The ceramic ecology of Florida: compositional baselines for pottery provenance studies

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Abstract The success of pottery provenance studies is fundamentally dependent upon spatially patterned variation in the composition of exploited clay resources. Uniformity in clay composition within a region and recognizable differences between regions of interest are essential requirements for determining provenance, but these parameters are difficult to satisfy in study areas such as the coastal plain of the southeastern USA in which chemical and mineralogical variation tend toward continuous gradients. In an attempt to improve the reliability and validity of pottery provenance studies in the area, this research investigates compositional variation in raw clay samples from across Florida and southern Georgia through NAA (n=130) and petrographic analysis (n=99). The results indicate that fourteen distinct compositional regions can be differentiated, ranging from 50 km to 400 km in length. These regions dictate the direction and minimum distance a pottery vessel must have been transported in order to be recognized as nonlocal through compositional analysis. The validity of the proposed compositional regions is supported by previous case studies focused on assemblages from three of the regions. In each case, vessels were transported from other compositional regions more than 100 km away.

Keywords Neutron Activation Analysis; petrographic analysis; pottery production; mobility; exchange

Introduction

The importance of artifact provenance in archaeological research has never been greater. Archaeological research programs are increasingly focused on movement, including movements constitutive of past interaction networks (e.g., Knappett 2013; Mills et al. 2015; Wright 2014), aggregation centers (e.g., Gilmore 2014; Schachner 2011; Spivey et al. 2015), migrations (e.g., Bader 2012; Bellwood 2014; Smith 2014), and biographies (e.g., Joyce and Gillespie 2015; Van Keuren and Cameron 2015). Materials analysis that investigates geochemistry, mineralogy, and mineral inclusions has proven integral to such efforts by furnishing archaeologists with perhaps their most direct means for tracing the routes of people and things across space, as well as into and out of various relationships. The techniques involved help provide the kind of quantitative data needed to lend scientific credence to largely theoretical network-based and biographical models (Jones 2004; Joy 2009; Joyce 2012).

Archaeologists have long used various geochemical and mineralogical analyses of pottery as a means to determine its provenance. If the resulting data can be resolved to a geographical scale that is compatible with the distance earthenware vessels are suspected to have been transported, provenance can be ascertained. As Neff (1998) points out, however, interpretations are constrained by the reliability and validity of the sampling and methods. Reliability is degraded by error, both analytical and random, as well as within-source variation. Validity is diminished by systematic effects that result from ceramic compositional changes during manufacturing, use, and post-depositional processes (e.g., leaching and diagenesis) (e.g. Buxeda i Garrigós 1999; Golitko et al. 2012; Mommersen 2001; Picon 1986, 1992). Both reliability and validity can be enhanced, in part, through raw material sampling and by combining complementary methods such as neutron activation analysis (NAA) and petrographic analysis (Arnold et al. 2000; Hein et al. 2004; Neff 1998:125).

In Florida and southern Georgia, stylistic and typological attributes of aboriginal pottery indicate that vessels may have been widely transported during every cultural historical period in which they were produced (ca. 2000 BC to AD 1700). Nevertheless,
confirmation of the movement of pots through geochemical and petrographic provenance research has often proven difficult due to the lithology of the southern Coastal Plain. Clays across this region are expected to be fairly homogeneous in terms of chemical composition and mineral inclusions, owing to the ultimate derivation of sediments largely from the same protolith, the southern Appalachian Mountains. Despite this fact, patterned regional variations do exist and have been the basis for successful identification of pottery provenance for more than two decades (e.g., Ashley et al. 2015; Cordell 1984, 2004; Gilmore 2014; Steponaitis 1996; Stoltman 2015; Wallis et al. 2010; Wallis 2011). In this study, NAA and petrographic analysis are used to outline spatial variation in the chemistry and mineral inclusions of clays from the Coastal Plain of Georgia and Florida. Based on these results, archaeological prospects for reliable provenance indicators are evaluated and the most appropriate spatial scale for sourcing vessels is presented.

The resulting data are considered in relation to successful archaeological case studies in three parts of the study area that each involved the circulation of Pre-Columbian pots over hundreds of kilometers.

**Geological Background**

The present study area includes the Coastal Plain region of southern Georgia and most of Florida. Broadly distributed across most of this area (except south of Lake Okeechobee) are high-quality clays suitable for pottery manufacture, having moderate to high plasticity and lacking excessive aplastics (Anderson 1988). Here, focus is directed toward the near-surface clayey deposits and associated sand-sized mineral inclusions that composed the array of potential raw material resources available to Pre-Columbian potters. Despite their shared ultimate origin in the southern Appalachian Mountains, the sediments in question exhibit a substantial range of variability in

![Figure 1 Exposed outcrop ages in the study region.](image-url)
chemistry and mineral inclusions due to differences in the timing, conditions, and mechanisms of deposition, as well as their frequently divergent post-depositional histories.

Georgia’s Coastal Plain encompasses more than half of the state, extending from the Fall Line south to the Atlantic Ocean and Florida border (Figure 1). It is partitioned into several sections by southwestern flowing rivers, most of which originate in the Piedmont. The Coastal Plain is Georgia’s youngest geological province, with most of its surface outcrops and deposits Miocene or more recent in age. These surficial units sit atop a basement of igneous and metamorphic rocks along the Fall Line and more recently formed limestone and sedimentary rock farther south (Herrick and Vorhis 1963).

Clays in the Coastal Plain are primarily alluvial and their composition is strongly influenced by the origin of the river transporting them. Along the valleys of rivers with headwaters in the Piedmont, such as the Savannah, Ogeechee, and Altamaha rivers, major clay minerals typically include kaolinite and vermiculite, with illite, chlorite, and montmorillonite (a type of smectite) forming minor constituents (Neiheisel and Weaver 1967; Peavear 1972). The kaolinite in this case is thought to be a product of the weathering of Piedmont feldspars within the warm, wet climatic conditions of the southeastern USA, while vermiculite is derived from muscovite and phengite schists (Peavear 1972:320). In contrast, river valleys such as the Satilla, which are wholly within the Coastal Plain, contain both montmorillonite and kaolinite eroded from Coastal Plain sedimentary rocks, along with smaller amounts of illite (Peavear 1972:320–321). Illite comprises a larger constituent of some clays along the Georgia coast, possibly a result of potassium uptake by other clay minerals in the marine environment (Peavear 1972:334). Additional clays such as palygorskite and sepiolite are common in Miocene-aged components of the Hawthorn Group, a heterogeneous limestone and clay unit that underlies virtually the entire study area, but is rarely exposed at the surface in Georgia (Hetrick et al. 1987).

A similar pattern exists with regard to sand-sized, heavy minerals that occur in conjunction with Coastal Plain clays. Piedmont draining river sediments are characterized by an abundance of very to moderately unstable minerals such as pyroxenes and epidote, while those from Coastal Plain rivers typically contain ultrastable to stable minerals, including zircon, tourmaline, rutile, staurolite, sillimanite, and kyanite, in addition to epidote (Windom et al. 1971:501). Other minerals found commonly throughout the Coastal Plain include micas (muscovite and biotite), feldspars, and various opaque minerals (Windom et al. 1971:502).

In addition to variation between river valleys, evidence exists indicating substantial differences along the length of individual Georgia rivers. In a geochemical mapping project of near-surface Georgia sediments, Cocker (1999) found that most measured elements from samples along rivers are depleted in direct proportion to their distance from the mountains, becoming especially low in the Coastal Plain. This general pattern has been corroborated by a subsequent study of clays and pottery along the course of the Altamaha/Ocmulgee drainage (Wallis 2011:101).

Whereas geological studies of near-surface sediments in Georgia suggest a number of largely predictable chemical and mineralogical trends, previous research in Florida instead points to a more complex patchwork of different sediment compositions. Florida’s near-surface geology reflects a long history of interspersed carbonate and siliciclastic depositional processes (Scott 1997, 2011). At the beginning of the Paleocene (65 mya), carbonate sediments came to dominate deposition on the platform, eventually resulting in a thick mantle of limestone, dolostone, and evaporites that covered virtually its entire expanse. A dramatic uplift of the Appalachians early in the Miocene (~25 mya) resulted in a marked increase in siliciclastic sedimentation across Florida that continued up to the Quaternary, albeit interspersed with additional periods of substantial carbonate deposition, especially in southern Florida. Miocene to Holocene sediments now blanket the entire platform, ranging from less than 1 m thick in some areas to more than 300 m in others (Scott 1997, 2011). These heterogeneous near-surface deposits were the primary source of the various clays, quartz sands, and heavy minerals used by pre-Columbian potters.

With a few exceptions in the northwest peninsula, the oldest exposed clays in the state are Miocene in age and belong to the aforementioned Hawthorn Group. The Hawthorn in Florida consists of varying mixtures of clay, sand, carbonates, and phosphates, most of which were deposited in a marine setting (Scott 1988, 1997). The diverse formations that make up the Hawthorn reflect a broad range of depositional conditions and repeated reworkings that have resulted in an array of lateral and vertical variations in lithological composition (Compton 1997; Hetrick et al. 1987; Ispihording 1971; Scott 1982, 1988). The upper layers of the Hawthorn are particularly clayey, containing frequent beds of the Mg-rich clay minerals palygorskite and montmorillonite (Scott 1982:133, 1988). Phosphates are virtually ubiquitous throughout the Hawthorn Group but are especially concentrated in southwest Florida within the Bone Valley region of the Peace River formation (Figure 1), where they have been extensively mined (Altschuler et al. 1964; Compton 1997; McClellan and Eades 1997). The Hawthorn is primarily a subsurface unit in Florida, but it outcrops along the edges of the underlying Ocala limestone platform, along the southwest coast, and in restricted areas of the eastern panhandle (Scott 1982:130).

Clays can also be found within more recent Plio-Pleistocene deposits in Florida. Secondary (i.e., sedimentary) clays occur in most counties in the northern half of the state, especially along the St. Johns River (Bell 1924:117). In western and northern parts of the
peninsula, impurities in limestone have also been weathered out to form localized residual clay deposits that are usually highly calcareous (Bell 1924:111). Kaolinite deposits occur in east-central Florida in a 40-km-wide belt from southern Clay County to southern Polk County, as well as in the panhandle (Calver 1949). The origin of these deposits, which rarely exceed 45 percent kaolin content, is poorly understood, with possibilities including weathering in place or deposition under deltaic conditions (McClellan and Eades 1997:150).

The accessory minerals found within and alongside Florida’s clay deposits, because they were ultimately derived from the Southern Appalachians and Piedmont, include the same light and heavy minerals listed above for the Georgia Coastal Plain (Isphording 1971; McClellan and Eades 1997). Heavy minerals are most abundant in the northern half of the state, where they were concentrated through wind and waves along ancient shorelines that now form terrestrial sand ridges (Fountain et al. 2009:20). One of these ridges, called Trail Ridge, extends for more than 200 km from the Altamaha River in southern Georgia south to Bradford County in north-central Florida. It has been extensively mined for a variety of heavy minerals and boasts one of the world’s highest concentrations of the titanium mineral ilmenite (Garnar 1971; McClellan and Eades 1997; Pirkle et al. 1971). Other heavy minerals common to northern Florida include leucoxene, rutile, zircon, and staurolite, epidote and amphibole, and less commonly, kyanite, sillimanite, tourmaline, spinel, topaz, and corundum (McClellan and Eades 1997). However, only ilmenite, rutile, zircon, epidote, amphibole, kyanite, and tourmaline have been observed in pottery and clays from the study region (e.g., Cordell 1992; 1993; 2006; 2007; Cordell and Deagan 2013; Pluckhahn and Cordell 2011).

**Archaeological Background**

Pottery manufacture began by ca. 5000 years ago on the coasts of South Carolina and Georgia and spread south into peninsular Florida within a few centuries (Gilmore 2015; Sassaman 2002). This “fiber-tempered” pottery was the earliest in North America and incorporated strands of Spanish moss (Tillandsia usneoides) into the fabric (Gilmore 2014, 2015; Simpkins and Allard 1986). By the beginning of the Woodland period ca. 3000 years ago pottery manufacture was ubiquitous across the entire study region and beyond, encompassing a diverse array of surface treatments and paste recipes. Surface treatments included various modes of smoothing, punctuating, incising, stamping, painting, slipping, pinching, scoring, and various combinations of these. Commonly used tempers included quartz sand, crushed limestone, charcoal, and grog. Sponge spicules, the biosilicate remains of freshwater sponges, are another common inclusion, but their origin in pottery is the subject of debate (Cordell and Koski 2003; Rolland and Bond 2003). Although spicules are undeniably naturally occurring inclusions in some clays, their extremely high frequency in pottery might also be accounted for by added tempers of muck or sponges.

Some of these broadly defined tempering traditions can be delimited in space and time. However, because all of the temper materials are available in many parts of the study region, none can be used alone as a reliable indicator of provenance. Quartz sand and “grit” (coarse and larger particle sizes, often polycrystalline or polycrystalline; also see Stoltman 1989:149) overwhelmingly dominates post-1000 BC pottery assemblages in many parts of the study region. In contrast, limestone tempering predominates between ca. 500 BC and AD 1000 on the northern Gulf coast of peninsular Florida, and charcoal tempering is confined to the mouth of the St. Johns River ca. AD 200 to 600 (Ashley and Wallis 2006; Wallis et al. 2011). Pottery with dense concentrations of sponge spicule inclusions, known as St. Johns, is found throughout Florida but is most prevalent in east Florida along the St. Johns River for which it is named and the parallel Atlantic coast.

Although local pottery production is assumed to have been possible in every part of the study region, no production locus or facility within a site has ever been documented archaeologically. The lack of archaeological visibility is likely due in part to the typically small, domestic scale of production that left ephemeral traces. However, this explanation seems unlikely for pottery production at some of the largest sites that served as villages and ceremonial centers, home to hundreds of people and arguably thousands of locally made pots at any one time. These large sites existed during every period in which pottery was made, and pottery was produced on a sufficiently large scale that the lack of evidence for manufacturing areas is enigmatic. Based on the physical properties of archaeological vessels and sherds and ethnohistorical records, most pottery in the region is known to have been made with clay coils, finished with a paddle and anvil technique, and fired in open bonfires (e.g., Milanich and Fairbanks 1980:78–79; Milanich 1994:129–130; Sassaman 2002:416–417; Holmes 1903:50–53).

A similar lack of evidence pertains to clayey sediment exploitation. No clayey deposit with signs of pre-Columbian quarrying has ever been recorded in the region. Presumably the lack of evidence stems from the fact that many clayey deposits are exposed in small and isolated areas, making them difficult for archaeologists to find, and along the exposed banks of various bodies of water clays are subject to erosion that obscures ancient evidence of quarrying (Albero 2014:60). In addition, clayey sediments are not often found within archaeological sites and therefore have not been the focus of intensive archaeological investigation. Small stockpiles of human-transported unfired clayey sediments have been documented within middens in a few cases (e.g., Ashley et al. 2015). Contemporary potters also yield few clues to the locations of exploited clays. Traditional pottery production by Native Americans ceased
during the mid-19th century by immigrant Seminoles (Weisman 1989) and the early-mid eighteenth century by native Florida peoples who did not survive the onslaught of disease, warfare, and enslavement brought about by European exploration and settlement (e.g., Milanich 1995). The use of local clays by contemporary artisans is quite rare. Commercial mining of clays for construction materials such as bricks gives some indication as to where the locations of clays suitable for making pottery but has also likely eradicated any evidence of more surficial mining practices of the past.

Given the limitations of archaeological visibility for clay exploitation and pottery production and the widespread distribution of clayey sediments, the probability of finding the exact locations from which ceramic resources were collected for making a particular archaeological pottery vessel is extremely low. Accordingly, our sampling efforts have been designed to document the “effective ceramic environment” (Rice 1987:314–315) of the study region in terms of the availability and variability in clayey resources. This project is built upon the premise that a series of samples can be used to understand the distribution and range of variation in bulk chemistry and mineral inclusions, among other properties, within available clayey soils. Given spatial patterning in the results, these data can serve as proxies for the actual clayey deposits that were exploited for making pottery in ancient times (Wallis 2011:92).

Sampling
Clay samples derive from many disparate archaeological projects over many years (e.g., Ashley et al. 2015; Cordell 1984; Gilmore 2014; Wallis 2011; Wallis et al. 2010) and are curated at the Ceramic Technology Laboratory, Florida Museum of Natural History. All samples with existing NAA and petrographic data were employed in the analysis, and additional samples were analyzed to fill geographic gaps in coverage. As part of the collection protocols, clay deposits were georeferenced and their form and extent were described. All samples derived from clayey soil deposits with easy accessibility, either exposed along the banks of rivers, streams, and estuaries, or excavated within two meters of the existing ground surface. Given the generally low rates of sedimentation and pedogenic accumulation in the region over the past 5000 years—the period in which pottery was produced—collected samples surely would have been accessible to ancient potters. Most of the clayey samples are suitable for making pottery based on measured characteristics such as water of plasticity, linear drying shrinkage, and firing behavior (e.g., Cordell 1984; 1985; 1992; Pluckhahn and Cordell 2011). A low percentage of samples may not have been suitable for pottery production because of excessive aplitic inclusions. However, most of these aplitics consist of quartz sand and could have been removed through sieving and levigation. All samples derive from natural sedimentary or pedogenic deposits with the exception of four samples from archaeological contexts. Each of these archaeological samples was a small prepared clay mass recovered from midden context (e.g., Ashley et al. 2015). A total of 99 samples was analyzed by petrography and 130 samples were analyzed by NAA. Sixty-three samples were analyzed by both methods.

Methods
NAA and multivariate statistical techniques for data analysis and interpretation are described in detail elsewhere and are only briefly summarized here (Baxter 1992; Baxter and Buck 2000; Bieber et al. 1976; Bishop and Neff 1989; Glasscock 1992; Neff 1992, 1994, 2000, 2002). NAA was conducted at the University of Missouri Research Reactor. Clay samples were placed in a drying oven for 24 hours at 100 degrees C and subsequently fired at 800 degrees C with a soak time of 30 minutes in order to drive off water and other volatile substances. The clay briquettes were ground into powder using an agate mortar and pestle. Powder from each clay sample was divided into two vials, allowing for separate short and long irradiations and a total of three gamma counts. SRM-1633a Coal Fly Ash and SRM-1633b Coal Fly Ash were used as the calibration standards for all elements except Ca, the former for all analyses prior to 2011 and the latter for all analyses during 2011 and after. The standard for Ca in all samples was SRM-688 Basalt Rock. Altogether, the two irradiations and three gamma counts resulted in the detection of 33 elements for each sample. Elements measured in the analysis were As, La, Lu, Nd, Sm, U, Yb, Ce, Co, Cr, Cs, Eu, Fe, Hf, Rb, Sb, Sc, Sr, Ta, Tb, Th, Zn, Zr, Al, Ba, Ca, Dy, K, Mn, Na, Ti, and V. Nickel (Ni) was below detection limits in the majority of samples and was not included in the subsequent analysis.

Statistical analysis of the data included converting raw elemental concentrations to base-10 logarithms to compensate for differences in magnitude between major and trace elements and reducing the data to principal components. Occasionally the concentration of an element was close to its detection limit and yielded missing data. Each missing value was substituted with a value that minimized the Mahalanobis distance for the specimen from the group centroid (Glasscock 1992). Spatial interpolations of chemical concentrations were calculated using an inverse distance weighted technique. For the purposes of spatial interpolations, elemental concentrations were normalised to the reference standard SRM-679 Brick Clay.

With respect to petrographic analysis, a briquette from each clay sample was formed, fired at 600°C for 30 minutes, allowed to cool, and then thin sectioned. This firing temperature and duration most closely approximates or just exceeds firing temperature of most pre-Columbian pottery in the study region (e.g., Cordell 1984) and therefore facilitates comparability. Using a petrographic microscope with a mechanical
stage, point counts were made for quantifying the relative abundance of inclusions (following Stoltman 1989, 1991, 2001, 2015). A minimum of 175 points were counted for each thin section. Each point or stop of the stage was assigned to one of the following categories: clay matrix, void, silt particles, clay lumps, ferric concretions or nodules, clayey/phosphatic nodules, limestone and shell, biogenic silica (sponge spicules, phytoliths, diatoms), and very fine through very coarse quartz and other crystalline aplastics of varying compositions. Most of the point counts were made using the 10X objective, but the 25X objective (with plane-polarized light) was used to search for occurrence of siliceous microfossils such as sponge spicules, phytoliths, and diatoms. Size of aplastics was estimated with an eyepiece micrometer with reference to the Wentworth Scale (Rice 1987:38). A comparison chart of percent particle abundance (Rice 1987:349 [Figure 12.2]) was also used for estimating relative abundance of constituents occurring in low frequency.

Results

NAA results

Interpolations of element concentrations demonstrate significant geographic patterning (Figure 2). Clays from
the center of the state are depleted in K, while those on the coasts are enriched, particularly those from northeast Florida and the Apalachicola River area. K enrichment is explained by the frequency of illite in the former location and inclusions of mica within samples from the latter. Rb shows a similar distribution, as is expected given known terrestrial abundance relationships of K and Rb and the association of Rb with illites (Schnug and Haneklaus 1996).

Ca is enriched in most, though not all, samples from southwest Florida, reflecting the prevalence of calcareous clays in that region. Sitting above the marl and limestone of the Hawthorn formation are beds of calcareous clays that are exposed and readily accessible for collection in southern Florida. The distribution of U enrichment overlaps with Ca enrichment. Clays in southwest and south-central Florida are enriched in U, which corresponds with the phosphate and kaolinite of the Peace River formation. All other regions are depleted in U with the exception of two anomalous samples in northern areas of the peninsula.

Other elements show distinctive distributions that are correlated with the age of exposed outcrops. Many elements show a pattern of enrichment in the western half of peninsular Florida, corresponding with older sediments, and depletion in the eastern half, mostly dominated by younger deposits. This is true of V, Cr, Eu, and Tb, but these elements vary in

Figure 3 Inverse distance weighted interpolation of clay sample principal component scores.
terms of how far east the higher concentrations extend and whether clays from north-central Florida or southwest Georgia are also enriched. Fe concentrations are highest in northeast Florida and the Florida panhandle and notably depleted in many of the samples from southwest and central Florida.

The results of Principal Components Analysis (PCA) also demonstrate spatial patterning (Figure 3). Interpolations of sample scores on the first three Principal Components (PC) show consistent distinctions among several regions. Southwest Florida scores high on PC1, with samples dominated by enrichment in Ca and Na. Central peninsular Florida shows high scores on PC2, with samples variously enriched in U or Sr and/or depleted in K and Na. In contrast, northeast Florida and the Apalachicola valley clays score low on PC2, owing to elevated concentrations of K and Na and depletion of U and Sr. Finally, the relative contributions to PC3 are distributed more-or-less evenly across many elements. Clays from the upper (southern) St. Johns region score low on PC3 due to depletion in most elements while areas of the central Gulf coast up through southwest Georgia score high because of enrichment in elements such as La, Lu, Tb, Eu, and Dy.

Drawing on the elements that exhibit the strongest spatial patterning in their concentrations within the clay samples, a maximum of 14 composition regions can be differentiated (Figure 4). These regions show mutually exclusive combinations of element concentrations (Table 1). Bivariate plots of PC scores generally demonstrate a high level of overall similarity among most samples within these regions (Figure 5). However, all but five of the composition regions contain at least one sample outlier with anomalous chemistry. Regions with no outliers include R2 (Ocmulgee River, n=4), R3 (Appalachicola valley, n=5), R4 (Tallahassee Hills, n=4), R7 (northeast Florida coast, n=16), and R9 (central peninsular Florida, n=5). Although sample sizes are too small to evaluate the statistical probability of group membership, partitions between these five groups can be consistently distinguished visually in bivariate plots.

Among composition regions that show overlapping bulk chemistry distributions in PC plots, one or more elements can be used to distinguish them. For example, R5 (north-central Florida) and R7 (northeast Florida coast) are similar to one another in the concentrations of many elements, but a partition is discernible in the concentrations of K and Cr (Figure 6).

Samples that could not be assigned to composition regions occur in areas peripheral to or between the defined regions and exhibit pronounced chemical variation. One group of eight samples from the western panhandle that might logically form a compositional region shows disparate elemental signatures that cannot be resolved.

Petrographic Results

Based on point counting of 99 samples, eight fabric groups were defined by the analysis (Table 2;
Table 1 Mean and standard deviation of element concentrations for each compositional region.

| Region | Na (ppm) | Ca (% | Fe (% | Zn (ppm | As (ppm | Sc (ppm | Ti (% | V (ppm | Cr (ppm | Mn (ppm | Co (ppm | Zr (ppm | Sb (ppm | Rb (ppm | Sr (ppm | Zr (ppm | Ba (ppm | La (ppm | Ce (ppm | Nd (ppm | Sm (ppm | Eu (ppm | Tb (ppm | Dy (ppm | Yb (ppm | Lu (ppm | Hf (ppm | Ta (ppm | U (ppm |
|--------|---------|-------|-------|---------|---------|--------|-------|-------|--------|-------|--------|-------|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1      | 832     | 10    | 15    | 45     | 3       | 1      | 0.38  | 45    | 50     | 220    | 10     | 252    | 0      | 45    | 316    | 34    | 342    | 26    | 112    | 5     | 46    | 72    | 4      | 0      | 9      | 7     | 3      | 3      | 3      |
| 2      | 1308    | 19    | 16    | 50     | 11.93   | 0.46   | 5.00  | 1308  | 11.93  | 205    | 50     | 160    | 3.84  | 1308  | 368    | 138   | 335    | 73    | 127    | 11    | 48    | 73    | 4      | 0      | 9      | 7     | 3      | 3      | 3      |
| 3      | 1991    | 20    | 17    | 173    | 17.93   | 0.67   | 0.97  | 1991  | 17.93  | 1357   | 17    | 79     | 1.27  | 1991  | 342    | 335   | 332    | 33    | 127    | 12    | 58    | 72    | 4      | 1      | 2      | 0     | 1      | 1      | 1      |
| 4      | 1107    | 13    | 13    | 173    | 17.93   | 0.67   | 0.97  | 1107  | 17.93  | 1357   | 17    | 79     | 1.27  | 1107  | 342    | 335   | 332    | 33    | 127    | 12    | 58    | 72    | 4      | 1      | 2      | 0     | 1      | 1      | 1      |
| 5      | 1049    | 15    | 15    | 115    | 15.01   | 0.67   | 0.97  | 1049  | 15.01  | 115    | 10    | 10     | 1.01  | 1049  | 342    | 335   | 332    | 33    | 127    | 12    | 58    | 72    | 4      | 1      | 2      | 0     | 1      | 1      | 1      |
| 6      | 709     | 14    | 14    | 1049   | 15.01   | 0.67   | 0.97  | 709   | 15.01  | 115    | 10    | 10     | 1.01  | 709   | 342    | 335   | 332    | 33    | 127    | 12    | 58    | 72    | 4      | 1      | 2      | 0     | 1      | 1      | 1      |
| 7      | 362     | 11    | 11    | 709    | 15.01   | 0.67   | 0.97  | 362   | 15.01  | 115    | 10    | 10     | 1.01  | 362   | 342    | 335   | 332    | 33    | 127    | 12    | 58    | 72    | 4      | 1      | 2      | 0     | 1      | 1      | 1      |
| 8      | 549     | 11    | 11    | 709    | 15.01   | 0.67   | 0.97  | 549   | 15.01  | 115    | 10    | 10     | 1.01  | 549   | 342    | 335   | 332    | 33    | 127    | 12    | 58    | 72    | 4      | 1      | 2      | 0     | 1      | 1      | 1      |
| 9      | 689     | 11    | 11    | 709    | 15.01   | 0.67   | 0.97  | 689   | 15.01  | 115    | 10    | 10     | 1.01  | 689   | 342    | 335   | 332    | 33    | 127    | 12    | 58    | 72    | 4      | 1      | 2      | 0     | 1      | 1      | 1      |
| 10     | 752     | 11    | 11    | 709    | 15.01   | 0.67   | 0.97  | 752   | 15.01  | 115    | 10    | 10     | 1.01  | 752   | 342    | 335   | 332    | 33    | 127    | 12    | 58    | 72    | 4      | 1      | 2      | 0     | 1      | 1      | 1      |
| 11     | 12253   | 12    | 12    | 709    | 15.01   | 0.67   | 0.97  | 12253 | 15.01  | 115    | 10    | 10     | 1.01  | 12253 | 342    | 335   | 332    | 33    | 127    | 12    | 58    | 72    | 4      | 1      | 2      | 0     | 1      | 1      | 1      |
| 12     | 7169    | 12    | 12    | 709    | 15.01   | 0.67   | 0.97  | 7169  | 15.01  | 115    | 10    | 10     | 1.01  | 7169  | 342    | 335   | 332    | 33    | 127    | 12    | 58    | 72    | 4      | 1      | 2      | 0     | 1      | 1      | 1      |
| 13     | 173     | 4     | 4     | 709    | 15.01   | 0.67   | 0.97  | 173   | 15.01  | 115    | 10    | 10     | 1.01  | 173   | 342    | 335   | 332    | 33    | 127    | 12    | 58    | 72    | 4      | 1      | 2      | 0     | 1      | 1      | 1      |
| 14     | 62      | 6     | 6     | 709    | 15.01   | 0.67   | 0.97  | 62    | 15.01  | 115    | 10    | 10     | 1.01  | 62    | 342    | 335   | 332    | 33    | 127    | 12    | 58    | 72    | 4      | 1      | 2      | 0     | 1      | 1      | 1      |
Figure 7. As Table 2 and Figure 7 show, there is tremendous overlap in matrix and sand percentages for the clay samples. Most clays contain sands in varying quantities, dominated by monocrystalline quartz, as does much of the pottery we have studied. Feldspars (plagioclase and microcline), muscovite mica, and epidote are commonly observed accessory minerals, but usually in trace amounts, less than one percent. Other accessory minerals noted more rarely include biotite, ilmenite, rutile, zircon, amphibole, kyanite, and tourmaline (e.g., Cordell 1992; 1993; 2006; 2007; Cordell and Deagan 2013; Pluckhahn and Cordell 2011).

But the fabric groups were not defined by matrix and sand percentages. Fabrics were defined on the
basis of abundance of particular mineral or rock constituents in some cases (e.g., mica, limestone, ferric nodules), and consistent presence of siliceous microfossils (sponge spicules, diatoms) in most others. The first group, designated Fabric SandB, makes up over half of the sample (n=50) and is characterized by quartz sand as the predominant constituent (Figure 8a), with a paucity of siliceous microfossils, mica, and other constituents. This category is heterogeneous in terms of quantity of sand and sand texture (particle size) (Figure 7b) but fairly homogeneous in sand composition (Figure 7c).

Two categories are similar to Fabric SandB but differ in the frequency of siliceous microfossils. Fabric
SandD (n=5) is characterized by the prominence of quartz sand and occasional but consistent occurrence of sponge spicules and phytoliths (Figure 8b). The grouping is heterogeneous in terms of bulk composition and sand texture but homogeneous in sand composition. Fabric SandEb (n=13) is similar to Fabric SandD but includes consistent occurrence of diatoms among the siliceous microfossils (Figure 8c). This grouping is heterogeneous in terms of bulk composition and sand texture but is fairly homogeneous in sand composition.

Fabric MICA is micaceous (n=4). The grouping is characterized by prominence of quartz sand, 3–5% mica (muscovite) (Figure 8d), and variable occurrence of siliceous microfossils. The grouping is fairly homogeneous in terms of bulk composition, sand composition, and sand texture. Fabric SPC (n=3) is characterized by common sponge spicules, between 10 and 19 percent (Figure 8e). The group is relatively heterogeneous in terms of bulk composition and sand texture, but homogeneous in sand composition. Fabric CALC (n=9) is characterized by a calcareous matrix composition (Figure 8f), indicated by calcite high order birefringence and vigorous positive reaction to HCl (matrix character of the other fabrics ranges from nearly opaque to very low birefringence). This grouping is heterogeneous in terms of bulk composition and sand texture, but is relatively homogeneous in terms of sand composition. Fabric LMS (n=5) contains limestone and/or shell constituents in an otherwise non calcareous matrix (Figure 8g). The grouping is fairly homogeneous in bulk and sand composition, but very heterogeneous in sand texture. Except for the limestone or shell constituents, members of Fabric LMS are consistent with SandB, SandD, and SandEb fabrics. Fabric NODULES (n=10) contains frequent ferric and/or clayey phosphatic nodules (Figure 8h). Nodule composition is heterogeneous, as is bulk composition. Sand texture is fairly homogeneous.

Despite apparent extreme variability in sand abundance in our sample, over 50 percent of samples within each fabric group exhibit compositions well within range of actual pottery samples (Table 2). In comparing our compositional data with actual pottery samples, it is apparent that composition variation in some pottery assemblages can be explained by variation in naturally present constituents in the clays (Figure 9). Although some samples were probably not viable candidates for pottery making owing to excessive sandiness, we speculate that over half of the samples whose compositional ranges occur outside those of the pottery could be processed with minimal effort to increase or decrease sand abundance. Sand texture or particle size
Table 2  Summary descriptions of fabric/resource groupings (petrographic data).

| clay fabric groups | sample size (pet/ NAA) | %matrix | %sand | sponge spicules | diatoms | mica | comments | % matrix (pottery)\(^a\) | % sand (pottery)\(^a\) |
|--------------------|-------------------------|---------|-------|-----------------|---------|------|----------|----------------|----------------|
| B                  | 50/27                   | 21-96\% | 1-78\%| none to rare    | none    | none | otherwise similar to matrix D | 43-70\% | 26-55\% |
|                    |                         | 50-5.5\%| 47\% |                 |         |      |           | 57\% (32)\(^b\) | 40\%(32)\(^b\) |
| D                  | 5/4                     | 40-84\% | 4-59\%| 1-3\%           | none    | none | otherwise similar to matrix B | 50-75\% | 21-47\% |
|                    |                         | 58\% | 36\% |                 |         |      |           | 62\% (16)\(^c\) | 35.5(16)\(^c\) |
| Eb                 | 13/8                    | 35-93\% | <1-60\%| 1-3\%          | occ to freq | none | otherwise similar to matrix D | 49-79.5\% | 19-47\% |
|                    |                         | 65\% | 28\% |                 |         |      |           | 62.5\% (9)\(^d\) | 35 \%(9)\(^d\) |
| SPC                | 3/1                     | 52-79\% | 11-26\%| 9-25\%         | none    | none | sandy St. Johns | 36-70\% | 16-40\% |
| calc               | 9/8                     | 29-99\% | 0-57\% | var            | var     | none | otherwise similar to matrix B | 53\%(11)\(^e\) | 23\%(11)\(^e\) |
| calc               |                         | 61.5\% | 32\% |                 |         |      | calcareous matrix | NA | NA |
| LMS                | 5/5                     | 30-74\% | 12-58\%| none in most    | none    | none | 1 case with 1% spc and 3% mica | 55-64\% | 28-35\% |
| MICA               | 4/4                     | 54-72\% | 14-41\%| var            | P in two cases | 3-5\% |           | 47-79.5\% | 13-49\% |
| NODULE             | 10/6                    | 30-86\% | 4-67\% | var            | none    | none | otherwise similar to matrix B | 31-74\% | 22-58\% |

\(^a\)selected samples from ongoing Swift Creek pottery study (Cordell et al. 2015) unless noted otherwise. Number after percentage in parentheses is sample size.

\(^b\)For %matrix, more than 50\% of samples fall into range of pottery samples; processing would be minimal in most other samples; for %sand, almost 50\% of samples fall into range of pottery samples; processing would be minimal in most other samples; excessive processing would be required for about 25\% of the samples outside the pottery range.

\(^c\)For %matrix, 2 of the 5 cases fall into range of pottery samples; processing would be minimal in 2 of the other samples. For %sand, 2 of the 5 cases fall into range of pottery samples; processing might be extensive in the other 3 samples.

\(^d\)For %matrix, more than 50\% of samples fall into range of pottery samples; processing would be minimal in most other samples. For %sand, almost 40\% of the samples occur within the pottery range; processing would be moderate to extensive for the other samples.

\(^e\)Sandy St. Johns pottery samples from Cordell 2007; Cordell and Deagan 2013; Cordell et al. 2015. For % matrix, 2 of the 3 samples are within range of pottery; processing of the third would be minimal. For %sand, 1 of the 3 samples occurs within the pottery range, but processing of the other 2 would be minimal.

\(^f\)For %matrix, 3 of the 5 samples are within range of pottery; processing of a fourth sample would be minimal. For %sand, all samples are within the pottery range.

\(^g\)For %matrix and % sand, all four micaceous samples occur within range of micaceous pottery.

\(^h\)For %matrix, 6 of the 10 nodule samples occur within the range of nodule fabric pottery; processing of the others would be minimal. For %sand, 5 of the 10 samples occur within the range of nodular pottery; minimal to extensive processing would be required of the others.
variation within Florida pottery also conforms to sand size variation observed in the natural clay samples. Given the known variability in Florida pottery, highly calcareous clays were not used in pottery making.

Some of the fabric groups show restricted spatial distributions while others do not (Figure 10). Among the groups that are ubiquitous or scattered throughout the study area are fabrics SandB, SandD, SPC, and NODULES. However, phosphatic nodules (n=5), with one exception, are restricted to western and southern Florida, reflecting exposures of the Hawthorn group.

Clays of Fabric SandEb, defined by the presence of siliceous microfossils that include diatoms, are nearly restricted to coastal northeast Florida and southeast Georgia, coincident with chemical composition Region 7. Single occurrences are also recorded in north-central Florida and southwest Florida. Nearly 80 percent of calcareous clays in the sample come from southwest Florida, but they also occur on occasion in northerly areas of the state. This distribution correlates with the Hawthorn group outcropping of carbonates in southwest Florida. One
calcareaous sample from southwest Florida also contained nine percent spicules, just below the threshold for membership in the SPC fabric. Micaceous clays with high frequencies of mica occur exclusively in southeastern Georgia and the Florida panhandle, although clays with occasional incidence of mica occur throughout the study area. Finally, the small sample of Fabric LMS occurs only in deposits from southwest and northwest Florida.

Trends in the raw compositional data are also notable (Figure 7). Most of the sandiest clays derive from the northwest part of the study area that includes north-central Florida, the Florida panhandle, and southwest Georgia. These areas also contain the finest textured clays in terms of sand size, while the coarsest are located in southwest Georgia, Florida panhandle, and the middle St. Johns. Finally, non-quartz mineral inclusions are most common in the northern half of the study area and decrease toward the south.

In summary, if compositional regions were to be constructed on the basis of fabric groupings alone, three broad regions could be identified: (1) southwest Florida, characterized by a high frequency of calcareous clays and phosphatic nodules; (2) coastal northeast Florida/southeast Georgia, typified by a high frequency of clays containing diatoms and fine textured sand particles; (3) and northwest Florida/southeast Georgia, with micaceous clays.

Discussion

Many of the fabric groupings identified by petrographic analysis show correlations with chemical composition and corresponding compositional regions (Figure 11). Not surprisingly, calcareous clays are enriched in Ca, but they also show consistency in the enrichment of other elements such as U and K, reflecting their southwest Florida provenance. Micaceous clays are, naturally, enriched in K and Rb but also enriched in Na and Fe. Fabric SandEb, defined primarily by the presence of diatoms, is nearly equivalent to chemical region 7, and thus members show consistent enrichment in Fe, Rb, and K. In terms of provenance indicators, the spatial distribution of fabric groupings therefore corroborate, rather than further separate, some of the suggested chemical composition regions.

Together, these data predict that the scale at which the provenance of pottery can be identified varies greatly across the study region. Compositional regions range from 50 km (e.g., R11) to nearly 400 km (e.g., R7) in length. Notably, almost none of the compositional regions are bounded on every side by clay samples with contrasting compositions, and therefore each region may be larger than presently defined. Moreover, outlier chemical and fabric compositions are common and boundaries between compositional regions are ambiguous. These sources of variation ultimately degrade the reliability of provenance studies conducted on too fine a scale or on the margins of compositional regions. The shape and scale of compositional regions and their often amorphous boundaries favor identification of nonlocal vessels transported between the coasts and the interior, or more generally, transported more than 150 km.

The direction of vessel transport is critically important to determining the travel distance required to identify nonlocal production. A pot from the coast of northeast Florida (R7) has a good possibility of being distinguished from pots made just 50 km inland (R6).

![Figure 11](image.png)  
Figure 11 Bulk chemistry of fabric groupings plotted on Principal Component 1 and Principal Component 2.
In contrast, a vessel made on the Atlantic coast of central Florida (R7) and transported 300 km north to the coast of Georgia (also R7) might blend into the local assemblage unless located far enough north that micaceous clays are more common (Figure 7).

Although useful in establishing baseline trends in regional chemistry and mineral inclusions, specific clays in the region have only occasionally provided convincing “matches” to pottery samples. In fact, the range of variation among clays within identified compositional regions tends to exceed the variation of earthenware vessels presumed to have been manufactured locally in those regions. A comparison of all pottery samples (n=1290) and clay samples (n=130) analyzed by NAA bears out these differences in terms of chemical composition (Figure 12). The pottery samples derive from three separate projects (Ashley et al. 2015; Gilmore 2014; Wallis 2011; Wallis et al. 2014) and encompass much of the time span during which pottery was produced as well as a large range of tempers such as fiber, quartz sand, grog, charcoal, and sponge spicules. These samples include vessels made locally in every one of the chemical composition regions except R13 and R14. Even with this variability in temper constituents, the range of variation in bulk chemical composition among the pottery samples is smaller than among the clay samples. This difference is undoubtedly due in part to the pottery manufacturing process, in which paste recipes achieved a degree of standardization by consistently removing and adding constituents. The difference between pottery and clays may also result from analysis of clays that are not suitable for vessel production, such as those that are too sandy or too calcareous. Future ceramic ecology projects in the study area can strengthen these inferences by screening clay samples according to manufacturing viability and performance characteristics.

Archaeological Implications

Fortunately, the scale and direction of ancient vessel transport in many cases matches the scale of reliability for nonlocal provenance indicators. Case studies from three regions demonstrate the efficacy of NAA and petrography in pottery provenance studies in the study area. Each project identified nonlocal vessels that had been transported between the compositional regions defined above and were located more than 100 km from their respective clay sources.

1. Gilmore (2014) investigated the scale of the social interactions conducted at Late Archaic Orange period (4600–3500 cal B.P.) shell mounds in Florida by focusing on the provenance of the fiber-tempered pottery contained within mounds and related places. A total of 288 sherds was analyzed from five contemporary Late Archaic contexts (including two large shell mounds, a specialized shellfish processing area, and two separate habitation spaces) at Silver Glen (sites 8LA1 and 8MR123), a sprawling shell mound complex in the middle St. Johns River valley. All of the sampled sherds were submitted for NAA, while 75 of them were also subjected to petrographic analysis.

Based on the NAA results, three distinct chemical composition groups were identified, which together account for 52.7% of the total analyzed sample. Group 1 (n=33) and Group 2 (n=46) are chemically very similar, with Group 1 exhibiting slightly higher concentrations of most measured elements. The only
exceptions are Mn, As, Zr, and Hf, all of which show higher concentrations in Group 2 than Group 1. Group 3 (n=73) stands out as the most chemically distinct and least internally variable of the three groups. It is characterized by substantially lower concentrations of most elements compared to Groups 1 and 2 and is especially deficient in Fe and Cr. Group 3 does, however, exhibit the highest levels of three elements—Na, Sb, and U.

A comparison of the chemical data from the pottery to clay reference samples reveals that Group 1 and Group 2 sherds align closely with clays found local to the Silver Glen complex and the surrounding area of northeast Florida. Like the pottery, local clays are relatively enriched in elements such as Fe, K, and Rb and correspondingly depleted in Na and U. This close correspondence is readily apparent in the consistent clustering of northeast Florida clays with Groups 1 and 2 across multiple principal components plots. In contrast, a chemical profile resembling Group 3—characterized by comparatively high concentrations of Na, Sb, and U but extremely low levels of Fe—has yet to be located in the region surrounding Silver Glen. The closest likely source is more than 200 km to the southwest, between Tampa Bay and Charlotte Harbor, where exposures of phosphate-rich clay deposits within the Hawthorn group exhibit a virtually identical chemical pattern.

The petrography results help to clarify and corroborate the provenance conclusions drawn from NAA. Overall, Group 1 and Group 2 sherds tend to mirror northern Florida clays in their relative richness in ferric nodules and mica. The primary distinction between these two groups is the higher concentration of heavy-mineral-rich sand present in Group 2, likely tying these sherds to Trail Ridge or a similar relic coastline feature in northern Florida. Group 3 sherds were conversely found to be finer-grained and largely devoid of mineral inclusions aside from occasional quartz sand. The most distinctive paste characteristic of Group 3 pottery is its consistent abundance of freshwater sponge spicules and other siliceous microfossils, most likely a sign of cultural tempering practices rather than natural clay composition.

Together, the NAA and petrography results suggest that Group 1 and Group 2 vessels were manufactured from raw materials collected locally in northeast Florida, while Group 3 vessels were imported, perhaps over a distance of hundreds of kilometers. Importantly, Groups 1 and 2 pottery is distributed across all five of the tested Silver Glen contexts, while Group 3 samples are restricted to the complex’s two shell mounds. These data indicate that Silver Glen’s mounds were the sites of larger, more socially inclusive social interactions than other types of contemporary places. This provides substantial empirical credibility to the argument that at least some Late Archaic monuments were the sites of large-scale gatherings that integrated people and pots from across large sections of peninsular Florida.

2. Two projects have focused on the Atlantic coast of northeast Florida and southeast Georgia spanning the Middle Woodland through Early Mississippian periods (ca. AD 200 to AD 1250). Among Woodland burial mounds and villages in northeast Florida and southeast Georgia, Wallis (2011; Wallis et al. 2010; Wallis and Cordell 2013) analyzed 313 vessels by NAA and 69 samples by petrography. Pottery samples across the entire project area were generally chemically similar to one another except in the concentrations of Co and Cr. Samples from southeast Georgia sites were dominated by consistently elevated Co concentrations and depleted Cr while pottery from northeast Florida sites were depleted in Co and enriched in Cr. Mineral inclusions were generally similar across the region except southeast Georgia samples contained consistently higher frequencies of mica (muscovite) inclusions while some northeast Florida samples were distinguished by frequent phytoliths and occasional sponge spicules.

A total of 11 pottery samples on lower St. Johns River sites were identified as likely originating from the area of the Altamaha River between Region 2 and Region 7, about 120 km north of the lower St. Johns. The nonlocal vessels were identified by Co enrichment and Cr depletion. Trends in vessel morphology, a fabric characterized by grit temper, and maker’s marks from the wooden paddles used to impress vessels with various designs all corroborated the identification of an Altamaha River provenance. Although making up only six percent of the total northeast Florida sample assemblage, the Altamaha-made vessels comprised 23 percent of the burial mound sample. All but two were Swift Creek Complicated Stamped vessels that exhibited impressions of the iconography from carved wooden paddles. These vessels were the basis for interpreting evidence of Middle Woodland interactions as consisting primarily of gift exchanges linked to mortuary ceremonies.

On the basis of NAA results alone, Ashley et al. (2015) identified nonlocal pottery on Early Mississippian period sites on the lower St. Johns and northeast Florida coastal barrier islands. A total of 116 sherds from across eastern Florida, Georgia, and southern South Carolina was analyzed. Thirteen Ocmulgee Cordmarked samples from southeast Florida (Region 7), making up 24 percent of the assemblages from that region, were identified as originating from the Ocmulgee/Altamaha River area (Region 2). The occurrence of these nonlocal wares was further supported by the results of sherid oxidation analysis. In this case, the distance between locations of production and deposition may have been as much as 200 km. As with the Wallis (2011) study, nonlocal samples were enriched in Co. However, Cr depletion was a less reliable indicator. The data were instrumental in identifying both imported and locally produced Ocmulgee Cordmarked wares in domestic and ritual St. Johns II (AD 900–1250) contexts. A consistent minority ware on lower St. Johns sites, the local and nonlocal Ocmulgee Cordmarked
vessels were indistinguishable stylistically, morphologically, and on a microscopic (45X) level, leading Ashley et al. (2015) to argue that their presence reflects extensive exchange and perhaps direct visits and intermarriage among residents of the two regions. These social relations would have been critical to providing access to the Early Mississippian world of the interior continent whereby St. Johns II communities obtained exotic materials such as copper, stone and a variety of other minerals.

3. As part of an ongoing project, Wallis et al. (2014) studied Middle and Late Woodland period (ca. AD 200 to 800) Swift Creek Complicated Stamped pottery from across the Gulf coastal plain of Florida and Georgia. Pottery from sites in Region 1 (southwest Georgia; n=73), Region 4 (eastern panhandle; n=65) and Region 8 (peninsular Gulf coast; n=149) were analyzed by NAA and petrography. Locally-made pottery vessels from these regions generally conform to the expectations of the clay analysis presented in this paper with one major exception. Pottery from sites in southwest Georgia, rather than being depleted in K as predicted by the clay analysis, is almost uniformly enriched. This difference indicates that the three clayey sediment samples analyzed so far are not representative of the available ceramic resources in the region.

Among the many locally-made vessels across the study region, one of the site assemblages on the peninsular Gulf coast was particularly notable for the high frequency of nonlocal pottery derived from the other two regions. Among 12 samples from the Hughes Island Mound (8DI45), five are local to Region 8, depleted in Ba and enriched in Cr. The remaining seven samples are clearly nonlocal, enriched in Ba and depleted in Cr. Most of the nonlocal vessels have a micaceous fabric. Differentiating between Region 1 and Region 4 has proved challenging, but on the basis of depleted Cr and enriched Na, five of the vessels were more likely made in Region 1 while two may have been made in Region 4. Matching maker’s marks of unique wooden manufacturing tools—“paddle matches”—that span these regions confirms the transport of vessels up to 300 km. These data denote a high frequency in the transport of vessels from the largest civic-ceremonial centers, located in compositional regions 1 and 4, to small burial mounds on the Gulf coast.

Conclusion

Through analysis of clay samples collected throughout Florida and southern Georgia, this study assessed variation in bulk chemistry and mineral inclusions among ceramic resources that were available to ancient potters. Compositional variation among clays is spatially patterned to the extent that 14 unique compositional regions can be identified. Elements with notable spatial patterning in clay samples across the region include K, Ca, V, Cr, Fe, Co, Rb, Sb, Ba, Eu, Tb, and U. Mineral inclusions with spatial patterning include mica (muscovite), calcareous matrix, phosphatic nodules, and diatoms. Variability in bulk chemistry and mineral inclusions among clayey samples even within compositional and the inferred paste processing traditions of ancient potters result in very few undeniable “matches” between clayey samples and archaeological pottery. Anomalies are not infrequent in the present sample, particularly in bulk chemistry, and demonstrate that the scale at which pottery provenance can be reliably identified is minimally hundreds of kilometers.

The defined compositional regions account for the success of multiple pottery provenance studies that have identified nonlocal vessels transported between 100 km and 300 km from their constituent clay sources. The distribution of diagnostic signatures in chemistry and mineral inclusions predicts that longitudinal transport of vessels, such as between the coasts and interior parts of the study area will be analytically recognizable at a smaller scale than most latitudinal movements such as along the interior of the Florida peninsula.

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Supplemental Data

Supplemental data for this research can be accessed at 10.1080/20548923.2015.1133119.

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