Stark, 1999), and the transmission of knowledge within communities of practice (Bedaux, 2000; David et al., 1991; Dietler and Herbich, 1989, 1998; Gelbert, 1999; Gosselain, 1992, 2000; MacEachern, 1998; Walde et al., 2000; Wallaert-Pêtre, 1999, 2001). Whereas these studies document the short-term dynamism of potting practices, far less is known about the long-term dynamics of African ceramic production and consumption (cf., Effah-Gyamfi, 1980; Mercader et al., 2000; Sterner and David, 2003; Usman et al., 2005). Instead, ceramic analysis in African archaeology has focused primarily on regional chronology building. Because potting has continued into recent times, particularly in rural contexts where many archaeologists work, there is a tendency to assume that, despite stylistic change, potting has survived as a traditional practice with long-term continuity (cf. Rice, 1996, pp. 189–190). Ethnographic perspectives are thus easily projected into the past as archaeologists, like their ethnographic predecessors, perceive themselves as operating in an "African Africa that [is] a going concern" (Moore, 1993, p. 6).

As in other world areas where perceived continuity between the ethnographically-documented 20th century and a deeper past informs our historical imaginations (Mills and Crown, 1995, p. 6), Africa's rich ethnographic heritage can be a mixed blessing as we investigate the processes that have shaped contemporary African societies (Stahl, 2004). Whereas it is recognized that Africa's incorporation into a colonial market economy eroded local craft production (e.g., O'Hear, 1986), competition with imports was not the only factor that reshaped West African craft production (Cruz, 2003). The last six centuries witnessed political economic restruc-

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turing as the gravity of trade shifted from northern trans-Saharan routes to Atlantic ones. The slave trade introduced new uncertainties into daily life, as did periods of warfare and political dislocation in the 19th century. While we are accustomed to thinking about the effects of these developments on political organization, we have been less attentive to their effects on craft production, particularly potting. Yet, as several studies have demonstrated, local production and consumption were recast as African societies coped with political economic dislocations in recent centuries. Potters in the Bassar region of northern Togo, forced into refuge zones under pressure of slaving, experimented with new clays and engaged in new patterns of exchange (de Barros, 2001, pp. 74–75). The dynamics of ceramic style in the Kadiolo region of southern Mali was similarly bound up in the history of slaving. Frank (1993) argues that a shared regional repertoire of pottery types masks a distinctive approach to vessel fashioning among Kadiolo potters, captives who retained their distinctive approach to the fashioning of ceramics despite their incorporation into Mande society. Such studies underscore the need to consider African potting practices as dynamic and enmeshed in broader political economic currents (Cruz, 2003).

In this paper, we document continuity and change in ceramic production, exchange and consumption over the last millennium in the Banda area of west central Ghana as part of a broader study of how daily life was conditioned by the region's shifting inter-regional entanglements and a complex history of state formation (Stahl, 2001b). We draw on instrumental neutron activation analysis (INAA; Bishop and Blackman, 2002; Glascock, 1992; Neff, 1992) complemented by insights from mineralogical analysis of ceramic thin sections and laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS; Speakman and Neff, 2005) of pastes and tempers to explore patterning in the locations and technological style of ceramic production from ca. AD 900 to 1900. Our research is informed by practice perspectives which approach technologies as learned traditions that are transmitted within and reproduce communities of practice (Fenn et al., 2006; Minar and Crown, 2001). The practices and technological choices of these communities are conditioned by the broader social, political economic contexts in which they operate (e.g., Neupert, 2000). Thus, in this study, we compare the compositional profiles of archaeological and ethnographic ceramics to assess whether the contemporary pattern of production, exchange and consumption—one in which villagers rely on neighboring communities for household ceramics—characterized earlier periods. Variability in temporal and spatial patterning provides a basis for considering how broader political economic shifts affected local practices.

The study area

The rural Banda area is today home to a chieftaincy comprising 25 villages centered on the Banda hills south of the Black Volta River (Fig. 1). The area is perceived as remote in contemporary context because of its poorly developed transportation infrastructure; however, it occupied a strategic position in relation to earlier trade routes. Before the British imposed colonial rule in the late 19th century, Banda was a province of the powerful Asante state that controlled much of contemporary Ghana from the early 18th through the 19th centuries. Asante's northward expansion was prompted by a desire to control the Niger River and Hausaland trade that passed through a series of entrepôts on Banda's southern margins (e.g., Begho; Bravmann and Mathewson, 1970; Posnansky, 1987). Oral historical accounts suggest a long standing involvement in the northern trade, which is corroborated by archaeological evidence for participation in extra-regional exchange from the early second millennium AD (Stahl, 2007). Thus, the second millennium AD was characterized by multiple political economic realignments that altered the social fields of the region's inhabitants (Stahl, 2001b). Whereas archaeologists of West Africa have long been interested in the effects of these developments on iron technology (e.g., de Barros, 1986, 2001; Goucher, 1981; MacEachern, 1993; Warnier and Fowler, 1979), we know less about their implications for the dynamics of ceramic production.

Since 1989 the Banda Research Project (BRP) has conducted archaeological excavations to investigate the effects of these historical dynamics on local life (Cruz, 2003; Smith, 2008; Stahl, 1994, 1999, 2001b, 2007; Stahl and Stahl, 2004). A provisional regional chronology of successive phases named for the sites at which their diagnostic features were first defined is based on extensive excavations at two "core" sites (Makala Kataa and Kuulo Kataa; Fig. 1) and a program of survey and regional testing (Table 1; Smith, 2008; Stahl, 2007). Makala Kataa is a multi-component village site first occupied in the early 19th century and again in the later 19th century and abandoned early in the British colonial period (after 1920). Makala Kataa was thus occupied at the height of the Atlantic trade. The nearby site of Kuulo Kataa is a large village occupied ca. 1300 to 1650 AD that was enmeshed first in Saharan and later Atlantic trade networks. Ceramics from Kuulo Kataa show stylistic affinities to pottery from Begho and Old Bima (Bravmann and Mathewson, 1970; Crossland, 1989; Posnansky, 1987; see also Effah-Gyamfi, 1980), entrepôts on Banda's southern margins that were linked to the Niger trade. Evidence of metallurgy, ivory-working and potting suggests that Kuulo Kataa's inhabitants produced goods for both regional and long distance exchange. A program of survey (Smith, 2008) and subsequent regional testing extended our chronology into the first millennium AD and provided insights into the expansion of the Niger trade. We currently recognize four phases among ceramics from second millennium AD contexts: Makala Phase, subdivided into two sub-phases based on changes in ceramic style (Makala Phase 1, ca. AD 1890 to 1920; and Makala Phase 2, later 1700s–1820s); Kuulo Phase (ca. 1400–1650 AD*); Ngre Phase (ca 1250–1400 AD*); and Volta Phase (ca. 1000–1300 AD*). An early (probably first millennium AD) but poorly dated occupation of the area was evidenced at two sites (Makala Kataa and A212). Occupations associated with painted pottery at these sites is generically referred to in this paper as "Iron Age 3."[1]

Though many Banda crafts have succumbed to competition from industrial imports (Cruz, 2003; Stahl and Cruz, 1998), pottery is made and used in the area today. In 1994, M. Dores Cruz undertook an ethnoarchaeological study of Banda potting (Cruz, 1996, 2003) that augmented studies of late 20th-century potting in Bondakile (Crossland, 1989, pp. 51–82), a village on Banda's southwestern margin that has been invoked as an analogical model of potting in the period of Begho's occupation (Crossland and Posnansky, 1978; see also Effah-Gyamfi, 1980). Rather than assume that the organization of contemporary potting mirrors past production, Cruz's ethnoarchaeological study provides a baseline for exploring change and continuity in Banda potting over recent centuries. Comparative analysis of contemporary and past production strategies is facilitated by the area's geological diversity which conditions the chemical signatures of local clays. A comparative

[1] In an initial survey of the Banda area, Stahl (1985) classified sites according to preliminary categories termed Iron Age 1, 2 and 3. Subsequent excavations provided the basis for a finer-grained ceramic chronology and phase names have been substituted for these generic terms. Iron Age 1 is more precisely delimited as Makala Phases 1 and 2, Iron Age 2 as the Kuulo and Ngre Phases, and Iron Age 3 as the Volta Phase. We retain the use of the generic term Iron Age 3 in this paper to refer to those sites with painted pottery whose temporal affiliations remain unclear. Phase descriptions and supporting dates appear in Stahl, 2007. The date ranges expressed here are based on dates calibrated using OxCal Program, v. 3.8 (Bronk-Ramsey, 1995). OxCal is available as a free download from the Oxford University Archaeological Research Laboratory (http://c14.arch.ox.ac.uk/embed.php?File=oxcal.html).

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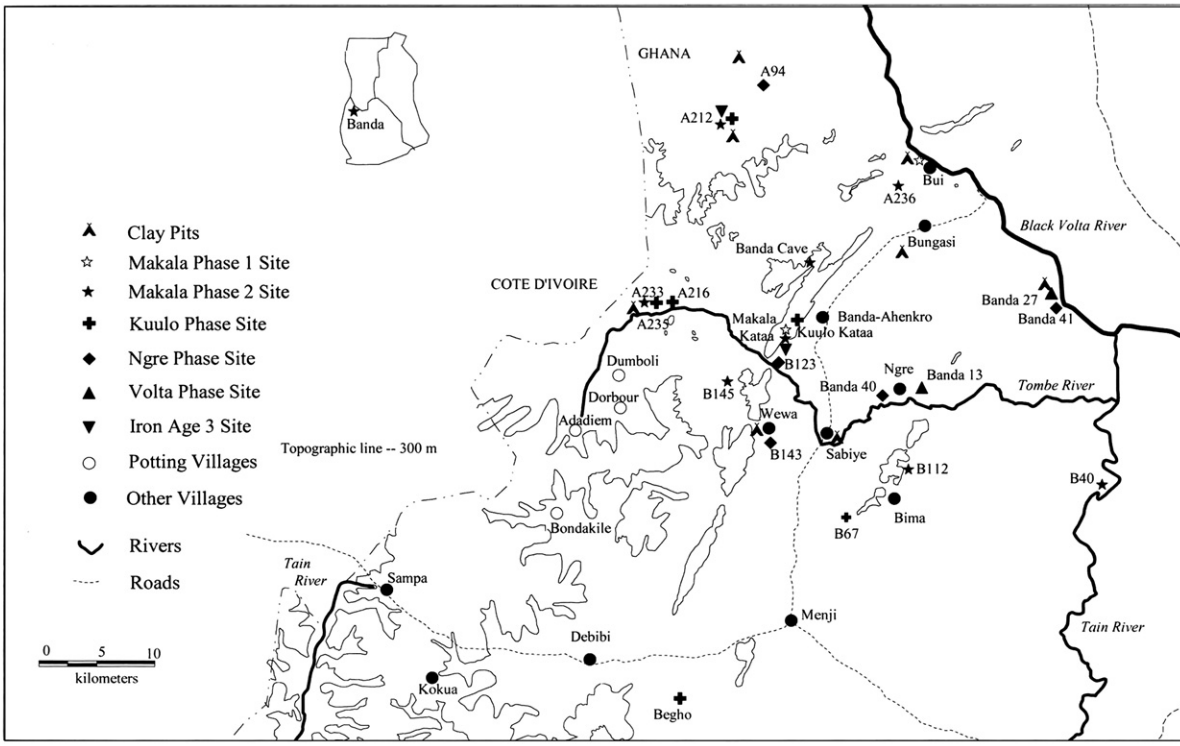

Fig. 1. Map of the Banda area.

Table 1
Working chronology of Banda area occupations (Stahl, 2007)

Phase[a]	Period	Comments
"Iron Age 3" (IA3)	AD 100 to 1300?	Poorly defined early occupation associated with red-painted pottery
Volta Phase (VP)	AD 1000–1300	Associated with red-painted pottery decorated with geometric motifs. No definitive evidence for northern connections
Ngre Phase (NP)	AD 1250–1400	Evidence for involvement in the Niger trade
Kuulo Phase (KP)	AD 1400–1650	Evidence for involvement in Niger & later Atlantic trade
Makala Phase 2 (MK2)	mid 1700s–1820s	Banda area incorporated into Asante state
Makala Phase 1 (MK1)	1890s–1920s	Period of early British colonial rule

[a] Abbreviations following the phase names are those used in Tables 3, 5a–5e, 7 and Electronic Table 1a-h, 3, 6.

analysis of INAA results on raw material samples, contemporary and archaeological ceramics provides evidence of change in ceramic production and consumption in the Banda area over the last millennium. We begin by outlining contemporary practices before discussing compositional patterning in archaeological ceramics that provides insight into the temporal dynamism of potting.

Contemporary Banda potting

Late 20th-century Banda potting is consistent with a model of "nucleated" production (Pool, 1992, pp. 280) or "community specialization" (Hegmon et al., 1995, pp. 33) in which specialists from a few communities produce for the region. Pottery produced by women in three villages west of the high hills that bisect Banda chieftaincy lands (Fig. 1) is distributed throughout the area. Cruz (2003) documented potting practices of Nafana women in the Banda villages of Dorbour and Nafana and Mo women in Adadiem.[2] The practices of Mo potters in Bondakile were the focus of earlier ethnoarchaeological research by Crossland (1989), with new patterns of production recorded by Cruz in 1994. Despite their linguistic and cultural differences, Mo and Nafana potters share, with minor differences,[3] a similar technological style, produce similar vessel forms and employ the same decorative treatments. Thus, there is no distinctive ethnic style of potting apparent in the area today.

Potting in Dorbour is pursued part-time by women who barter or exchange their wares for cash. Clays are obtained from pits a short distance (ca. 1 km) from the village. Potters mix plastic and sandy clay from the same source to achieve a workable potting clay. The mixed clay is transported to the village where it is dried, pounded, and sifted to obtain uniformity. Batches of potting clay are subsequently prepared as needed by adding water and kneading to achieve proper consistency. Potters produce bowls and jars in a variety of sizes through drawing (Rice, 1987, p. 125) or what Roy (2000) terms the "direct pull" technique. Pots are formed by drawing vessel walls up from a lump of clay using a seed pod or corn cob to smooth and trim the clay. Rims and carinations (angled

[2] For details on the area's ethnic-linguistic diversity, see Stahl, 1991, 2001b, pp. 51–60.

[3] Slight manufacturing differences were observed between Dorbour, on one hand, and Adadiem and Bondakile on the other. Mo and Nafana potters in Adadiem and in Bondakile fashion pots while standing, walking around the pots as they form them. Nafana potters in Dorbour use a turntable to reposition the pot as they work on it. When questioned about these differences, the potters related it to whether they had learned to pot in Dorbour or Adadiem. These minor differences in posture are thus related to apprenticeship and not ethnic affiliation.

shoulders) are fashioned by adding a coil of clay that is subsequently shaped using a seed pod or sharp-edged piece of plastic. The vessel body and rim are left to dry overnight, after which the base is added, sometimes using a wooden paddle to shape and thin the clay as it is added in small patches. The completed vessel is left to dry to a leather-hard state, after which an iron ring is used to scrap and thin the vessel walls. Exterior surfaces may be surface-treated by rolling a dry maize cob over the vessel body, and/or decorated with shallow grooves produced with a small burnishing pebble or triangular impressions made with the edge of a calabash. Some potters apply a red slip prior to firing. Though vessel fashioning is an individual activity, firing is a collective one. Stacked pots are covered with small pieces of firewood and grass which are set alight and left to burn for 30–45 min. Vessels are removed from the fire while hot and dipped in a solution of pounded tree bark and water that produces a shiny though transitory finish. Vessels used for water storage are not finished in this way, presumably because it would reduce the porosity that serves to cool the water (for details see Cruz, 2003, pp. 229–245; on Bondakile potting, Crossland, 1989, pp. 51–78).

Although no motorable roads directly connect villages east and west of the hills, goods, including pottery, are transported by head-loading on well-traveled footpaths that cross the hills. Pottery from Dorbour and Adadiem (where production has declined considerably in recent decades) is distributed by head-loading via foot paths to consumers east of the Banda hills (see Cruz, 1996, 2003; Stahl, 2001b, Fig. 3.6; Stahl and Cruz, 1998). Here, the pots are sold at small weekly markets, or hawked door-to-door. Pots made in Bondakile are distributed by lorry or head-loaded to local market centers (Sampa, Wenchi, or Bonduku in nearby Côte d'Ivoire). Banda residents east of hills periodically travel by lorry to these distant market centers where they may acquire Bondakile pottery. The pottery produced by Nafana and Mo women is consumed by all groups in comparable proportions in this ethnically and linguistically complex area (Cruz, 2003). Pottery is therefore a poor proxy for contemporary cultural diversity (Stahl, 1991).

Though potting is often presumed to be a conservative practice (e.g., Sappelsa, 2000), we should not assume that the model of contemporary potting outlined here mirrors past practice. Oral historical evidence attests shifts in the locations and practices of potting through time, while archaeological evidence documents changes in vessel morphology and decorative treatment. Elderly Banda residents report that pottery was formerly made in villages east of the Banda hills (e.g., Bui, Kabruno, Bungasi and Sabiye), which is corroborated by a series of abandoned clay pits. Late 20th-century potting is attenuated in relation to earlier periods since pottery consumption has declined with increased availability of alternative vessels (metal and plastic; Cruz, 2003, pp. 276–290 cf. O'Hear, 1986). Our focus here, however, is on the deeper dynamism of ceramic production and consumption, and more specifically on patterns of continuity and change in the sources and practices of potting over the course of the last millennium. Late 20th-century potting practices thus serve as a baseline against which to compare archaeological and historical evidence. When viewed in relation to the area's geological diversity, outlined below, compositional analysis of archaeological ceramics and provenanced clay samples enables us to build on oral historical insights to explore the dynamics of pottery production and exchange through time and across space (cf. Mills and Crown, 1995). Working assumptions that guide this analysis are that: (1) production locations probably occurred in the range of one to three km of clay sources based on commonly accepted procurement distance thresholds (Arnold, 2000, pp. 322–342; Rice, 1987, pp. 116–118); (2) that transport of pottery across the Banda hills involving distances of ten km and more, were likely obtained through some form of exchange, though whether through potters transporting their wares or consumers traveling to potting centers is unknown; and (3) that sites of recovery represent sites of consumption. In instances where sites of consumption fall within the source zones of compositional groups represented at those sites, we are unable to ascertain whether consumers were also producers; however, in cases where consumption sites are located at some distance from the source zones of compositional groups, we can infer that consumers obtained their household pottery from communities of producers in other areas, probably through some form of exchange.

Banda geology and associated clay sources

The potential for identifying compositional groups among Banda ceramics is enhanced by the diversity of Banda's underlying geology. The area is dominated by the geologically diverse Bui Belt (Fig. 2) comprised of an older Birimian supergroup and a younger Tarkwaian group (Gay, 1956; Hirdes et al., 1993, p. 14; Zitzmann, 1997; Zitzmann et al., 1997, p. 64). Bands to the east and west are dominated by Birimian metasedimentary rocks interbedded with igneous rocks and intrusives.[4] Though geologists distinguish multiple facies among the metasedimentary Birimian, (Zitzmann et al., 1997, pp. 22–25; see Electronic Appendix 1 for details), our analysis of multiple clay sources in the western regions show no chemical distinctions (see below). Our data from Birimian contexts east of the hills are insufficient to assess whether clays formed from its various facies differ in their chemical composition. The Tarkwaian group is a younger stratigraphic unit that accumulated in a long, narrow intramontane basin created by rifting. Its outer margins are marked by the razor-backed hills that are a conspicuous feature of the Banda landscape. The group occurs as a long (100 km), narrow (up to 18 km) NE–SW trending strike in the central Bui Belt dominated by quartzites and conglomerates. Sedimentary rocks of the younger Voltaian group that dominates other areas of northern Ghana are found only on Banda's eastern margins (Zitzmann et al., 1997, p. 30). Granitoid intrusions occur in the region's northern and western reaches, while Quaternary accumulations of alluvial gravel, sand and clay occur along the Black Volta River and its larger tributaries (Zitzmann et al., 1997, pp. 38, 77). Relatively sandy alluvial clays have been noted in "almost all the stream valleys, river terraces and flats" (Gay, 1956, p. 15), and clay deposits along the Mane stream north of the Volta extended to a depth of 7.5–9 m (Gay, 1956, p. 16).

Banda clays occur primarily as alluvial deposits along small, often seasonal tributaries of major rivers (i.e., Tombɛ, Volta). Although parent material lay upstream, it is reasonable to infer that it derives from a relatively limited catchment since tributaries are short. This strengthens the likelihood that alluvial clays reflect the geological diversity summarized above.

Raw material from 12 currently used and abandoned clay pits as well as several exposures that may have been mined in the past was included in the present study (Table 2; Fig. 2). Samples east of the hills derived from: (1) an abandoned clay pit along the Kane River, formerly used by potters resident in Bui village (BUC01 & BUC02); (2) a considerably smaller abandoned pit south of Bungasi (BGC01); (3) an abandoned pit northeast of Sabiye (SBC01 to SBC03); (4) a possible source near the Wewa gap in the Banda hills (ABS182); and (5) an exposure close to the Volta River (ABS183). Samples west of the hills were collected from currently used clay pits and several clay exposures that may have been used for potting. These include samples from (6) contemporary raw materials (clay, temper and mixed clays) used by Adadiem potters (ADC01

[4] These were formerly interpreted as chronostratigraphic units (Lower and Upper Birimian, respectively), sequentially formed through processes of sedimentation, deformation and later mafic intrusion (Zitzmann et al., 1997, p. 21). More recent work has documented interbedding of Birimian sediments and volcanics, suggesting that they represent synchronous lateral facies that were later folded and metamorphosed.

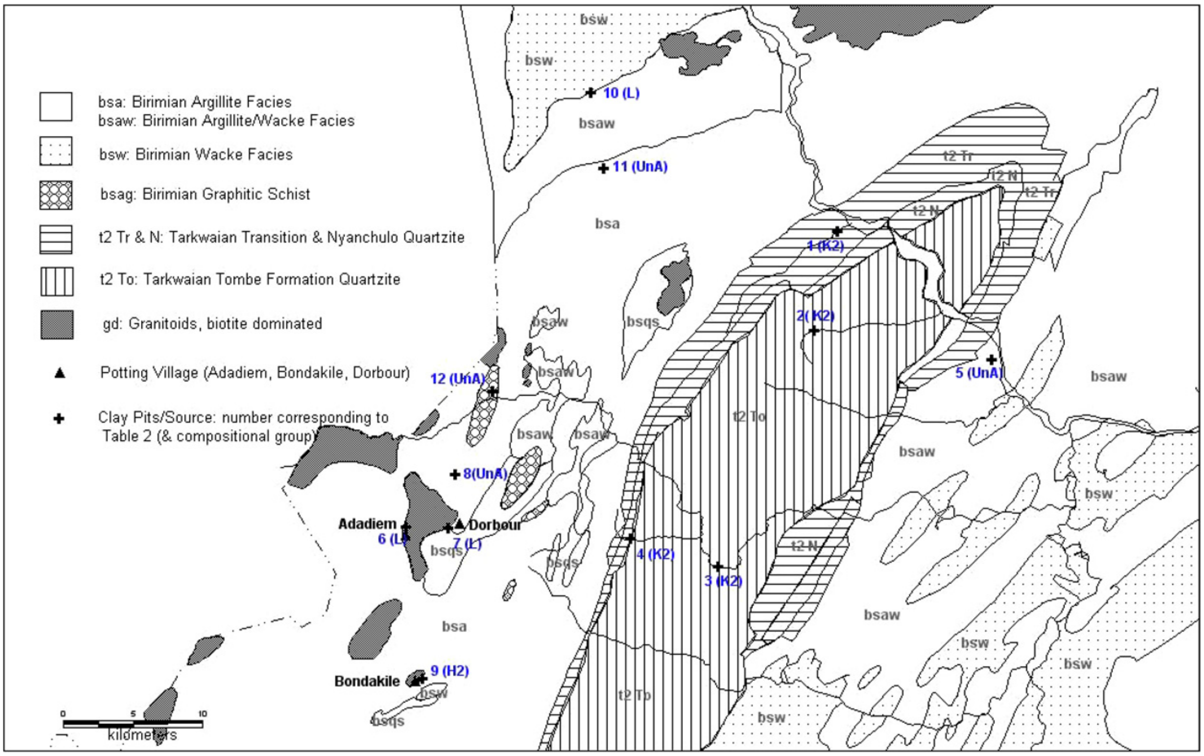

Fig. 2. Banda geology and locations of clay pits/samples.

Table 2
Raw material samples

Position[a]	MURR ID	Description	Map location	INAA compositional group
East	BUC01	Clay from abandoned pit, Bui	1	K2
	BUC02	Clay from abandoned pit, Bui	1	K2
	BGC01	Clay from abandoned pit, Bungasi	2	K2
	SBC01	Clay from abandoned pit, Sabiye	3	Unass
	SBC02	Clay from abandoned pit, Sabiye	3	K2
	SBC03	Clay from abandoned pit, Sabiye	3	Unass
	ABS182	Clay from Wewa stream bed	4	K2
	ABS183	Clay from stream bed near site Banda 27	5	Unass
West	ADC01	Adadiem: clay	6	L
	ADC02	Adadiem: temper	6	Unass
	ADC03	Adadiem: mixed clay & temper	6	L
	ADC04	Adadiem: mixed clay & temper	6	L
	DBC01	Dorbour: temper	7	L
	DBC02	Dorbour: plastic	7	L
	DBC03	Dorbour: mixed	7	L
	DBC04	Dorbour: mixed	7	L
	DBC05	Dorbour: mixed	7	L
	DBC06	Dorbour: mixed	7	L
	DBC07	Dorbour: mixed	7	L
	DUC01	Dumboli: clay	8	Unass
	BKC01	Bondakile: clay	9	H2
	BKC02	Bondakile: temper	9	H2
	BKC03	Bondakile: mixed	9	H2
	BKC04	Bondakile: clay	9	H2
	BKC05	Bondakile: temper	9	H2
	BKC06	Bondakile: mixed	9	H2
	ABS179	Clay from Dokochina; possible historic use	10	L
	ABS180	Clay near Site A-212	11	Unass
	ABS181	Clay from tributary of Tombe, near site A-233	12	Unass

Map location refers to Fig. 2.
[a] Position relative to the Banda hills.

to ADC04); (7) raw materials from pits near the Palati River used by Dorbour potters (DBC01 to DBC07); (8) clay from a source near Dumboli (DUC01); (9) raw material samples collected from two Bondakile clay pits (Crossland, 1989, p. 54–56; Cruz, 2003) to the south (BKC01 to BKC06), and samples from clay exposures near (10) Dokachina that may have seen historic use (ABS179) as well as exposures near (11) archaeological sites A212 (ABS180) and (12) A233 (ABS181).

Sampling and analytical methods

These raw material samples were included among the 491 samples in an INAA study conducted at the University of Missouri Research Reactor Center (MURR) in 1995, 1997 and 2003. The analyzed samples comprised raw materials ($n = 29$), contemporary ceramics from known potting villages ($n = 15$), and archaeological ceramics ($n = 447$) from 21 sites spanning the period from the early first millennium AD to roughly AD 1960 (Table 3; Electronic Tables 1a–h).[5] Together, the raw material and ethnographic pottery samples provided baseline data for known clay sources.[6] Though the archaeological INAA samples were dominated by pottery vessels, a small sample of locally-produced clay smoking pipes ($n = 37$) and spindle whorls ($n = 6$) were also submitted for analysis.

We selected archaeological ceramics for INAA based on provenance, vessel form and macroscopically apparent differences in fabric (e.g., texture, inclusions). Cruz stratified her 1995 study of Makala Kataa ceramics primarily by vessel form and size, analyzing a comparable number of small and large bowls and everted-rimmed jars. Whereas compositional group varied by vessel form (bowls compared to jars), no differences were noted among small and large vessels of the same category (see below). We did not, therefore, stratify the 1997 sample of Kuulo Kataa specimens by vessel size. Because Kuulo Kataa yielded a distinctive globular jar form that was not represented at Makala Kataa, we instead sampled a comparable number of bowls, everted-rimmed jars and globular jars. The 1997 study also included several shallow oil lamps ($n = 4$) from Kuulo Kataa, and spindle whorls from Early ($n = 3$) and Late Makala ($n = 3$), in addition to seven locally-made smoking pipes from Early Makala. In all cases, we sampled decorative treatments and fabrics that might signal variation in production sites.

The 2003 INAA study increased geographic coverage by incorporating sites located both east and west of the Banda hills and included sites occupied early in the second millennium AD (Fig. 1). Although we endeavored to achieve spatial (east and west of the Banda hills) and temporal (by phase) balance in our 2003 study, the samples ($n = 196$) are unevenly distributed across contexts (Table 3). Sites east of the hills ($n = 8$) are represented by more samples ($n = 116$) than sites west of the hills (6 sites; 80 samples). Because no Volta Phase sites (distinguished by red-painted pottery) were identified west of the Banda hills, all samples from this phase come from sites east of the hills (Banda 13 and 27; $n = 25$). A single site west of the hills with red-painted ceramics (the multi-component A212 site) fell outside the range of Volta Phase red-painted pottery (Stahl, 2007) and is referred to somewhat generically as "Iron Age 3." A small number ($n = 6$) of these ceramics were included in INAA samples from site A212. Ngre Phase sites are represented by more sites and samples east of the hills (4 sites, 66 samples: sites B123; B143; Banda 40; Banda 41) than west (one site, 10 samples: site A94). Sherds from regional testing Kuulo Phase sites ($n = 22$) derive exclusively from areas west of the hills (sites A212, A216 and A235). This is counterbalanced by an over representation of Kuulo Phase ceramics from our more extensive excavations at Kuulo Kataa, located east of the Banda hills ($n = 98$). Makala Phase 2 contexts were represented in our 2003 study by 25 samples from two sites (A236 and B112) east of the hills, and 42 samples from three sites (A212, A233 and B145) west of the hills. Finally, our study includes 18 samples from two sites (B40 and B67, also known as Old Bima; Bravmann and Mathewson, 1970) south of the Tombɛ River tested by Leith Smith as part of his doctoral research. Whereas the uneven temporal and spatial distribution of samples and problems associated with inferring patterns from relatively small data sets (Plog, 1995, p. 274) must be kept in mind, our results provide preliminary insight into the spatial and temporal patterning of compositional groups, enabling us to generate working hypotheses about the dynamics of ceramic production and consumption over the course of the last millennium in the Banda area.

Table 3
Summary of Banda INAA samples by location and phase

Samples	Year	Location	Position[b]	Phase/Date	*N*
Contemporary	1995	Adadiem	W		8
		Banda-Ahenkro	E		1
		Bondakile	W		8
		Bungasi	E		2
		Bui	E		2
		Dorbour	W		14
		Dumboli	W		1
		Sabiye	E		3
	2003	2001 RT clay pit samples	E		2
		2001 RT clay pit samples	W		3
		Total			**44**
Archaeological	1995	Ahenkro middens	E	1930-1960	14
		Banda Cave	Banda Hills	MK2	2
		Bui Kataa	E	MK1	8
		Makala Kataa	E	MK1, MK2, VP	111
		Kuulo Kataa	E	KP	76
	2003	Kuulo Kataa	E	KP	22
		A94	W	NP	10
		A212	W	MK2, KP, IA3	24
		A216	W	KP	8
		A233	W	MK2	16
		A235	W	KP	8
		A236	E	MK2	11
		B112	E	MK2	14
		B123	E	NP	20
		B143	E	NP	15
		B145	W	MK2	14
		Banda 13	E	VP	10
		Banda 27	E	VP	15
		Banda 40	E	NP	16
		Banda 41	E	NP	15
	[a]	B40	E		4
	[a]	B67	E		14
		Total			447

[a] Samples from Leith Smith's survey south of the Tombe River.
[b] Relative to Banda hills.

Instrumental neutron activation analysis

The raw material and ceramic samples described above were prepared and analyzed using standard MURR procedures. These and the quantitative techniques for analyzing ceramic compositional data are described in detailed elsewhere and are not rehearsed here (see Bishop and Neff, 1989; Glascock, 1992; Neff, 1992, 2002; for a synopsis, see Electronic Appendix 2). Principal components analysis (PCA) of the chemical data was used to iden-

[5] Whereas most of the samples derive from Banda Research Project investigations (1989, 1990, 1994, 1995, 2000, 2001), the small sample ($n = 14$) of pottery from historic middens (1930s–1960s) at Banda–Ahenkro was excavated in 1992 by Andrew Black, then a doctoral candidate at Binghamton University.

[6] Cruz's, 1995 study of 161 samples was conducted under MURR's Archaeometry Laboratory visiting doctoral student program (Cruz, 1996, 2003), which was augmented by an additional 89 samples analyzed by MURR staff in 1997. Archaeological specimens in the 1995 and 1997 analyses derived primarily from excavations at Makala and Kuulo Kataas Stahl (1994, 1999, 2001b). These were supplemented by smaller samples collected from the surface of Bui Kataa (Makala Phase 1) and the Banda Cave (Makala Phase 2), and excavations of historically-recent middens (1930–1960) at Banda-Ahenkro conducted by Andrew Black. An additional 241 samples derived from expanded excavations at Kuulo Kataa and our program of regional site testing in 2000 and 2001.

Table 4
Compositonal groups identified in the Banda INAA data set ($n = 491$)

Compositional group	Number of specimens	Provenance and geological group (Fig. 2)
L	118	West of Banda hills; Birimian
K1	132	Likely east of Banda hills
K2	113	East of Banda hills; Tarkwaian
H1	15	East of Banda hills?
H2	11	Bondakile; west of Banda hills; Birimian
I	4	Adadiem; west of Banda hills; Birimian
Whorls	6	Likely east of Banda hills
Unassigned	92	

Bolded groups are linked to provenanced clay sources.

tify compositionally homogeneous groups that, based on the "provenance postulate" (Weigand et al., 1977), are assumed to represent geographically restricted sources or source zones. The location of these source zones was inferred on the basis of chemically analyzed, provenanced samples (e.g., clay samples from known sources and ethnographic pottery produced from known sources).

Seven compositional subgroups were identified in the INAA data set (Table 4): L ($n = 118$), K1 ($n = 132$), K2 ($n = 113$), H1 ($n = 15$), H2 ($n = 11$), I ($n = 4$) and Whorls ($n = 6$). Ninety-two samples could not be assigned to any group. These groups were differentially represented through time and across space (Electronic Tables 1a–h). The Mahalanobis distance-based probabilities of membership in the three largest reference groups (L, K1 and K2) are listed in Electronic Table 2.[7] A PCA plot based on the correlation matrix of the complete data set is shown in Fig. 3. Figs. 4–8 are bivariate plots of elemental concentrations that further demonstrate the subgroup partitioning discussed below (projections of the data with unassigned specimens labeled are available as Electronic Figs. 9 to 13).

The seven compositional groups recognized in the Banda area sample are differentiated reasonably well on the first two principal components of the data (Fig. 3). As indicated by the diagonal line in the figure, the groups appear to divide into three groups associated with sources west of the Banda hills and four groups with sources on the east side (see below). Sodium is a key element discriminating east and west side groups. Fig. 4, a sodium–iron plot, shows the clear separation of east side (K1 and K2) from west side (L and I) groups along the sodium axis, as does Fig. 5, a sodium–vanadium plot that further separates groups K1 and K2 along the vanadium axis. The probabilities of group membership (Electronic Table 2) confirm that the east–west separation extends to the full 33-element concentration space: with few exceptions (MK0615, ABS071, ABS080, ABS085 and ABS172) members of group L (west side) show less than 0.1% probability of membership in either group K1 or K2 (east side). Similarly, most specimens assigned to groups K1 and K2 show less than 1% probability of membership in group L.

Group I, which is linked with the west side based on sodium concentrations, occupies the extreme low end of Principal Component 1 (Fig. 3). This marginal status reflects extremely low concentrations of many elements, most prominently the highly correlated heavy rare earth elements, ytterbium (Yb) and lutetium (Lu). Fig. 6, a bivariate plot of Yb and Cr concentrations, confirms the marginal status of group I relative to all other analyses in the data set.

Although there are no posterior misassignments based on Mahalanobis distances, the two main east side groups, K1 and K2, overlap somewhat on the PCA plot (Fig. 3), and, a number of Mahalanobis distance-based probabilities of group membership exceed 1% for both groups (Electronic Table 2). Transition metal compositions provide the main basis for defining two distinct groups: Zinc (Zn) and iron (Fe), for instance, effect an unambiguous separation (Fig. 7), as does vanadium in the bivariate plot of vanadium–sodium (Fig. 5).

Group H1 and K1 overlap substantially on the PCA plot, while group H2 shows somewhat less overlap (Fig. 3). A similar pattern holds for sodium–iron concentrations (Fig. 4). However, clear separation of the three groups is apparent in the bivariate plot of thorium-arsenic (Fig. 8). H2 shows lower concentrations of arsenic relative to H1, while H1 has slightly lower thorium concentrations relative to group K1. The separation of groups H1 and K2 is further substantiated by their profiles of transition metals as shown in the bivariate plot of zinc–iron (Fig. 7).

The final compositional group ("Whorls") is named for its sole constituents (spindle whorls) that cluster on the PCA plot (Fig. 3) at the same time as they overlap with group K2. The same transition metals that sorted groups K1 and K2 separate the tightly clustered spindle whorl sample from specimens assigned to group K2 (Fig. 7).

Specimens were left unassigned either because they were marginal to all groups or showed compositional affiliations with more than one group. Positions of the unassigned specimens on Principal Components 1 and 2 (Electronic Fig. 9) identify only one (MK0642) that is divergent enough to suspect that it might come from outside the Banda area. When unassigned specimens are plotted against known groups, whether in the PCA space (Electronic Fig. 9) or in relation to individual bivariate plots (Electronic Figs. 10–13), unassigned specimens spread evenly between the east and west side groups. With respect to zinc and iron, most specimens fall within the ranges of variation of either group K1 or K2. It is notable that 7 (24%) of our 29 provenanced raw material samples were unassigned (Table 2), as was one contemporary pot produced in Adadiem (Electronic Table 1h).

LA-ICP-MS and petrographic analysis

The compositional groups identified through INAA cannot be taken as a direct indicator of clay "sources" since various processes (levigation, mixing of clays, addition of aplastic materials; constraints on procurement) can affect the chemical composition of ceramic fabrics (Arnold et al., 1991; Bishop et al., 1982; Blackman, 1992; Neff et al., 2003:202; Neupert, 2000; Rice, 1996, pp. 168–172). As a number of previous studies have demonstrated (Arnold et al., 1999; Faber et al., 2002; Neff et al., 2003; Stark et al., 2000; Stoltman et al., 1992; Tsolakidou et al., 2002; Zedeño, 1994, pp. 50–54), complementary analytical techniques can aid in discerning variation in fabric recipes (Arnold's [2000:367] "resource-selection and paste-preparation signature units") and their effects on bulk composition. In this study, we augment INAA data with insights from laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS; Speakman and Neff, 2005) and mineralogical analysis of a subset of INAA specimens in order to assess (1) the effects of slag temper on the bulk chemical composition of the K1 compositional group; and (2) the proportion and kinds of aplastic inclusions in ceramics from two sites (Kuulo Kataa and A212). Both analyses provide insights into fabric recipes employed by Banda potters and their variation through time.

We selected a subset of INAA samples from two sites for thin-sectioning and petrographic analysis. We analyzed 14 samples from one site east of the Banda hills (Kuulo Kataa) and 16 samples from a site west of the Banda hills (A212).[8] Sherds from Kuulo Kataa sampled the range of Kuulo Phase vessel forms (bowls, everted-rim and globular jars). The sample of sectioned ceramics

[7] Mahalanobis probabilities are based on the full suite of 33 determined elements and are "jackknifed" (i.e., removed from their presumed group before calculating probability of membership; Baxter, 1994; Leese and Main, 1994).

[8] Thin sections of ceramics from Kuulo Kataa were originally made by Josh Trapani in 1996. Bretton Giles subsequently sectioned and analyzed additional sample from Kuulo Kataa and site A212 in 2003. Details of Giles analysis appear in an unpublished manuscript on file with the authors (Giles, 2005).

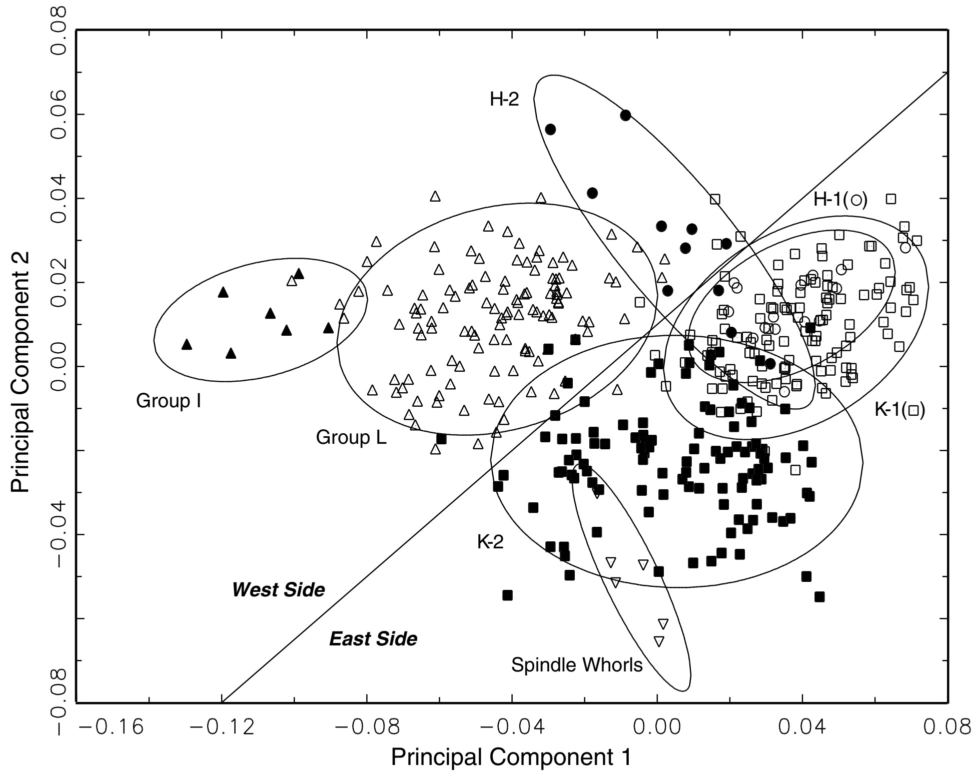

Fig. 3. PCA plot of Principal Components 1 and 2 of the correlation matrix of the Banda area data ($n = 491$). Ellipses represent 90% confidence level for membership in the groups.

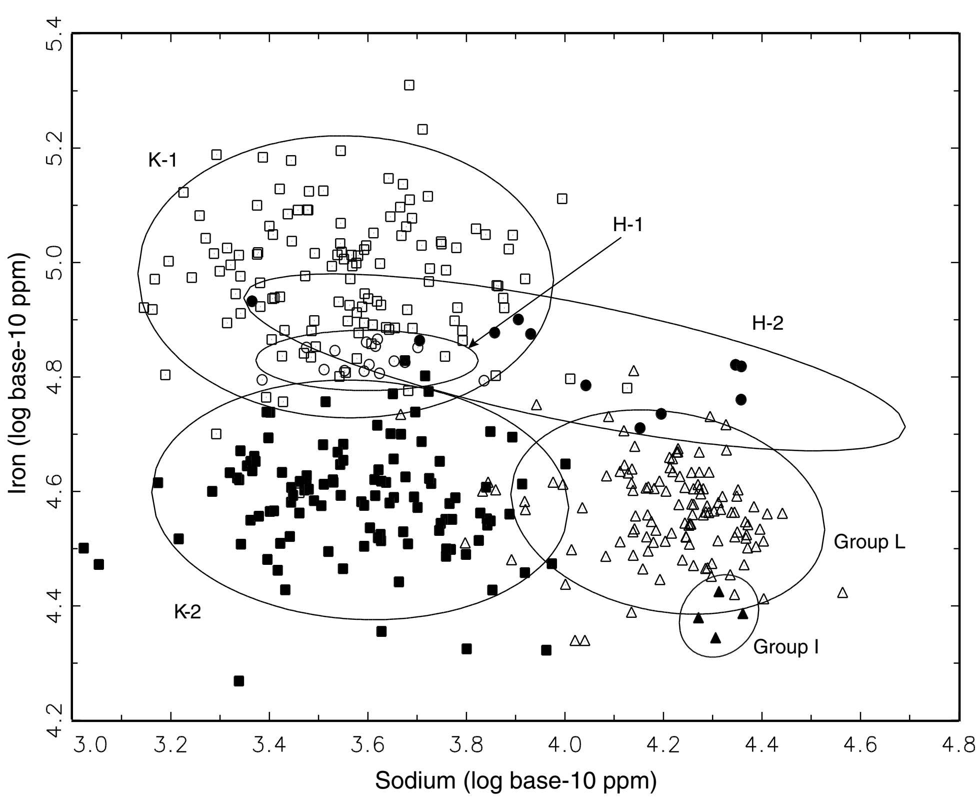

Fig. 4. Bivariate plot of sodium and thorium concentrations in six Banda area reference groups. Ellipses represent 90% confidence level for membership in the groups.

from site A212 derived from each of the three occupational phases represented at the site (Makala Phase 2, Kuulo Phase and "Iron Age 3") and a range of vessel forms (bowls and jars). Though all thin-sectioned sherds had been subject to INAA, the analyst (Giles) did not know the assignment of sherds to compositional groups at the time of the petrographic study. The study employed Stoltman

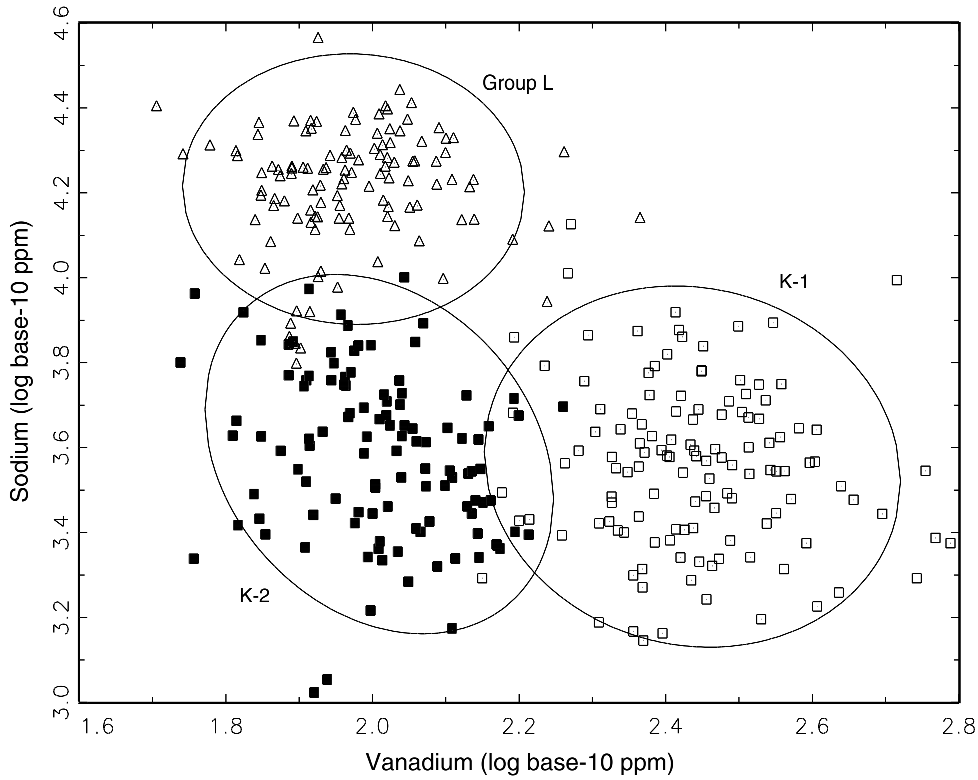

Fig. 5. Bivariate plot of vanadium and sodium concentrations in three Banda area reference groups. Ellipses represent 90% confidence level for membership in the groups.

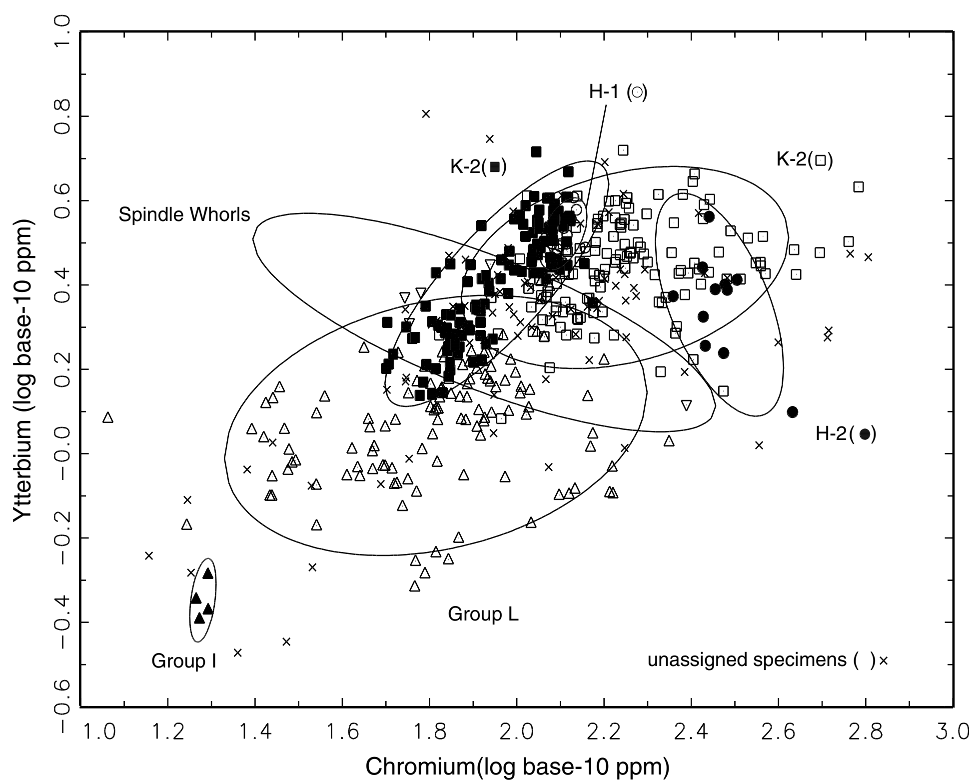

Fig. 6. Bivariate plot of chromium and ytterbium concentrations in the Banda area data. Ellipses represent 90% confidence level for membership in the groups. Unassigned specimens are plotted as well.

(1989, 1991) two-step method of qualitative analysis of mineral constituents followed by a fixed interval (1 mm) quantitative point counting procedure (Giles, 2005). Points were recorded as void, matrix, silt, grit or temper, with a minimum of 100 non-void points recorded for each thin section. Temper was distinguished from natural inclusions by particle shape. Rounded minerals were

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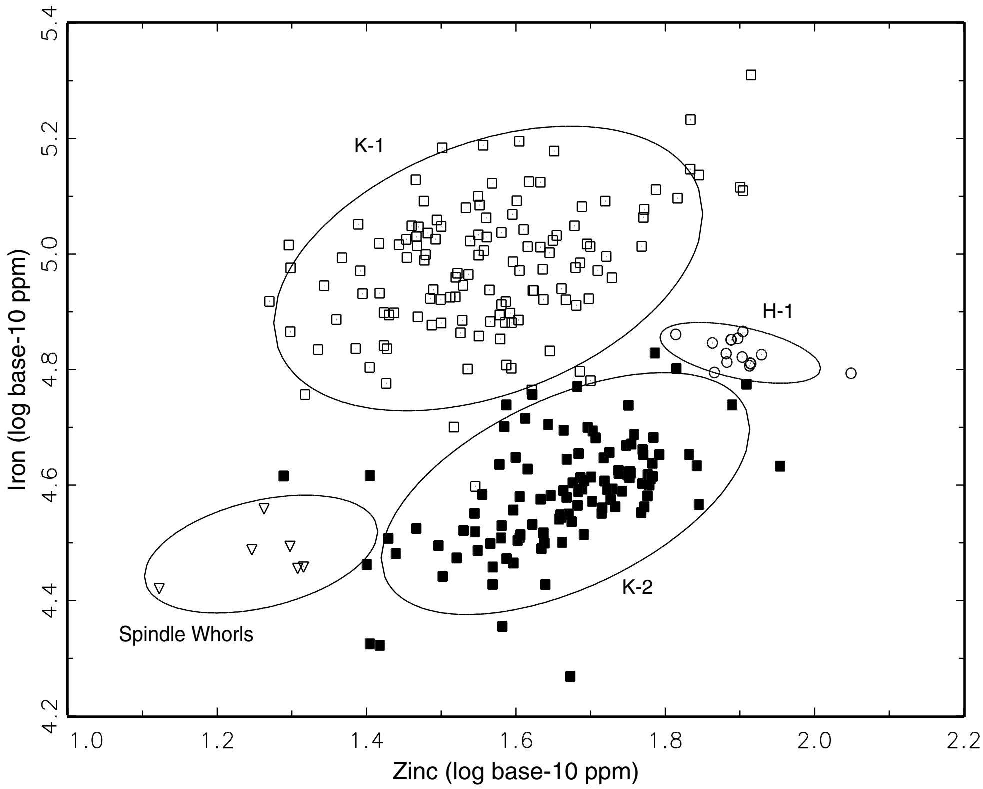

Fig. 7. Bivariate plot of zinc and iron concentrations in four Banda area reference groups. Ellipses represent 90% confidence level for membership in the groups.

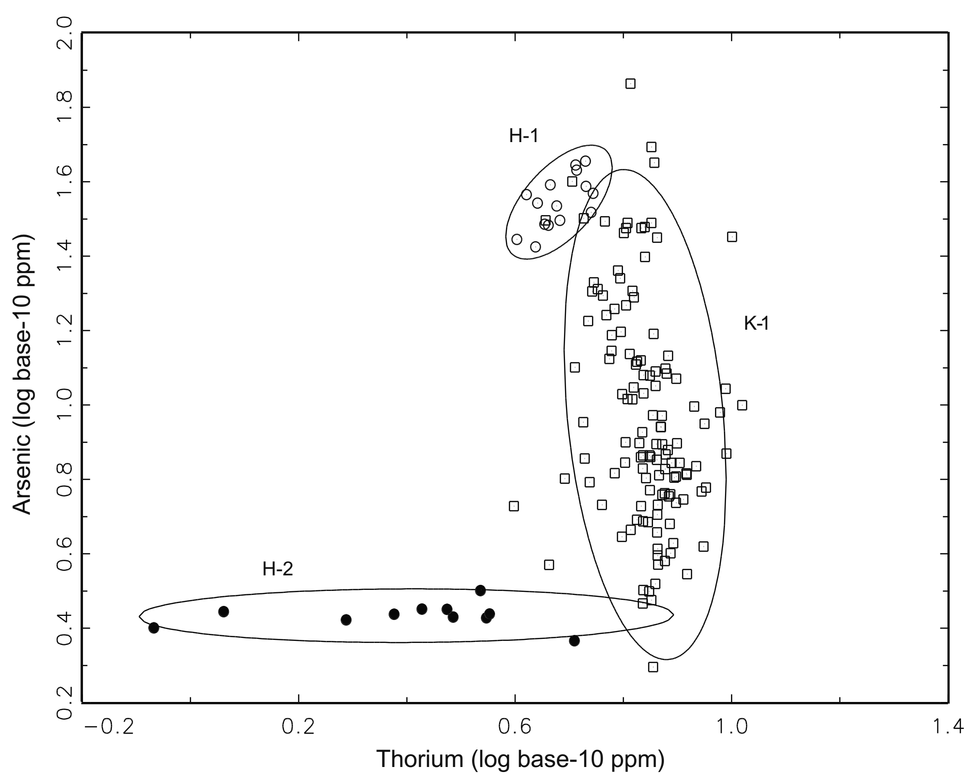

Fig. 8. Bivariate plot of thorium and arsenic concentrations in three Banda area reference groups. Ellipses represent 90% confidence level for membership in the groups.

interpreted as natural inclusions, and included quartz, iron oxide and feldspar. Angular inclusions were interpreted as temper, and included quartz, slag and two undetermined minerals. Though the petrographic study was small scale, its results, explored below, underscore the value of complementary analyses in exploring the spatial and temporal dynamics of potting.

Patterning in the compositional data

The INAA results summarized above provide a robust starting point for assessing patterns of ceramic production, exchange and consumption in the Banda area over the course of the last millennium. Four compositional groups can be linked to clay samples from known pits or to contemporary pottery made from provenanced sources. Three compositional groups are not linked to provenanced samples; however, their likely location east or west of the Banda hills can be inferred based on their chemical characteristics in relation to provenanced groups. After discussing the evidence for provenanced compositional groups, we explore the possible provenance of others and describe their patterning as evidenced in archaeological ceramics. This provides a platform for exploring changing patterns of ceramic production and consumption in the final section of the paper.

Provenanced compositional groups

Four of the seven compositional groups can be linked to locations east (Group K2) or west (Groups L, H2 and I) of the Banda hills. Those from the west side can be pinpointed somewhat more closely based on the chemical signatures of known clay pits and associated geology.

Group L: The provenance of compositional group L is established on the basis of raw material and fired pottery samples from the contemporary potting villages of Adadiem and Dorbour (Cruz, 2003, pp. 230–232, 532) as well as from a clay sample collected from an abandoned pit located near site A212 (Fig. 2; Electronic Appendix 3). The data from these three locations firmly places L-group sources on the western side of the Banda hills in areas associated with intrusive granitoid and/or Birimian metasedimentary geological formations.

Group I: Provenanced samples among compositional group I included two finished vessels collected in Adadiem by Cruz (ADP01 and ADP03; Electronic Table 1f) made from clays that potters obtained in the village vicinity. This is a minor compositional group in that only two archaeological specimens have been assigned to it (below). Though sample size is small, the relatively secure ethnographic link with clays obtained near Adadiem allows us to assign this a provenance west of the Banda hills.

Group H2: Compositional group H2 is closely linked with the contemporary potting village of Bondakile (Crossland, 1989, pp. 51–82). Six raw material samples (BKC01 to 06) and two finished vessels (BKP01-02), collected from Bondakile by Cruz were assigned to the H2 group (Table 2; Electronic Table 1e; Electronic Appendix 3).

Group K2: Several provenanced samples firmly link the K2 compositional group to sources east of the Banda hills (Table 2; Electronic Appendix 3), including: (1) two raw material samples (BUC01-02) from a large abandoned clay pit formerly used by potters from Bui village; (2) a clay sample (BGC01) and finished vessel (BGP01) made from a clay source south of Bungasi along the Mundale stream; (3) a raw material sample (SBC02) from an abandoned clay pit adjacent to the Tombɛ River near the village of Sabiye; and (4) a raw material sample (ABS182) from a clay source near the Wewa stream.

Unprovenanced compositional groups

Three compositional groups (K1, H1 and Whorls) included only archaeological specimens and cannot therefore be linked unequivocally to raw material sources east or west of the Banda hills. However, as indicated by overlap in the PCA plot (Fig. 3), chemical similarities between these three groups and the securely provenanced K2 group suggest an eastern provenance for all three. The relatively small samples of the H1 (Electronic Table 1d) and Whorl groups (Electronic Table 1g) preclude a fuller assessment of their relationship with the K2 source; nonetheless, K1 is distinguished from K2 by elevated concentrations of rare earth elements (thorium [Th] Fig. 4) and transition metals (vanadium [V] and iron [Fe]; Figs. 5 and 7). Because virtually all K1 specimens included some proportion of crushed slag temper,[9] there is the possibility that the distinctive K1 bulk chemical signature reflects the chemical constituents of slag inclusions, a problem known in the literature as the "tempering problem" (Larson et al., 2005; Neff et al., 1988, 1989; Rice, 1977, 1996, pp. 168–172).

This possibility was assessed through a microprobe analysis using LA-ICP-MS (Speakman and Neff, 2005). Temper and paste were separately analyzed for ten archaeological specimens assigned to group K1 and five assigned to group K2. Results are listed in Electronic Table 4. Electronic Table 5 lists the average values for ferric oxide (Fe_2O_3) and vanadium pentoxide (V_2O_5) in the temper and paste of K1 and K2 specimens. As expected, the concentrations of ferric oxide in K1 temper (slag) were significantly elevated ($\overline{X}$ = 496,365 ppm; 49.6%) compared to inclusions in K2 specimens ($\overline{X}$ = 87,497 ppm; 8.7%) which comprised angular white (likely quartz) grit and rounded laterite. Levels of vanadium pentoxide (V_2O_5) were similarly elevated (K1 $\overline{X} = 897$ ppm compared to K2 $\overline{X}$ = 198 ppm). Concentrations of V_2O_5 were relatively similar in the K1 and K2 pastes ($\overline{X}$ = 249 and 292 ppm, respectively). However, higher concentrations of Fe2O3 ($\overline{X}$ = 119,852 ppm; 12%) in K1 compared to K2 pastes ($\overline{X}$ = 85,280 ppm; 8.5%) may reflect ion exchange between the clay body and slag temper in K1 specimens with transition metals from the slag migrating into the paste—either during manufacturing or after firing. Definitive assessment of this possibility would require microprobe analysis of experimental clay tiles made from provenanced K2 clays tempered with and without slag. In the absence of such an experiment, our working hypothesis is that the K1 compositional group reflects a distinct fabric recipe in which K2 clays were combined with crushed slag temper. This interpretation is strengthened by the fact that virtually all specimens assigned to the K1 group included crushed slag temper (see Footnote 9).

Table 4 summarizes the presumed provenances of the seven compositional groups distinguished by INAA. These provide a basis for exploring the dynamics of ceramic production and consumption as evidenced by 447 archaeological specimens in the INAA study.

Group affiliations of archaeological pottery

Tables 5a–5d summarize[10] the frequency of archaeological pottery assigned to each of the seven compositional groups by vessel form and phase, with the values for unassigned specimens shown in Table 5e (smoking pipes are discussed in a subsequent section). Not all vessel forms shown in the tables occur in all phases. Whereas bowls (both restricted and unrestricted) and everted rim jars occur

[9] Slag was visible in freshly broken sections using a hand lens. Of the 114 archaeological INAA specimens assigned to compositional group K1 that were inspected, only two did not contain visible crushed slag (ABS069; ABS151; MK2 NP contexts respectively). K1 group sherds from Bui Kataa were not examined.

[10] Specimens from Sites B-40 and B-67 are not included in the discussion that follows. These sites were tested by Leith Smith during the course of his doctoral dissertation research. Both sites appear to have occupied during multiple phases, and the specific temporal affiliations of the INAA samples are unclear. Specimens ABS224 through 226 from site B-40 fit comfortably within the range of Makala Phase 2 ceramics, while specimen ABS 227 from the same site is clearly Volta Phase. Site B-67 (Old Bima) witnessed a long history of occupation extending from at least the Volta Phase through the Kuulo Phase. INAA specimens from B-67 include vessels consistent with each of these phases, though not clearly stratified. Because of these uncertainties, these sites are not included in the discussion that follows; however, their inclusion would not alter the patterns described below.

Table 5a
L group archaeological specimens by phase and vessel form (Br = bowl, restricted orifice; Bu = bowl, unrestricted orifice; Jev = jar everted rim; Jg = jar, globular; Jr = jar, recurved rim)

Phase	Br	Bu	Jev	Jg	Jr	Other	Total	Provenance
MK1	5	1	7			1	14	E
MK2	7	2	24			3	36	E&W
KP		1	1			2	4	E&W
NP	8	2	6	4	5	2	27	E&W
VP		1				3	4	E
IA3						3	3	E&W
Total	20	7	38	4	5	14	88	

Provenance: east or west of Banda hills.

Table 5b
K1 group archaeological specimens by phase and vessel form (codes as listed for Table 5a)

Phase	Br	Bu	Jev	Jg	Jr	Other	Total	Provenance
MK1						3	3	E
MK2	8	6	7			2	23	E&W
KP	18	11	19	19	3	4	74	E&W
NP	5	1	6	4	1	1	18	E&W
VP								
IA3								
Total	31	18	32	23	4	10	118	

Table 5c
K2 group archaeological specimens by phase and vessel form (codes as listed for Table 5a)

Phase	Br	Bu	Jev	Jg	Jr	Other	Total	Provenance
MK1	5	1	7			3	16	E
MK2	2	2	6			1	11	E
KP								
NP	7	3	2	2	1	5	20	E (1W)
VP	4	6	1			8	19	E
IA3	7	4	11				22	E
Total	25	16	27	2	1	17	88	

Table 5d
H1 group archaeological specimens by phase and vessel form (codes as listed for Table 5a)

Phase	Br	Bu	Jev	Jg	Jr	Other	Total	Provenance
MK1								
MK2	13	2					15	E
KP								
NP								
VP								
IA3								
Total	13	2					15	

Table 5e
Unassigned archaeological specimens by phase and vessel form (codes as listed for Table 5a)

Phase	Br	Bu	Jev	Jg	Jr	Other	Total	Provenance
MK1	4	2	1			2	9	E
MK2	3		4			4	11	E&W
KP	5	2	4	3	3	13	30	E&W
NP	1		4	1	1	4	11	E (1W)
VP	1		1				2	E
IA3	1	2	2	1		3	9	E& W
Total	15	6	16	5	4	26	72	

across all phases, globular jars (Jg) and jars with recurved rims (Jr) are associated exclusively with the Ngre and Kuulo Phases. We explore patterning in the frequency with which compositional groups are represented in the archaeological assemblages as a source of insight into the temporal and spatial dynamics of ceramic production and consumption.

L Group

Compositional group L, linked to sources west of the Banda hills, is represented by specimens from all six phases of our working chronology (Iron Age 3, Volta Phase, Ngre Phase, Kuulo Phase, Makala Phase 2 & 1; Table 5a). Though color varies, L group ceramics are most often light to medium brown-gray. Fabrics typically include white grit inclusions (i.e., quartz), which are often large, angular and abundant. Rounded laterite inclusions are less common. These are interpreted as natural inclusions in contrast to the distinctly angular quartz inclusions that appear to have been added as temper (e.g., thin sections KK10 and A212-13; Electronic Table 3).[11] Notably, both L group sherds included in the thin section analysis (Giles, 2005) contained small percentages of crushed slag temper, though in smaller proportions that the K1 group discussed below.

Temporal and spatial patterning

Though L group sherds were associated with all six temporal phases, they were variably present in areas east and west of the Banda hills. Two "Iron Age 3" contexts, one east and one west of the Banda hills (Makala Kataa and A212), yielded L group sherds ($n = 3$). By contrast, the small number ($n = 4$) Volta Phase L group specimens derived from a single site east of the Banda hills (Banda 13). In the larger sample of Ngre Phase L group sherds ($n = 27$), sites east of the hills (B123, Banda 40 and Banda 41) yielded the majority ($n = 23$) and included a full range of vessel forms (restricted and unrestricted bowls, everted, globular and recurved rimmed jars). A smaller sample ($n = 4$) derived from site A94 west of the hills but included both bowl and one jar form. The frequency and range of L group specimens in Ngre Phase contexts contrasts sharply with the subsequent Kuulo Phase, in which L group specimens were uncommon ($n = 4$) at the same time as they were recovered from sites both east (Kuulo Kataa) and west (A216) of the Banda hills. Makala Phase 2 contexts both east (Early Makala, A236 and B112; $n = 32$) and west (Banda Cave, A233 and B145; $n = 4$) of the hills yielded L group sherds. Everted rim jars ($n = 23$) dominated the Makala Phase 2 L group sample from east side sites, though bowls ($n = 7$) occurred as well. All ($n = 12$) Makala Phase 1 L group specimens derived from sites east of the hills (Late Makala and Bui Kataa) and included both bowls and everted rimmed jars. L group specimens occurred also in the small sample of analyzed sherds from the Ahenkro middens, also located on the east side of the hills.

These patterns suggest changes in the production and consumption of ceramics made from L group sources. Commonly accepted thresholds for procurement distances suggest that potters typically obtain raw materials within a short distance (typically within one, and seldom more than three km) of their residences (Arnold, 2000, pp. 342–343; Rice, 1987, pp. 116–118). On this basis, we assume that L group ceramics were produced in villages

[11] Two L group samples were included in a pilot microprobe analysis undertaken by Cruz at the Geology Department at Binghamton University (DBP07, an ethnographic sample from Dorbour; and MK612, an everted jar rim from Early Makala; Cruz, 2003, pp. 629–631). DBP07 had abundant, somewhat angular quartz inclusions that ranged from.1 to 3 mm in size, as well as an albite fragment with mica crystals. MK612 was characterized by abundant, somewhat rounded quartz (.3 mm) and somewhat less abundant feldspar inclusions. Small (.1 mm) inclusions of garnet were noted in both fabrics.

west of the hills. Accordingly, sites west of the Banda hills with L group specimens may be sites of both production and consumption, while sites east of the hills reflect consumption practices.

The presence of L group specimens in Iron Age 3 and Volta Phase sites east of the hills suggests transport, and therefore perhaps exchange, of pottery in the late first and early second millennium AD. In the subsequent Ngre Phase, potters (ca. cal AD 1250–1400) produced a wide range of vessel forms from L group sources (west of the hills), including the globular jars and recurved-rimmed jars that are associated with both Ngre and Kuulo Phase contexts. L group vessels were transported to the easternmost extent of the study area (Banda 41, located near the Volta River), a minimum distance of more than 20 km, suggesting that settlements east and west of the hills were linked by exchange relations. This pattern was notably curtailed in the subsequent Kuulo Phase, during which the L group is represented by only 2 specimens east of the Banda hills, suggesting a sharp decline in the consumption by people living east of the hills of ceramics made from these western sources. Though our sample of Kuulo Phase sites west of the hills is small (Table 3), they yielded few L group specimens, hinting that diminished production may account for the shifts in consumption relative to the preceding Ngre Phase. The dearth of L group sources in Kuulo Phase contexts is associated with expanded exploitation of K1 sources, as discussed below. The L group is more prominently represented in the succeeding Makala Phase 2 (mid 1700s–1820s), where again we see evidence for transport of L group products to the east side of the Banda hills. Whereas sample size ($n = 3$) is too small to discern consumer preferences west of the Banda hills, L group specimens from east side sites are dominated by everted rim jars ($n = 23$) though bowls are also present ($n = 6$; Electronic Table 1a). L group bowls ($n = 6$) and jars ($n = 7$) are more evenly represented in subsequent Makala Phase 1 contexts east of the hills.

In sum, potters used L group sources continuously—though variably—over the course of the second millennium AD. The Ngre Phase saw a marked increase in the repertoire of vessel forms in a period when the area was developing links with the Niger trade (Stahl, 2007). L group vessels were transported relatively long distances in this period, a pattern that contrasts with the subsequent Kuulo Phase when L group sources were uncommon on both sides of the hills. This suggests changes in both Kuulo phase production and consumption, discussed below. Available evidence suggests that production and consumption of L group vessels rebounded in the later 18th and early 19th century (Makala Phase 2) when consumers east of the Banda hills preferentially selected L group jars. Vessels continued to be transported to sites east of the hills in the later 19th century, but with more balanced representation of bowls and jars in Makala Phase 1 contexts.

K1 Group

Compositional group K1 is provisionally linked to sources east of the Banda hills, and is distinguished from the chemically related K2 group by the presence and effects of crushed slag temper. Our working hypothesis is that sites east of the hills may be sites of both production and consumption, while those west of the hills represent consumer assemblages. K1 specimens varied considerably in color, ranging from very dark to medium brown-gray to yellowish red-brown. This group is associated with three of six phases in our working chronology: Ngre Phase, Kuulo Phase and Makala Phase 2 (Table 5b). Virtually all K1 group sherds were tempered with crushed slag, with slag inclusions accounting for an average of 11% of recorded point counts (Electronic Table 3). K1 fabrics typically included angular quartz as well, accounting for an average 4% of point counts. Rounded laterite inclusions are interpreted as natural components of the ceramic fabric.

Temporal and spatial patterning

K1 specimens first appear in Ngre Phase contexts ($n = 18$). Though jars predominate in the relatively small sample, identified specimens are distributed across vessel categories (restricted and unrestricted bowls, everted, globular and recurved rim jars). K1 specimens were recovered from three sites east of the hills (B123, B143 Banda 40; Table 5b) and one site west of the hills (A94). The K1 group dominates the INAA sample from subsequent Kuulo Phase contexts. Most ($n = 70$; 95%) of the K1 specimens derive from the site of Kuulo Kataa, where other compositional groups were present in minor quantities (e.g., group L). The full range of Kuulo Phase bowl and jar forms were produced from K1 sources, as were special purpose vessels (oil lamps, funnels; Table 5b). The K1 group appears as a common element of Makala Phase 2 sites west of the hills (A212, A233 B145), whereas it is less commonly represented at sites east of the hills (a single bowl rim each at sites B112 and Makala Kataa). K1 specimens did not appear among MK1 ceramics at Makala Kataa, though three sherds from unspecified vessel forms collected from the surface of Bui Kataa were assigned to the K1 group.

These data suggest that the distinctive recipe represented by the K1 compositional group (K2 clays combined with crushed slag temper) was first used in Ngre Phase contexts to produce a wide range of vessel forms, including the temporally diagnostic globular and recurved rimmed jars. Sites of production were probably located east of the Banda hills. If this working assumption is correct, the presence of K1 group ceramics on the northwest margins of the study area (site A94) implies that K1 pottery was transported distances of at least 10 km during the Ngre Phase, a pattern which suggests exchange. A similar range of vessel forms is present among Kuulo Phase K1 group specimens; however, the dramatic increase in the frequency of the K1 group in KP contexts suggests changes in ceramic production, particularly when viewed in relation to the declining importance of L group specimens described above. Our working hypothesis is that during the Kuulo Phase specialist potters east of hills (e.g., at Kuulo Kataa) produced ceramics for exchange across the region, as discussed in greater detail below. The Makala Phase 2 pattern represents a departure from this earlier pattern in that K1 group ceramics are confined almost exclusively to sites west of the hills, despite the likelihood that they were produced east of the hills. This raises the possibility that ceramics made from K1 fabrics were being produced but not widely consumed east of the hills in the terminal 18th and early 19th centuries. The presence of the distinctive K1 recipe among Makala Phase 1 sherds at Bui Kataa raises the intriguing possibility that this distinctive recipe continued to be used by potters in the northern reaches of the Banda area after it had been abandoned by those further south, suggesting varying degrees of conservatism in technological style across the region (cf. Nelson and Habicht-Mauche, 2006, p. 2004).

In sum, the K1 group is best interpreted as a distinctive recipe used by potters during the Ngre, Kuulo and Makala Phases to produce an array of vessel forms. Production sites were likely east of the hills, but K1 products were consumed both east and west of the hills during the Ngre and Kuulo Phases. Based on analyzed samples, K1 fabrics dominated local ceramic assemblages during the Kuulo Phase, a pattern consistent with specialized production and exchange that characterizes a variety of crafts in this phase (Stahl, 2001b, pp. 123–140; Stahl and Stahl, 2004). Some Makala Phase 2 potters continued to produce pottery from K1 fabrics, but these vessels were consumed primarily at sites west of the Banda hills, having been transported distances of more than 10 km (assuming production sites east of the hills). Though questions remain about the provenance of the K1 clay body source, our analysis underscores the value of multiple analytical techniques in assessing the effects of fabric preparation on chemical signatures (e.g., INAA, LA-ICP-MS and mineralogical analysis; e.g., Arnold et al., 1999; Faber et al., 2002; Stark et al., 2000; Stoltman et al., 1992; Tsolakidou et al., 2002).

K2 Group

K2 is a securely provenanced eastern compositional group associated with known but widely distributed clay sources in areas under laid by Tarkwaian group rocks east of the Banda hills. Documented K2 clay pits extend from the Tombɛ River in the south (Sabiye) to the Volta River in the north (Bui). Archaeological specimens assigned to the K2 group are associated with five of our six working phases (Iron Age 3, Volta Phase, Ngre Phase, Makala Phase 2 and Makala Phase 1; Electronic Table 1c). K2 specimens presented a variety of surface colors, ranging from grey to reddish brown and brown. No K2 sherds were included in the thin-section analysis; however, visual inspection of K2 group sherds suggests a range of natural and cultural inclusions. Laterite inclusions were common. While rounded granules may represent natural inclusions, some are angular suggesting that they were crushed and deliberately added as temper. Quartz inclusions are typical, though less abundant than in L group clays, and probably similarly reflect a mix of natural and deliberately added inclusions.

Temporal and spatial patterning

The K2 group dominated the small sample of Iron Age 3 sherds submitted for INAA analysis, most of which derived from a single eastern site (Makala Kataa; $n = 22$) and included both bowls and jars (Table 5c). The small sample of Volta Phase sherds submitted for INAA was similarly dominated by the K2 group. All analyzed specimens from Banda 27 were assigned to group K2, while those from Banda 13 were split between groups K2 and L. Our sample of test-excavated Volta Phase sites is restricted to the east side of the hills, so we have no insights into this phase in the western portion of our study area. K2 specimens were common in Ngre Phase contexts east of the Banda hills (sites B123, B143 Banda 40) and are represented by a range of vessel forms, including two crucibles (Electronic Table 1c). Only one Ngre Phase K2 specimen (a body sherd from site A94) was identified from sites west of the hills. No K2 specimens were identified in Kuulo Phase contexts, suggesting a disruption in production practices from the preceding phase. K2 group specimens appear once again in Makala Phase 2 contexts east, but not west of the Banda hills, and continue to be represented in Makala Phase 1 contexts in which they were to used to produce the full array of vessel forms (bowls and everted rim jars; Table 5c; Electronic Table 1c).

Despite evidence that K2 group sources were relatively continuously exploited by eastern potters, their products were not as widely distributed as those associated with the L or K1 compositional groups. A single body sherd in an Ngre Phase context (A94; Electronic Table 1c) is the only evidence of this securely provenanced eastern source appearing in a western site. Kuulo Phase potters did not exploit K2 group sources, at least not in the same form as their predecessors. As outlined in the K1 group discussion above, these clays were probably still exploited but the fabrics altered through the addition of crushed slag temper. Some Makala Phase potters discontinued this practice as evidenced in the reappearance of K2 group specimens in Makala Phase 2 contexts, while others continued to produce pottery linked to the K1 group, now consumed almost exclusively west of the hills (as discussed above).

H1 Group

As outlined above, compositional group H1 has not been linked to any known clay sources; however, chemical similarities with K2 group specimens suggests an eastern provenance. H1 fabrics are uncommon but distinct. Vessels are typically burnished, red-brown to dark red in color, and characterized by rounded laterite and other gritty inclusions. One H1 group bowl rim was included in Cruz's pilot microprobe study, which documented rounded laterite inclusions that incorporated hematite, garnets and quartz (Cruz, 2003, p. 631). Small rounded quartz inclusions were also noted. The group is represented by only 15 bowl rims (Table 5d), all from Makala Phase 2 contexts. Though H1 bowls were identified at two sites (Early Makala & B112), all but one specimen came from Early Makala (Electronic Table 1d).

We can say little about this compositional group. Though uncommon among INAA samples, chemical characteristics suggest that the source was local to sites east of the Banda hills. Small sample size precludes robust interpretation; however, the exclusive emphasis on bowls hints at either productive specialization and/or consumer preference as factors shaping the use of H1 vessels in Makala Phase 2 contexts, to which use of this compositional group was restricted.

H2 Group

Compositional group H2 is linked to contemporary sources near the potting village of Bondakile on the west side of the Banda hills. Based on fieldwork conducted in the middle, 1970s, Crossland (1989, pp. 54–55) described Bondakile fabrics as a mixture of plastic clay from deep pits mixed with 10–20 percent black earth to enhance elasticity. Although potters were secretive about the additive's source, Crossland adduced evidence that it derived from termite mounds. In the mid 1990s, Cruz (2003, p. 540) observed Bondakile potters mixing a sandy, coarse-grained clay with a plastic clay dug from deeper within the same clay pits. Vessels produced in Bondakile today are known for their incorporation of golden particles or specks (Cruz, 2003, pp. 367–368). Crossland (1989, p. 54) interpreted these as mica inclusions, but refiring experiments led Cruz (2003, p. 368) to conclude that their distinctive appearance more likely resulted from vermiculite inclusions. The only archaeological samples assigned to the H2 group ($n = 3$) came from three historic midden loci at Banda–Ahenkro tested by Andrew Black (Electronic Table 1e). Bondakile is located more than 25 km from Banda–Ahenkro, and the appearance of this compositional group coincides with the establishment of periodic lorry traffic connecting eastern Banda with the market town of Sampa, near the Côte d'Ivoire border. Until the mid-1990s, lorry traffic from Banda–Ahenkro traveled south to Menji where it connected with the road leading east to the district center of Wenchi or west to Sampa. Banda consumers sometimes traveled to the Sampa market, returning with pottery produced in Bondakile (Cruz, 2003, pp. 259–263).

Group I

Linked by INAA to ethnographic specimens from Adadiem, group I is a western source that was represented by only two archaeological specimens, both recovered from historic middens at Banda-Ahenkro (Electronic Table 1f). As in the case of group H2, the appearance of vessels assigned to this distant source likely is a product of mid-20th-century motorized transport to and from Sampa market.

Whorls

Six spindle whorls from Makala Kataa (three each from Makala Phase 2 and Makala Phase 1 contexts) were assigned to a distinct Whorls group. The group remains unprovenanced; however, it shares chemical characteristics with the east side K2 group. Our working assumption is, therefore, that spindle whorls were produced on clays from east of the Banda hills. This contrasts with the recent and historic pattern in which spindle whorls are a specialist product of Muslim men in the village of Kokoa, located roughly 40 km southwest of the Banda area (Crossland, 1989, p. 52; Cruz, 2003, pp. 273–275). As we have discussed elsewhere (Cruz, 2003, pp. 160–171, 556–579; Stahl and Cruz, 1998), textile production appears to have become a household-based craft during Makala Phase 2, and the whorls used in spinning locally produced cotton thread appear to have been a local product as well.

Unassigned specimens

A total of 72 archaeological specimens could not be assigned to any of the above compositional groups (Table 5e). Unassigned specimens occurred across the full range of archaeological phases, and were associated with sites both east and west of the Banda hills. Kuulo Phase contexts yielded the most unassigned specimens ($n = 30$), which reflects in part the inclusion of tuyere[12] fragments and less common vessel forms (oil lamps, funnels) in the Kuulo Phase INAA sample. With a single exception (MK0642), the chemical composition of the unassigned specimens does not diverge markedly from the range of Banda compositional groups. Many of these sherds therefore probably derive from one among the sources described above. An inspection of thin section point counts (Electronic Table 3) indicates that a number of the unassigned Kuulo Phase specimens from Kuulo Kataa and site A212 (KK8, A212-7, −8, −11, and −12) are similar in proportional representation of natural and cultural inclusions to the K1 compositional group. All but KK8 included crushed slag in similar proportions to Kuulo Phase K1 sherds, though on average they contained a higher proportion of angular quartz that did K1 sherds from either site. By contrast, the unassigned sherds from Iron Age 3 contexts at site A212 diverged from this pattern of mineralogical composition (A212-14 to 16; Electronic Table 3). They contained no slag inclusions, a lower proportion of natural inclusions, and somewhat higher proportions of angular quartz, suggesting a distinctive fabric recipe, though the small sample of unassigned IA3 provides an insufficient basis for generalization.

Group affiliations of smoking pipes

Locally produced clay smoking pipes are a post-Columbian phenomenon in West Africa (McIntosh et al., 2003, pp. 172–174) that first appear in the Banda sequence at the end of the Kuulo Phase. They continued to be made and used through Makala Phase 2, after which they were replaced by imported European ball clay pipes (Stahl, 2002). Twelve smoking pipes from Kuulo Phase contexts at Kuulo Kataa (an east side site) were submitted for INAA, along with 25 Makala Phase 2 pipes from two east side (Early Makala, B112) and two west side sites (A212, B145). The Kuulo Phase pipes (Electronic Table 6) contrast markedly with the patterning of compositional groups among Kuulo Phase ceramics at Kuulo Kataa. As outlined above, Kuulo Phase ceramics were dominated by the K1 group. By contrast, only two of the 12 Kuulo Phase smoking pipes were assigned to the K1 compositional group (Table 6). The remaining pipes were split between the L ($n = 4$) and K2 ($n = 3$) groups, or were unassigned ($n = 3$). These data imply that the smoking pipes consumed at Kuulo Kataa derived from a wider array of sources than did the associated pottery. Of particular interest is the presence of L group pipes in this phase when L group sources were rare among Kuulo Phase pottery (as discussed above). Whereas K1 and K2 sources may have been "local" to Kuulo Kataa (in the sense of being located on the east side of the Banda hills),

Table 6
Summary of pipe compositional groups by phase

Compositional group	Kuulo Phase	Makala Phase 2	
	East side	East side	West side
L	4	2	3
K1	2	1	9
K2	3	6	0
Unassigned	3	2	2
Total	12	11	14

and we hypothesize that Kuulo Kataa was a site of ceramic production (Stahl, 2001b, pp. 123–128), smoking pipes produced from L group sources were probably transported to the site from west of the hills. This implies that pipes were not necessarily fashioned by the same craft producers who made Kuulo Phase pottery.

The sample of Makala Phase 2 smoking pipes derived from a variety of locations. Sites east of the hills yielded smoking pipes assigned to compositional groups L ($n = 2$), K1 (1), and K2 (6), while two remained unassigned (Electronic Table 6). Smoking pipes from sites west of the hills were assigned to groups L ($n = 3$) and K1 ($n = 9$), with two unassigned. Though sample sizes are small, the absence of K2 group pipes in sites west of the hills and their predominance at eastern sites is consistent with the pattern of Makala Phase 2 pottery. Similarly, the presence of pipes made from L group sources east of the hills and of K1 pipes west of the hills suggest transport of products consistent with the broader Makala Phase 2 patterns described above.

The temporal dynamics of ceramic production and consumption in Banda

Many archaeologists who work in rural Africa have had the good fortune to witness the production and use of traditional technologies, particularly pottery. Ethnographic studies of 20th-century African potting have contributed immensely to broader literatures on technological style. They have enhanced our appreciation of the extent to which technologies exist as embodied practices transmitted intergenerationally, with implications for our understanding of the materiality of social networks. Their emphasis on practice provides insight into how traditions are maintained, at the same time as directing attention to issues of choice, agency and the processes through which change occurs (Dietler and Herbich, 1989, 1998; Frank, 1993; Gelbert, 1999; Gosselain, 1992, 2000; see also Lechtman, 1977; Lemonnier, 1986; Stark, 1999). Yet compelling as ethnographic insights are, they inform on contemporary rather than past practice. They provide an essential baseline for investigating past ceramic production and consumption, but their archaeological value is as a comparative model against which to assess archaeological patterning (Stahl, 2001b, pp. 19–40). Only through detailed study of temporally controlled archaeological assemblages can we assess the extent to which technological practices and the consumption of resulting products varied through time.

Cruz (2003) study of ceramic production and consumption in late 20th-century Banda provides a baseline against which to compare patterning in the compositional analyses discussed above. At the end of the 20th-century, potting was practiced as a community specialization (Hegmon et al., 1995, p. 33) in which women from two ethnic groups in three villages west of the Banda hills produced ceramics on a part-time basis. Obtained through exchange and used by all of the ethnic–linguistic groups in the areas, the pottery produced by these women was distributed across the region via motorized transport and head-loading. Compositionally, this pattern of nucleated production and dispersed consumption (*sensu*

[12] Tuyeres are ceramic pipes used to introduce air into metallurgical furnaces.

Table 7
Summary of compositional groups by phase. Number of ceramic specimens (smoking pipes in parentheses); E&W indicate side of hills on which products were consumed

Phase	L[a]	K1	K2	H1	H2[a]	I[a]	Whorls	Unassigned	Total
1930-60[b]	2		4		3	2			11
MK1[b]	14	3	16				3	9	45
MK2	36 (5); E&W	23 (10); E&W	11 (6); E	15 (E)			3; E[1]	11 (4); E&W	124
KP	4 (4); E&W	74 (2); E&W	(3); E[b]					30 (3); E&W	120
NP	27; E&W	18; E&W	20; E&W					11; E&W	76
VP[b]	4		19					2	25
IA3	3; E&W		22; E					9; E&W	34
Total	90 (9)	118 (12)	92 (9)	15	3	2	6	72 (7)	435

[a] Sources located west of the Banda hills.
[b] Sample includes only sites located east of the Banda hills.

Pool (1992, pp. 280–281)) is reflected in a predominance of L group sources (e.g., pottery from Dorbour/Adadiem) with some representation of H2 sources (pottery from Bondakile). This model of geographically-restricted community specialization might be taken as a model for past practice (Crossland and Posnansky, 1978). However, when viewed comparatively against the evidence of compositional analyses, it is clear that the same pattern of geographically-restricted specialized community production cannot be extrapolated even so far back as the early 20th-century, when oral histories and compositional analyses indicate that potting was also practiced in villages east of the Banda hills.

Table 7 summarizes the number of pottery specimens from each source by phase (number of smoking pipes indicated in parentheses) and the side of the hills on which they were consumed. Though our insights must be considered preliminary and subject to modification with expanded sampling, our data suggest significant shifts in both the location of production and patterns of consumption of ceramics over the course of the last millennium, as detailed above. On the eve of British colonial occupation (Makala Phase 1), our data suggest that pottery was produced on both the east and west sides of the Banda hills. Though Banda villagers east of the hills consumed some ceramics produced in western villages (L group), eastern sources were somewhat more commonly represented (K1, K2). The Volta basin in this period was characterized by a predatory landscape (Swanepoel, 2006) of warfare and raiding linked to the internal slave trade (Stahl, 2001a, in press). In the wake of these dislocations, a range of archaeological evidence suggests that village activities appear to have become more circumscribed (Cruz, 2003, p. 542; Stahl, 2001b, pp. 204–212). This is witnessed in patterns of more localized hunting and a contraction of local exchange in Makala Phase 1 contexts compared to earlier phases. These insecurities may have made local exchange a risky business, prompting women in villages east of the hills to become involved in potting rather than rely on their western neighbors. Alternatively or additionally, the siphoning off of male labor—to serve as carriers for colonial officials or to seek waged labor on cocoa plantations to the south—may have prompted women east of the hills to engage in potting as a means to generate income, whether through cash sales or barter of pottery, in a context in which Banda peoples were increasingly enmeshed in a monetized economy (Stahl and Cruz, 1998, p. 221).

The Makala Phase 1 pattern departs from that of Makala Phase 2 (terminal 18th-early 19th-century) when there appears to have been robust exchange in local products between villages east and west of the Banda hills (Stahl, 2001b, pp. 175–177). Seen from the perspective of consumer assemblages (Faber et al., 2002, p. 13), many of the bowls consumed at Makala Kataa likely derived from eastern sources (H1 group; Electronic Table 1d), while jars were produced on western sources (L group; Electronic Table 1a). We have insufficient data to assess whether this reflects consumer preference in product selection or specialized, community-based complementary production (Pool, 1992, pp. 283, 287; Rice, 1987, pp. 187–188). But in either case, the pattern speaks to exchange connections between communities east and west of the Banda hills. Similarly, we may be seeing the effects of consumer preference in the differential consumption of K1 group ceramics in Makala Phase 2 contexts. Although K1 group ceramics were probably produced east of the hills, they were uncommon in samples from eastern sites compared to their relative abundance in western sites (Electronic Table 1b). The overall diversity of sources used to produce both ceramic vessels and smoking pipes in MK2 contexts (Table 7) suggests multiple, geographically dispersed sites of ceramic production. Consumption was not, however, geographically restricted; our data suggest that products circulated both east and west of the hills. By this period Banda had been drawn into Atlantic exchange networks and incorporated into the Asante state, yet the warfare that plagued the region later in the century had not as yet disrupted the exchange networks that connected communities across the region and particularly across the Banda hills.

Though our Kuulo Phase data is dominated by samples from a single site (Kuulo Kataa), they suggest a model of specialized production that is unique in relation to both earlier and later occupation phases in the area. Dominated by the K1 compositional group, our working hypothesis is that Kuulo Phase ceramics were produced for exchange by specialist potters in a pattern consistent with community specialization[13] (Hegmon et al., 1995, pp. 32–33). In this period Banda peoples participated in long-standing exchange networks with the Niger River, but they were also being drawn into emerging Atlantic networks. Production for exchange appears to have characterized a number of technologies (metallurgy, ivory working and potting; Stahl, 2001b, pp. 143–145; Stahl and Stahl, 2004), integrating the region into a single market zone (Minc, 2006, p. 88). The production of ceramics from K1 fabrics incorporating slag appears to have taken place on sites where iron was smelted, suggesting a link between metallurgy and potting in this period, though we should not assume that this indicates the presence of "casted" blacksmiths and potters that have been documented ethnographically in neighboring regions of West Africa (Frank, 1993; McNaughton, 1988; Tamari, 1991). Though the sample of analyzed smoking pipes was small, the variety of sources represented among the pipes compared to pottery vessels suggests differential production, with pipes perhaps produced by different craftspeople using distinct sources (e.g., L group) compared to pottery. Smoking would have only recently diffused in this context, and the production of smoking pipes would have been a relatively novel undertaking associated with the exploitation of different clay sources (e.g., L group) compared to pottery (dominated by K1 group).

Like the Kuulo Phase villagers who succeeded them, Ngre Phase inhabitants of the Banda area were enmeshed in interregional exchange networks that connected the West African forest with the

[13] Though this should not be taken to imply that all villagers were producers (Hegmon et al., 1995, p. 33; Plog, 1995, p. 274; cf. Pool and Santley, 1992, pp. 213–214).

Niger River. However, the compositional data summarized above suggests a pattern of more dispersed ceramic production compared to the succeeding Kuulo Phase. Ngre Phase potters east of the hills appear to have pioneered the use of K1 fabrics, innovating in the practices of fabric preparation by mixing crushed slag with K2 clays for the first time. But K2 clays continue to have been used as well. Pottery was also produced west of the hills, and products from each source circulated on both sides of the hills. This pattern appears more similar to the later Makala Phase 2 than it does to the Volta Phase that precedes it or the Kuulo Phase that succeeds it. Of note is that both Ngre and Kuulo phase potters operated in a context of wide-ranging inter-regional trade (dominated by Niger River connections in the Ngre Phase and both Niger River and Atlantic connections in the Kuulo Phase), yet only in the Kuulo Phase do we see evidence for spatially restricted and presumably specialized pottery production that is sometime assumed to be a correlate of involvement in long distance exchange. Our datasets for the Volta Phase and generic "Iron Age 3" ceramics are too small to support robust inference; however, the painted pottery recovered from eastern sites was clearly being produced using locally-available eastern sources, undermining the conventional assumption that painted pottery in the Volta basin was imported (Davies, 1964; Mathewson, 1968).

Though a detailed assessment of change and continuity in technological style would require a comparative analysis of forming techniques, vessel form and decoration (e.g., Zedeño, 1994), the compositional data presented here provides some insight into technological styles of archaeological ceramics (e.g., in relation to the choice of raw materials and the preparation of fabrics). Of note is that preliminary analyses suggest a complex pattern of change and continuity in technological style that blurs the boundaries of our working chronology and leaves us with the impression that innovation in the practices of ceramic production and consumption did not occur in lock-step fashion across the region (Abbott and Walsh-Anduze, 1995, p. 92). For example, preliminary data suggest a shift in forming techniques from the Volta to the Ngre Phase. There is evidence that at least some Volta Phase pottery was formed by coiling (as evidenced in joins visible in cross-section on some sherds), whereas Ngre and later phase pottery does not show obvious signs of coil construction (Stahl, 2007). Some might interpret this as evidence of a shift in the cultural identity of potters (e.g., as belonging to distinct ethnic-linguistic groups; Frank, 1993; Sappelsa, 2000); however, continuities carry across the Volta/Ngre interface in terms of the choice of sources (L & K2 groups), the composition of fabrics, as well as continued use of red paint, albeit incorporated into a new grammar of design. When viewed in relation to recent literature on technological style, communities of practice and the transmission of knowledge (Minar and Crown, 2001) discussed above, the evidence for continuity alongside change raises new questions about the complexity of associated processes (e.g., Gosselain's "technical multilingualism" [2000:206]; also Gelbert, 1999). Long-exploited sources (L and K2 groups) and fabric recipes carry across these boundaries, though in some cases were used to produce new vessel forms shaped in new ways as illustrated by a shift from coiling to direct pull techniques that may characterize the transition from Volta Phase to Ngre Phase contexts. The K1 group, which we argue represents a distinctive fabric combining K2 clays with crushed slag, appears as an innovation associated with Ngre Phase potters, the knowledge of which continued through the succeeding Kuulo and Makala Phases. This continuity in fabric recipe is masked by distinctions in vessel form and decorative techniques that mark the transitions between the Ngre, Kuulo and Makala Phases, at the same time as a similar grammar of design carries across the Kuulo and Makala Phases (Cruz, 2003, pp. 501–521; Stahl, 2001b, 2007). Such insights encourage us to consider the processes through which technological knowledge is transmitted and shared (Minar and Crown, 2001) and confirm Gelbert's (1999) observation that we should evaluate each stage of the operational sequence in relation to its conservatism.[14] The boundaries between phases, defined primarily on the basis of ceramic form and decoration, become blurred as we come to appreciate the continuities in raw material choice, preparation and forming technique that cross the boundaries of our working chronology (Fenn et al., 2006). At the same time, temporal variability in the consumption of ceramics associated with different compositional groups underscores the complexity of intercommunity interactions through time (cf. Nelson and Habicht-Mauche, 2006).

Consistent with recent views of technology as historically contingent and variable (Faber et al., 2002, p. 130), our compositional data undermines notions of directional change in technological practice. For example, we might interpret the shift from a diversity of sources consumed both east and west of the Banda hills in the Ngre Phase to the dominance of K1 group ceramics in Kuulo Phase contexts as associated with increasing specialization (assuming that a homogeneity in raw material source is linked to increased production by communities associated with those sources). Yet data for the subsequent Makala Phase 2 (Table 7) suggests a pattern more similar to the preceding Ngre Phase in which pottery was produced from sources both east and west of the Banda hills, at the same time as it was exchanged across the hills. Whereas the Ngre Phase data shows no correlation between vessel form and source, the MK2 data suggest a pattern in which specific vessel forms were associated with specific compositional groups (e.g. H1 group represented exclusively by bowls; Cruz, 2003, pp. 535–538). Sorting out whether this reflects selective consumption or specialized production depends upon expanded research at Makala Phase 2 production centers.

The differential "persistence" of the K1 fabric recipe is one of the most intriguing insights to emerge from our INAA data. It underscores the extent to which changes in production may occur differentially across a region (Nelson and Habicht-Mauche, 2006). As Abbott and Walsh-Anduze (1995) stress, we need to consider the effects of exchange and social interaction on archaeological ceramic patterning if we are to develop more detailed understandings of such production shifts. This study represents a first step in understanding these dynamics in the Banda area. Although our insights are subject to revision with further analysis, our work demonstrates the value of comparative analyses of archaeological and ethnographic data sets using multiple analytical techniques to understand the dynamics of technological style in relation to the broader political economic contexts in which craft production occurs.

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[14] Though note that Gelbert (1999, pp. 219–221)) suggests that the procurement and mixing of pastes are "weakly resistant" to external influence and therefore more likely to change than aspects of vessel fashioning that are linked to apprenticeship networks.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jaa.2008.04.001.

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