

**RESEARCH ARTICLE**

# Mineralogical Analysis of Ancient Pottery in the Swahili Settlement of Siyu, North Coast of Kenya

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## ABSTRACT

This paper presents the mineralogical analysis of ancient pottery from Siyu, one of the ancient Swahili settlements on Kenya's north coast. The application of mineralogical analysis on ancient pottery was conducted as an adjunct to a broad archaeological investigation of the early occupation of Siyu using the exchange networks perspective. One of the study's objectives was to determine the quality of potting material in the potsherds and resource base that premediated the exchange of pottery among other household goods. The samples for comparative mineralogical analysis comprised potsherds and raw clay from Siyu. The results indicate that the mineral compositions in the potsherds are not like those of the raw clay. The crockery and clay utilized by the earlier inhabitants of this city-state was sourced from sources outside the Lamu archipelago. In conclusion, the Siyu pottery was not made locally, rather it was imported from other cities. The city-state had the necessary structures to tap into the local exchange networks that enabled merchants to access finished pottery from far. The study recommends further multidisciplinary analysis of more samples to map out pottery production sites, routes, and catchment areas to supply households to this once important city-state.

**KEYWORDS:** Exchange, settlement, mineralogy, plasticity, networks

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## Introduction

There is no doubt that pot-making and utility were important crafts for the East African coastal settlements and their adaptation to the coastal environment. Researchers working on the early coastal settlements have yielded overwhelming amounts of pottery (Soper 1967; Chittick, 1967; Langdon and Robertshaw 1985; Mutoro 1987; Abungu, 1998; Chami, 1994; Horton, 1996; Kiriama et al. 2006; Busolo et al. 2019). These works have revealed that sites along the East African Coast were indeed productive in terms of the numbers of archaeological potsherds. For instance, Kilwa alone produced over one million sherds in a single excavation by Chittick (1984 cited in Chami 1994: 44). The site of Shanga on the north coast of Kenya produced well over 100,000 potsherds (Horton 1996). Finally, the site of Pate located west of Siyu yielded 30,283 potsherds in a study that did not emphasize the provenance of raw materials (Wilson and Omar 1997). Whether Kilwa, Shanga, and Pate potteries were procured from outside or made internally remains unclear since none of the three studies above did focus on the provenance of raw materials and the composition of fabrics.

Nevertheless, some researchers have attempted to investigate the sources of pottery and other fabrics with varying levels of success. For instance, Chami (1994) attempted petrographic microscopy on thin sections of pottery from four sites on the southern coast of Tanzania. The objective was to find out whether pottery from different sites portrayed different features. The results indicated that most of the vessels within the site show a similar or almost identical composition of clay and that there was great variation among the sites (Chami, 1994: 89). The conclusion was that pottery at each individual site was made from raw material collected from only one clay deposit. Many of the sherds came from pots that were made internally at the sites, with a very small number of sherds from an external source.

Other scholars have combined ethnoarchaeological approaches to compare potting materials between contemporary and ancient pottery. For instance, Ndiiri (1996) investigated how contemporary pottery was produced in several sites around Mombasa and Lamu. Wangari (2013) attempted to establish the sources of raw materials used in the Evurore pottery in Mbeere of Northeastern Kenya. The study concluded that the clay had a naturally occurring temper of small grained-quartz and mica flecks with additional semi-decomposed lava, suggesting that the clay was sourced locally (Wangari, 2013: 87).

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Oteyo and Doherty (2006), on the other hand, investigated pottery provenance from Engaruka by reviewing the geology and soil maps of the study area as a means of predicting the types of minerals which should be present in the local clays in the Engaruka, Sonjo and Kondoa districts. The aim of the study was to establish whether Engaruka pottery was made locally or was imported from other sites and, if imported, whether or not it showed similarities with the pottery from the nearby site of Kondoa. They also aimed at investigating whether there were similarities with pottery fabrics from other Engaruka Complex sites. The results indicated that the mineral inclusions of the Engaruka pottery did not match either those observed in the clay samples obtained from Engaruka or those expected for clays in the Engaruka area, suggesting that none of the pottery was made locally (Oteyo and Doherty 2006: 109). Furthermore, the clay fabrics in the Engaruka pottery matched those from Kondoa and Sonjo, suggesting that these two sites were the possible source of raw material for Engaruka pottery.

Fleisher and Wynne-Jones (2011) note that petrographic studies at several early Tana Tradition (ETT) sites in eastern Africa have repeatedly demonstrated the localized production of ETT ceramics. They conclude that temper inclusions are fairly uniform, with significant proportions of sandy grit suggesting a clay source that was already sandy. They also make an exceptional observation of one ETT site of Chibuene that had a significantly different fabric from other ceramics, suggesting outsourcing of either finished pots or clay for local manufacture (Fleisher and Wynne-Jones, 2011: 267).

Besides provenance studies in the coastal sites, Langdon and Robertshaw (1985) conducted petrographic and Physico-chemical analysis on pottery from south-western Kenya. The purpose of their investigation was to provide a basic description of the fabrics found in the pottery and to ascertain whether some or all of the pottery found in the Loita-Mara region was procured from outside or made internally (Langdon and Robertshaw 1985:3). The study utilized a combination of four techniques, namely, petrography, x-ray fluorescence, atomic absorption spectrometry, mechanical separation, and x-ray diffraction on samples of pottery and clay from at least twelve sites within the region. Without giving specific results as per the techniques above, the study made three very useful discoveries (Langdon and Robertshaw 1985:27). First, that the Akira, one of the pottery traditions represented in the Loita-Mara region, was probably made from non-local clay sourced 25km north of the Mara River. Second, an Early Iron Age sherd of Urewe group found in the region had a fabric that was distinct from the rest, suggesting it may have been exchanged from the west. And, lastly, the presence of mica temper in Elmenteitan pottery

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was probably a decorative motif on pots and not a plasticity agent as might be the case in pottery of other sites. This was arrived at for the following reasons: First, the petrographic microscopy of the sherds revealed very fresh mica particles, and that the pottery samples with minerals also had the amount of aluminum exceeding that of any clay sample. Second, since mica is glittery and readily available in the Elementaitan sites, it was probably added as the unconventional equivalent of a decorative motif on vessels. In a separate study, Kiriyama (1984) conducted petrological analysis of Nderit potsherds and concluded that Nderit pottery was produced locally as a function of livelihood strategy of its makers. The results indicated that although the pottery from Nderit River site appeared in three different ecozones, the ware maintained the same decorative technique, motif, and form.

Further in the Nile Valley, mineralogical analysis has been applied to investigate the potential of thin section and chemical analysis of pottery to determine where the fine wares of Meroe were made and whether these techniques could provide the needed evidence for trade networks (Smith, 1997). The main study was carried out by comparison between the sherds from the site of utility and the raw materials from known sites. The results of this study indicated that the clays from north and south of Moreo manifest a reasonable degree of variability (Smith 1997: 81). The fabrics from the northern region were characterized by a buff matrix colour and a high percentage of angular-subrounded quartz of moderate grain size together with random iron oxide grains. The so-called Kalabasha clays had fabrics of reddish, iron oxide matrix, very frequent subrounded iron oxide grains and fairly frequent pale, calcitic inclusions. From the southern region, the clays were taken from the vicinity of Meroe itself. These clay fabrics tend to have very frequent quartz, fairly frequent iron oxide grains, micas, and random opaque minerals (Smith 1997:82). Cluster analysis of ceramics and clay samples indicated that the presence of some pottery specimens from the northern region in the predominantly southern Cluster, suggesting that some material was produced in the south and traded to the north. It also possible the presence of an apparent mixture of the fabrics in the clustered samples is due to the terrestrial overlap between northern and southern clay composition.

The site of Siyu, a close neighbour of Shanga on Pate Island, produced nearly twenty thousand sherds (Busolo 2019). Despite the similarities in cultural affinities of Siyu and Shanga potteries, it is not yet clear where the Siyu pottery was made. We also do not know the quality of the clay and pottery found in Siyu. This could be one useful window through which to understand the mineralogical composition and,

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therefore, provenance of the pottery in other sites on Pate Island and whether these potteries were procured as finished products or were made internally.

The foregoing literature need not overemphasize the significance of mineralogical analysis towards the provenance of pottery and clay or related material for pot making. Through this approach, we can understand how large amounts of pottery could have been transported across the Siyu Channel from inland sites.

### **Relationships between coastal and hinterland settlements**

Mutoro (1998) and Pearson (1998) have used pottery to discuss relationships between hinterland societies and coastal towns. Though drawn from different linguistic groups, socioeconomic interactions between the hinterland and coastal people partly influenced the trajectory of the Swahili culture (Kusimba 2004: 239). Technological advancements in ironworking and improved potting techniques influenced subsistence agriculture and specialization in fishing and herding of livestock (Abungu 1998; Horton, 1996). The growth of agriculture led to the improved quality of life, increased population, and economic prosperity that eventually attracted foreign political interests (Kusimba 2004). As a result, complex settlements emerged along the East African Coast (EAC) from Somalia to Mozambique around 500CE (Abungu 1998; Juma 2004). However, the coastal towns did not develop in isolation; instead, smaller settlements in the hinterland grew alongside as they too improved their socio-political order to control the emergent trade (Kusimba and Kusimba 2005).

However, ancient stone buildings had been erroneously linked to the emergence of settlements and urbanism, implying no urban life predated 500CE. Yet, documentary evidence of the first century CE, such as the *Periplus of the Erythraen Sea*, records the trans-Indian Ocean trade's prosperity involving East African coastal seaports, the hinterland, and overseas ports (Freeman-Grenville 1975; Huntingford 1980). We barely understand how the north coast settlements and their south coast counterparts interacted. Further, the nature of relationships between the coastal settlements and their hinterland counterparts before 1500CE was not very clear before this study, and we could not precisely state the role of ancient settlements such as Siyu in the exchange network then. There was also no archaeological material to show the significance of Siyu in shaping island-hinterland interactions before 1500CE. This

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study has uncovered material evidence in the form of potsherds exchanged between the north coast settlements and southern settlements.

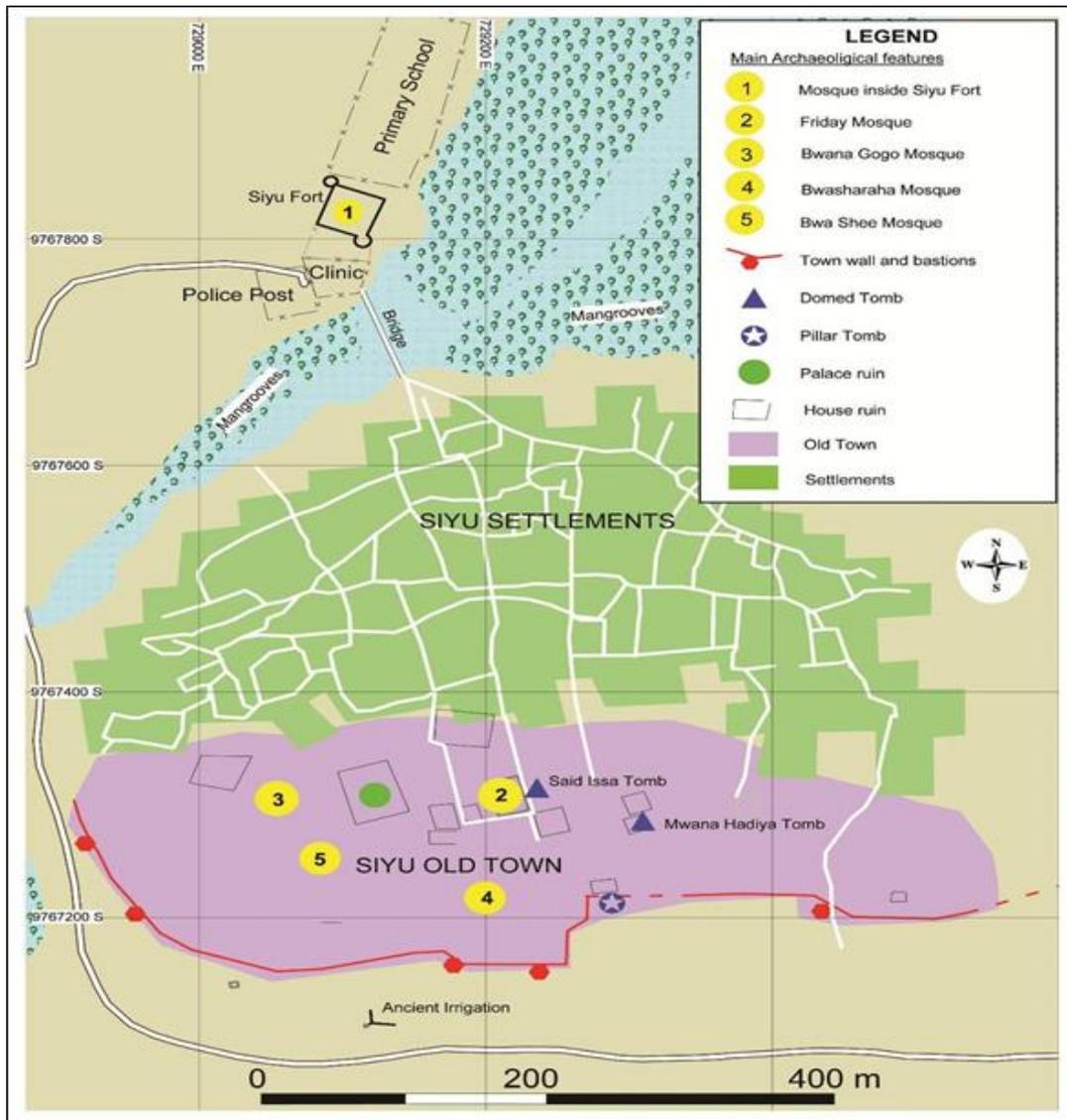
### **Issue for analysis**

Archaeological excavations of ancient coastal settlements, including the Swahili city-states, have yielded thousands of potsherds and other related materials that have enabled researchers to understand the incipient settlements along the north coast of Kenya and hinterland sites. However, it appears like it is not tenable to generalize the sources and quality of the raw materials for pot-making across sites, areas, or regions. Instead, pottery assemblages from each site should be treated as unique and thus merits an exclusive investigation of pot-making raw materials, including fabric characteristics and their sources. While settlements were located in the same geophysical landscapes, they had unique adaptive strategies that varied from their neighbours. As more complex social order set in, competition and tendencies towards sovereignty premediated some settlements to have the monopoly of access to essential resources and craft specialization. Since craft specialization can be observed in archaeological pottery using mineralogical analysis, we are posing the following questions: Is it possible to identify fabric characteristics within a particular site where the finished products were utilized? The use of comparative geochemical analysis of pottery allows analysts to narrow down to potting materials and temper sources as potters sought to achieve the clay's plasticity.

### **The Study Area**

Siyu is a settlement located on Pate Island, one of the islands that make up the Lamu archipelago on Kenya's north coast. Pate Island lies in the Coastal Plain zone and is characterized by relief of up to 140m above sea level and a series of raised dune terrace complexes (Tychsen, 2006: 16). Siyu covers 22 hectares between Pate town and Faza town on Pate Island at the following coordinates, 02° 06'.070''' S, 41° 03'.400''' E. As with other island settlements, Siyu is located strategically at the end of a shallow winding creek that provides a sea route to the West's Siyu Channel (Fig.1). The creek is only navigable during high tide when the water volume is high enough to accommodate medium-sized boats. There is an airstrip to the northeast for light aircraft, but it is seldom used. The ancient town of Shanga was located 3 kilometres to the south of Siyu, and it is today survived by an elaborate cluster of ruins and two modern villages settled near the ruins, namely, Shanga Ishakani and Shanga Rubu (Horton, 1996:17).

The site of Siyu borders a shallow creek that circumnavigates the entire northern and western ends of the settlement. The eastern part of the site is covered in mangrove forest lying between 0 and 3m above sea level. There is a steady increase in altitude from the sea level at the shoreline of Siyu creek to 12m above sea level towards the mid-west and northwest of the site.



Source: CHDA - Africa 2009

Figure 1: Location of Siyu

The paleoenvironment of Kenya's north coast region was very much a result of geological events starting from the Pleistocene and continuing onto the Holocene, a period that witnessed numerous sea-level

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changes (Braithwaite, 1984; Abuodho, 1992). Rocks of sedimentary origin dating to between the Triassic and Recent are most dominant. Some of these are the Duruma sandstones with the Mariakani and the Pate Island's topography is generally flat with rugged terrain in a few places (Personal observation). Poorly developed soils dominate the central regions, while sandy plains commonly occur on the shoreline. The foreshore area between Pate and Mbui and between Siyu and Shanga consists of wide low-gradient extensive beaches that submerge during spring tides.

Mazeras variants (Tychsen, 2006: 14). These rocks formed under subaqueous conditions before the present state of the Indian Ocean. Limestones and shales of the Upper Mesozoic are also present, as do the clay conglomerates and gravels of Marafa Beds (Busolo, 2020: 46). Magarini Sands, limestone cemented sands, and coral sands of the late Pleistocene and early Holocene characterize the mid-north coastal region, while Recent riverine silts, sands, and some corals overlie the older units at several depths (Abuodho, 1992: 4). According to Tychsen (2006: 14), some sands in the Lamu archipelago result from deposits of the ancient river system and aeolian dunes. During the Pleistocene, sea-level fluctuations associated with glacial/interglacial phases in the polar regions were responsible for the raised coral reefs and white sands around the islands (Braithwaite, 1984:24). Pate Island's geology portrays an assemblage of these aeolian sediments, riverine sandstone pebbles, and coral limestone (Tychsen, 2006: 15). Kairu (1997:10) has documented in this region calcarenites and intercalations of quartz sands underlying the Pliocene period's older sandstones.

### **Methodology**

A desktop study of local geology and soil maps was done to understand the various minerals found in the Lamu archipelago, especially in Pate Island and other coastal localities.

### **Sampling and data collection**

These categories of samples were studied;

- a. samples of local clay and rocks to predict minerals in Pate Island and its environs
- b. fifteen samples of potsherds drawn from excavated vertical profile of the site

### **Data analysis**

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The investigation involved comparative mineralogy of samples of clay, rock and local sherds. This was to help trace the mobility of clays or finished pottery products from manufacturing sources to places of utility. The interest in exchange networks led to the application of atomic mass absorption spectrometry (AMS) of potsherds and clay to determine the mineralogical similarities with samples from known sites. The AMS method involved generating, separating, and characterizing gas phase ions according to their relative mass as a function of charge (Dougherty, 1981). This method, when applied to samples of clay, rock and potsherds follows five steps as outlined below after Dougherty (1981:287)

- a. Pieces of portsherds crushed into powder form
- b. The powder is dissolved in methane to form a solution
- c. Molecules are subjected to a high-energy beam of electrons, converting some of them to ions
- d. Acceleration and separation of ions according to mass-to-charge ratio
- e. Detection and quantification of ions (by the spectrometer)

### **Ceramic Systems Theory**

The paper utilizes exchange systems theory to discuss resource mechanisms in clay as one primary raw material for pottery production. According to Dillian and White (2010) cited in Busolo *et al.* (2019:34), the prehistoric exchange system serves as an interpretative tool for cultural processes and regional studies, and there is a wide range of scientific techniques to describe the composition of certain types of raw materials and identifying their sources with great precision. Exchange networks connect people and are also productive such that people in one area acquire items by exchange through trade depending on the nature of the socio-political organization. Applying the exchange systems and comparative mineralogical techniques can reveal non-local material in archaeological and historical assemblages (Earle 1982: 201). According to Arnold (1985: 16), culture and the environment constitute the “system” that allows people to adapt to the external environment and consists of an integrated whole. This system is composed of subsystems such as the techno-economic, socio-cultural, and ideological foundations. Pottery is a highly specialized part of the techno-economic subsystem that enables societies to adapt and modify the physical environment (Arnold 1985:17).

This study focused on the raw material for pot making and threshold distance to the sources of clay. The raw material for pottery production must be of good quality to produce fine pots. Initially, all clay may

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not be of working quality, but potters do a thorough search to pinpoint localities with comparatively suitable clays. Good quality clay means a desirable level of mineral composition, degree of crystallinity, plasticity, particle size, and soluble salts. Other features may include exchangeable cations and the non-plastics present. Where such minerals are below the desirable levels, potters may source and improvise non-plastics from within to enhance clay quality. According to Arnold (1985: 21), non-plastics include but are not limited to materials such as sand or crushed stone, ground potsherds, or organic materials. Organic materials such as crushed bone, shell, and charcoal might also be added to the clay.

Another aspect of the study concerned the measured distance to those resources (clay and temper) with desirable quality. The space to the sources of raw material provides a vital feedback relationship for pottery production. The raw materials must be available in their work area for pottery production to develop into a full-time craft. The interrelationship of ceramics to the physical environment and culture provides the channel through which information and materials flow between the physical environment and the people. This approach has been helpful in investigating how Siyu acquired pottery from far other than make their own.

### **Conceptual Framework**

Archaeologists concerned with pot-making resources agree that there are predictable factors that influence the development of a specialization in pottery manufacture. These factors can be subdivided into two parts, the quality of ceramic resources and their availability in terms of distance to their source location. These are seen as either limiting or stimulating pottery specialization. According to Arnold (1985:20), readily available resources provide a conducive environment for the craft's origin and its development into a full-time specialty. On the other hand, resources of poor quality or those too far from the 'potter's household may prevent the craft from developing. However, threshold distance to the source of potting materials may not constrain a settlement from accessing pottery products.

Societies that had developed an effective socio-political order did not need to be producers of valuable items such as pottery. Such communities were only required to hook up into the exchange networks that linked them to supply routes. As long as the societies had effective demand for the items created by the enabling economic and subsistence environment, communities would thrive into complex city-states. However, the communities had to deal with rampant rivalries which in most cases, would escalate into

warfare with neighbouring states. These would eventually lead to loss of linkages to already established exchange networks. Potters in the hinterland sites serviced coastal city-states if the states lived in harmony with their neighbours. In the case of warfare, there was the possibility of involuntary transfer of merchandise where enemy states plundered wealth.

### Results of desktop survey

The contribution of mineralogical analysis in archaeology has been discussed extensively in several overviews of techniques and nature of materials applied. A review was done of the geology maps of the study area with the purpose of predicting the types of minerals expected in the local clays in the selected sites (Table 1).

	<b>Pate Island (Siyu)</b>	<b>Kilifi</b>	<b>Mombasa (includes Kwale)</b>	<b>Taita /Taveta</b>
<b>Rock type</b>	Quaternary sediments	Tertiary sediments Triassic sediments Jurassic sediments	Tertiary sediments Triassic sediments Jurassic sediments	-Tertiary sediments -Tertiary Volcanoes Carboniferous, -Permian/Basement
<b>Minerals and rock particles expected in clay</b>	Evaporates, mudstone, halite, gypsum, silts	Titanium minerals, gemstones, barytes, gypsum, manganese, sandstones, limestone, shale, quartz, calcium sulfates	Silica sand, rare Earth elements, Niobium, calcium sulfates,	Iron ore, manganese, graphite, calcium sulfates
<b>Soil composition</b>	Fluvisols, planosols, silts	Alluvium, sand	--	--

Table 1: The geology of Pate Island, Kilifi, Mombasa, and Taita/Taveta

### Results of microscopy of temper

The raw materials for temper were identified using a light microscope (x40) and a hand lens of x5 magnification (Table 2). This approach, combined with the skills in identifying geological materials, made it possible to identify different materials within the fine clay paste. The main petrographic group that characterize tempering materials were quartz, limestone, mica grit, pebble grit and gravel or coarse sand with grain size of approximately 0.5 millimetres (mm). A combination of quartz with other materials such

as crushed charcoal, coarse sand, unidentified plant material, and pebble grit was noted as a major phenomenon in the clay paste.

<b>Tempering materials</b>	<b>Frequency</b>	<b>Percentage</b>
Quartz and limestone	96	26.2
Quartz and unspecified shiny mineral	84	22.0
Quartz	56	15.3
Gravel and quartz	22	6.0
Fine sands	20	5.5
Indefinable	18	4.9
Mica	18	4.9
Quartz and charcoal	9	2.5
Gravel	8	2.2
Quartz and sand	6	1.6
Quartz and fine sand	5	1.4
Quartz and plant materials	5	1.4
Limestone	3	0.8
Coarse sand	3	0.8
Pebbles and quartz	3	0.8
Gravel and limestone	3	0.8
Fine sand and gravel	3	0.8
Charcoal	1	0.3
Pebbles	1	0.3
Unspecified shiny mineral particles	1	0.3
Limestone and dull white pieces	1	0.3
<b>Total</b>	<b>366</b>	<b>100.0</b>

Table 2: Frequencies of tempering material

A desktop study of geological maps helped predict the possible mineral compounds expected in the pottery if these were made using local clay. However, microscopic analysis revealed more non-local minerals, as summarized in Table 3.

Clay source	Observed mineral present in the potsherds	Predicted minerals from geological maps and desktop survey
Pate Island	Quartz, silica sands, limestone, calcium, manganese, magnesium, iron, tin	Evaporates, mudstone, halite, gypsum, silts
Kilifi	Manganese, sandstones, limestone, shale, quartz, calcium sulfates	Titanium minerals, gemstones, barytes, gypsum, manganese, sandstones, limestone, shale, quartz, calcium sulfates
Mombasa (including Kwale)	Calcium sulfates	Silica sand, rare Earth elements, Niobium, calcium sulfates,
Taita/Taveta		Iron ore, manganese, graphite, calcium sulfates

Table 3: Observed and predicted mineralogy of potsherds

### Atomic mass spectrometry (AMS)

The samples used in the Atomic Mass Spectrometry (AMS) procedure comprised 15 potsherds, five from each category of sherds, clay and rock. The samples were drawn by simple random sampling from three trenches. Mineralogical analysis of the selected samples was done at the National Department of Geology and Mines (NDGM), Nairobi. The results are presented in Tables 4-7.

Five sherds samples were tested for their mineralogical composition. The five sherds show similar mineralogical composition, as seen in Table 4. However, sherd 4 shows an isolated case of relatively low Calcium Oxide (CaO) and Magnesium Oxide (MgO) at 0.67% and 0.26%, respectively. Sherd 4 also shows a relatively low light on Ignition (LOI) of 4.95% against an average of 5.25% on ignition.

Trench	Sample	SiO <sub>2</sub> (%)	Al <sub>2</sub> O <sub>3</sub> (%)	CaO (%)	MgO (%)	Na <sub>2</sub> O (%)	K <sub>2</sub> O (%)	TiO (%)	Mno (%)	Fe <sub>2</sub> O <sub>3</sub> (%)	LOI (%)
Sherds	1	67.16	13.16	1.20	3.10	2.59	0.90	0.45	0.08	2.91	5.14
	2	66.51	15.69	1.01	3.20	2.52	1.10	0.39	0.06	3.46	5.19
	3	65.35	15.72	1.62	2.70	1.84	0.90	0.21	0.10	3.83	5.67
	4	66.88	16.89	0.67	0.26	3.19	1.70	0.94	0.05	3.63	4.92
	5	68.34	13.16	1.03	3.22	2.50	1.03	0.23	0.09	2.90	5.34
	A*	<b>66.84</b>	<b>14.92</b>	<b>1.10</b>	<b>2.49</b>	<b>2.52</b>	<b>1.12</b>	<b>0.44</b>	<b>0.07</b>	<b>3.34</b>	<b>5.25</b>

A\*-Average

Table 4: Mineralogy of potsherds

Five clay samples were tested for mineralogical composition as shown in Table 5. Sample 1 shows the highest level of Silicon Oxide (SiO<sub>2</sub>) at 68.66%. Sample 5 contains the lowest level of SiO<sub>2</sub> at 35.70%. Except for small variation between sample 1, on the one hand, and samples 2, 3, 4, and 5, on the other, the mineralogical composition of the samples is similar. The intensity of light emitted when the crashed clay is ignited appears to be the lowest in sample one at 8.92% compared to the other samples and against the total average of 13.83%.

Trench	Sample	SiO <sub>2</sub> (%)	Al <sub>2</sub> O <sub>3</sub> (%)	CaO (%)	MgO (%)	Na <sub>2</sub> O (%)	K <sub>2</sub> O (%)	TiO (%)	Mno (%)	Fe <sub>2</sub> O <sub>3</sub> (%)	LOI (%)
Clay	1	68.66	10.77	0.32	0.05	0.56	0.79	0.32	0.40	7.00	8.92
	2	45.17	15.66	8.50	5.10	1.23	1.82	0.91	0.40	5.46	16.21
	3	40.05	18.12	6.09	3.45	2.43	0.97	0.34	1.02	7.56	17.67
	4	46.98	17.76	5.23	2.34	1.15	0.14	0.65	0.05	4.30	16.83
	5	35.70	16.65	8.56	3.75	2.56	0.78	0.29	0.21	4.70	9.56
	A*	<b>47.31</b>	<b>15.79</b>	<b>5.74</b>	<b>2.93</b>	<b>1.58</b>	<b>0.9</b>	<b>0.50</b>	<b>0.41</b>	<b>5.80</b>	<b>13.83</b>

\*Average Table 5: Mineralogy of clay

Five rock samples were tested and found to have mineralogical composition levels as shown in Table 6 above. All five samples depict similar mineralogical composition with minor variations observed in sample 2. Sample 2 depicts a high level of Ferrous Oxide ( $\text{Fe}_2\text{O}_3$ ) at 7.12% against an average of 5.64%.

Trench	Sample	$\text{SiO}_2$ (%)	$\text{Al}_2\text{O}_3$ (%)	CaO (%)	MgO (%)	$\text{Na}_2\text{O}$ (%)	$\text{K}_2\text{O}$ (%)	TiO (%)	Mno (%)	$\text{Fe}_2\text{O}_3$ (%)	LOI (%)
Rock	1	40.23	15.71	6.34	4.98	0.67	1.98	0.34	0.45	5.67	9.34
	2	35.09	16.23	10.96	5.32	1.45	1.56	0.91	0.42	7.12	8.45
	3	36.89	15.67	8.34	6.06	2.09	1.87	0.56	0.56	6.23	10.89
	4	49.01	14.50	7.06	2.48	0.45	1.78	0.43	0.60	5.75	11.01
	5	37.07	16.67	7.94	2.56	0.93	1.35	0.78	0.01	3.45	11.47
	<b>A*</b>	<b>39.65</b>	<b>15.75</b>	<b>8.12</b>	<b>4.28</b>	<b>1.11</b>	<b>1.70</b>	<b>0.60</b>	<b>0.40</b>	<b>5.64</b>	<b>10.23</b>

Table 6: Mineralogy of rock samples

There is a marked variation between the averages of the mineralogical composition of potsherds, clay, and rock samples as shown in Table 7. However, clay and rock samples have relatively close averages of Tin oxide (TiO) and Manganese Oxide (MnO).

Type of sample	$\text{SiO}_2$ (%)	$\text{Al}_2\text{O}_3$ (%)	CaO (%)	MgO (%)	$\text{Na}_2\text{O}$ (%)	$\text{K}_2\text{O}$ (%)	TiO (%)	Mno (%)	$\text{Fe}_2\text{O}_3$ (%)	LOI (%)
Sherds	66.84	14.92	1.10	2.49	2.52	1.12	0.44	0.07	3.34	5.25
Clay	47.31	15.79	5.74	2.93	1.58	0.90	0.50	0.41	5.80	13.83
Rock	39.65	15.75	8.12	4.28	1.11	1.70	0.60	0.40	5.64	10.23

Table 7: Average mineralogical composition of potsherds, clay, and rock samples

Table 8 shows that there is a marked similarity in the averages of the mineralogical composition of sherds and clay. However, a little variation is depicted in the averages of Calcium oxide (CaO) at 1.32% against an average of 5.79%.

Trench	Sample	SiO <sub>2</sub> (%)	Al <sub>2</sub> O <sub>3</sub> (%)	CaO (%)	MgO (%)	Na <sub>2</sub> O (%)	K <sub>2</sub> O (%)	TiO (%)	Mno (%)	Fe <sub>2</sub> O <sub>3</sub> (%)	LOI (%)
Sherds	1	63.99	16.31	0.98	3.25	3.37	0.84	0.44	0.06	3.26	4.86
	2	65.06	14.75	0.86	2.30	3.52	2.87	0.37	0.03	2.76	5.07
	3	67.65	16.02	1.56	3.53	2.01	1.90	0.32	0.05	3.45	5.84
	4	68.76	15.23	1.27	3.26	3.76	2.14	0.95	0.12	2.73	4.63
	5	69.22	17.01	1.93	2.78	2.10	0.99	0.19	0.07	3.52	5.76
<b>Average</b>		<b>66.94</b>	<b>15.86</b>	<b>1.32</b>	<b>3.02</b>	<b>2.95</b>	<b>1.75</b>	<b>0.45</b>	<b>0.07</b>	<b>3.14</b>	<b>5.23</b>
Clay	1	69.85	11.56	1.22	2.41	3.22	1.81	0.43	0.08	4.12	6.56
	2	60.82	15.54	7.93	2.87	2.07	2.6	0.91	0.4	3.46	4.98
	3	67.26	17.87	5.65	3.39	3.15	0.91	0.34	1.02	3.52	5.04
	4	64.19	19.03	6.45	3.11	3.65	1.17	0.65	0.05	2.75	5.61
	5	65.68	15.82	7.71	2.57	2.72	1.76	0.29	0.21	3.64	4.43
<b>Average</b>		<b>65.56</b>	<b>15.96</b>	<b>5.79</b>	<b>2.87</b>	<b>2.96</b>	<b>1.65</b>	<b>0.52</b>	<b>0.35</b>	<b>3.50</b>	<b>5.32</b>

Table8: Averages of the mineralogical composition of potsherds and clay samples from Jomvu in Mombasa

### Discussion

One objective of this study was to identify the main ingredients, or the raw materials used in the manufacture of the pottery found at Siyu. Most of the mineral ingredients observed in the sample of Siyu pottery are not endemic in the Lamu archipelago. From the review of geological maps, it was expected that the samples of potsherds would exhibit minerals such as evaporates, halite, gypsum, and silts or their derivatives. Instead, mineral compounds with high levels of quartz, silica sands, limestone, and calcium were revealed. Other minerals or their compounds observed in the potsherds but do not

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occur naturally in the Lamu archipelago are manganese, tin, and ferrous iron. There are no known natural sources of quartz in the coast region except for some amounts in the upper coast region of Voi and Kitui (Ochola, 2011). The only possibility for the presence of clays or temper-containing quartz in the manufacture of the ancient pottery found at Siyu is through import. Importation or procurement of finished pottery from other places may have occurred with Siyu being a major recipient of wares from southern settlements such as Ungwana, Mombasa and Jomvu.

In this study, comparative mineralogical analysis of archaeological potsherds and clay from the site of Siyu reveals that the mineral composition in the samples is not similar. It is, therefore, less likely that the pottery was made with clay from Siyu. What does this mean regarding ceramic innovation and production among the ancient people of Siyu? From the results above, it appears that there was minimal technological innovation relating to ceramic production. Although Chittick (1984) suggests that Pate Island may have been the source of clay for Manda pottery, no pottery kilns have been found on the island or anywhere near the ancient settlements of Siyu, Shanga or Mbui (Horton 1996; Chami et al. 2012). It is unlikely that any innovation was attempted to produce pottery for local use. The urbanite population was able to devise a way to meet the huge demand for pottery. One plausible explanation was to take adaptive advantage of a flourishing supply of finished pottery products or materials from other localities. For instance, the variability in the Tana Tradition pottery from sites in the Lamu Archipelago and those around the Tana Delta was attributed to outsourcing clay and an unavailability of suitable materials due to geological set up (Horton 1996; M'mbogori 2013). The analysis of Tana tradition sherds from these sites tend to have in common but varying in proportion, petrographic groups such as coarse sand, fine sand, grit mica, limestone (shell and coral) (Nkirote, 2013: 208) (Table 2). However, it is not uncommon to have sherds from the same vessel to depict a marked variation in petrographic components such as these due to the potter's technical behaviour or diversity of geologic set up that invariably determined the mineralogical component of clay. Using ethnographic data Nkirote (n.d.) has determined that some of the coastal communities have a choice of more than one source including one where customers brought in their own clay. In other cases, potters travelled for more than 20km to fetch the clay bearing the desired quality.

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The ancient urbanite settlement of Siyu has registered one of the largest assemblages of Tana tradition pottery in the Lamu Archipelago. One would expect that such a large volume of pottery assemblage could be attributed to local manufacture. However, previous research has not been able to recover evidence of local kilns and nearby sources of clay (Namunaba 2020; Horton 1996; Chittick 1984). It is credible that through the established exchange networks in the southern urbanite settlements around the Tana Delta and beyond the potters were able to connect with the demand for pottery in Siyu and other urban centres in the Lamu archipelago.

### **Conclusion**

In conclusion, an effective exchange network worked very well as a counteracting mechanism to prevent the innovation of local pot-making in Siyu. Further, it is clear that for the industrial production of pottery to flourish, certain environmental pre-requisite resources were necessary, such as potting skill, fuel for firing, water, and clay. However, where such pre-requisites lacked, people were able to withstand the friction of distance to procure finished products from far. The study has shown that Siyu did not make her pottery, rather procured finished products from other sites by hooking up in an already thriving exchange network.

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