WOODLAND POTTERY SOURCING IN THE CAROLINA SANDHILLS

Edited by

Joseph M. Herbert
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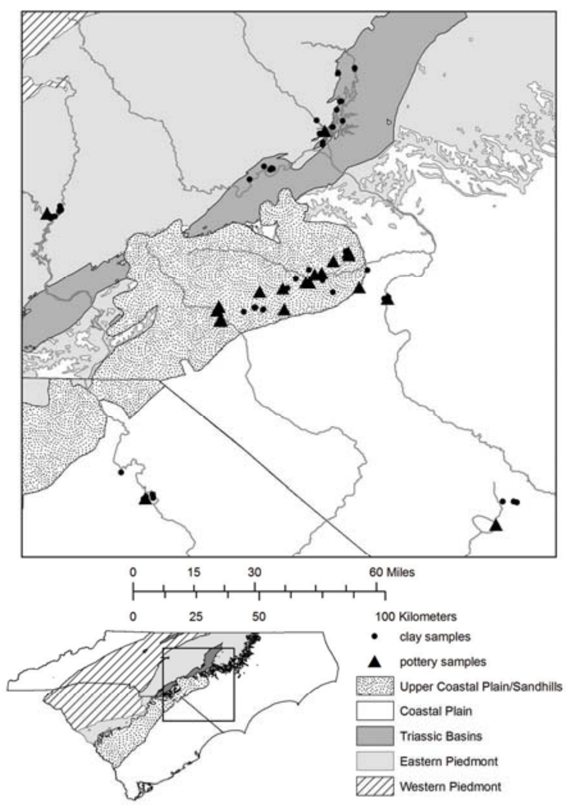
Theresa E. McReynolds



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Abstract

This study compares local clays with pottery from archaeological sites in the Carolina Sandhills, Piedmont, and Coastal Plain to explore patterns of residential mobility and resource use among people living in the Fort Bragg region of the Sandhills during the Woodland period (ca. 1500 BC–AD 1600). The performance characteristics of clays from each region were assessed through experiments that served to focus the study on anthropologically appropriate clay samples, i.e., those that might actually have been used to make pottery. Neutron activation analysis (NAA), X-ray diffraction (XRD), and petrography were combined to characterize regional variation in the chemical and mineral constituents of prehistoric pottery and clay resources in order to identify the sources of raw materials used to make pottery found on Sandhills sites.

Although it is often assumed that serviceable clay is ubiquitously distributed across the Carolina landscape, this study demonstrates that clay resources with the right combination of strength and plasticity are difficult to find and may be largely absent from some regions. Replication experiments revealed that there are very few clay resources in the North Carolina Sandhills that are suitable for making pottery vessels, suggesting that most pottery found on Fort Bragg sites was made from nonlocal resources and subsequently transported into the region.

The results of geochemical and mineralogical analyses support this conclusion. They confirm that Piedmont and Coastal Plain resources are compositionally distinct. They also indicate that most Fort Bragg pottery samples more closely resemble Coastal Plain and Piedmont resources than local Sandhills materials. The available evidence indicates that Coastal Plain resources may be better represented among the Sandhills sherds than Piedmont resources, but at least three Fort Bragg sherds appear to have been fashioned from Piedmont materials.

The significant implication of these results is that pottery was transported over broad regions, implying that the acquisition of pottery from distant sources was a routine feature of Woodland-period subsistence in the Sandhills. Such materials could have been obtained through high levels of residential mobility, exchange, or both, and we recommend that additional studies be designed to evaluate the specific strategies Woodland people used to obtain pots.

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Preface

This report is a companion volume to *Stone Quarries and Sourcing in the Carolina Slate Belt* (Steponaitis et al. 2006). Both of these multiyear, interdisciplinary research projects reflect the commitment of the Cultural Resources Management Program at Fort Bragg to understanding the archaeological record of prehistoric cultures inhabiting the Sandhills of North Carolina. The idea for these projects was conceived in what might seem an unlikely setting, a lively holiday party hosted by the Research Laboratories of Archaeology. A conversation with John Rogers, emeritus professor of Geological Sciences at the University of North Carolina at Chapel Hill, concerning the use of samarium and neodymium isotopes to identify metavolcanic stone sources set the lithic sourcing study in motion. A significant conclusion of that study was the importance of using multiple analytical methods to assign artifacts to specific source locations, and those methods were modeled for the present study.

The pottery sourcing project described in this volume was supported by several institutions involving many participants. It was funded by the Department of Defense and contracted through the Army Corps of Engineers Construction Research Engineering Laboratory, supervised by Mike Hargrave (and formerly by Tad Britt), and by Jeff Irwin, Program Manager, Cultural Resources Management Program at Fort Bragg. Contractual arrangements with consultants were managed by Paul Webb, Regional Manager, TRC Environmental, Inc., who also provided valuable editorial assistance. A number of scholars were recruited for their expertise and skills: Mike Glascock and Jeff Speakman of the University of Missouri for their expertise in element geochemistry and archaeological sourcing, Michael Smith of the University of North Carolina Wilmington for his knowledge of ceramic petrography, and Paul Schroeder and Sheldon Skaggs of the University of Georgia for their expertise in X-ray diffraction. Theresa McReynolds was brought into the project for her background in both archaeology and geology. The research was designed and implemented by the editors, with Vin Steponaitis at the University of North Carolina at Chapel Hill acting in an advisory capacity.

Prior to beginning this research, it was known that some pottery found on Sandhills sites contained crushed rock that originated in the Piedmont. With this knowledge serving as the starting point of exploration, we posed these questions: if some pottery was being transported into the Sandhills from Piedmont locations, then how common was the practice, and where were the original sources? To address these questions, it was necessary to characterize both pottery and clays found in the Sandhills and surrounding regions. As a result of this study, it may now be asserted with confidence that pottery vessels were being transported into the Sandhills from both Piedmont and Coastal Plain sources on a regular basis. Significantly, results indicate that the quality of clay necessary for making pots is not at all common in the Sandhills. In fact, clay of pottery-making quality was difficult to find in every region surveyed, including the Piedmont and lower Coastal Plain. The implication of this finding for modeling resource procurement strategies in a Woodland-period economy is that scheduling visits to resource areas with good clay would be a high priority, perhaps an essential condition for determining the location of settlements. This conclusion is not likely to come as a surprise to modern potters, but may be surprising to many archaeologists who have routinely assumed that pottery clay is ubiquitously distributed across the landscape, perhaps because pottery is everywhere to be found in abundance. One significant achievement of this project therefore is that the results represent an important first step in dispelling this myth. Also important is the fact that this research demonstrates with some chemical and mineralogical specificity that clay resources in the Carolina Piedmont and Coastal Plain provinces differ in ways that are geologically predictable. The data presented here should therefore be useful in future attempts to determine source areas for pottery found in these regions.

A number of people, other than those previously mentioned, contributed to this project in important ways. Hal Pugh spent a long day visiting clay exposures on Fort Bragg and assessing their quality. Hal and his wife Eleanor Minnock-Pugh were also very gracious in assisting with firing clay test tiles and providing information about matters concerning the assessment of pottery clays. Steve Watts provided assistance in building and firing pots using primitive technologies. Steve Davis, Brett Riggs, and Carl Steen assisted in acquiring pottery samples from key sites in the study area. Dolores Hall was instrumental in obtaining the Archaeological Resources Protection Act permit necessary to collect clays near the Doerschuk site, and Gene Ellis assisted in gaining access to the site. Sandra Bonner aided in the collection of clay samples near the Waccamaw site. Francis Ferrell assisted in securing a Special Gamelands Permit for collecting clay from the shoreline of B. Everett Jordan Lake. Pat Day graciously provided the opportunity to fire test tiles and replica pots. We were surprised and delighted by the interest of so many who contributed to this project, and we pleasantly anticipate future collaborations.

Joseph M. Herbert
Cultural Resources Management Program at Fort Bragg

Chapter 1

Introduction

Joseph M. Herbert and Theresa E. McReynolds

Archaeological surveys at Fort Bragg, a 65,000-ha Army installation in the North Carolina Sandhills, have identified thousands of prehistoric sites that indicate people utilized the region throughout prehistory. Component size and tool diversity suggests that most sites were occupied by small groups for relatively short periods of time. The presence of metavolcanic projectile points and debitage reveals that Archaic flintknappers in the Sandhills obtained raw materials from Piedmont sources (Steponaitis et al. 2006). The use of Piedmont-derived stone to temper pottery found at sites on Fort Bragg suggests that this pattern of reliance on resources from outside of the Sandhills may have persisted into the Woodland period. One way to positively identify and determine the extent of long-distance resource procurement during the Woodland is to establish the sources of the raw materials used to make the pottery found on Sandhills sites.

This study is designed to explore Woodland-era clay procurement by identifying possible source areas in the Sandhills, Piedmont, and Coastal Plain through the comparison of chemical and mineral constituents of pottery and clays. The identification of regional clay sources and the ability to link them with Sandhills pottery provides a means to address broad economic issues such as the degree of residential mobility and the geographic regions frequented by Woodland hunter-gatherers. There are three specific objectives: (1) to characterize pottery and clays from the Sandhills and neighboring regions, (2) to match pottery found in the Sandhills with specific regions of clay and temper resources, and (3) to use the resulting information to address questions related to the role of ceramic production in residential mobility and social interaction.

Multiple lines of evidence are combined to assess variation in pottery and clays from several sites in the Sandhills and a few key sites in the Coastal Plain and Piedmont. Performance tests and replication experiments identify clays suitable for making low-fired earthenware, and geochemical and mineralogical analyses reveal potentially diagnostic differences between resource regions. Based on the combination of physical, geochemical, and mineralogical evidence, Sandhills pots are tentatively associated with other resource regions.

Recognizing where pottery was made and how widely it was transported is essential to reconstructing the Woodland cultural and economic landscape. If ceramic resources were procured directly, the movement of pots can be used to infer the scale of settlement mobility (Binford 1979:261). If pots were obtained through exchange, their distribution reveals aspects of cultural interaction. Recognizing pottery source locations and subsequent movement of pots improves our understanding of Woodland-period settlement, economy, and social dynamics.

Woodland Occupation of the North Carolina Sandhills

Our perspective on prehistoric human ecology in the Sandhills is strongly influenced by the modern landscape and our understanding of the available natural resources. Located in the upper Coastal Plain, the Sandhills are the remnants of an ancient coastal dune environment (Figure 1.1). Today they consist of sandy terraces dissected by low-gradient streams and narrow wetlands. The dry uplands are dominated by pine-savannah, pine-scrub-oak-Sandhill, and xeric-Sandhill-scrub vegetation communities (Noss 1989:211; Russo et al. 1993; Schafale and Weakley 1990; Sorrie et al. 2006). The moister slopes and bottomlands are characterized by mast-producing hardwoods and the fauna they attract. As a result of the low carrying capacity of the uplands, the region is often viewed as less productive than the adjacent Piedmont and has been called the “Pine Barrens,” “Pine Plains,” and even “Sahara of the Carolinas.”

Nevertheless, a decade of archaeological survey on Fort Bragg has identified at least 4,200 prehistoric sites and isolated finds, demonstrating that the Sandhills attracted hunter-gatherer bands for 10,000 years (Abbott 1994; Benson 2000; Benson and Braley 1998; Braley 1989a, 1989b, 1992; Braley and Schuldenrein 1993; Clement et al. 1997; Culpepper et al. 2000; Gray and McNutt 2004, 2005; Grunden and Ruggiero 2007; Idol 1999; Idol and Becker 2001; King 1992a, 1992b; Loftfield 1979; Ruggiero 2003, 2004; Ruggiero and Grunden 2004; Trinkley, Adams, and Hacker 1996; Trinkley, Barr, and Hacker 1996a, 1996b, 1997, 1998). On the 38,573 ha surveyed at Fort Bragg thus far, approximately one prehistoric site has been found for every 8 ha, and Woodland (pottery-bearing) components are found at approximately 900 of these sites. The ephemeral nature and small size of most Woodland components suggest that hunter-gatherer groups employed foraging strategies designed to exploit dispersed resource patches through high mobility (Cable and Cantley 2005:391).

The geographic area exploited by these hunter-gatherers was presumably very large. The distance from archaeological sites in the North Carolina Sandhills to Piedmont metavolcanic resources is approximately 80 km (Steponaitis et al. 2006). If we assume 80 km as the maximum diameter of an annual foraging-range area, then the squared radius of the range (1,600 km^2) multiplied by π yields an area of 5,026.5 km^2. Although the magnitude of such a foraging area is within the range of ethnographically-documented cases (e.g., foraging areas of the Nunamiut are higher), it would be among the highest documented worldwide (Kelly 1995: Table 4-1). A more likely estimate for the maximum annual foraging area of groups occupying the Sandhills would be 2,000–3,000 km^2, an area comparable to the foraging areas of groups such as the Montagnais, Nez Perce, Ngadadjara, Hadza, Ju/’hoansi (Dobe), Mlabri, Semang, and Washo (Kelly 1995:Table 4-1).

Although foraging models have not been thoroughly developed for the Sandhills, the procurement of resources from the Piedmont could have been undertaken by long-distance logistical procurement parties, down-the-line trade, or family groups mapping onto distant resources through regular long-range residential moves. By whatever means, procuring pottery from distant sources must have been costly, and consequently pots used in Sandhills settings were very likely regarded as valued properties. This is suggested by the commonness of mend holes and repeatedly fired coil-seam failures and the absence of reconstructable vessels, all signs of prehistoric efforts to extend the use-life of pottery (Herbert 2001). This apparent economy of vessel conservation may reflect a dependence on nonlocal pottery resources resembling the Archaic-period “tethering effect” of high-quality Piedmont stone resources for Sandhills groups. Accordingly, it is suggested that Woodland groups would have been able to extend their foraging

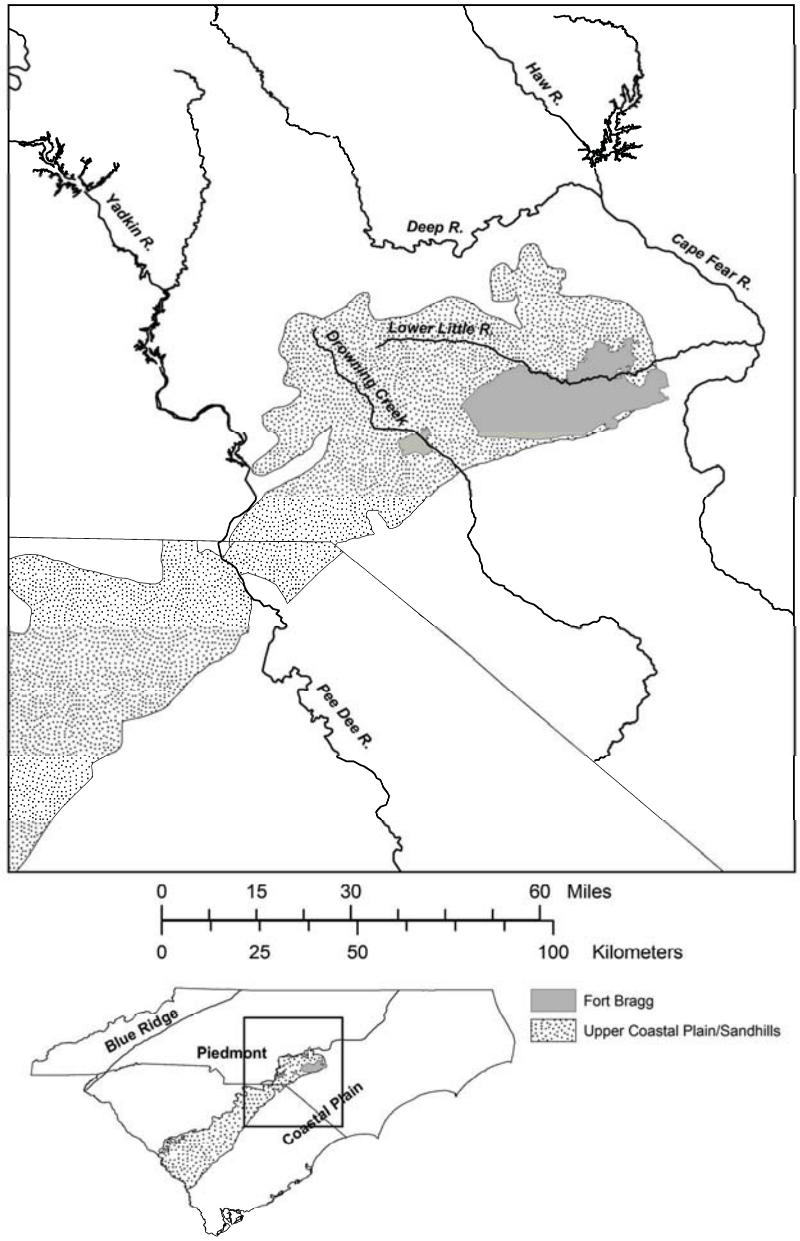


Figure 1.1. The Sandhills region of the Carolinas (United States Geological Survey 2002).

ranges away from clay-source locations by periodically provisioning themselves with vessels and then conserving or possibly caching pots as they moved away from the procurement areas.

Sourcing Ceramics

This study tests the proposal that Woodland-period Sandhills pottery was fashioned from nonlocal resources. It has two components: a characterization phase and a provenance phase. The characterization phase combines multiple analytical techniques to describe and classify physical, chemical, and mineralogical variation in 70 pottery and 84 clay samples from the Sandhills and neighboring regions. The provenance phase compares the ceramic and clay data in an effort to identify the regional sources of the raw materials used to manufacture pottery. Identifying source locations provides a basis from which to explore patterns of prehistoric ceramic production and distribution.

This sort of comprehensive, multi-component sourcing investigation is the first of its kind for the North Carolina Sandhills region, but its validity has been established by archaeologists working in other areas. In the past two decades, ceramic sourcing projects have increasingly utilized a combination of chemical and mineralogical evidence to distinguish pots and/or clays (e.g., Bartlett et al. 2000; Fitzpatrick et al. 2006; Fowles et al. 2007; Klein et al. 2004; Lane 1999; Phillips and Morgenstein 2002; Porat et al. 1991; Stoltman et al. 1992; Stoltman and Mainfort 2002).

A variety of analytical methods can be used to quantify the elemental compositions of ceramic and clay samples, including neutron activation analysis (NAA), inductively-coupled plasma spectrometry (ICP), X-ray fluorescence (XRF), and scanning electron microprobe analysis (SEM). This study employs NAA, which provides precise data on the chemical composition of aplastic components. Statistical procedures are applied to distinguish groupings within the data that may have interpretive significance. Considered in combination with other lines of evidence, groups identified on the basis of elemental composition can narrow the range of possible source locations. In cases where group membership is based on a specific trace element with a restricted geologic distribution, it may even be possible to isolate the exact location of origin.

Common techniques for determining mineralogical components of pottery and clays include petrography and X-ray diffraction (XRD). Petrography is typically used to identify aplastic inclusions. Under favorable circumstances, it may be used to differentiate purposefully added temper from natural inclusions, thereby providing a means of distinguishing among paste recipes. XRD is uniquely capable of identifying plastic minerals in unfired clays, but it cannot detect original clay minerals in pottery because the firing process destroys their characteristic crystalline structures. Both petrography and XRD are also useful for cross-checking and interpreting patterns identified through chemical analyses.

Unlike chemical and mineralogical analyses, field and laboratory techniques for assessing the physical variability of clays are not a regular component of most sourcing studies. Nevertheless, physical properties such as workability and shrinkage may provide keys to understanding why specific sources were exploited or ignored. This study incorporates performance and replication experiments for evaluating the physical properties of clays in order to both reduce the number of samples submitted for chemical and mineralogical analyses and to gain insights into factors that may have influenced the decisions and behaviors of prehistoric potters.

Research Design

This study was inspired by evidence that many prehistoric pottery vessels were brought into the Sandhills from distant sources. Some sherds from Fort Bragg sites contain inclusions such as granitic rock and weathered feldspar that presumably originated in the Piedmont (Herbert et al. 2002). Signs of resource conservation and occasional stylistic clues such as check- or complicated-stamped surface treatments, uncommon in the Sandhills, also suggest that pots may

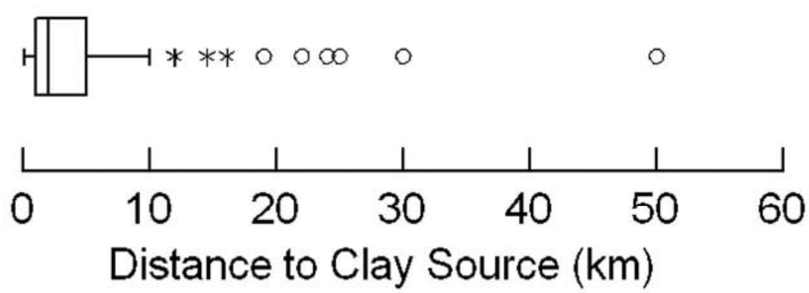


Figure 1.2. Distance from clay source to pottery production locale for 108 ethnographic cases (data from Arnold 1985).

have been imported from other areas. Finally, clay samples collected opportunistically from exposures on Fort Bragg did not seem to have enough plasticity or strength to make useful pots.

We therefore set out to test the notion that pottery found on Sandhills sites originated in surrounding regions. Several related assumptions guided our selection of an appropriate geographic scale of analysis. The first is that pots, rather than raw materials, were transported from source locations to the archaeological sites in which they were found. The construction of an average cooking pot with a capacity of 3.8 liters (1 gallon) would require approximately 2.7 kg (6 pounds) of clay (Zug 1986:145). Data collected during our firing experiments (see Chapter 4 and Appendix B) suggests that same pot would weigh only about 2 kg (4.4 pounds) after firing. We therefore consider it likely that mobile hunter-gatherers would choose to fire pots as close to the raw material source as practically possible, and ethnographic data support this assumption. Data from a sample of 108 cases worldwide reveals that the median distance from clay source to production locale is less than 5 km (Figure 1.2; Arnold 1985).

A second, related assumption is that the effort necessary to transport fragile, finished pots limited the distance over which they were regularly transported. This assumption has played an important role in previous studies of this sort, as it underlies the belief that the constituent materials of archaeological pottery specimens reflect the clay and temper resources of their immediate environs (e.g., Steponaitis et al. 1996).

Based on these two assumptions, we limited our study area to the Sandhills and adjacent regions of the Coastal Plain and Piedmont. For sampling purposes, river drainages are considered to be the relevant geographic units. Pottery and clay samples representing the Sandhills came from the Lower Little and Drowning Creek drainages, and comparative samples were collected from the Cape Fear, Waccamaw, and Pee Dee drainages in the Coastal Plain and the Yadkin, Haw, and Deep drainages in the Piedmont (Figure 1.1). Analyses were designed to characterize materials from these eight drainages in the hopes of understanding patterns of resource procurement and movement of pots.

Organization of this Volume

The next three chapters discuss pertinent background information and the details of sample selection. Chapter 2 describes the general geological, pedological, and hydrological characteristics of the study area. In Chapter 3, the pottery samples (numbered throughout this volume with the prefix JMH) are discussed in the context of the sites from which they were drawn. Chapter 4 describes the clay samples (specified with the prefix FBR) and presents the results of field and laboratory performance tests.

Chapters 5–7 present the results of chemical and mineralogical characterization analyses. In Chapter 5, the geochemical data are summarized. Chapter 6 presents the petrographic analyses, and the XRD data are interpreted in Chapter 7.

Chapter 8 summarizes the most important findings of each of the various lines of evidence, compares these results, and evaluates the implications for the model of Woodland period social and economic behaviors discussed above.

Chapter 2

Geology

Theresa E. McReynolds

Samples for this study were drawn from the Carolina Coastal Plain and the North Carolina Piedmont (Figure 2.1). The general geological, pedological, and hydrological characteristics of these two physiographic provinces are therefore relevant to our results and interpretations.

The Carolina Coastal Plain

The Carolina Coastal Plain is a region of broad, relatively flat terraces of primarily unconsolidated sediments and carbonate rocks (Figure 2.2). These materials, ranging in age from Cretaceous to Quaternary, were deposited in shallow seas by rivers draining the Blue Ridge and Piedmont provinces (Rogers 1999).

Accumulation of sediments over 100 million years has gradually expanded the Coastal Plain seaward. During the same period, continuous uplifting of the interior has given the region a wedge-like cross section, with the thickest and youngest deposits occurring along the coast and the thinnest and oldest deposits exposed in the upper Coastal Plain. Cretaceous, Tertiary, and Quaternary deposits form roughly parallel belts that follow the southwest to northeast trend of the coastline, and elevation gradually increases from the coast to the Piedmont.

In the southwestern Coastal Plain of North Carolina, the Cape Fear Arch disrupts this general pattern. The axis of this active structural upwarp runs northwest to southeast and extends from offshore into the Appalachian Mountains (Rogers 2006; Siple 1999 [1957]). At least 250 million years of uplift along the arch has preserved the relict dunes of the North Carolina Sandhills and exposed Cretaceous strata that are buried elsewhere in the Coastal Plain.

Geologic Formations

Upper Cretaceous deltaic and marine deposits are divided into four stratigraphic units (Figure 2.3): the Cape Fear Formation, the Middendorf Formation, the Black Creek Group, and the Peedee Formation (North Carolina Geological Survey 1985; Sohl and Owens 1991).[1] The lowermost unit, the Cape Fear Formation, consists of interbedded clays and sands exposed along deeply entrenched rivers such as the Cape Fear and Lower Little (Sohl and Owens 1991). The overlying Middendorf Formation includes fluvial-deltaic sands and clays commonly exposed on valley slopes and uplands in the Sandhills. Above the Middendorf Formation, the Black Creek Group encompasses the Tar Heel, Bladen, and Donoho Creek Formations and is generally characterized by carbonaceous clays and micaceous and fossiliferous sands. The uppermost Cretaceous unit, the Peedee Formation, comprises massive sands, clays, and limestones.

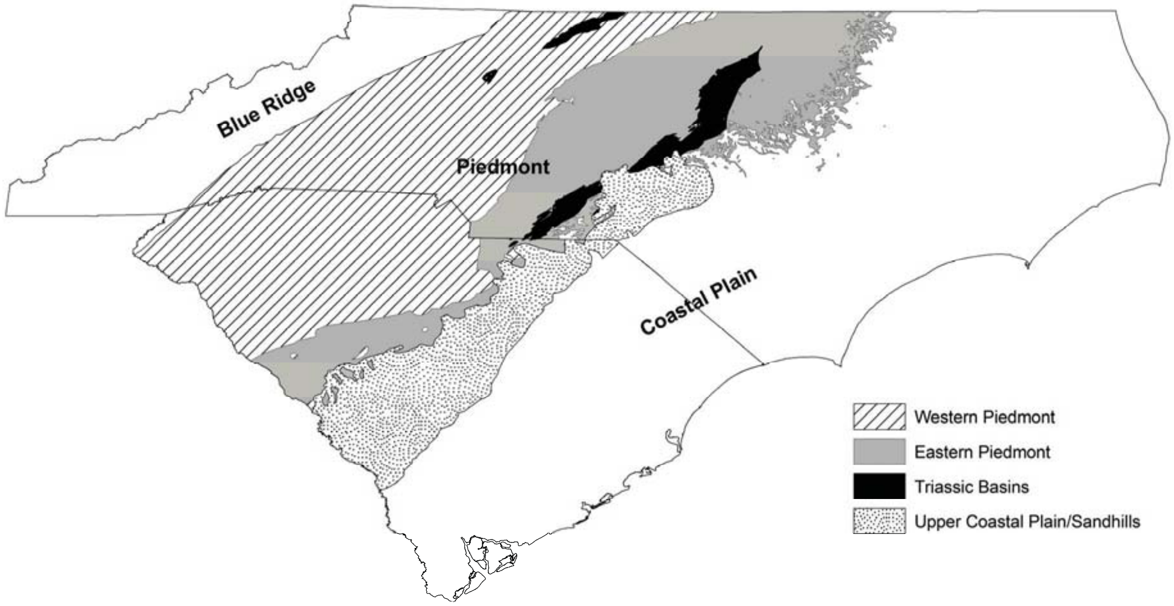


Figure 2.1. Major physiographic regions of the Carolinas (North Carolina Geological Survey 1998a; South Carolina Geological Survey 2005).

Tertiary sand and limestone deposits are located north and south of the study area. Quaternary deposits are largely undifferentiated and consist of marine and fluvial sands, clays, and gravels (North Carolina Geological Survey 1985).

Soils and Clays

Upland soils derived from Coastal Plain sediments are generally quartz-rich with sandy surface textures. Diagnostic heavy minerals include zircon, tourmaline, rutile, staurolite, sillimanite, and kyanite (Windom et al. 1971). Soil composition within floodplains is influenced by the nature of fluvial deposits: rivers originating in the Coastal Plain are associated with quartz-rich soils, while rivers originating in the Piedmont give rise to soils of mixed mineralogies derived from Piedmont and Coastal Plain sediments (Buol 2003; Neiheisel and Weaver 1967; Windom et al. 1971).

Sedentary clays are rare in the Coastal Plain and particularly unusual in the Sandhills. They are most likely to be found on the upper terraces of major rivers where stable conditions have persisted long enough to allow the formation of argillic horizons (Buol 2003). Such settings generally exhibit extreme textural variation over relatively small distances, however, making it difficult to locate sedentary clay pockets.

Most sedimentary clays belong to the smectite group, although kaolinite and illite are common in some Cretaceous deposits (Heron 1960; Reves 1956; Sohl and Owens 1991). Consequently, alluvial clays deposited by rivers originating in the Coastal Plain are generally smectite-rich (Neiheisel and Weaver 1967; Steponaitis et al. 1996; Windom et al. 1971). In contrast, clays deposited by Piedmont-draining rivers typically contain a mixture of Coastal Plain-derived smectite and Piedmont-derived kaolinite (Neiheisel and Weaver 1967; Windom et al. 1971).

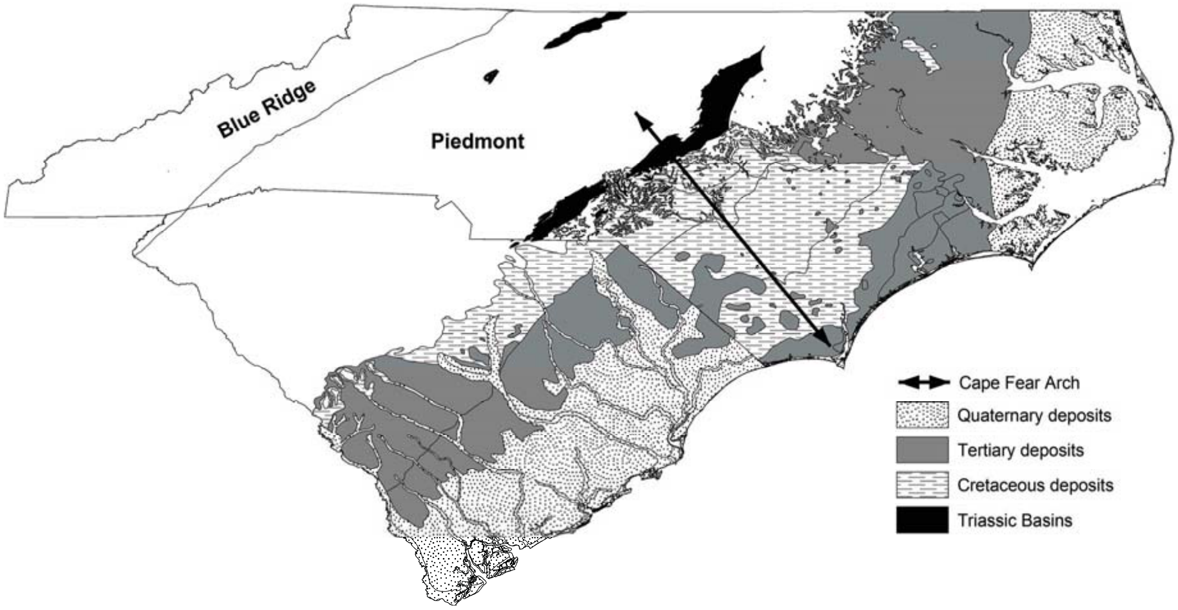


Figure 2.2. Geologic features of the Carolina Coastal Plain (North Carolina Geological Survey 1998a; South Carolina Geological Survey 2005). The arrow representing the axis of the Cape Fear Arch approximates the location of maximum uplift.

The North Carolina Piedmont

The North Carolina Piedmont is a region of gently rolling hills and low ridges underlain by Proterozoic and Paleozoic metamorphic and intrusive igneous rocks. For present purposes, it can be divided into eastern and western halves (Figure 2.1). The eastern Piedmont consists primarily of low-grade metavolcanic and metasedimentary rocks of the Carolina Slate Belt (Figure 2.4). The western Piedmont is dominated by higher-grade gneisses, schists, and amphibolites. All Piedmont samples included in this study come from the eastern Piedmont.

The Carolina Slate Belt

The metamorphic rocks of the Carolina Slate Belt commonly contain chlorite, epidote, and other greenschist-facies minerals. Volcaniclastic parent rocks were primarily Late Proterozoic quartz- and plagioclase-rich dacites (Rogers 2006), although approximately 150 metagabbro and metabasalt dikes are apparently derived from Early Phanerozoic mafic intrusions.

The North Carolina portion of the Slate Belt comprises two rock suites. The Virgilina synclinorium extends from Durham into Virginia, and the Uwharrie or Albemarle suite encompasses the Uwharrie Mountains of the Albemarle-Asheboro region. The Virgilina sequence is older than the Uwharrie suite and experienced local deformation around 600 million years ago (Butler and Secor 1991; Rogers 2006). Taconic regional metamorphism of the entire belt occurred sometime after 500 million years ago when the terrane moved away from the western margin of South America and collided with eastern North America (Rogers 2006). Undeformed granitic intrusions dating to approximately 300 million years ago constrain the

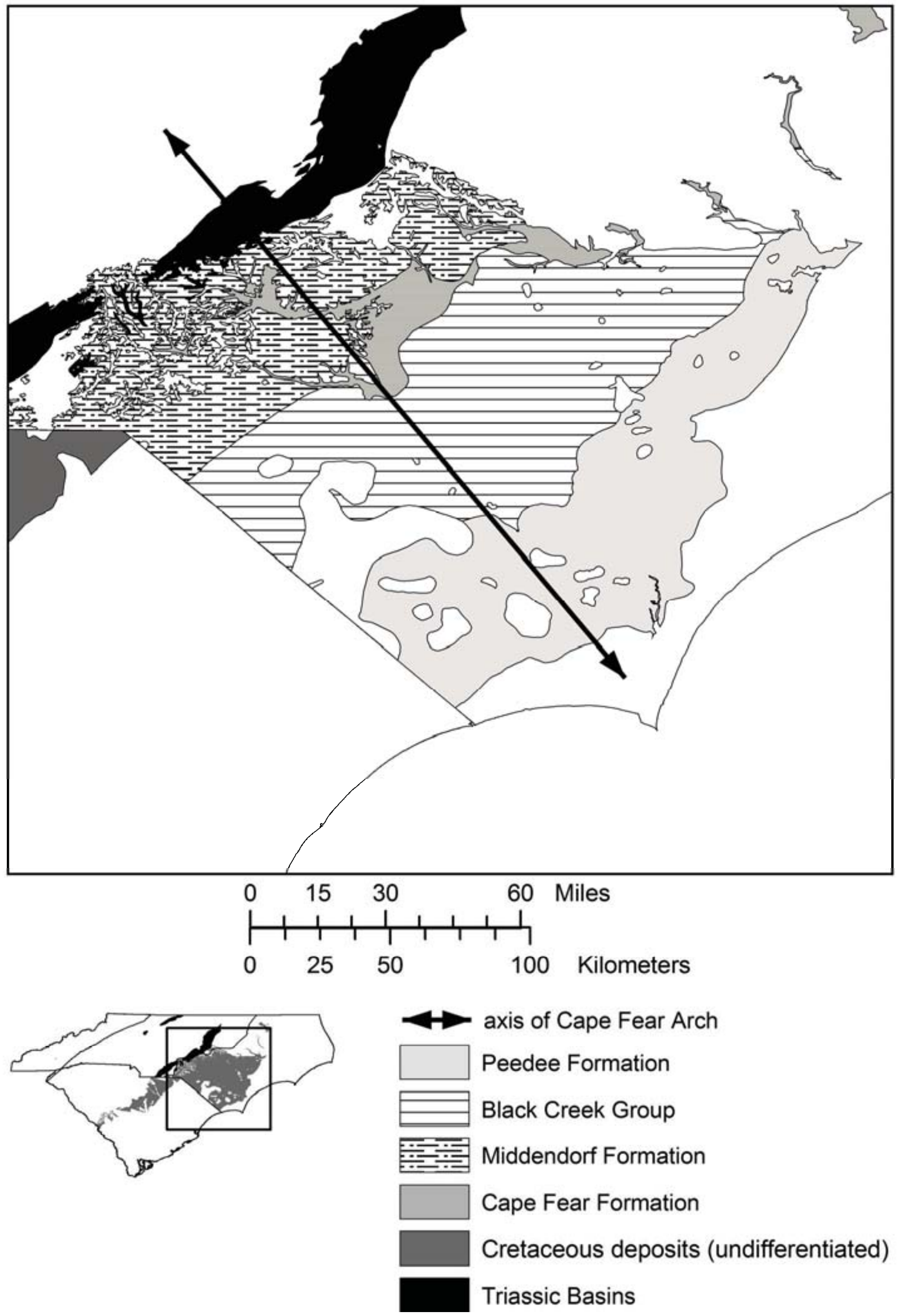


Figure 2.3. Cretaceous deposits of the North Carolina Coastal Plain (North Carolina Geological Survey 1998a; South Carolina Geological Survey 2005).

timing of the regional metamorphism, and potassium-argon dates suggest it occurred around 480–450 million years ago (Butler 1991).

Piedmont soils derived from Carolina Slate Belt rocks are generally quartz-, feldspar-, and mica-rich clays and loams (Buol 2003), although sandy soils can be found in some upland areas. Diagnostic heavy minerals include amphiboles (especially hornblende), epidote, and pyroxenes (Neiheisel and Weaver 1967; Windom et al. 1971).

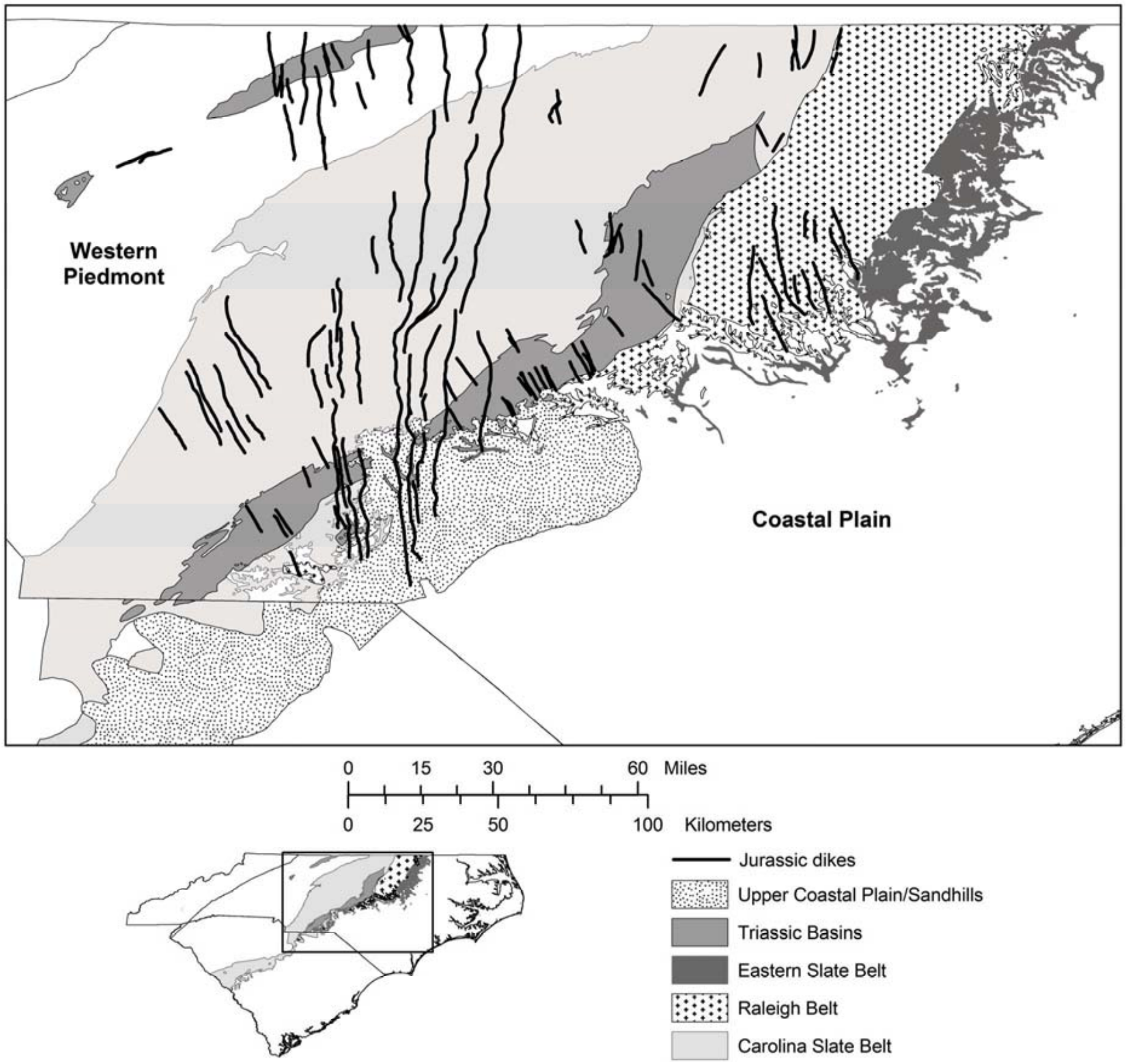


Figure 2.4. Geologic features of the eastern Piedmont (North Carolina Geological Survey 1998a, 1998b; South Carolina Geological Survey 2005).

Feldspars weather into kaolin group minerals, which are consequently the dominant clay minerals in the Carolina Slate Belt. Illite, chlorite, vermiculite, and hydroxy-interlayered vermiculite are also locally present, but smectite is generally absent except in the vicinity of metagabbro intrusions in the Albemarle-Asheboro region (Buol 2003; Neiheisel and Weaver 1967; Olive et al. 1989; Steponaitis et al. 1996; Windom et al. 1971).

The Deep River Triassic Basin

East of the Slate Belt, the Deep River Triassic basin contains sedimentary rocks. The basin extends approximately 240 km in length and is bounded by the Sandhills to the southeast and by amphibolite-facies gneisses and schists of the Raleigh Belt to the northeast. It is believed to have formed during rifting accompanying the breakup of Pangea and the opening of the Atlantic Ocean approximately 200–190 million years ago (Olsen et al. 1991; Rogers 2006).

The general stratigraphic sequence within the Deep River basin reveals fluvial, lacustrine, and deltaic deposits. It includes four units: (1) a basal conglomerate overlain by sandstones and mudstones, (2) clay shale and mudstone, (3) cross-bedded sandstones and massive mudstone, and (4) poorly sorted conglomerate and sandstone (Olsen et al. 1991:148). Soils derived from these deposits are generally loams and sandy loams.

Deep River basin clays are typically a mixture of smectite and kaolinite and provide the basis for North Carolina's brick industry (Feiss et al. 1991). It is unclear whether the smectite component is an in situ weathering product or has a sedimentary origin (Buol 2003). Regardless, clays in the Deep River basin are more similar to upper Coastal Plain clays than they are to clays found in the Carolina Slate Belt (Olive et al. 1989).

Mafic Dikes

Two swarms of Early Jurassic igneous dikes cut across the eastern Piedmont. An older swarm of olivine- and quartz-normative-diabase intrusions trends northwest, while a slightly younger swarm of quartz-normative-diabase dikes strikes approximately north-south (Beutel et al. 2005). The northwest-striking dikes tend to be shorter, narrower, and more closely spaced than the north-trending dikes (Ragland 1991:173). Both swarms formed sometime between 199 and 197 million years ago (Beutel et al. 2005).

In some cases, samples from the two swarms can be distinguished based on normative mineralogy. It may also be possible to discriminate between northwest-striking dikes from the Carolina Slate Belt and those from the Deep River basin based on Rb/Sr ratios, which decrease from west to east (Ragland 1991:177).

River Basins and Drainages

The samples collected for this study represent eight drainages in three river basins: the Haw, Deep, Lower Little, and Cape Fear drainages of the Cape Fear River basin; the Yadkin and Pee Dee drainages of the Yadkin-Pee Dee River basin; and the Drowning Creek and Waccamaw drainages of the Lumber River basin (Figure 2.5).

The Cape Fear River Basin

The Cape Fear River basin incorporates the Haw, Deep, Lower Little, and Cape Fear drainages (Figure 2.6). The Haw and Deep Rivers originate in the western Piedmont and cut through the Carolina Slate Belt and Deep River Triassic basin before merging to form the Cape Fear River. Approximately 6 km above the confluence of the Haw and Deep Rivers, the B. Everett Jordan dam floods approximately 5,641 ha of the Deep River Triassic basin, including the location of the Haw River site (31Ch29) from which pottery samples were drawn for this study (see Chapter 3).

The Cape Fear River passes through the Raleigh Belt and a small segment of the metamorphic Eastern Slate Belt before draining the North Carolina Coastal Plain. It is fed by the Lower Little River, which originates in the Sandhills and drains most of Fort Bragg.

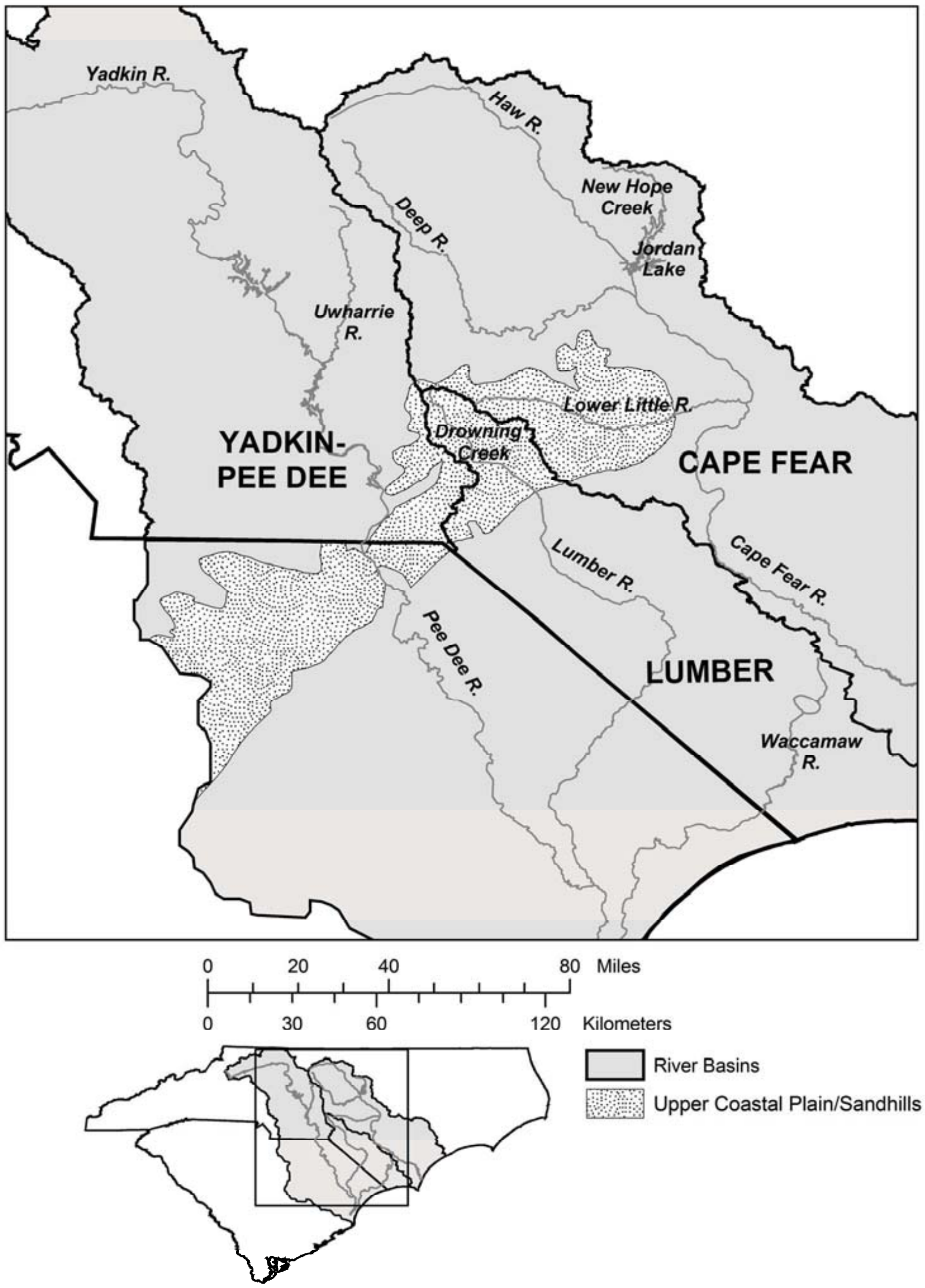


Figure 2.5. Rivers and river basins mentioned in the text (United States Department of Agriculture 1998; United States Geological Survey 2002).

The Yadkin-Pee Dee River Basin

The Yadkin-Pee Dee River basin includes the Yadkin, Uwharrie, and Pee Dee Rivers (Figure 2.7). The headwaters of the Yadkin lie in the eastern Blue Ridge province, but the bulk of the river's length spans the western Piedmont. The Yadkin cuts through the Uwharrie suite, where it

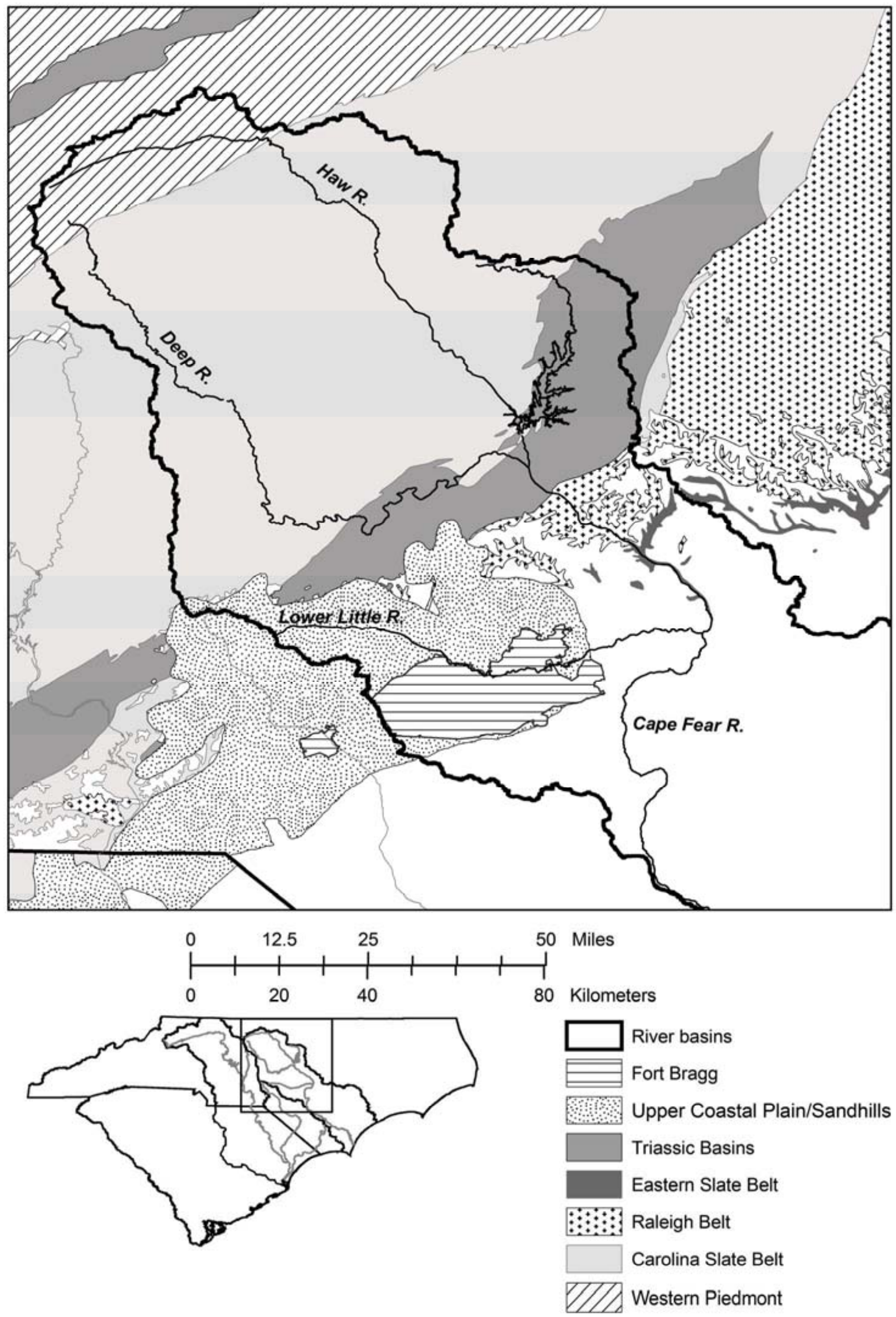


Figure 2.6. The Cape Fear River basin (North Carolina Geological Survey 1998a; South Carolina Geological Survey 2005; United States Department of Agriculture 1998; United States Geological Survey 2002).

ultimately merges with the Uwharrie River to become the Pee Dee. The Pee Dee River then traverses the Deep River Triassic basin and more of the Carolina Slate Belt before entering the Coastal Plain of South Carolina.

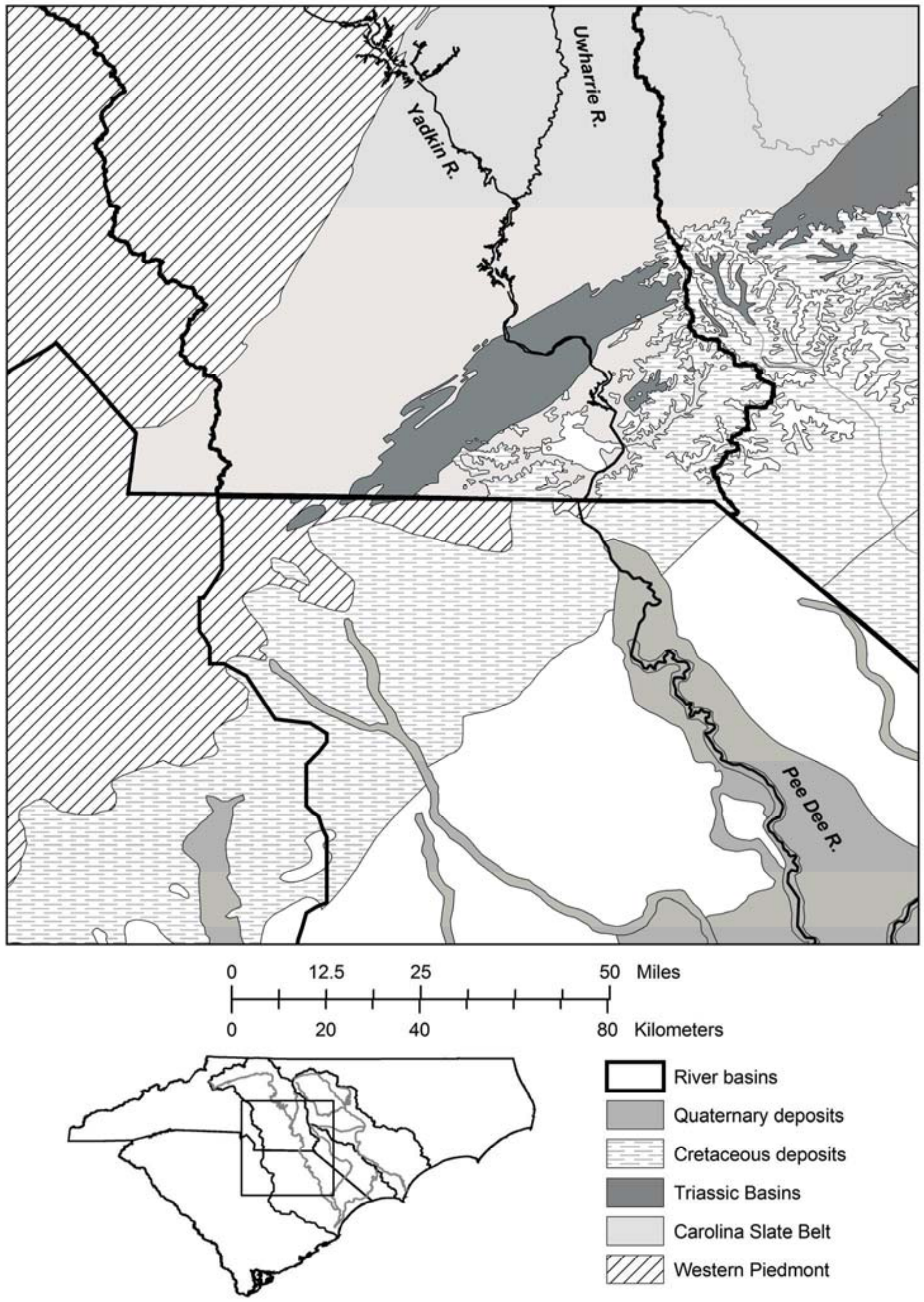


Figure 2.7. The Yadkin-Pee Dee River basin (North Carolina Geological Survey 1998a; South Carolina Geological Survey 2005; United States Department of Agriculture 1998; United States Geological Survey 2002).

The Lumber River Basin

The Lumber River basin is situated entirely within the Coastal Plain (Figure 2.8). Samples representing this basin were collected from the vicinity of Drowning Creek in the Sandhills and along swampy tributaries of the Waccamaw River in North Carolina's lower Coastal Plain.

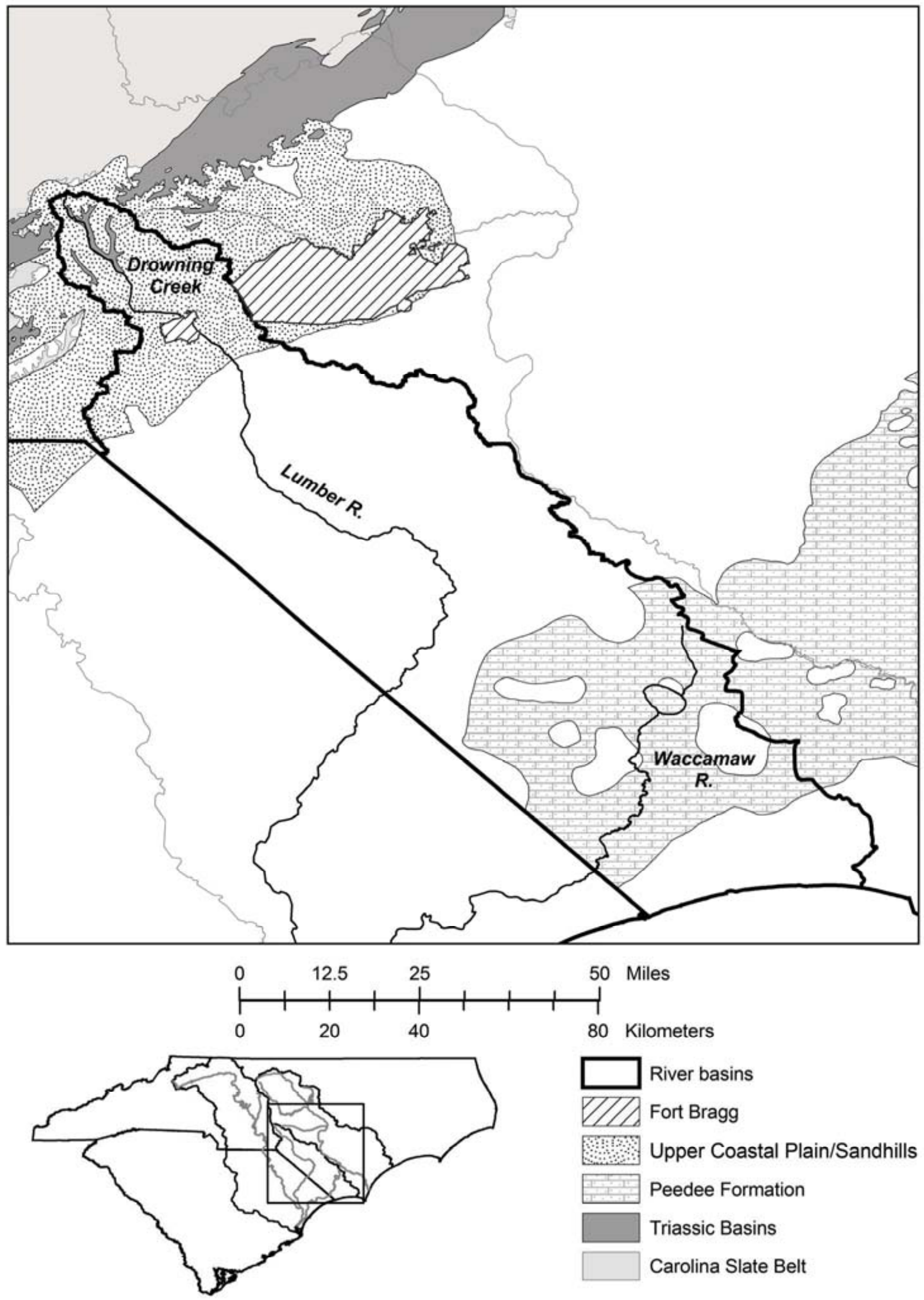


Figure 2.8. The Lumber River basin (North Carolina Geological Survey 1998a; South Carolina Geological Survey 2005; United States Department of Agriculture 1998; United States Geological Survey 2002).

Drowning Creek originates in the Sandhills and represents the headwaters of the Lumber River. It passes through part of the Deep River Triassic basin and drains Camp Mackall, an outpost approximately 65 km west of the main Fort Bragg installation. South of Camp Mackall, Drowning Creek becomes the Lumber River, which meanders into South Carolina and ultimately feeds into the Pee Dee River.

The Waccamaw River and the majority of its tributaries originate in the sands, clays, and limestone of the Peedee Formation. In North Carolina, the Waccamaw River is surrounded by swamps and marshes. It flows approximately parallel to the coast and into South Carolina, where it also joins the Pee Dee River.

Conclusion

Geological distinctions between the Coastal Plain and Piedmont suggest that pottery made from resources obtained in these two physiographic provinces should exhibit different geochemical and mineralogical characteristics. Because the eight river drainages from which samples for this study were drawn pass through different geologic formations within the Coastal Plain and Piedmont, it is possible that precise geochemical and mineralogical analyses could allow us to further discriminate specific resource areas within these broad provinces.

Notes

Acknowledgments. I thank John Rogers, Michael Smith, and Edward Stoddard for reviewing drafts of this chapter and sharing their expertise on the geology of the Carolinas.

[1]Recent research suggests that the name "Middendorf" has been applied to a variety of units with similar lithologies but different stratigraphic positions and ages (Prowell et al. 2003). Prowell et al. (2003) therefore recommend that the name Middendorf be restricted to strata from the type section locality in Chesterfield County, South Carolina and that its application to other units be reconsidered. In this study, however, we utilize the description and stratigraphic position of the "Middendorf Formation" as provided by the work of the North Carolina Geological Survey (1985) and Sohl and Owens (1991).

Chapter 3

Ceramics

Joseph M. Herbert

Seventy pottery samples were analyzed in this study. They were drawn from 30 sites with Woodland occupations representing cultures spanning the period from 1500 BC–AD 1500. Sites were selected on the basis of their ability to characterize relevant geographic regions, the types of pottery included in their assemblages, and their capacity to represent the regional ceramic sequence. Also taken into consideration were factors concerning the contexts in which the specimens were found. As many of the analytical procedures are destructive, sherds were selected from contexts where provenience was mixed, including the surface, plow zone, excavation balk, and shovel test.

The sample includes sites in three river basins (the Cape Fear, Yadkin-Pee Dee, and Lumber) chosen to represent the Piedmont, Sandhills, and Coastal Plain provinces (Figure 3.1). Appendix A provides a general description of each of the 70 pottery samples.

Piedmont Sites and Samples

Piedmont assemblages are represented by 10 sherds from the Doerschuk site (31Mg22) on the lower Yadkin River and 10 from the Haw River site (31Ch29) on the lower Haw River (Table 3.1).

The Haw River Site (31Ch29)

The Haw River site is located along an ancient meander loop of the Haw River, now submerged beneath B. Everett Jordan Lake in Chatham County, North Carolina (Figure 3.1). So situated, the site provides pottery representing the Piedmont portion of the Cape Fear River basin. The site was first tested and recorded in the 1960s and 1970s (McCormick 1970; Smith 1965; Wilson 1976) and excavated in 1979 by Commonwealth Associates for the U.S. Army Corps of Engineers prior to inundation of the reservoir (Claggett and Cable 1982). Excavation revealed numerous rock hearths, pit features, and single-vessel clusters of pottery buried within the upper strata of alluvium composing the floodplain terraces of the Haw.

The pottery sample from the Haw River site used in this study was from the plow zone and therefore lacked stratigraphic provenience. Nine of the 10 pottery specimens in this sample were classified as Yadkin in consequence of their being tempered with angular quartz particles granule size (2–4 mm) and larger, which are assumed to have been prepared by crushing and winnowing

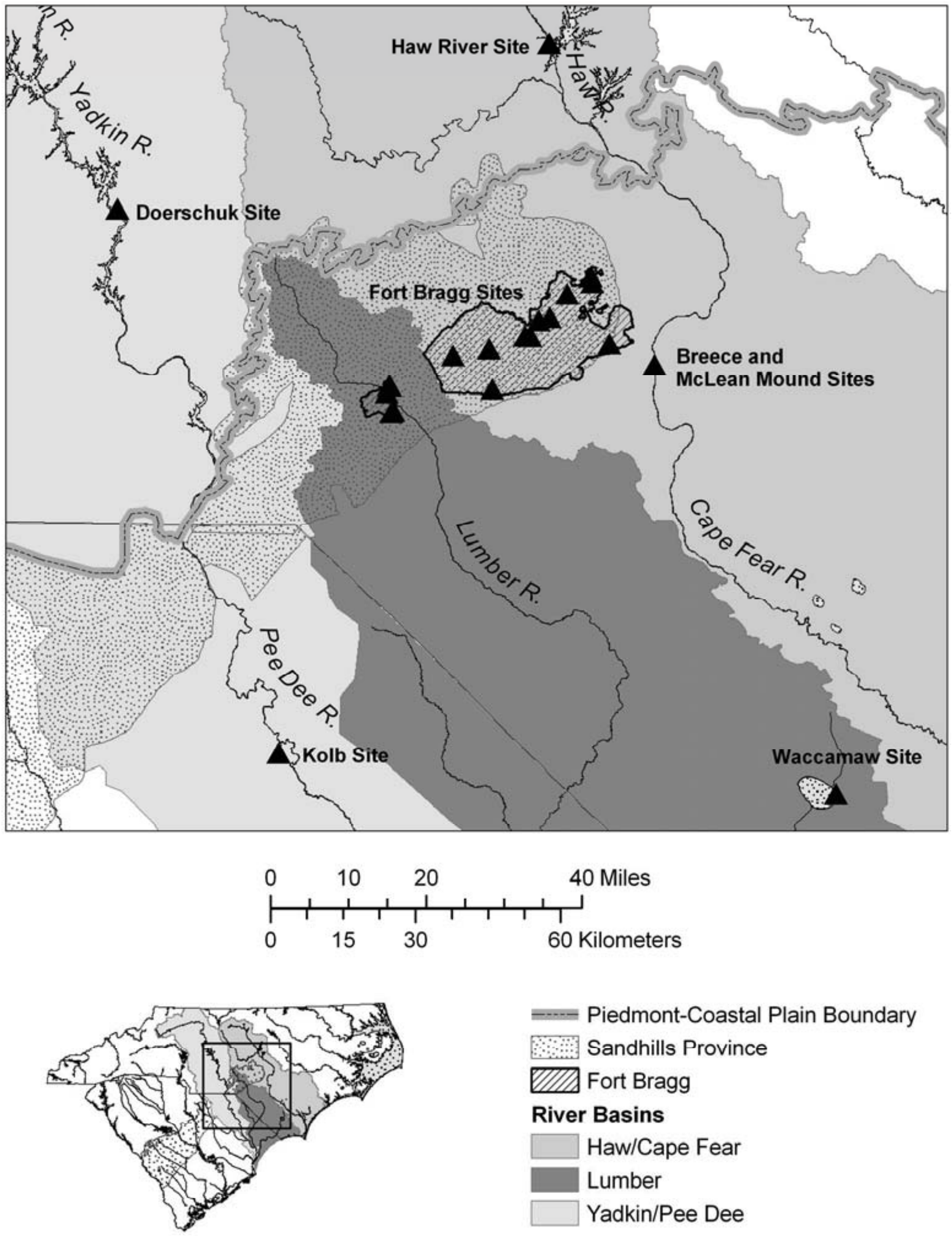


Figure 3.1. Archaeological sites from which pottery samples were drawn (United States Department of Agriculture 1998; United States Geological Survey 2002).

(Table 3.2; Figure 3.2). Petrographic analysis identified grog in very low proportion (2–3%) in two of the Yadkin sherds (Appendix A). The combination of angular quartz and grog in the Yadkin series is not without precedent, having been observed in a minority of sherds at the Doerschuk site (Coe 1964:33) and the Mattassee Lake sites in South Carolina (Anderson et al. 1982:299). One sand-tempered, fabric-impressed specimen in the Haw River site sample was classified as Cape Fear.

Table 3.1. Distribution of Pottery Samples by Physiographic Region and Drainage.

Site	Physiographic Region	Drainage	Count
Haw River	Piedmont	Haw	10
Doerschuk	Piedmont	Yadkin	10
Fort Bragg	Sandhills	Lower Little	12
Fort Bragg	Sandhills	Drowning Creek	8
Breece	Coastal Plain	Cape Fear	10
Waccamaw	Coastal Plain	Waccamaw	10
Kolb	Coastal Plain	Pee Dee	10
			70

The Doerschuk Site (31Mg22)

The Doerschuk site is situated on the banks of the Yadkin River where it is narrowly constrained between steep flanks of the Uwharrie Mountains just below Falls Dam in Montgomery County, North Carolina (Figure 3.1). Excavations were begun by the University of North Carolina at Chapel Hill in 1946 and continued for several years thereafter, uncovering luxuriant assemblages of projectile points and pottery within the deeply stratified alluvial terraces below the falls. The Archaic projectile point types from Doerschuk, so lavishly described by Coe (1964:14–55), have all but become household names, certainly the fundamental units of North Carolina's archaeological lexicon. The Woodland pottery types defined on the basis of those excavated assemblages also remain in use, although their ages and distributions are, perhaps, more in need of refinement. The sample of 10 sherds from the Doerschuk site used in this study was from an excavation wall that slumped, leaving no stratigraphic provenience for these specimens (Figure 3.3).

Coe recognized five pottery series among the Doerschuk site materials, and four of these are represented in the current sample (Table 3.2). He conceived Badin as the earliest series, a fine-sand-tempered ware comprising three surface treatment types (fabric marked, cord marked, and net impressed). Two sherds of this ware, one net impressed and one cord marked, were identified in the current study and are considered to be the same as the Early Woodland New River Net Impressed and New River Cord Marked types, estimated to date from 1200–500 BC (Herbert et al. 2002:102).

The Yadkin series, thought to be somewhat younger than Badin in Coe's scheme and now considered to range in age from 1000 BC–AD 200 (Herbert et al. 2002:103), is represented in this study by five sherds from Doerschuk (Table 3.2). Of the five, two are fabric marked, one is cord marked, one is check stamped, and one is net impressed. Coe did not recognize a net-impressed component of the Yadkin series, but this designation seems most accurate given the sherd's characteristics.

Two Late Woodland series are recognized in the Doerschuk sample: Dan River and Jenrette. Coe (1964:33) envisioned the Dan River series as the Late Woodland component of the Piedmont sequence consisting of Badin, Yadkin, Uwharrie, Dan River, and Caraway. Dan River Net Impressed was the only type originally recognized in the Doerschuk site report (Coe 1964), but Dan River Simple Stamped was identified in this study. A single Jenrette Plain sherd was

Table 3.2. Distribution of Pottery Samples by Period and Type.

Site	Early Woodland: Thom's Creek	Early Woodland: New River	Middle Woodland: Deptford	Middle Woodland: Cape Fear	Middle Woodland: Yadkin	Middle Woodland: Hanover	Middle Woodland: Hanover I	Middle Woodland: Mount Pleasant	Middle Woodland: Yadkin/ Hanover	Late Woodland: Cape Fear III	Late Woodland: Hanover II	Late Woodland: Dan River	Late Woodland: Jenrette	Sand tempered	Total
Haw River				1	9										10
Doerschuk		2			5							2	1		10
Fort Bragg		3	2	1	2	1	3	1		1	5			1	20
Breece		1		1			3				5				10
Waccamaw	1			5		1	1				2				10
Kolb		3		2	2		1		2						10
Total	1	9	2	10	18	2	8	1	2	1	12	2	1	1	70

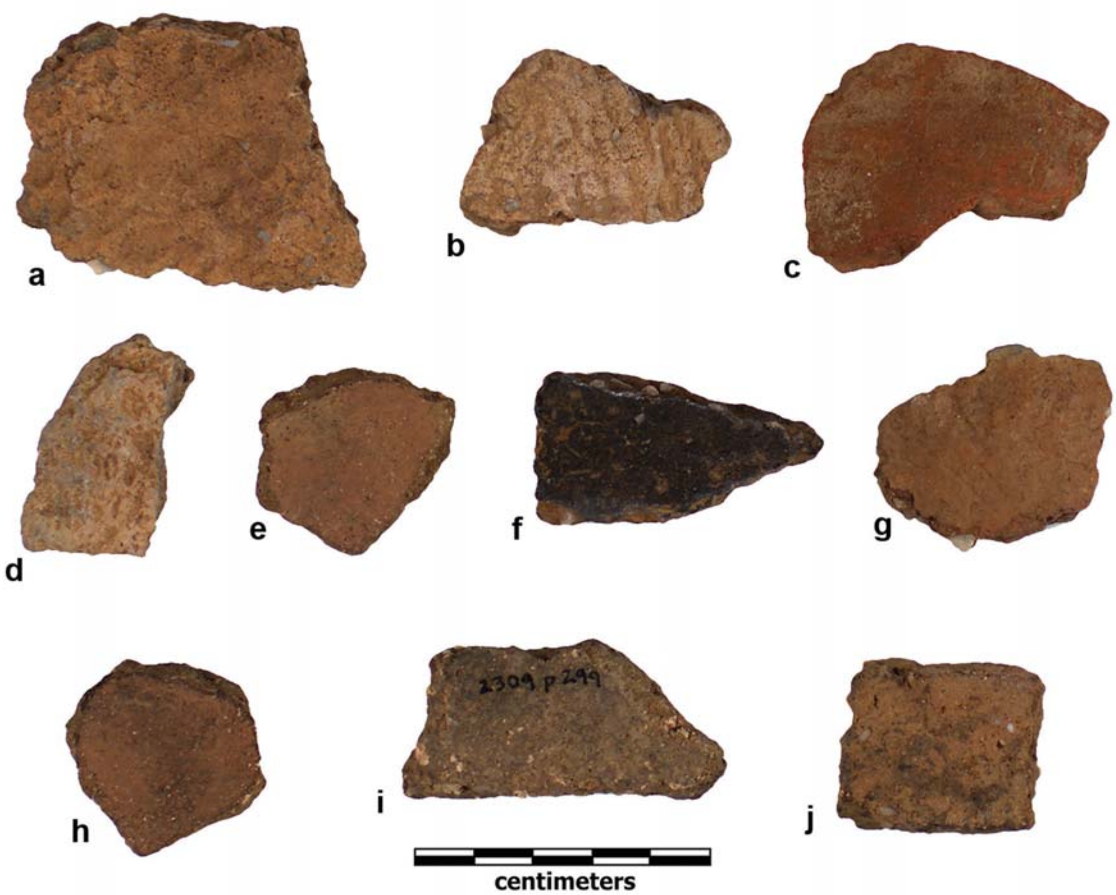


Figure 3.2. Pottery samples from the Haw River site (31Ch29): (a) JMH041, Yadkin Paddle-edge Stamped; (b) JMH042, Yadkin Cord Marked; (c) JMH043, Yadkin Plain; (d) JMH044, Cape Fear Fabric Impressed; (e) JMH045, Yadkin Plain; (f) JMH046, Yadkin Plain; (g) JMH047, Yadkin/Hanover eroded; (h) JMH048, Yadkin Plain; (i) JMH049, Yadkin Plain; (j) JMH050, Yadkin eroded.

also identified in the current sample. Slightly burnished or very highly smoothed and tempered with very coarse subangular quartz, this sherd is very similar to those found at the Mitchum site in Orange County. The Jenrette Phase is considered to be contemporary with Caraway, dating to the seventeenth century.

Sandhills Sites and Samples

Sandhills assemblages are characterized by 12 sherds drawn from Fort Bragg sites on the Lower Little River in the Cape Fear basin and 8 sherds from Fort Bragg sites at Camp Mackall on Drowning Creek in the upper Lumber River basin.

One potsherd each was drawn from 12 sites in the Lower Little River drainage in Cumberland, Hoke, and Harnett Counties on Fort Bragg (Figure 3.1). These samples represent the Sandhills area of the upper Coastal Plain within the Cape Fear River basin (Table 3.1). Eight potsherds were also drawn from six sites in the Drowning Creek drainage in Moore and Scotland Counties on the western boundary of Fort Bragg or on Camp Mackall. This sample also

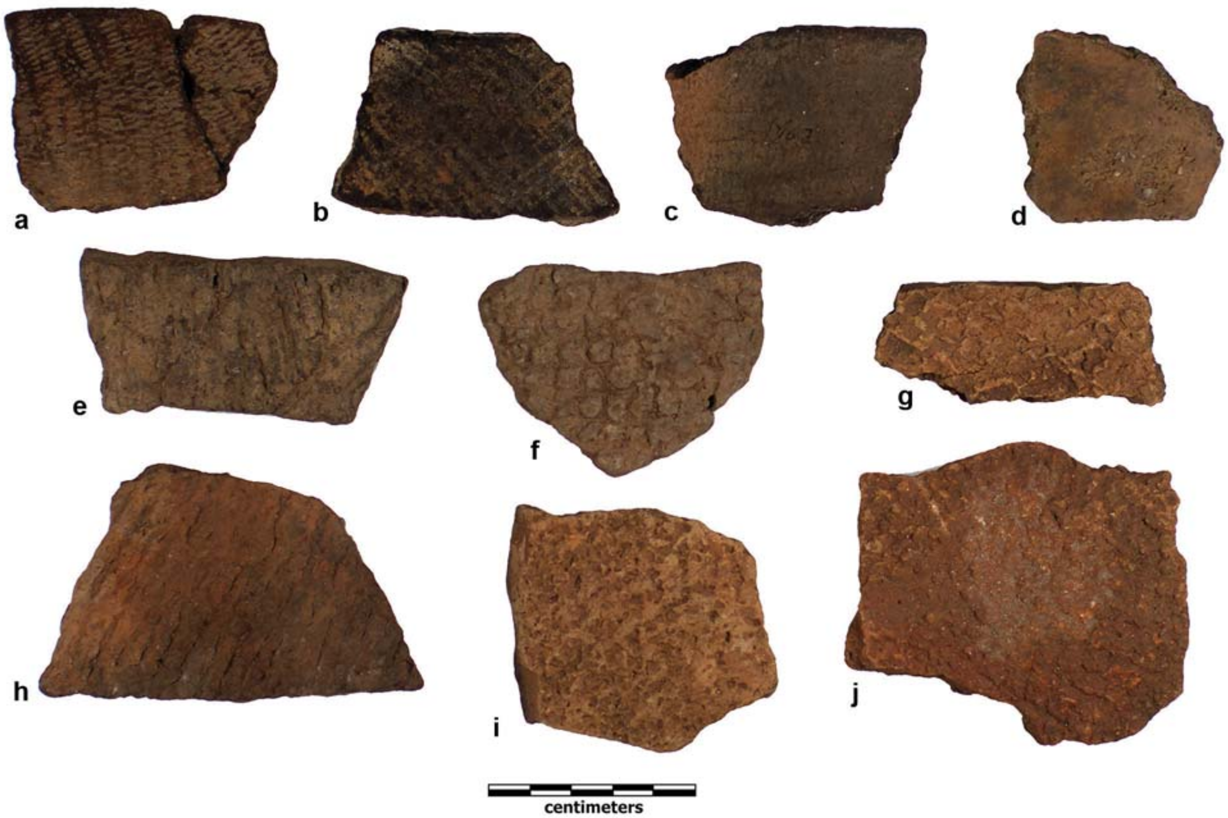


Figure 3.3. Pottery samples from the Doerschuk site (31Mg22): (a) JMH031, Yadkin Fabric Impressed; (b) JMH032, Dan River Simple Stamped; (c) JMH033, Yadkin Fabric Impressed; (d) JMH034, Jenrette Plain (Bruton); (e) JMH035, New River Cord Marked; (f) JMH036, New River Net Impressed; (g) JMH037, Yadkin Check Stamped; (h) JMH038, Yadkin Cord Marked; (i) JMH039, Dan River Net Impressed; (j) JMH040, Yadkin Net Impressed.

represents the Sandhills area of the upper Coastal Plain, although specifically that portion within the upper reaches of the Lumber River basin.

Pottery samples from these sites were selected with the idea of gaining a reasonable representation of the variability across the geographic area represented by Fort Bragg. As might be expected, the number of pottery types represented in the 18-site, 20-specimen sample from Fort Bragg is greater than that seen in the 10-specimen samples from individual sites. Pottery types from sites in the Lower Little River and Drowning Creek watersheds include Early Woodland New River; Middle Woodland Deptford, Yadkin, Mount Pleasant, Cape Fear I, and Hanover I; and Late Woodland Hanover II and Cape Fear III (Table 3.2; Figures 3.4–3.5).

Coastal Plain Sites and Samples

The Coastal Plain is represented by 10 sherds from the Breece site (31Cd8) adjacent to the former location of the McLean Mound site in the Cape Fear basin, 10 from the Waccamaw site (31Cb1) in the Lumber River basin, and 10 from the Kolb site on the central Pee Dee River in South Carolina.

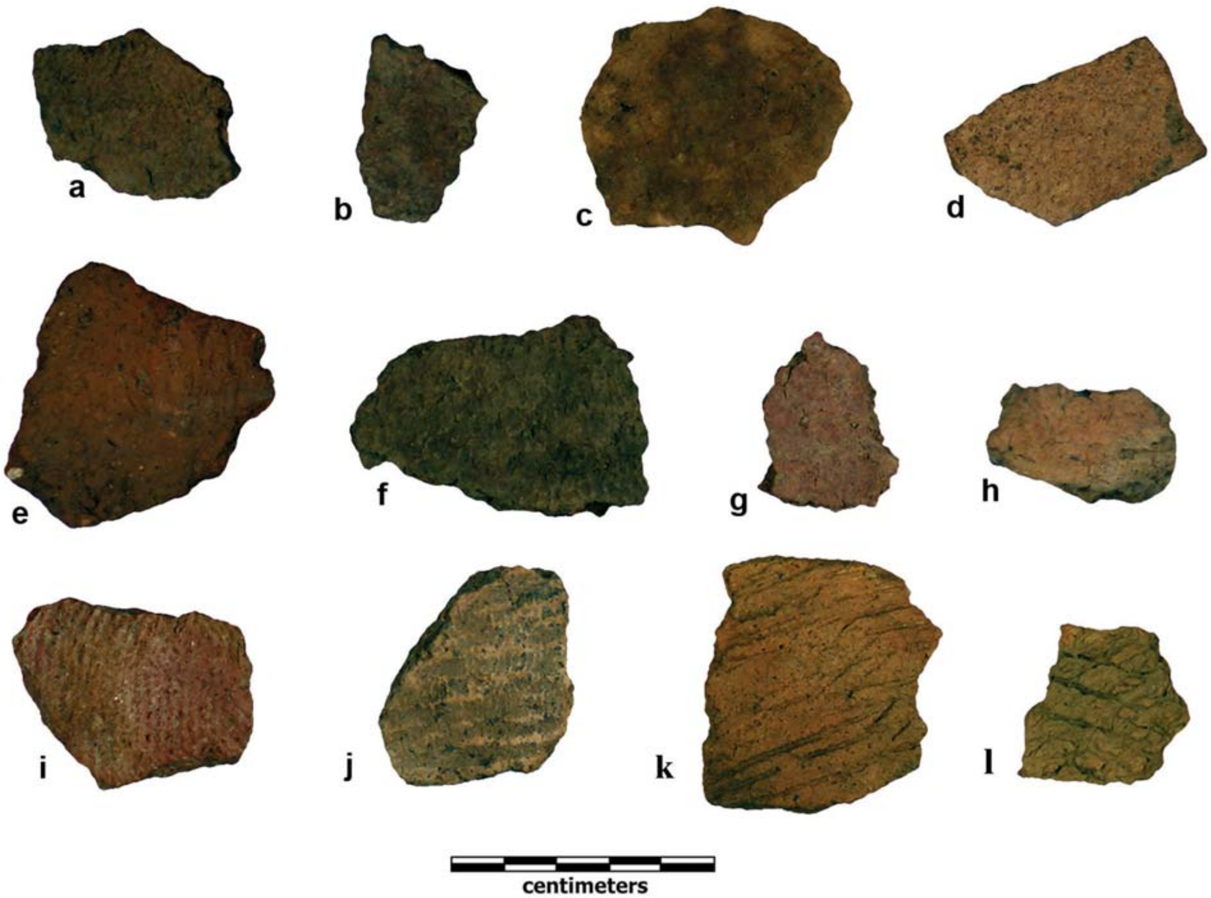


Figure 3.4. Pottery samples from Fort Bragg sites in the Lower Little drainage: (a) JMH001, Hanover II Fabric Impressed; (b) JMH002, Hanover II Fabric Impressed; (c) JMH003, Cape Fear III Fabric Impressed; (d) JMH004, Hanover II Fabric Impressed; (e) JMH005, Hanover I Cord Marked; (f) JMH006, Yadkin Fabric Impressed; (g) JMH007, Hanover I Paddle-edge Overstamped; (h) JMH008, Mount Pleasant Cord Marked; (i) JMH009, Cape Fear Cord Marked; (j) JMH010, Hanover Fabric Impressed; (k) JMH017, New River Cord Marked; (l) JMH019, Hanover II Cord Marked.

The Breece Site (31Cd8)

The Breece site is located about 200 m north of the former site of the McLean burial mound on a high terrace overlooking the broad alluvial floodplain of the Cape Fear River near Fayetteville (MacCord 1966:39–44, 62–66; Figure 3.1). Testing of the site by volunteer members of the North Carolina Archaeological Society in 1962 consisted of the excavation of 13 1.5 m (5 ft) squares dug in three arbitrary 20 cm (8 in) levels. Sherds recovered in the plow zone (from which the current sample came) comprised mostly fabric-impressed (63%) with some cord-marked (17%) types in association with small triangular projectile points. Assemblages from the lower levels were characterized by more cord-marked pottery than fabric impressed and medium-sized triangular points. Although Breece is adjacent to the McLean Mound, it was evident to the original excavators that the diversity of pottery represented many occupational components over several hundred years. Radiocarbon dates for charcoal from the mound (including one date for soot from a fabric-impressed sherd) indicate that burials were interred

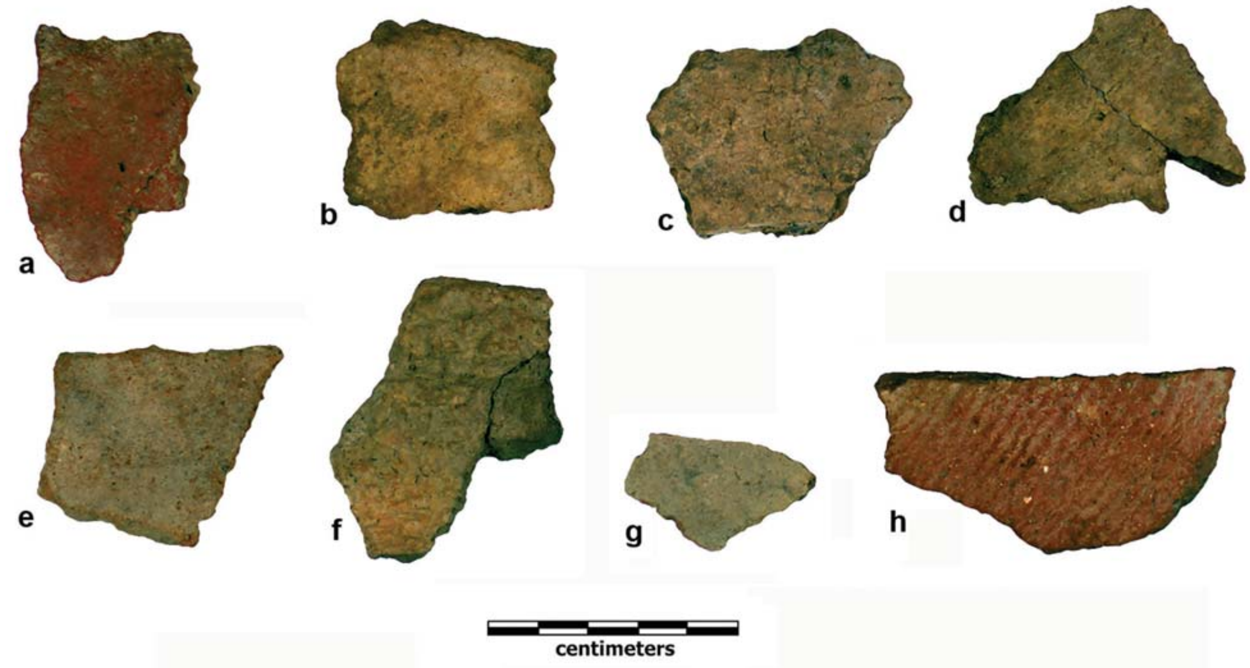


Figure 3.5. Pottery samples from Fort Bragg sites in the Drowning Creek drainage: (a) JMH011, Hanover I Cord Marked; (b) JMH012, Hanover II Fabric Impressed; (c) JMH013, Deptford Linear Check; (d) JMH014, Yadkin Fabric Impressed; (e) JMH015, Sand-tempered Plain; (f) JMH016, New River Paddle-edge Overstamped; (g) JMH018, Deptford Check Stamped; (h) JMH020, New River Cord Marked.

here from about AD 750–1300 (MacCord 1966:17; Herbert et al. 2002:105). This is just the time when, given regional trends, we might expect to see a shift in pottery-making technology from sand tempering to grog tempering (Irwin et al. 1999:63–71).

The pottery sample from the Breece site consisted of one Early Woodland New River Fabric-Impressed sherd, one Middle Woodland Cape Fear Cord-Marked sherd, three Middle Woodland Hanover I Fabric-Impressed sherds, and five Late Woodland Hanover Fabric-Impressed sherds (Table 3.2; Figure 3.6). It is likely that the Hanover specimens from the Breece site sample date to the period when the McLean Mound was in use.

The Waccamaw Site (31Cb5)

The Waccamaw site is located on a low rise occupying the northern bank of Lake Waccamaw, a large poccosin lake or Carolina Bay in Columbus County, North Carolina (Figure 3.1). The collection from the site from which our pottery samples were drawn consisted of materials collected from the surface and donated to the Research Laboratories of Archaeology (RLA) at The University of North Carolina at Chapel Hill.

The pottery sample from the Waccamaw site consisted of one Early Woodland Thom's Creek Punctate specimen (with a simple, random punctation pattern); seven sherds from the Middle Woodland period, including five Cape Fear Fabric Impressed and two Hanover I Fabric Impressed; and two Middle-to-Late Woodland period Hanover II Fabric-Impressed specimens (Table 3.2; Figure 3.7).

Figure 3.6. Pottery samples from the Breece site (31Cd8): (a) JMH021, Hanover II Paddle-edge Overstamped; (b) JMH022, New River Fabric Impressed; (c) JMH023, Hanover II Fabric Impressed; (d) JMH024, Hanover II Fabric Impressed; (e) JMH025, Cape Fear Cord Marked; (f) JMH026, Hanover II Fabric Impressed; (g) JMH027, Hanover I Fabric Impressed; (h) JMH028, Hanover I Fabric Impressed; (i) JMH029, Hanover I Fabric Impressed; (j) JMH030, Hanover II Fabric Impressed.

The Kolb Site (38Da75)

The Johannes Kolb site lies on a relict channel of the Great Pee Dee River in Darlington County, South Carolina (Figure 3.1). Documents record the fact that this ancient meander was artfully cut off by an enterprising landowner in the 1870s, and consequently we assume that the Woodland period habitations on the site would have occupied the first terrace of the active river channel. The site was found and recorded in 1973 and obtained by the South Carolina Department of Natural Resources Heritage Trust Program (HTP) in 1992. In 1997 historical and archaeological investigations began in earnest at the Kolb site, and they continue to this day under the sponsorship of the HTP and the Diachronic Research Foundation.

A sample of nine pottery sherds from the Kolb site was generously donated by the Diachronic Research Foundation, and one sherd (JMH057) was collected near the Kolb site on the surface of a sandy bluff overlooking the Pee Dee River (Table 3.3; Figure 3.8). Six of the nine sherds from the Kolb site are from Feature 99-32 in Unit 60E55N, and two are from Feature 02-22 in Unit 45E47N.

Steen (2008:123) describes Feature 99-32 as a deep pit containing "a thick deposit of shell and what seems to be most of a poorly fired fabric impressed vessel." Shell from the base of this

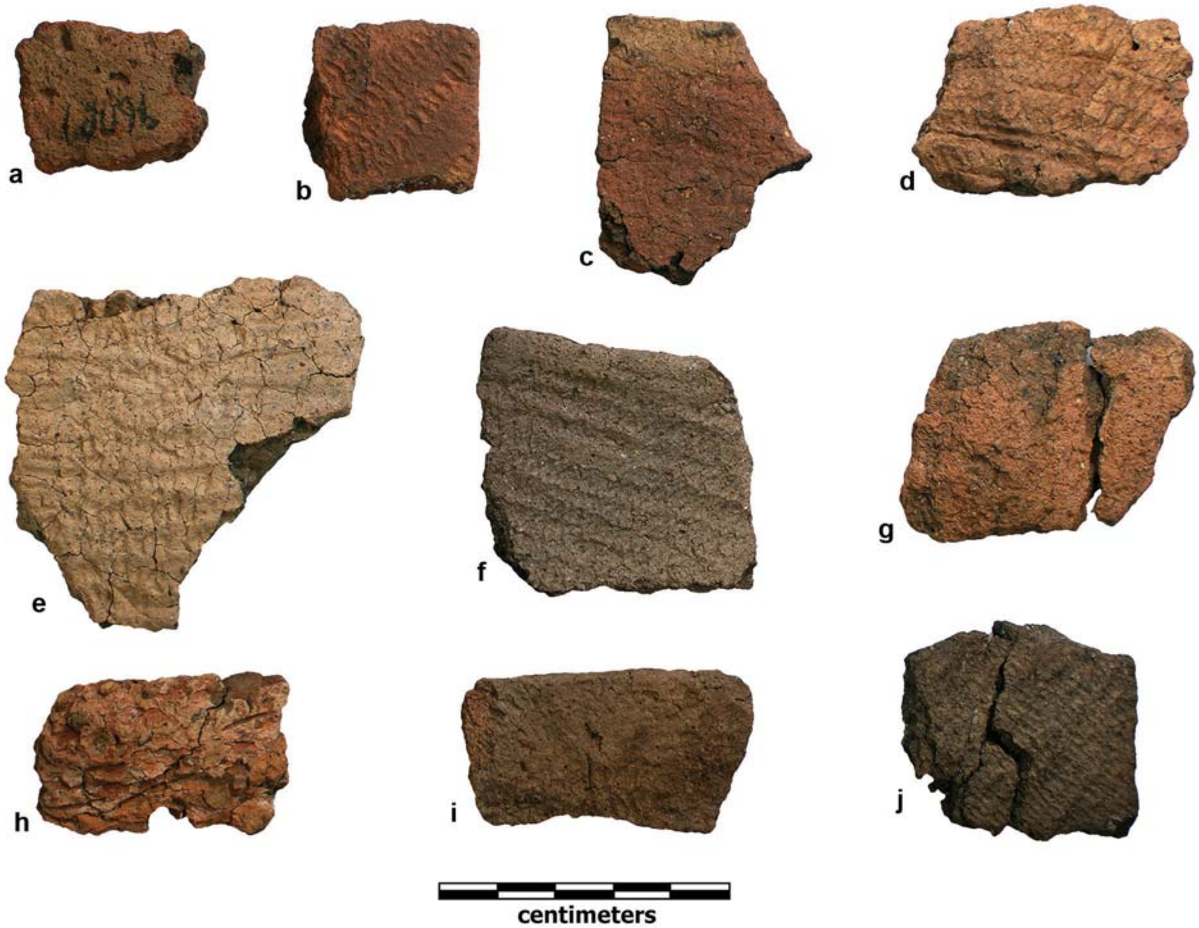


Figure 3.7. Pottery samples from the Waccamaw site (31Cb5): (a) JMH061, Thom's Creek Punctate (random); (b) JMH062, Cape Fear Fabric Impressed; (c) JMH063, Hanover II Fabric Impressed; (d) JMH064, Hanover II Fabric Impressed; (e) JMH065, Hanover I Fabric Impressed; (f) JMH066, Cape Fear Fabric Impressed; (g) JMH067, Cape Fear Fabric Impressed; (h) JMH068, Hanover eroded; (i) JMH069, Cape Fear Fabric Impressed; (j) JMH070, Cape Fear Fabric Impressed.

feature was radiocarbon dated 1440 ± 40 BP (UGA-013302, mussel shell, $\delta^{13}C = -10.84‰$) cal AD 872–1041 (p = .95).[1]

The six pottery specimens from Feature 99-32 are quite varied, indicating that multiple cultural components are represented and suggesting that the contents of the feature might be mixed (Table 3.3). Early Woodland components are represented by sand-tempered New River Cord-Marked and New River Fabric-Impressed sherds, elsewhere dating to the period 1200–400 BC. Four Yadkin sherds are distinguished by the presence of crushed quartz temper, and two of these also include some crushed ceramic or grog in the paste. Although the combination of these two temper types is not altogether unique, it is uncommon and at present can only be considered a minority variant of the Yadkin tradition that otherwise has been estimated to date to the period 1000 BC–AD 200 (Herbert et al. 2002:103). As grog tempering continued to be popular well into the Late Woodland Period, after AD 900, it is suspected that the Yadkin sherds containing grog probably date to the late end of the expected age range for this type.

Table 3.3. Pottery Samples from the Kolb Site.

Sample ID	Unit	Level	Feature	Period	Series	Type
JMH059	60E55N	8	Feat 99-32	Middle Woodland	Cape Fear	Fabric Impressed
JMH052	60E55N	3	Feat 99-32	Middle Woodland	Yadkin + grog	Fabric Impressed
JMH053	60E55N	3	Feat 99-32	Middle Woodland	Yadkin + grog	Cord Marked
JMH055	60E55N	3	Feat 99-32	Early-Middle Woodland	Yadkin	Cord Marked
JMH051	60E55N	3	Feat 99-32	Early-Middle Woodland	Yadkin	Fabric Impressed
JMH054	60E55N	3	Feat 99-32	Early Woodland	New River	Cord Marked
JMH056	60E55N	8	Feat 96-106	Early Woodland	New River	Fabric Impressed
JMH057	-	surface	-	Early Woodland	New River	Cord Marked
JMH060	45E47N	10	Feat 02-22	Middle Woodland	Hanover I	Fabric Impressed
JMH058	45E47N	18	Feat 02-22	Middle Woodland	Cape Fear	Fabric Impressed

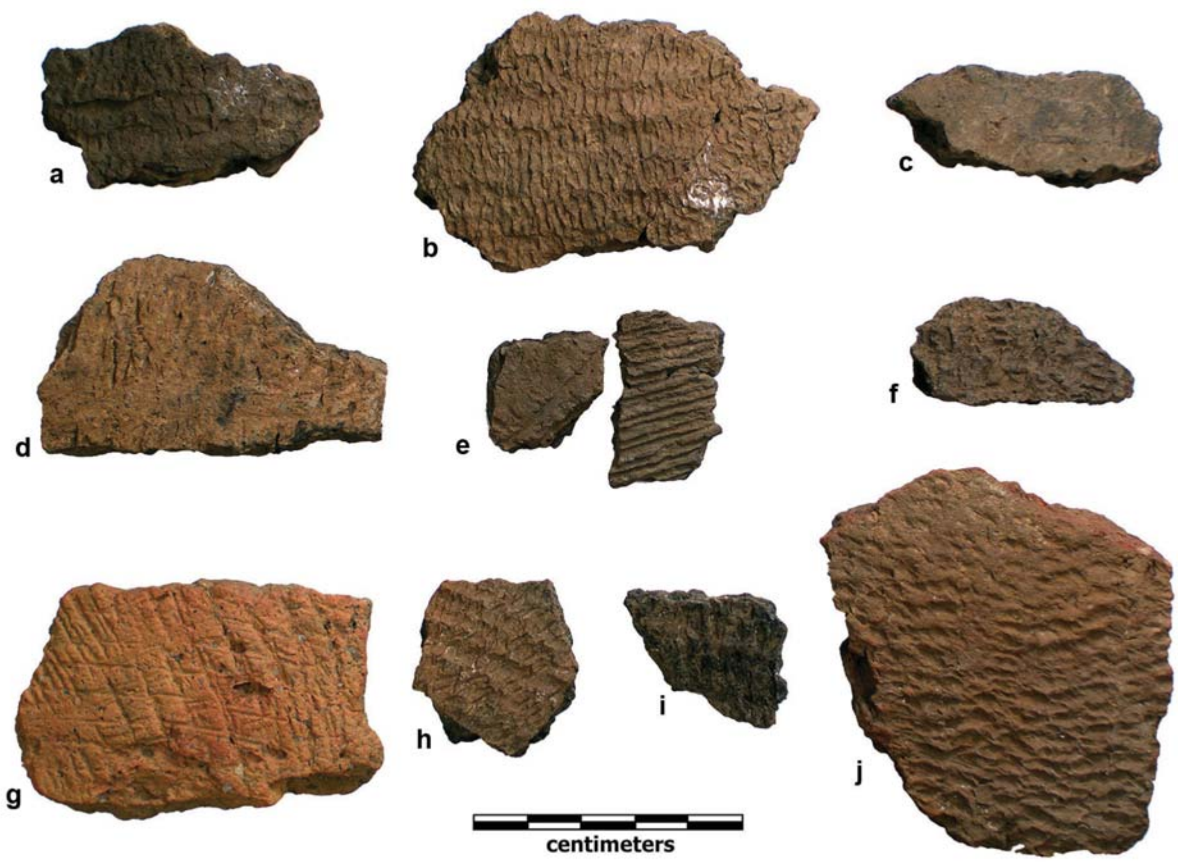


Figure 3.8. Pottery samples from the Kolb site (38Da75): (a) JMH051, Yadkin Fabric Impressed; (b) JMH052, Yadkin/Hanover Fabric Impressed; (c) JMH053, Yadkin/Hanover Cord Marked; (d) JMH054, New River Cord Marked; (e) JMH055, Yadkin Cord Marked; (f) JMH056, New River Fabric Impressed (flex warp); (g) JMH057, New River Cord Marked; (h) JMH058, Cape Fear Fabric Impressed; (i) JMH059, Cape Fear Fabric Impressed; (j) JMH060, Hanover I Fabric Impressed.

Encountered at a depth of 50 cm below the surface, Feature 02-22 was notable for a dense deposit of mussel shell that contained fish, turtle, and deer bone as well as fabric-impressed sherds (Steen 2008). The shell lens capped a deep pit that extended to a depth of 125 cm below surface. Although the pit was nearly empty below the shell lens, the two sherds studied here were found in the fill. A Hanover Fabric-Impressed sherd was recovered at Level 10 about 60–65 cm below the surface, and a Cape Fear Fabric-Impressed sherd was found in Level 18 roughly a meter below the surface. A radiocarbon date was obtained for shell from the capping lens: 1400 ± 40 B.P. (UGA-013305, mussel shell, $\delta^{13}C = -10.55‰$) cal AD 905–1068 (p = .95).

Notes

Acknowledgments. Vin Steponaitis and R. P. Stephen Davis facilitated access to collections housed at the RLA and provided pottery samples for this study. Dr. Davis also assisted in classifying materials from the Doerschuk and Haw River sites. Carl Steen, Diachronic Research Foundation, provided pottery samples, contextual information, and radiocarbon data from the Kolb site.

[1]The Kolb site radiocarbon dates (UGA-13302 and UGA-13305) for shell from Features 99-32 and 22-02 were calibrated with the Calib 4.3 program using INTCAL98 calibration curves (Stuiver and Reimer 1993). As these were lacustrine shell samples (freshwater mussels), they were calibrated with the marine data set to compensate for differences in availability of radiocarbon in aquatic reservoirs. The marine calibration incorporates a time-dependent global ocean reservoir correction of about 410 years. Local reservoir effects were corrected by applying the Δ-R value derived from coral dates in the Bahamas (-5 ± 20), currently the closest analog for these samples (Stuiver and Braziunas 1993). Age estimates are reported as calibrated intercepts (BP) and minimum and maximum calibrated 2-δ (.95) ranges (AD).

Chapter 4

Clays

Theresa E. McReynolds and Joseph M. Herbert

Eighty-four clay samples were collected from the Sandhills, Coastal Plain, and Piedmont to provide a basis for characterizing regional variability in ceramic resources. An important goal of this raw materials survey was to acquire samples that could potentially be geochemically or mineralogically correlated with the 70 pottery samples described in Chapter 3. Another key objective was to evaluate the suitability of the clay samples for making low-fired earthenwares. Specifically, the study was designed to determine if serviceable raw materials would have been locally available in the Sandhills, and if not, where they might have been most readily obtained.

On an even more fundamental level, we wanted to understand why people selected particular materials in the first place. Ethnographic evidence indicates that potters typically choose resources in an attempt to maximize quality while minimizing costs of procurement. In particular, workability, distance, and accessibility are important factors influencing decisions about raw material selection (Rieth 2002:201). Yet these three factors are not the only ones with the potential to influence potters' behaviors. An understanding of the performance characteristics of specific resources could help us recognize the technical, economic, and cultural factors that might also have influenced prehistoric decision making.

This chapter describes our clay sample collecting strategy, the results of field and laboratory performance tests, and some implications of these results for interpreting the behaviors of Woodland potters. The geochemical and mineralogical characteristics of the clay samples are discussed in Chapters 5–7.

Throughout this chapter and elsewhere in the report, the term "clay" is loosely used to refer to any plastic soil material. Thus, a "clay" sample may not conform to standard chemical, mineralogical, or particle-size definitions. It may not even correspond to a "natural" clay defined on the basis of functionality (Rice 1987:52). Nevertheless, because our criteria for identifying suitable plastic raw materials were presumably similar to those employed by Woodland potters, we refer to any potential or collected sample as a "clay."

Sample Collection

To facilitate comparison of raw materials with the ceramic samples, our clay sampling strategy focused on exposed and near-surface resources in the vicinities of the sites from which sherds were selected. The sampling universe was initially constrained by ethnographic data indicating that potters typically procure resources within 5 km of their pottery-manufacturing areas (Arnold 1985). The ideal number of samples was set at 10 per site locality, but the actual number of samples collected depended on the natural distribution and variation of resources.

Samples were located through systematic survey of accessible riverbanks and streambeds within approximately 5 km of each site (although see the discussion of the Waccamaw samples for an exception). Road cuts, tree falls, erosional features, and other natural and artificial disturbances were utilized in nonalluvial settings. Potential locations of clay deposits were also predicted using topographic, soil, and geologic maps.

Traditional potters base their selection of clay resources on plasticity, or the ability to deform without cracking. Thus whenever a deposit of clay was located, we performed a simple "coil" test to evaluate its plasticity (Figure 4.1). The clay was moistened (if necessary), rolled into a rope approximately 1 cm in diameter, and wrapped around a finger. If the coil broke or cracked severely during the test, no sample was collected. If the clay passed the coil test, a couple of liters were collected and stored in plastic bags for additional analyses (Figure 4.2).

If fewer than five potentially suitable samples were found within a site locality, the search was expanded beyond the initial 5-km radius. Surprisingly, this situation occurred more often than not. In fact, most materials in the Sandhills failed the coil test. Because we wanted geochemical and mineralogical data for every region, however, we ultimately decided to collect samples from the Sandhills regardless of their coil-test performances.

A few additional samples were collected from areas for which we do not have corresponding ceramic samples. Preliminary results of petrographic analysis (Chapter 6) revealed that some sherds contain rock fragments that may have been derived from diabase dikes such as those found in the Deep River basin. We therefore collected 13 clay samples near mapped diabase outcrops in Chatham and Lee counties. These samples allowed us to characterize an additional region of the Piedmont and assess whether diabase inclusions identified in the sherds are more likely to be naturally occurring components of the clay matrices or intentionally added temper.

Finally, nine aplastic samples were collected for possible use as tempering materials in replication experiments (described below). These temper samples include sands, quartz chunks, metavolcanic rocks, and volcanic rocks.

Sample Descriptions

A total of 84 clay samples were collected from eight areas: the Lower Little and Drowning Creek drainages in the Sandhills; the Cape Fear, Pee Dee, and Waccamaw drainages in the Coastal Plain; and the Haw, Yadkin, and Deep drainages in the Piedmont (Figure 4.3). General descriptions of the samples collected from these areas are given below; detailed descriptions of each sample are included in Appendix B (Tables B.1–B.2).

Sandhills Samples

Locating potentially suitable materials in the Sandhills proved difficult despite systematic surveying, use of GIS-generated predictive models based on soils and geology data, and our relative familiarity with the distribution of resources on Fort Bragg. After three days of systematic searching revealed only a single, localized deposit capable of passing the field coil test, we decided to collect samples exhibiting any evidence of plasticity in order to have some

Figure 4.1. “Coil” test to evaluate plasticity.

basis for identifying the geochemical and mineralogical characteristics of Sandhills sediments. Of the 21 samples ultimately collected from the Lower Little and Drowning Creek drainages, fewer than half passed the field coil test.

Lower Little River. Twenty clay samples and a sand temper sample were collected in the Lower Little drainage (Figure 4.4). All samples consist of transported sediments and come from deposits within the boundaries of Fort Bragg. At least one clay sample was collected within 7.5 km of every relevant archaeological site.

Eleven of the Lower Little River samples were located through systematic survey. About half of these samples are from lowland alluvial deposits (FBR004, FBR005, FBR007, FBR010, FBR017, FBR018). The other half are from upland settings, some of which may represent Cretaceous deposits (FBR001–FBR003, FBR008, FBR009).

Nine additional samples were opportunistically collected in conjunction with archaeological testing on Fort Bragg. Samples FBR059–FBR061 were collected in the vicinity of the historic Cabin Branch Crossing sites (31Hk1640 and 31Hk1641) after a survey team observed clay deposits in a nearby stream. The recovery of several fired coil segments at the Middle Woodland Fox Ridge site (31Hk1567) prompted collection of samples FBR062–FBR067 from the adjacent wetland bottom.

Compared to samples from other drainages, the Lower Little River samples display considerable variability with respect to color and texture. Munsell colors range from white to black, and textures vary from pure clay to fine micaceous sand.

Figure 4.2. Joe Herbert using a bucket auger to collect an upland clay sample from a tree fall.

A single sand sample was collected from a sand bar in the streambed of McFadyen Branch for use as a tempering material (FBR092). This very homogenous sand is primarily composed of medium-sized (0.25–0.5 mm) subangular quartz fragments, although a dark mineral (possibly biotite) also occurs in low frequency.

Drowning Creek. Despite extensive searching, a single sample obtained approximately 8 km from the nearest archaeological site is the sole representative of the Drowning Creek drainage (Figure 4.4). Sample FBR006 is a dry, blocky white clay collected from an upland setting exposed by erosion. Several recent borrow pits were observed along this exposure where clay is sometimes mined for consumption (i.e., geophagia).

Coastal Plain Samples

It was relatively easy to find materials that passed the field coil test in the Cape Fear, Pee Dee, and Waccamaw drainages. Five or more promising samples were collected from each drainage, in many cases within 2 km or less of the archaeological sites from which pottery samples were drawn.

Cape Fear River. In the middle Cape Fear drainage, six alluvial clay samples were collected within a 2-km radius of the Breece site (31Cd8; Figure 4.4). The samples were obtained from streambank (FBR011, FBR014), streambed (FBR015, FBR016), and floodplain (FBR012, FBR013) deposits along tributaries of the Cape Fear River. All six Cape Fear samples are

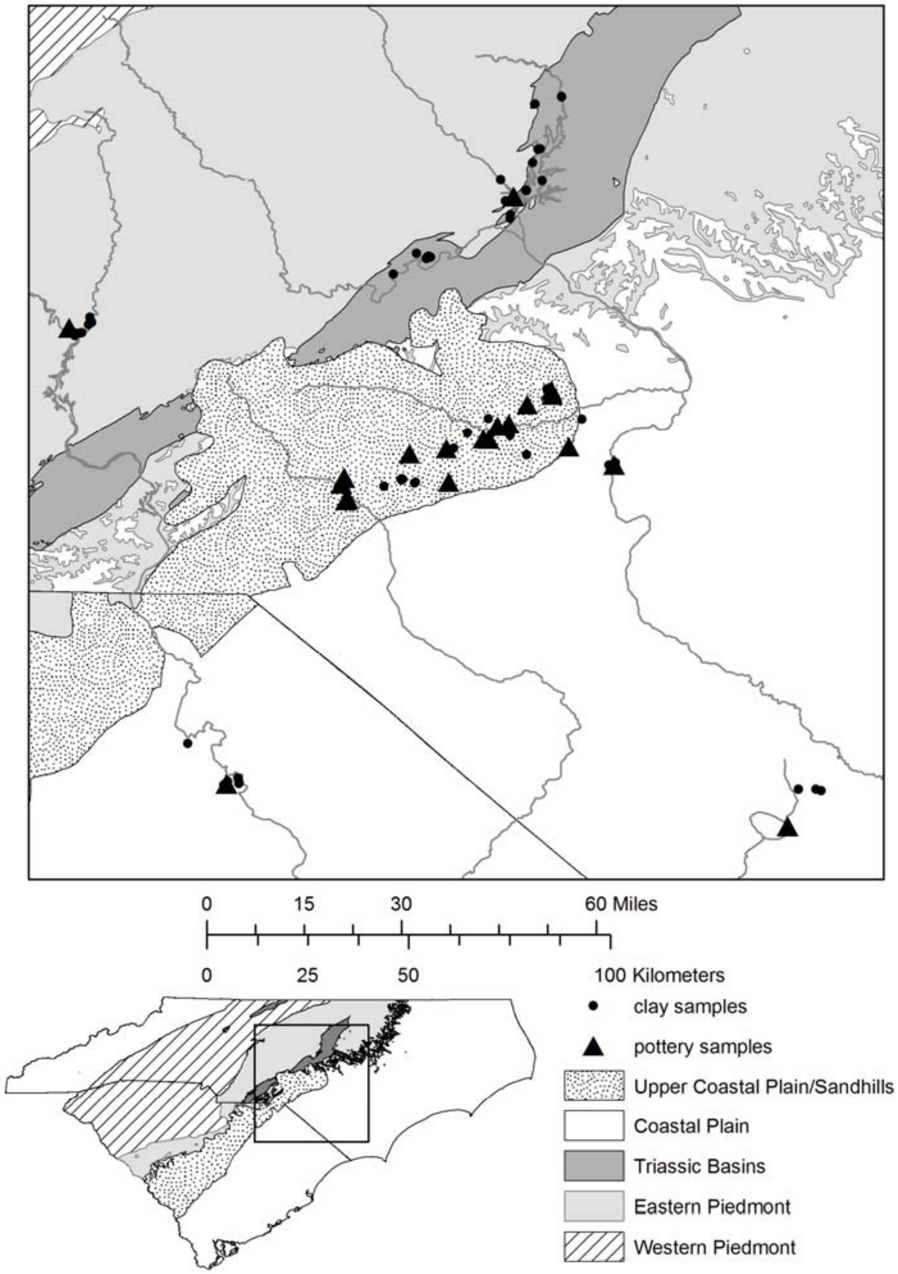


Figure 4.3. Clay and pottery sample locations (North Carolina Geological Survey 1998; South Carolina Geological Survey 2005; United States Geological Survey 2002).

relatively similar to each other with respect to color and texture and can generally be described as brown clay with sand or grit.

Pee Dee River. Nine samples collected near the Kolb site (38Da75) in South Carolina represent the middle Pee Dee drainage (Figure 4.5). The samples came from lacustrine (FBR019, FBR023), floodplain (FBR020–FBR022, FBR026), and riverbank (FBR024, FBR025, FBR027) settings. All but one of the samples were collected within 2 km of the site. Sample

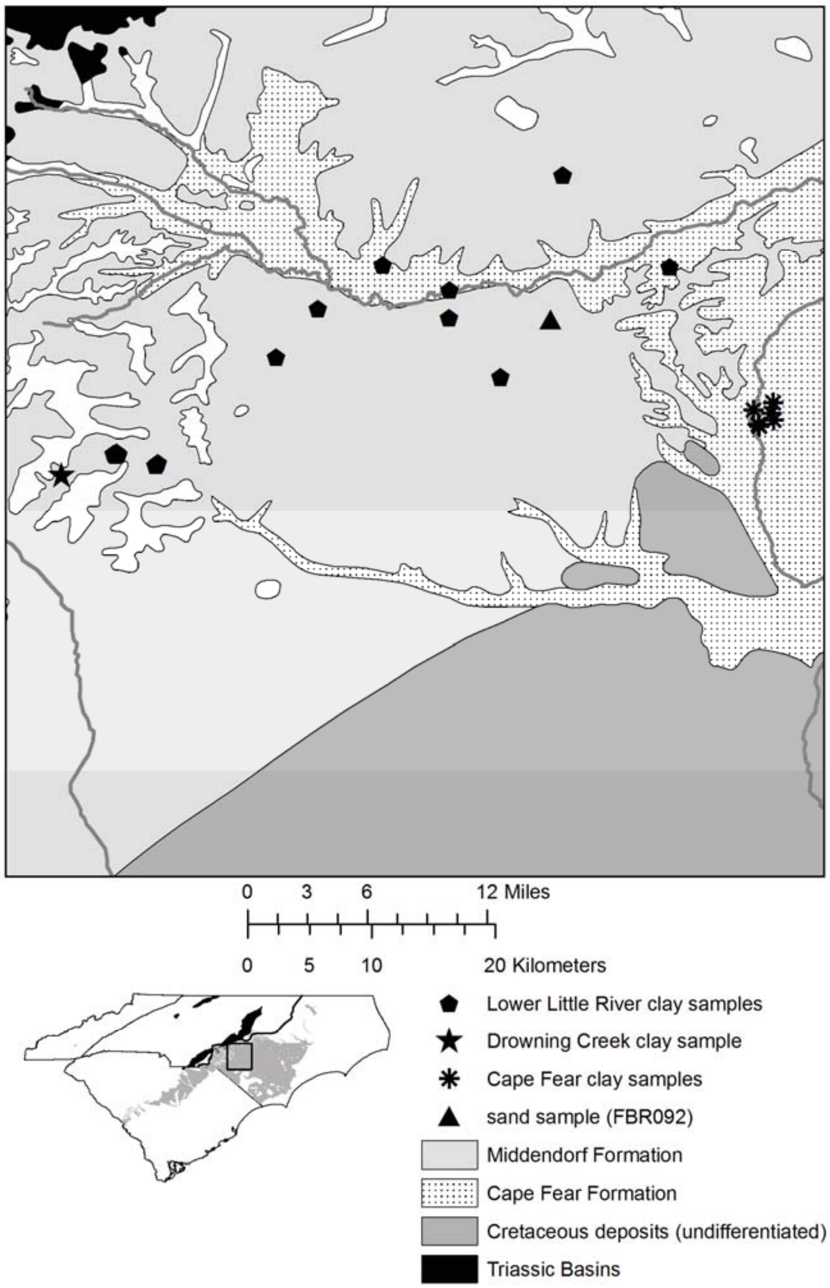


Figure 4.4. Clay and temper sample locations in the Lower Little, Drowning Creek, and Cape Fear drainages (North Carolina Geological Survey 1998; South Carolina Geological Survey 2005; United States Geological Survey 2002).

FBR023 was collected from the bank of an oxbow lake near the archaeology crew's field house, approximately 13 km northwest of the Kolb site. The Pee Dee samples include brown or yellow clays containing sand or grit, organics, and/or clay lumps.

Waccamaw River. The collecting strategy in the Waccamaw drainage differed from the systematic surveying undertaken in other sampling regions. Sandra Bonner, a member of the

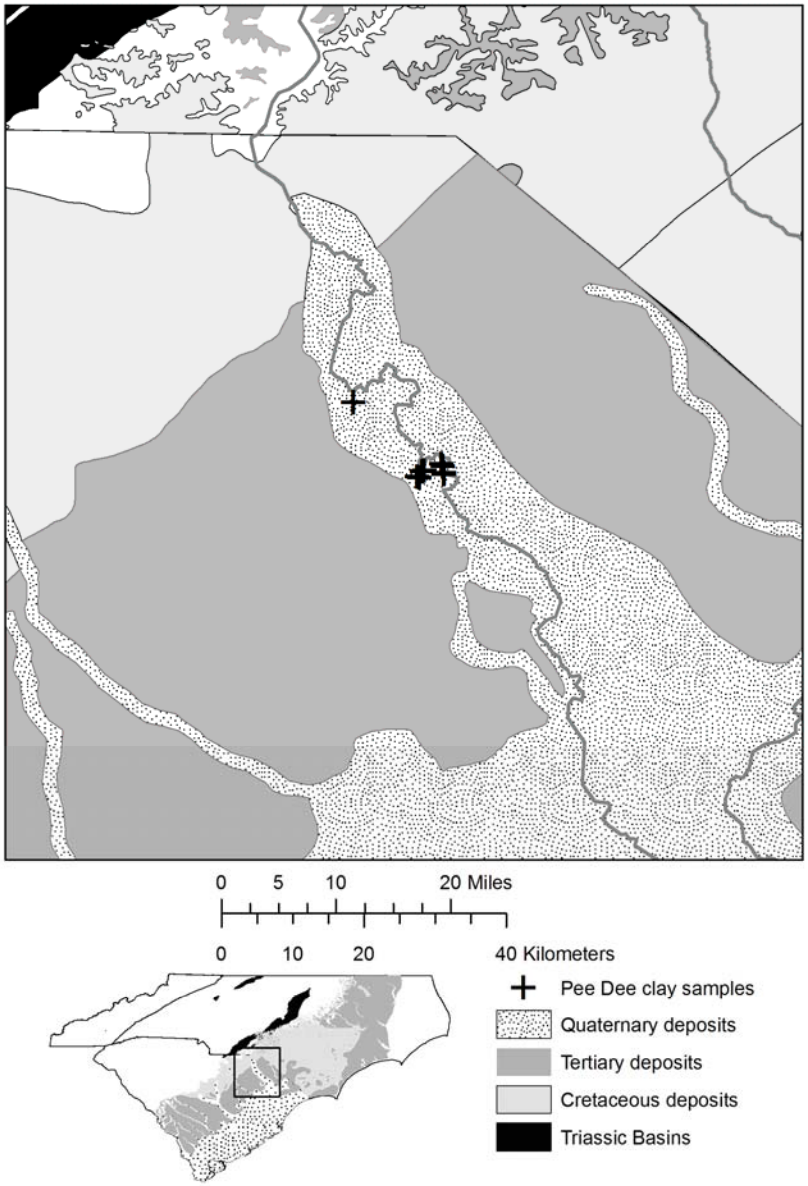


Figure 4.5. Clay sample locations in the Pee Dee drainage (North Carolina Geological Survey 1998; South Carolina Geological Survey 2005; United States Geological Survey 2002).

Buckhead community in Bolton, North Carolina, served as our guide and helped us locate four floodplain samples (FBR081–FBR084) and one streambed sample (FBR085; Figure 4.6). These samples were collected 9–11 km from the Waccamaw site. In general, the samples consist of gray and brown clay containing some sand.

Piedmont Samples

The landscapes surrounding the Haw River and Doerschuk sites have both been altered by modern hydroelectric projects, making it more challenging to locate clay sources that would have

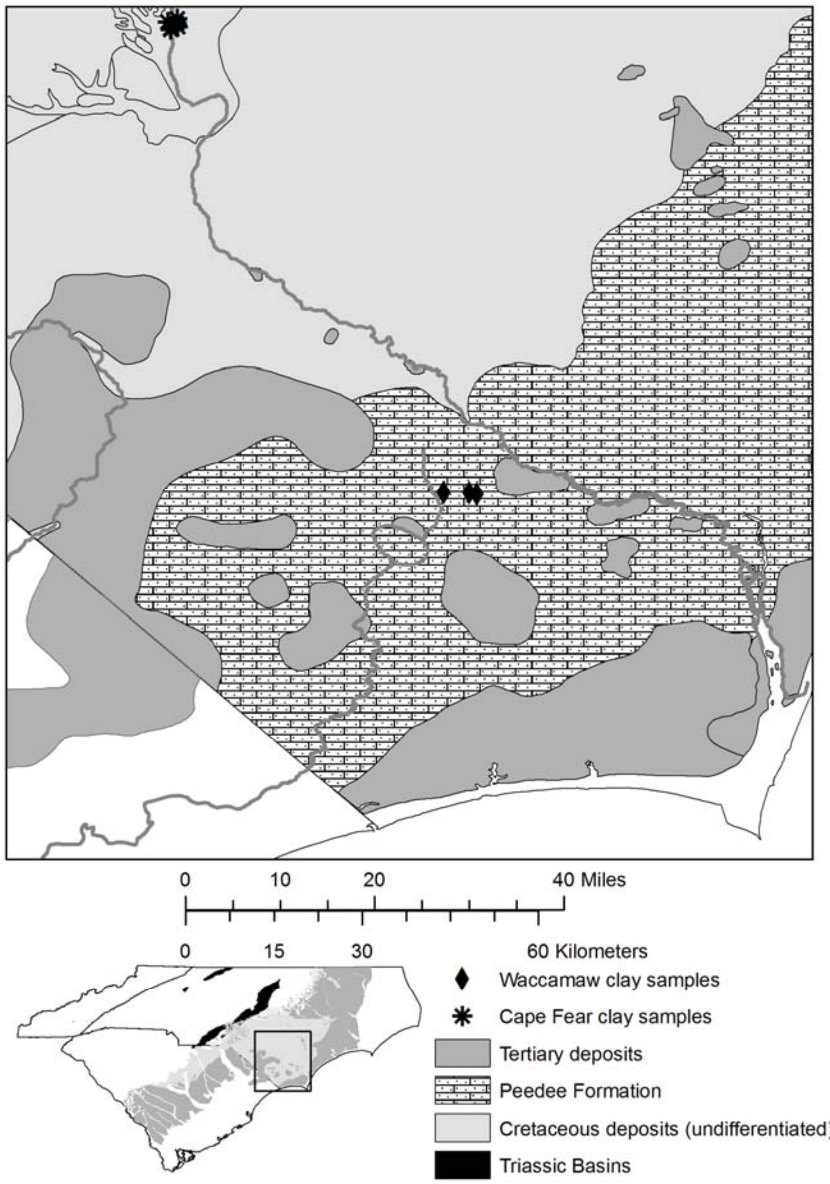


Figure 4.6. Clay sample locations in the Waccamaw drainage (North Carolina Geological Survey 1998; South Carolina Geological Survey 2005; United States Geological Survey 2002).

been available to prehistoric potters. Potentially suitable deposits were likely inundated when the Haw River site was flooded by Jordan Lake in 1983. Likewise, the construction of the Narrows Dam in 1917 flooded part of the Yadkin drainage only a few kilometers northwest of the Doerschuk site. Yet even if the specific clay sources exploited by Woodland potters are now inaccessible, samples collected in the vicinity of the sites should still allow us to broadly distinguish the drainages with respect to geochemical and mineralogical characteristics.

Haw River. While excavating the Haw River site (31Ch29) in 1979, Stephen Claggett and John Cable (1982) collected nine clay samples from the Haw River floodplain and surrounding uplands. Although these clay samples apparently no longer exist, Claggett and Cable (1982:108) concluded that

> it is apparent, even on a preliminary examination of the pottery and local clays, that the variety of pottery found in the archaeological record could have been produced with local clays. … Local clays would have been entirely adequate to produce the range of prehistoric pottery.

Claggett and Cable (1982:108) suggest that the best clays could be obtained right along the riverbank near the site or slightly north and east of it. They also assert that quartz fragments similar to those observed in pottery from the site are locally present along the riverbank (Claggett and Cable 1982:108).

Unfortunately, the clay and quartz locations sampled by Claggett and Cable in 1979 are now inundated by Jordan Lake, and attempts to relocate the samples they collected were unsuccessful. Consequently, the 18 samples representing the lower Haw drainage in this study came primarily from the banks of Jordan Lake and its tributaries (Figure 4.7). Nine clay samples were collected within 7.5 km of the Haw River site (FBR028–FBR036), and five more were collected within 15 km of the site (FBR037–FBR041). Four samples were collected from the Morgan Creek and New Hope Creek tributaries more than 20 km north of the site (FBR042–FBR045).

Aplastic samples were also obtained from the Haw drainage for use as tempering materials. Sand samples were collected from the bank of Jordan Lake and the streambed of Morgan Creek. The Jordan Lake sample is a poorly sorted, subrounded quartz sand with dark mineral inclusions and fragments of weathered metavolcanic rock. The Morgan Creek sample contains subrounded quartz, granite, and possibly quartzite fragments. Although these two sand samples were not subjected to mineralogical or chemical analyses, they were used to temper test tiles for drying and firing experiments.

Two samples of weathered, metamorphosed granitic rock were also acquired. Sample FBR088 came from an archaeological context at the Webster site (31Ch463), located approximately 19 km upriver from the Haw River site. Sample FBR089 was collected along a roadside approximately 13 km from the Haw River site.

Yadkin River. Twelve alluvial samples collected in Montgomery County near the Doerschuk site (31Mg22) represent the lower Yadkin drainage (FBR046–FBR057; Figure 4.8). All but two of the samples were found in streambank settings along the Yadkin or Uwharrie Rivers; samples FBR055 and FBR057 came from floodplain deposits. We were able to reach the perimeter of the Doerschuk site by canoe, but no suitable clay sample could be found in the immediate vicinity. The nearest promising sample was found approximately 1.5 km downstream (FBR057). Accessibility and time constraints prohibited searching on the Stanly County side of the Yadkin River, but it is likely that the 12 samples from Montgomery County are adequate to generally characterize alluvial deposits near the Doerschuk site. They are relatively homogeneous and consist of olive gray or olive brown silty clay with sand and organics.

A quartz nodule from the Yadkin-Pee Dee River basin was obtained for use as a tempering material (FBR087). The sample came from an outcrop in Richmond County more than 40 km southeast of the Doerschuk site.

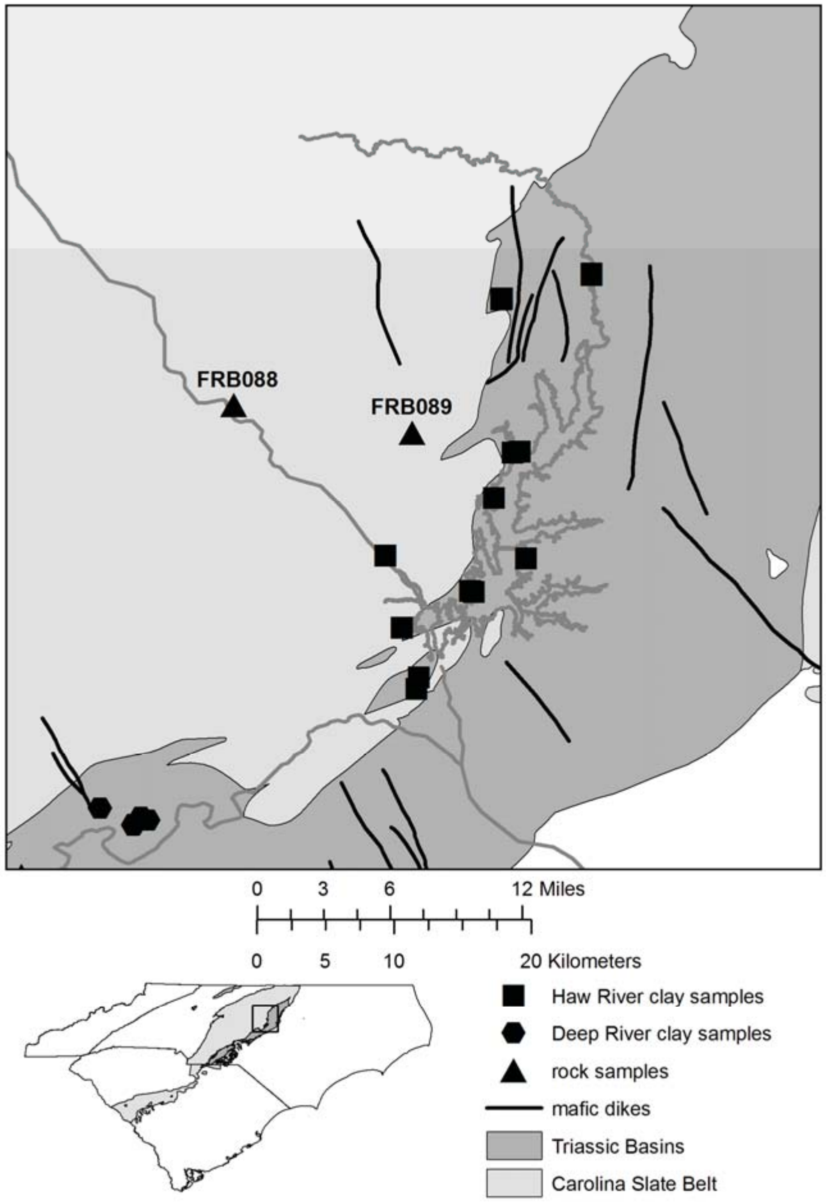


Figure 4.7. Clay and temper sample locations in the Haw drainage (North Carolina Geological Survey 1998a, 1998b; South Carolina Geological Survey 2005; United States Geological Survey 2002).

Deep River. Pottery specimens from the Deep drainage were not included in our ceramic sample, but four sherds contain diabase rock fragments that could be derived from outcrops in the Deep River area (JMH006, JMH031, JMH046, JMH047; see Chapter 6). To determine if the fragments observed in these sherds did indeed originate in the Deep drainage, we collected clay and aplastic samples in the vicinity of several mapped diabase dikes (North Carolina Geological Survey 1985).

Two clay samples were collected from the bank of the Deep River just below an abandoned hydroelectric dam in Carbonton, North Carolina (FRB058 and FBR080; Figure 4.9). Eleven

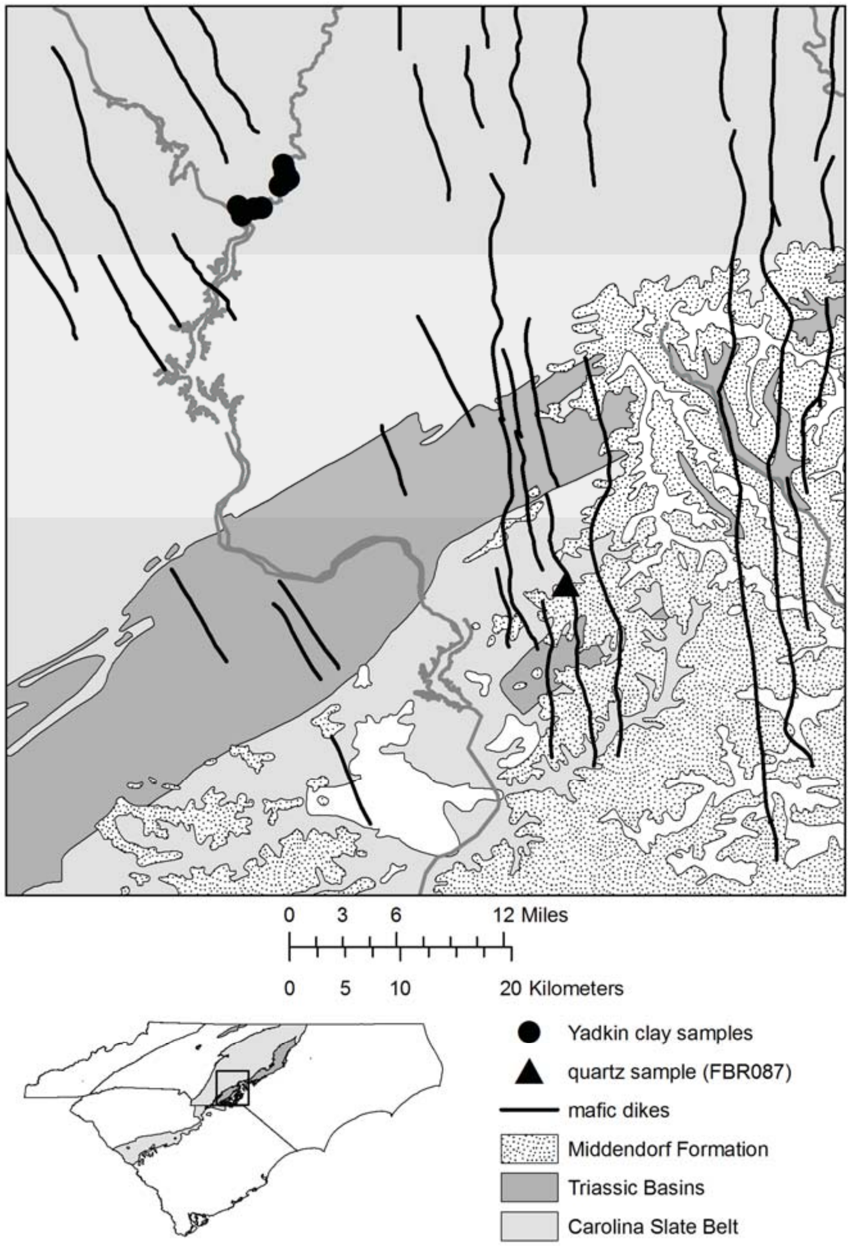


Figure 4.8. Clay and temper sample locations in the Yadkin drainage (North Carolina Geological Survey 1998a, 1998b; South Carolina Geological Survey 2005; United States Geological Survey 2002).

additional samples were collected from abandoned clay mines near the small town of Gulf (FBR068–FBR078). These 13 Deep River clay samples were relatively heterogeneous with respect to color and texture, but still not as variable as the Lower Little River samples.

Three aplastic samples were collected for use as tempering materials. Quartz (FBR086) and weathered metavolcanic (FBR090) cobbles were collected from the same location along the Deep River as clay samples FBR058 and FBR080. An unweathered diabase sample was collected from boulders on the opposite side of the river (FBR091).

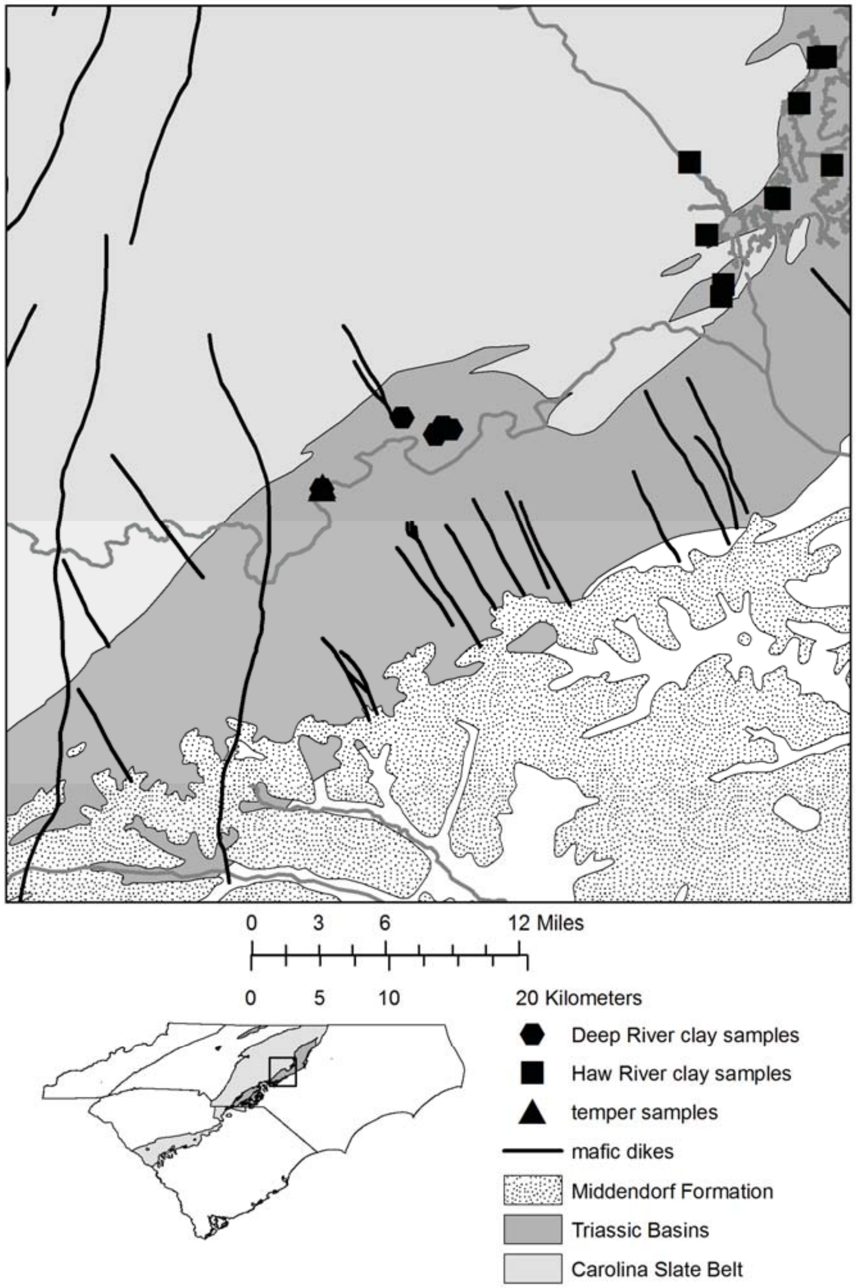


Figure 4.9. Clay and temper sample locations in the Deep drainage (North Carolina Geological Survey 1998a, 1998b; South Carolina Geological Survey 2005; United States Geological Survey 2002).

Performance Trials

The field coil test allowed us to reject materials that were obviously unsuitable for making coil-built pots, but the 84 collected samples still varied considerably in quality. To further assess the suitability of the samples for manufacturing pottery, additional performance tests were conducted to evaluate workability, drying behavior, and firing behavior. The most promising clays were ultimately subjected to replication experiments involving building, drying, and firing coil-built, conical-based vessels.

The performance trials and results are summarized below. Detailed results for each sample can be found in Appendix B (Tables B.2–B.5).

Workability

To be suitable for building pottery, a clay-water mixture must be able to (1) deform without cracking, (2) retain its deformed shape under the force of gravity, and (3) withstand moderate pressure. Various quantitative measures have been devised to describe the degree to which a given clay possesses one or more of these properties when mixed with an appropriate amount of water, but such measures tend to be difficult, time-consuming, or of limited applicability (Barna 1967; Rice 1987:60). Moreover, the equipment required for such quantitative measures would not have been available to prehistoric potters, who would have devised nonquantitative means of determining a clay's suitability for pottery making.

Consequently, we chose to assess the suitability of our samples by judging "workability," a nonquantitative quality describing plasticity, stiffness, and strength based on an individual potter's "feel" for the clay with respect to its intended purpose (Rice 1987:61; Rye 1981:20–21). Workability is generally ranked in terms such as poor, fair, good, or excellent. In this study, workability was judged on the basis of three tests designed to evaluate a material's suitability for fashioning coil-built pots.

The coil test evaluates a clay's ability to be shaped into a desired form without cracking, i.e., plasticity (Figure 4.10a). Regardless of their performances on the field coil test, all samples were subjected to another coil test under more controlled conditions in the laboratory. Before performing the test, large inclusions such as gravels or organic matter were removed, water was added if necessary, and the clay was thoroughly mixed to crush lumps. As in the field, the clay was then rolled into a 1-cm diameter coil and wrapped around a finger. A plasticity ranking was assigned according to the degree of cracking: "plastic" samples did not crack, "moderately plastic" samples cracked, and "weakly plastic" samples broke.

The "loop" test evaluates stiffness, or a clay's ability to retain its deformed shape in the presence of gravity (Figure 4.10b). Samples were rolled into a 1-cm diameter rope and fashioned into a "loop" with an inside diameter of approximately 6 cm. The loop was then set upright for several minutes and a stiffness ranking was assigned according to the degree of sagging (Bjørn 1969:43). "Stiff" samples retained their shapes, "moderately stiff" samples sagged, and "soft" samples collapsed.

Finally, the "ball" test evaluates a sample's plastic strength in response to moderate pressure (as opposed to fired strength, which is discussed in another section; Figure 4.10c). Samples were fashioned into golf-sized balls and then compressed to approximately 1 cm in thickness. A plastic strength ranking was assigned according to the extent of cracking: "strong" samples did not crack, "moderately strong" samples cracked slightly, and "weak" samples cracked extensively. (Shepard [1974:153] describes a slightly different version of this test.)

Results. Considered together, the results of the coil, loop, and ball tests allow us to qualitatively describe the workability of the samples (Table B.2). In general, samples that performed poorly on all three tests are classified as lean (Figure 4.11). At the other extreme, clays that performed well on all three tests are said to possess good workability (Figure 4.12).

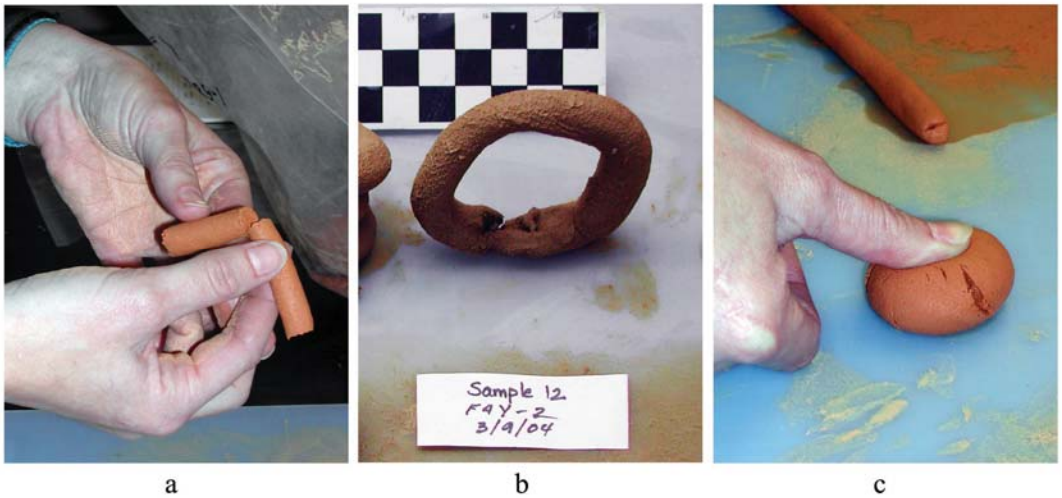


Figure 4.10. Laboratory performance tests to evaluate workability: (a) coil test; (b) loop test; and (c) ball test.

Clays with intermediate performance rankings are typically designated moderately lean (Figure 4.13), although some samples subjectively judged to be "almost good" or "almost lean" were moved up or down accordingly. A fourth classification, "fat," was reserved for clays that have too much plasticity and consequently feel sticky and lack sufficient stiffness or strength.

Based on these criteria, only 25% of the 84 clay samples exhibit good workability (Table 4.1). The majority of samples are moderately lean (52%), and nearly one-fifth are lean. Of course, many of the lean samples would not have been collected had it not been decided to include Sandhills materials regardless of their performances on the field coil test.

The workability data exhibit some geographic patterns. Nineteen of the 21 good clays are alluvial or lacustrine samples. More significantly, Sandhills samples tend to be lean while Coastal Plain clays tend to be good. Piedmont materials are typically moderately lean.

Despite their homogeneity with respect to color and texture, the Sandhills samples are remarkably consistent in being unsuitable as ceramic resources. All but one of the samples from this region lack adequate plasticity. The single good sample was collected from a shallow, probably localized deposit in the bank of Jumping Run Creek in the Lower Little drainage (FBR017). Several fired clay lumps recovered from the nearby 31Ht355 site suggest that its inhabitants may have taken an interest in the deposit as well.

In sharp contrast, samples from elsewhere in the Coastal Plain are generally good. Only about 15 km east of the Sandhills, three good clay samples were collected within 2 km of the Breece site. Pee Dee clays are even more consistently rated as good, and all five samples collected in the Waccamaw drainage exhibit good workability.

Although the majority of Piedmont samples are moderately lean, a few good clays were collected in the Haw and Deep drainages. Interestingly, not a single sample collected near the Doerschuk site appears to be suitable for pottery making.

Drying and Firing

Besides exhibiting good workability, ceramic clays must also avoid excessive shrinkage, warping, and cracking during drying and firing. To test drying and firing behavior, a minimum

Figure 4.11. A lean sample (FBR018). Note the broken coil (upper left), sagging loop (upper right), and deeply cracked ball (bottom).

Figure 4.12. A good sample (FBR040). The coils and ball did not crack, and the loop retained its shape.

Figure 4.13. A moderately lean sample (FBR044). Note the cracked coil (left), sagging loop (middle), and cracked ball (right).

of five untempered samples from each region (except Drowning Creek) were fashioned into standard 10-×-10-×-1-cm test tiles. In most cases, the first five samples chosen from each region were those demonstrating the best workability. Supplementary samples were selected to ensure representation by all clays exhibiting good workability or containing potentially diagnostic aplastic components. Finally, additional Lower Little River samples were included to encompass the considerable variability of Sandhills materials. In all, 62 of the 84 samples were fashioned into untempered test tiles (Table B.2).

To understand how tempering might affect drying and firing behavior, tempered test tiles were also produced from some samples. Temper types and quantities were modeled on the archaeological specimens from the various regions (Chapter 3). Accordingly, Sandhills and Coastal Plain clays were tempered with grog or sand. Piedmont samples were tempered with sand, crushed quartz, weathered granitic rock fragments, weathered metavolcanic rock fragments, or fresh diabase fragments (Table B.3). Grog was obtained either by crushing fired test tiles made from the same sample clays ("local grog") or by crushing unprovenienced sherds ("nonlocal grog"). With few exceptions, local sands were used. Quartz and rock fragments were collected as described above.

Drying Behavior. Water lost through drying is known as shrinkage water. In the plastic state, shrinkage water separates and lubricates clay particles so that they glide over one another (hence a plastic clay's ability to deform). During drying, this water migrates from the clay body's interior to the surface and ultimately evaporates. Its loss generates tensions that draw the clay particles closer together, and the bulk volume of the clay-water body shrinks. If shrinkage is excessive or uneven, as is common with fine clays, the piece is likely to warp or crack. Adding a coarser tempering material to a fine clay reduces the risk of shrinkage defects by

Table 4.1. Results of Workability Performance Tests.

	Workability			
Region: Drainage	Lean (*n*)	Moderately Lean (*n*)	Good (*n*)	Fat (*n*)
Sandhills:				
Lower Little	10	9	1	
Drowning Creek	1			
Coastal Plain:				
Cape Fear		3	3	
Pee Dee		1	6	2
Waccamaw			5	
Piedmont:				
Haw		14	4	
Yadkin	3	9		
Deep	2	8	2	1
Total:	16	44	21	3

decreasing total particle surface area and increasing pore space, thereby reducing the amount of shrinkage water in the system and facilitating its even movement (Rice 1987:59, 63–71).

Drying shrinkage can be evaluated linearly or volumetrically. In this study, linear drying shrinkage was measured following methods described by Binns (1947), Rice (1987), and Ries (1927). A 5-cm line was incised on the face of each tile while it was still in the plastic state. The tiles were laid flat and allowed to air-dry for 48 hours. They were then oven dried at 105°C for 24 hours. Linear drying shrinkage (LDS) was calculated as a percentage according to Rice's (1987:71) equation:

$$\%\ LDS = [(length_{wet} - length_{dry}) / length_{wet}] \times 100 \qquad (1)$$

where $length_{wet}$ is the length of the incised line prior to drying (i.e., 5 cm) and $length_{dry}$ is the length of the same line after oven drying.

The oven-dried tiles were also examined for warping and cracking. Warping reflects uneven shrinkage, manifest as upward curling of the corners when a tile dries on a flat surface. In this study, warping is expressed as a range according to the distance (in mm) between the flat surface and each of the four corners of the test tile. Cracks may also occur as a consequence of stresses created by uneven shrinkage, although they are more likely to occur in vessels than in test tiles of uniform thickness. In the few cases where cracking did occur, it was simply noted (Table B.3).

Finally, drying weight loss was recorded for most samples as a proxy measure of water of plasticity (WP), or the amount of water that must be added to a dry clay to achieve a workable paste (Rice 1987:62). Water of plasticity is expressed as a weight percentage and is sometimes used as a quantitative measure of plasticity. It typically ranges from 25–40% in ceramic clays (Binns 1947:21) and can be calculated by comparing the wet and dry weights of tiles according to another of Rice's (1987:62) equations:

$$\% \text{ WP} = [(\text{weight}_{wet} - \text{weight}_{dry}) / \text{weight}_{dry}] \times 100 \quad (2)$$

where weight_{wet} is the weight of the tile to the nearest 0.1 g prior to any drying and weight_{dry} is the weight after oven drying.

Drying Results. Two test tiles made from Lower Little River samples failed during drying (FRB002, FBR003; Table B.3). Both samples exhibit lean workability and would not have been subjected to the drying tests had we not been particularly concerned with representing the variation in materials from the Lower Little drainage. Sample FBR002 disintegrated and was eliminated from further testing. FBR003 began to crumble but was retained for firing so that we might obtain a thin section for petrographic analysis.

Linear drying shrinkage data reveal that most untempered clay samples have values ranging from 8 to 10% (Figure 4.14; Table B.3). Lower Little River samples exhibit the greatest variance in drying shrinkage, while Waccamaw clays have the highest average shrinkage values relative to samples from other regions. As expected, the addition of temper tends to reduce shrinkage. There was no clear correlation between workability and linear drying shrinkage.

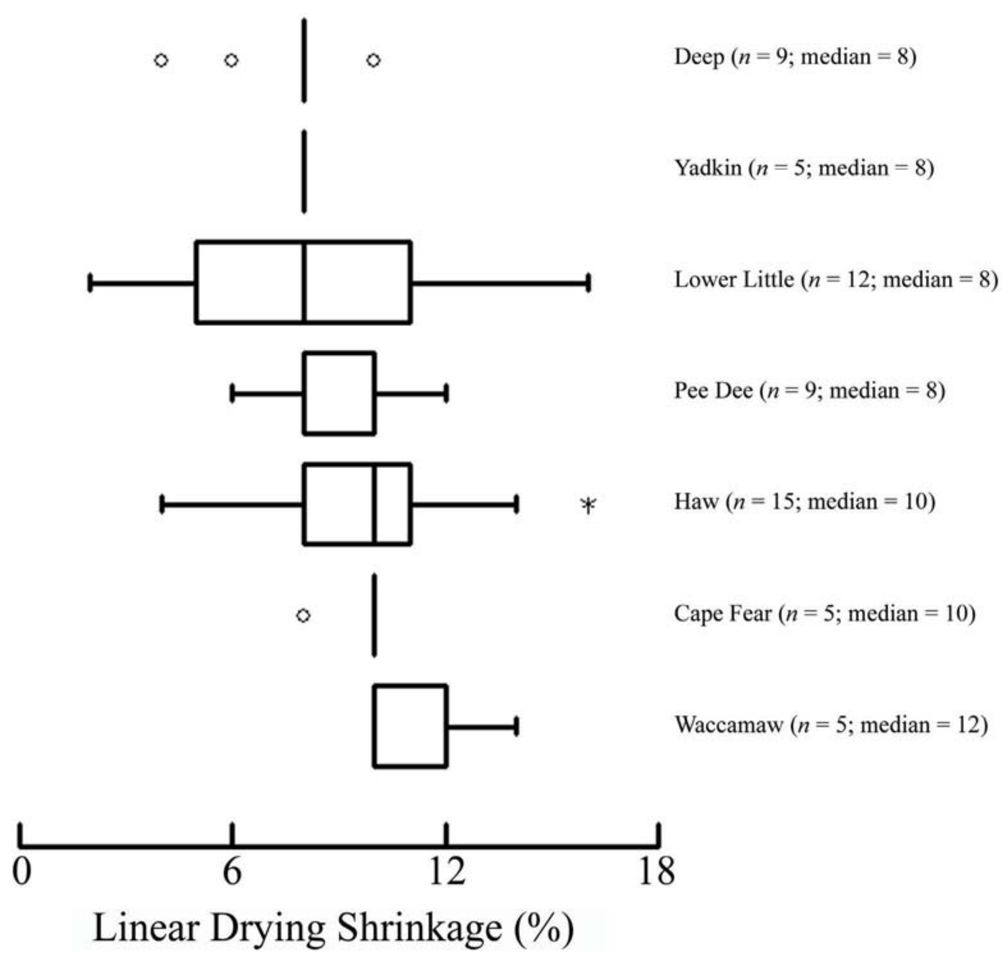


Figure 4.14. Boxplots of linear drying shrinkage values for each drainage.

Percentage water of plasticity values generally increase with increasing plasticity and workability, but they are not a particularly sensitive measure. Most values fall between 25 and 40% as Binns (1947) predicts (Table B.3), and plastic samples have the highest median value (Figure 4.15). However, there is considerable overlap in the range of values for plastic, moderately plastic, and weakly plastic samples (although too few weakly plastic samples are represented to make a valid comparison). A similar trend is observed when water of plasticity values are compared with workability rankings, although again there are too few lean samples and the overlap in range of values for good and moderately lean samples limits the usefulness of the measure (Figure 4.16).

Firing Behavior. As the temperature of a clay body is raised to 200–300°C, water trapped in the pores between particles volatilizes and evaporates. Between 200°C and 600°C, organic matter moves toward the surface where it oxidizes and is lost as CO_2. Water contained within the layers of clay minerals is largely driven off by about 600°C, and by 800°C most carbonates and salts have decomposed. Vitrification begins around 900–1000°C and is generally complete by 1300°C, but Woodland potters rarely achieved firing temperatures above 900°C (Rice 1987:86–91, 102–103; Rye 1981:27).

The volatilization and loss of water, organics, carbonates, and salts during firing results in weight loss and shrinkage. The shrinkage may expand any existing cracks formed during drying, and new cracks may appear if water or other constituents are driven off too fast (Rice 1987). Additional stresses may be generated as some clay minerals and mineral inclusions experience differential expansion and contraction during heating and cooling (Rye 1981:27).

Consequently, all test tiles that survived the drying stage were fired and examined for additional linear shrinkage (or expansion), weight loss, warping, and cracking (Table B.4). Most specimens were fired to 893°C in an electric kiln at the University of North Carolina's Art Lab. One batch of tiles was fired by Hal Pugh at the New Salem Pottery in Randleman, North Carolina; firing temperature for these test tiles was 950°C.

Linear firing shrinkage (LFS) was calculated as:

$$\%\ LFS = [(length_{dry} - length_{fired}) / length_{dry}] \times 100 \qquad (3)$$

where $length_{dry}$ is the length of the incised line after oven drying and $length_{fired}$ is the length of the same line after firing. Similarly, firing weight loss (FWL) was calculated as:

$$\%\ FWL = [(weight_{dry} – weight_{fired}) / weight_{dry}] \times 100 \qquad (4)$$

where $weight_{dry}$ is the weight of the tile after oven drying and $weight_{fired}$ is the weight of the tile after firing (see Table B.4).

Finally, all fired test tiles were subjected to a very simple hardness test. This test provides a nonquantitative measure of resistance to deformation that can be used to evaluate the fired strength of a ceramic material. A corner of the tile was grasped between thumb and forefinger and force was applied in an attempt to break it. A hardness ranking was assigned according to the ease with which the corner broke. A tile was said to be "very soft" if the corner easily crumbled in response to the stress and the detached piece or pieces could be ground into fine particles between the thumb and forefinger. The corner of a "soft" tile could also be removed

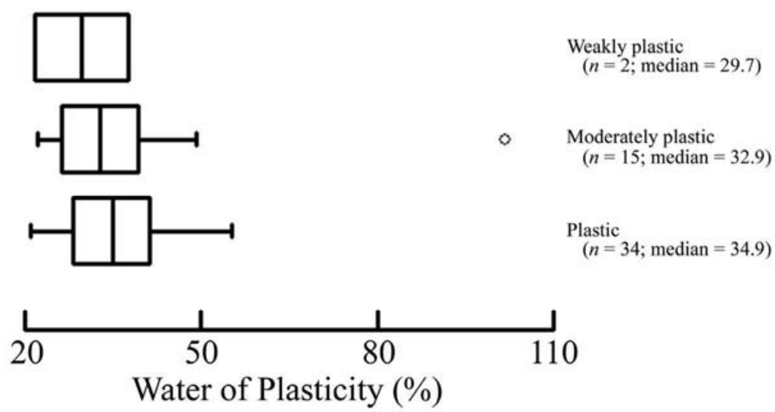


Figure 4.15. Boxplots of percentage water of plasticity values for plastic, moderately plastic, and weakly plastic samples.

easily and often even broken down into smaller fragments, but it could not be crushed into fine particles. “Moderately hard” tiles broke only with considerable effort and yielded a cleanly detached piece that could not be broken further. “Hard” tiles could not be broken.

Firing Results. Two more Lower Little River test tiles failed during firing (FBR001 and FBR005; Table B.4). Although only four complete failures out of 118 total test tiles seems surprisingly low, it likely reflects the fact that small tiles of uniform thickness are more resistant to uneven shrinkage than are typical coil-built vessels. Indeed, most samples did not shrink or deform much at all during firing, and some even expanded.

It is also possible that the lack of additional cracking during firing is at least partially attributable to our use of an electric kiln, which gradually raised the temperature of the tiles over several hours. In contrast, open fires that reach high temperatures rapidly and are subject to variations in ambient air temperature, humidity, and wind are more likely to drive off volatile constituents too quickly or unevenly.

Finally, hardness and strength generally increase with firing temperature (Rice 1987). It is thus possible that test tile quality would have varied more at a lower firing temperature.

The results of the hardness test are more useful for discriminating between suitable and unsuitable pottery-making resources (Table B.4). As anticipated, most of the Sandhills samples were not hard enough to be useful for making pottery. Of the 14 samples tested, only FBR008 and FBR017 produced hard test tiles, and FBR008 is a lean sample that would not be capable of building a pot. The five samples from the Yadkin drainage were also too soft.

Clays from the other regions performed better. Twelve Coastal Plain and six Piedmont samples exhibit good workability and also fire hard test tiles: FBR011 and FBR012 from the Cape Fear drainage; FBR019–FBR022, FBR023, and FBR027 from the Pee Dee drainage; FBR082–FBR085 from the Waccamaw drainage; FBR035 and FBR039–FBR041 from the Haw drainage; and FBR070 and FBR071 from the Deep drainage.

In most cases, the addition of a tempering material had no effect on hardness. In all but one of the cases where the addition of temper did affect hardness, it decreased it, presumably because finer-grained materials are generally more resistant to mechanical deformation than coarser-grained materials (Rice 1987:355).

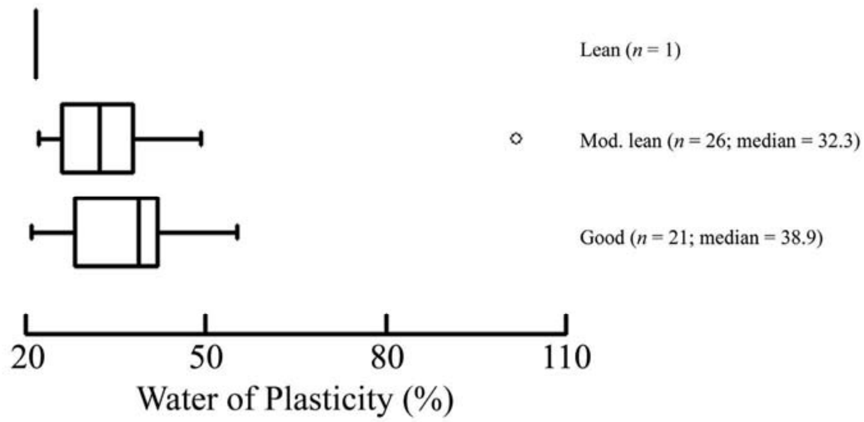


Figure 4.16. Boxplots of percentage water of plasticity values for good, moderately lean, and lean samples.

Finally, workability and post-firing hardness appear to be related. Over 90% of good clays fired hard test tiles, while only 20.4% of moderately lean samples and 12.5% of lean samples were hard after firing. This suggests that while it might be possible to coax vessels out of clays that are too lean, the fired products would likely be poor substitutes for vessels made from good quality clays.

Replication

Workability, drying, and firing tests conducted in a laboratory can predict which clays have pottery-making potential, but the only way to verify a given sample's suitability for crafting non-kiln-fired, earthenware vessels is to fire a successful pot. The final performance tests consequently entailed building replica pots from promising clay samples and firing them in an open-air setting.

Nine samples representing five regions were chosen for replication experiments: FBR017 from the Lower Little drainage; FBR011 and FBR012 from the Cape Fear drainage; FBR019, FBR020, and FBR027 from the Pee Dee drainage; FBR035 and FBR040 from the Haw drainage; and FBR085 from the Waccamaw drainage. Small replica pots were fashioned from these samples using the coil method (Figure 4.17). Coils were rolled out on a tabletop and then wrapped and stacked to form a semi-conical vessel. The coils were annealed by hand, and the entire pot was paddled. Throughout the building process, the samples were monitored for cracking or slumping.

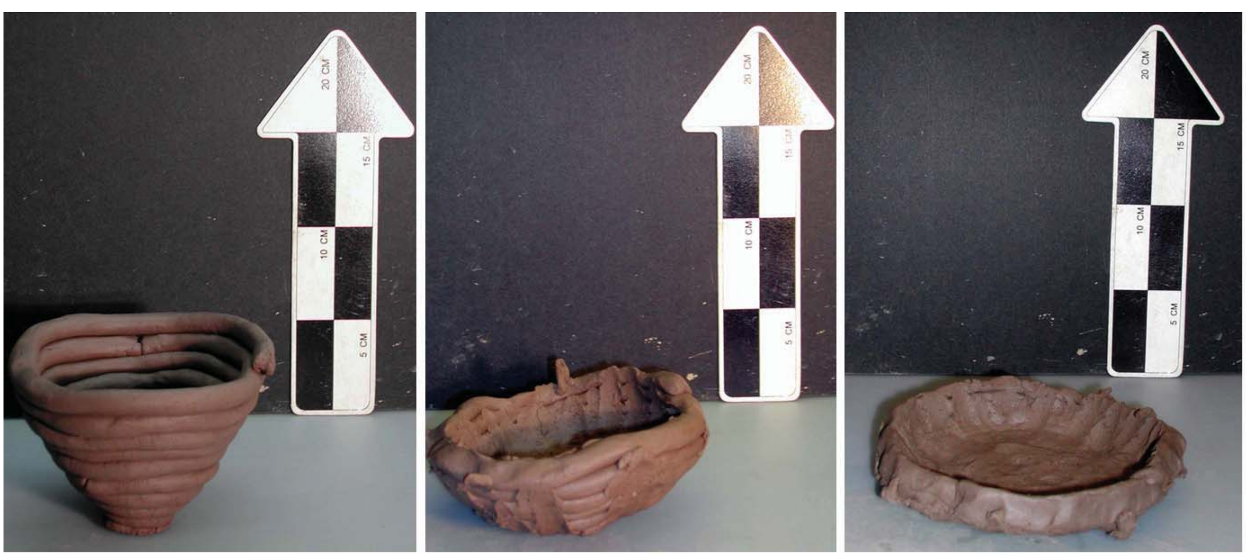
As a final test, the two most suitable samples (FBR040 and FBR085) were used to build several larger, tempered vessels that were dried completely and fired in an open fire pit at the University of North Carolina's Art Lab.

Results. The replication experiments revealed that even clays that performed well on all prior performance tests are still not always capable of making successful coil-built pots. Five of the samples cracked or slumped during the building process (Table B.5). The Lower Little River sample could not even be fashioned into a conical base, and Cape Fear sample FBR011 slumped

a b

Figure 4.17. Building a replica pot from sample FBR040 using the coil method: (a) coils are wrapped, stacked, and annealed by hand; and (b) the entire pot is paddled with a net-wrapped paddle.

badly (Figure 4.18). Significantly, all three of the Pee Dee samples slumped, although not as badly as FBR011 (Figure 4.19). Adding temper (e.g., sand, crushed rock, or grog) did not appreciably improve the performance of these samples.



a b c

Figure 4.18. Replication results for Cape Fear sample FBR011: (a) the stacked coils initially retain shape; (b) the vessel walls begin to slump as the coils are annealed; and (c) the vessel walls completely collapse when paddled.

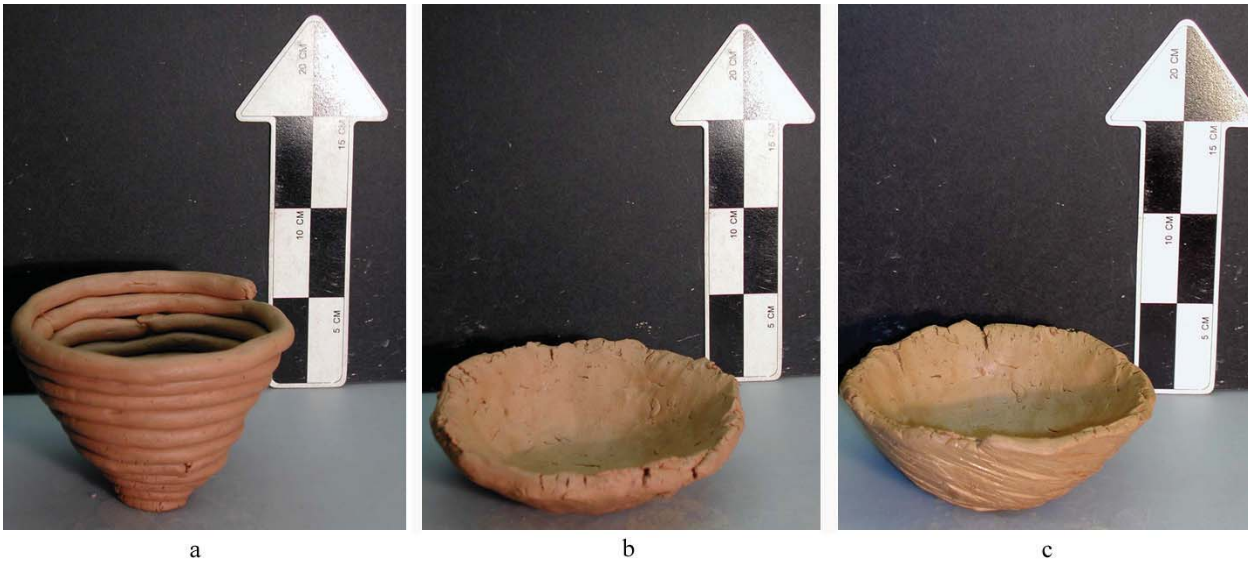


Figure 4.19. Replication results for Pee Dee sample FBR020: (a) the stacked coils initially retain shape; (b) the vessel walls slump and develop large, vertical cracks as the coils are annealed; and (c) the vessel walls gain a little more strength when paddled, but they split significantly at the rim.

Four samples do appear to have the right combination of plasticity, stiffness, and strength to be suitable for pottery making (FBR012, FBR035, FBR040, and FBR085). These samples were successfully paddled without slumping or cracking (Figure 4.20).

Larger pots made from Haw River sample FBR040 and tempered with sand or crushed quartz fired successfully (Figure 4.21). However, pots made from Waccamaw sample FBR085 and tempered with sand cracked during firing. This relatively fine-grained sample had one of the highest drying shrinkage values (% LDS = 16), so it is likely that rapid heating in an open-air fire caused the remaining pore water to evaporate too quickly and resulted in cracking. Nevertheless, we suspect that additional experimentation with different kinds and quantities of temper, longer drying periods, and/or different ways of firing could yield successful pots from sample FBR085.

Discussion

The results of the four stages of experimentation can be summarized as follows:

- Clays that pass initial workability tests can be readily found in the vicinities of the Haw River site in the Piedmont and the Breece, Kolb, and Waccamaw sites in the Coastal Plain. However, no good clays were encountered near the Doerschuk site in the Yadkin drainage, and only one workable sample was discovered near the pottery-source sites in the Sandhills.

- Clays that pass initial workability tests also make successful test tiles.

- Nevertheless, clays that are suitable for making actual pots are difficult to find.

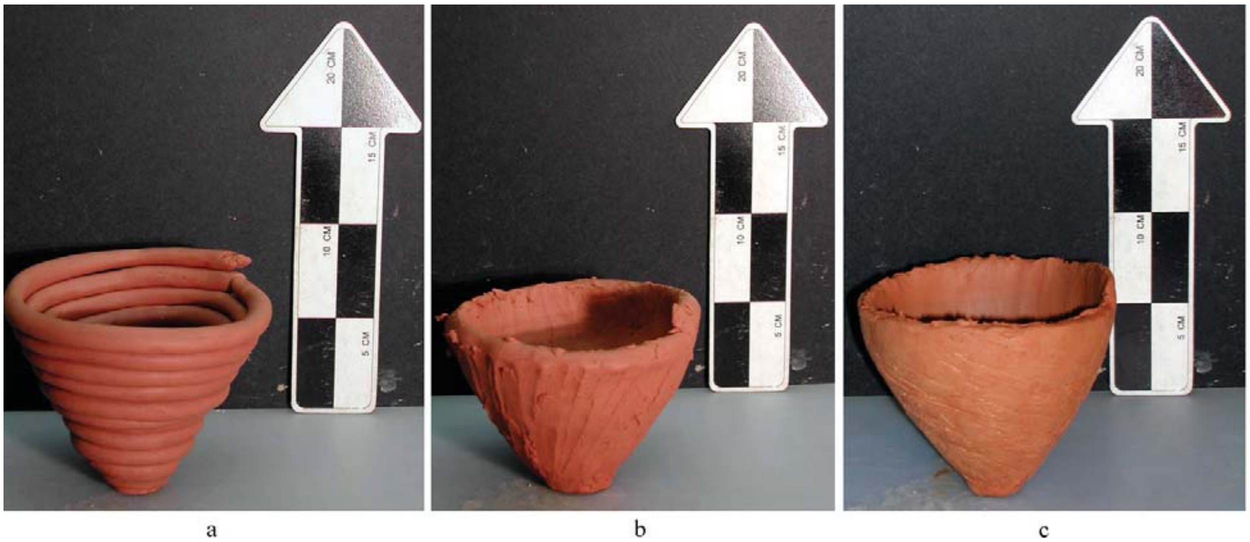


Figure 4.20. Replication results for Haw River sample FBR035: (a) the stacked coils retain shape; (b) the vessel does not slump during annealing; and (c) the vessel neither slumps nor cracks after paddling.

It is possible that localized pockets of better materials were not discovered during our survey. However, the sampling method used in this study approximates prehistoric strategies and technologies and likely provides a fairly accurate representation of the available resources in the site localities.

It is also likely that some samples could be improved with further experimentation. Drying, crushing, slaking, and settling could enhance the workability of some samples, although there is no evidence for this in the prehistoric pottery analogs that typically include a wide range of particle sizes. Other techniques to improve a clay's workability include "souring" it through storage in an environment conducive to the growth of bacteria or adding plasticizers such as tannic acid or animal dung (Matson 1965; Rye 1981:31). However, the archaeological record in the Sandhills argues against long periods of site occupation, seemingly necessary for such involved processes.

Alternatively, prehistoric potters may have mixed two or more clays with different properties to create a workable product. Mixing clays is common among traditional potters and in the modern ceramics industry (Arnold 1992; Rice 1987; Vitelli 1984). We did not mix any of the samples in this study because the number of potential combinations would be enormous, and the probability of discovering the exact recipe used by Woodland potters would be very low.

Yet even with modifications to the pottery-making techniques or the clays themselves, it is still unlikely that any of the samples from the Sandhills could be used to fashion a successful pot. The results of geochemical (Chapter 5) and petrographic analyses (Chapter 6) of artifacts and clay samples strengthen our conviction that local clays were not used to fashion the pottery found at Woodland sites on Fort Bragg. The results of the performance tests suggest that higher quality clays could have been obtained to the north in the lower Haw drainage, to the east in the Cape Fear drainage, and to the south in the Waccamaw and Pee Dee drainages.

The five most promising samples from each drainage (except Drowning Creek) were retained for the geochemical and mineralogical analyses discussed in Chapters 5–7. An additional six samples from the Lower Little drainage were retained to represent the variability of Sandhills

Figure 4.21. Firing replica pots: (a) the pots are prepared by gradually moving them closer to the fire; (b) the fire is built up; (c) the pots are completely covered with fuel and fired in a large bonfire; and (d) as the fuel is consumed, the fired pots are exposed and allowed to cool.

materials. In all, 42 untempered clay samples were submitted for neutron activation (NAA) and X-ray diffraction (XRD) analyses (Table B.6). The same 42 untempered samples and 17 tempered samples were submitted as test tiles for petrographic analyses (Table B.7).

Conclusions and Implications

> Even a brief and clumsy attempt at working in clay … introduces the archaeologist to the complexities of that medium, to the range of understanding, experience, and pride of the ancient practitioner. By stumbling through the processes ourselves, making choices, responding to successes and failure, we learn the processes, but we also become more conscious of the people who made the objects which we excavate. It helps us remember that, in the end, it is these people whose lives we are trying to understand [Vitelli 1984: 126].

By discovering the mechanical properties of natural clay resources, we begin to gain some insight into the behaviors of Woodland potters and the decisions that shaped their pottery-making practices. Ideological, social, and/or political factors may have influenced potters' selection of particular resources, but it is clear from the results of our performance tests that the physical characteristics of local clays played a major role in the Sandhills region.

The results of this study demonstrate that finding a suitable clay source in an unfamiliar landscape can be very costly in terms of time and energy. Once a suitable raw material was discovered, it would likely have become a valuable, perhaps even guarded, resource, extraction of which would likely have been scheduled into seasonal activities. Alternatively or additionally, ceramic vessels may have become important commodities of exchange between Sandhills groups and their neighbors. In any case, the value of pots to Woodland people occupying the Sandhills, and possibly many other resource-poor regions, was probably much greater than has been commonly assumed.

Notes

Acknowledgments. An Archaeological Resources Protection Act permit was issued by the North Carolina Department of Cultural Resources, Office of State Archaeology under the guidance of Dolores Hall, Deputy State Archaeologist. Mr. Gene Ellis of Alcoa Badin Works was instrumental in gaining access to the Doerschuk site. We thank Mr. Francis Ferrell, USACE and NC Wildlife Resources Commission, Division of Wildlife Management, for help securing a Special Gamelands Permit for collecting clays from the shoreline of B. Everett Jordan Lake.

Bill Covington accompanied us on several collecting expeditions, graciously shared his RV, and donated quartz and unprovenienced pottery for use as tempering materials. Nicole Brannan helped collect clay samples on Fort Bragg. Hal Pugh of New Salem Pottery helped find and evaluate clays on Fort Bragg, and he and his wife Eleanor fired one batch of test tiles. Sandra Bonner, Brett Riggs, and Linda Carnes-McNaughton suggested potential locations for clays. Steve Davis donated a granite sample for use as a tempering material, and Vin Steponaitis let us use his canoe.

We also wish to thank Charles Heath for helping weigh and measure test tiles. Pat Day, Manager of the UNC Art Lab, allowed us to use those facilities for firing test tiles and replica pots. Finally, we thank Vin Steponaitis for his advice and feedback at multiple stages of this study.

Chapter 5

Geochemistry

Robert J. Speakman, Michael D. Glascock, and Vincas P. Steponaitis

One hundred and nineteen samples of clay (*n* = 42), rock and sand temper (*n* = 7), and pottery (*n* = 70) from the various drainages in and around the North Carolina Sandhills were analyzed by instrumental neutron activation analysis (NAA) at the University of Missouri Research Reactor Center (MURR). Here we report the analytical methods and describe some of the chemical patterns identified in the data set. Given the overall low number of samples and the low number of samples analyzed from each site, we have less confidence in the certainty of our explanations and conclusions than we might if the sample were larger. Consequently, we consider it likely that conclusions may change as additional samples from this area are analyzed.

Pottery samples were prepared for NAA and irradiated using procedures standard at MURR (see Appendix C). The analyses resulted in data for 33 elements, namely As, La, Lu, Nd, Sm, U, Yb, Ce, Co, Cr, Cs, Eu, Fe, Hf, Ni, Rb, Sb, Sc, Sr, Ta, Tb, Th, Zn, Zr, Al, Ba, Ca, Dy, K, Mn, Na, Ti, and V. In many samples, concentrations of As, Ni, and Sr were below detection limits, and these three elements were consequently removed from consideration. The analysis of data was subsequently carried out on base-10 logarithms of concentrations for the remaining 30 elements. Use of log concentrations rather than raw data compensates for differences in magnitude between major elements such as Ca on one hand and trace elements such as the rare-earth or lanthanide elements on the other. Transformation to base-10 logarithms also yields a more normal distribution for many trace elements.

Interpreting Chemical Data

The interpretation of compositional data obtained from the analysis of archaeological materials is discussed in detail elsewhere (e.g., Baxter and Buck 2000; Bieber et al. 1976; Bishop and Neff 1989; Glascock 1992; Harbottle 1976; Neff 2000) and will only be summarized here. The main goal of data analysis is to identify compositionally homogeneous groups within the analytical database. Based on the provenance postulate of Weigand et al. (1977), such groups are assumed to represent geographically restricted sources. For lithic materials such as obsidian, basalt, and cryptocrystalline silicates (e.g., chert, flint, or jasper), raw material samples are frequently collected from locations known to have been, or likely to have been, resource procurement sites, such as archaeologically identifiable quarry sites, outcrops and secondary deposits exposed on the surface. The compositional data obtained for the raw material samples is then used to define the source localities or boundaries.

For ceramics the process is complicated by the fact that resource procurement locations are not often known. The absence of archaeologically identifiable clay mines or quarries generally makes it impossible to collect samples from known procurement sites, or "sources," to create groups of knowns to which unknowns can be compared. General locations of sources can, however, be inferred by comparing ceramic artifacts to clay samples, by indirect methods such as the "criterion of abundance" (Bishop et al. 1982), or by arguments based on geological and sedimentological characteristics (e.g., Steponaitis et al. 1996).

Compositional groups can be viewed as "centers of mass" in the compositional hyperspace described by the measured elemental data. Groups are characterized by the locations of their centroids and the unique relationships (i.e., correlations) between the elements. Decisions about whether to assign a specimen to a particular compositional group are based on the overall probability that the measured concentrations for the specimen could have been obtained from that group.

Initial hypotheses about source-related subgroups in the compositional data can be derived from noncompositional information (e.g., archaeological context, decorative attributes, etc.) or from application of various pattern-recognition techniques to the multivariate chemical data. Some of the pattern recognition techniques that have been used to investigate archaeological data sets are cluster analysis, principal components analysis (PCA), and discriminant analysis. Each of the techniques has it own advantages and disadvantages which may depend upon the types and quantity of data available for interpretation.

The variables (measured elements) in archaeological and geological data sets are often correlated and frequently large in number. This makes handling and interpreting patterns within the data difficult. Therefore, it is often useful to transform the original variables into a smaller set of uncorrelated variables in order to make data interpretation easier. Of the above-mentioned pattern recognition techniques, PCA is a technique that transforms the data from the original correlated variables into uncorrelated variables most easily.

PCA creates a new set of reference axes arranged in decreasing order of variance subsumed. The individual principal components are linear combinations of the original variables. The data can be displayed on combinations of the new axes, just as they can be displayed on the original elemental concentration axes. PCA can be used in a pure pattern-recognition mode, i.e., to search for subgroups in an undifferentiated data set, or in a more evaluative mode, i.e., to assess the coherence of hypothetical groups suggested by other criteria. Generally, compositional differences between specimens can be expected to be larger for specimens in different groups than for specimens in the same group, and this implies that groups should be detectable as distinct areas of high point density on plots of the first few components.

One frequently exploited strength of PCA, discussed by Baxter (1992), Baxter and Buck (2000), and Neff (1994, 2001), is that it can be applied as a simultaneous R- and Q-mode technique, with both variables (elements) and objects (individual analyzed samples) displayed on the same set of principal component reference axes. A plot using the first two principal components as axes is usually the best possible two-dimensional representation of the correlation or variance-covariance structure within the data set. Small angles between the vectors from the origin to variable coordinates indicate strong positive correlation; angles at 90˚ indicate no correlation; and angles close to 180˚ indicate strong negative correlation. Likewise, a plot of sample coordinates on these same axes will be the best two-dimensional representation of Euclidean relations among the samples in log-concentration space (if the PCA was based on the variance-covariance matrix) or standardized log-concentration space (if the PCA was based on the correlation matrix). Displaying both objects and variables on the same plot makes it possible to observe the contributions of specific elements to group separation and to the distinctive shapes of the various groups. Such a plot is commonly referred to as a "biplot" in reference to the simultaneous plotting of objects and variables. The variable interrelationships inferred from a biplot can be verified directly by inspecting bivariate elemental concentration plots (note that a bivariate plot of elemental concentrations is not a biplot).

Whether a group can be discriminated easily from other groups can be evaluated visually in two dimensions or statistically in multiple dimensions. A metric known as the Mahalanobis distance (or generalized distance) makes it possible to describe the separation between groups or between individual samples and groups on multiple dimensions. The Mahalanobis distance of a specimen from a group centroid (Bieber et al. 1976, Bishop and Neff 1989) is

$$D^2_{y,X} = [\, y - \overline{X}\,]^t I_x [\, y - \overline{X}\,] \tag{1}$$

where y is the $1 \times m$ array of logged elemental concentrations for the specimen of interest, X is the $n \times m$ data matrix of logged concentrations for the group to which the point is being compared with $\bar{X}$ being its $1 \times m$ centroid, and I_x is the inverse of the $m \times m$ variance-covariance matrix of group X. Because Mahalanobis distance takes into account variances and covariances in the multivariate group, it is analogous to expressing distance from a univariate mean in standard deviation units. Like standard deviation units, Mahalanobis distances can be converted into probabilities of group membership for individual specimens. For relatively small sample sizes, it is appropriate to base probabilities on Hotelling's T^2, the multivariate extension of the univariate Student's t test.

When group sizes are small, Mahalanobis-distance-based probabilities can fluctuate dramatically depending upon whether or not each specimen is assumed to be a member of the group to which it is being compared. Harbottle (1976) calls this phenomenon "stretchability" in reference to the tendency of an included specimen to stretch the group in the direction of its own location in elemental concentration space. This problem can be circumvented by cross-validation, that is, by removing each specimen from its presumed group before calculating its own probability of membership (Baxter 1994; Leese and Main 1994). This is a conservative approach to group evaluation that may sometimes exclude true group members.

Small sample and group sizes place further constraints on the use of Mahalanobis distance: with more elements than samples, the group variance-covariance matrix is singular, thus rendering calculation of I_x (and D^2 itself) impossible. Therefore, the dimensionality of the groups must somehow be reduced. One approach would be to eliminate elements considered irrelevant or redundant. The problem with this approach is that the investigator's preconceptions about which elements should best discriminate samples may not be valid. It also squanders the main advantage of multielement analysis, namely the capability to measure a large number of elements. An alternative approach is to calculate Mahalanobis distances with the scores on principal components extracted from the variance-covariance or correlation matrix for the complete data set. This approach entails only the assumption, entirely reasonable in light of the above discussion of PCA, that most group-separating differences should be visible on the first several components. Unless a data set is extremely complex, with numerous distinct groups, using enough components to subsume at least 90% of the total variance in the data can be generally expected to yield Mahalanobis distances that approximate Mahalanobis distances in full elemental concentration space.

Lastly, Mahalanobis distance calculations are also quite useful for handling missing data (Sayre 1975). When many specimens are analyzed for a large number of elements, it is almost certain that a few element concentrations will be missed for some of the specimens. This occurs most frequently when the concentration for an element is near the detection limit. Rather than eliminate the specimen or the element from consideration, it is possible to substitute a missing value by replacing it with a value that minimizes the Mahalanobis distance for the specimen from the group centroid. Thus, those few specimens which are missing a single concentration value can still be used in group calculations.

Chemical Composition of Pottery

After elemental concentrations were log-transformed and missing values were replaced (as described above), a PCA was carried out on a variance-covariance matrix computed from the entire database of pottery and clay samples, using all 30 elements (Table 5.1). Five chemical groups of sherds were identified by inspecting various projections of the logged concentrations and the principal-component scores. Sixty-one sherds were assigned to these groups, and nine were left unassigned (Table 5.2).

A biplot of the first two principal components shows the distribution of these groups in multivariate space (Figure 5.1). Although the separation among groups is marginal, it appears that Ca and Na contribute significantly to the separation that exists. Better separation can be seen when the scores for the first and fourth principal components are plotted (Figures 5.2–5.3). Even so, group separation on these components is still marginal.

There are three possible explanations, not mutually exclusive, for our inability to effect a clear separation among the groups. One is that some of the groups are represented by fewer than ten samples, which makes it harder statistically to define a “tight” cluster. A second reason is that some groups contain significant heterogeneity. For example, a bivariate plot of Cs and Sm suggests that, although the samples in Group 1 are chemically similar in many projections, chemical differences may be significant enough to warrant division of this small group into three subgroups (Figure 5.4). Group 2 also exhibits substantial variation (Figures 5.1–5.3), as well as hints of multiple subgroups (Figure 5.5). Finally, a third possibility is that chemical variation in the study area is intrinsically continuous to some degree, and the chemical signatures associated with geographical regions are not as discrete as in some other parts of the world. Investigating these possibilities will require the analysis of a significantly larger sample of pottery from the study area.

Despite problems with small group sizes and group heterogeneity, it is possible to show clear separation of the groups in elemental space (Figure 5.6). In addition, when the PCA scores are recalculated using a reduced set of 10 elements (Lu, Yb, Cr, Eu, Sc, Th, Ba, Ca, Mn, Na), it is possible to effect a reasonably clear separation of these groups using scores derived from the first and third components (Table 5.3; Figures 5.7–5.9).

As discussed previously, Mahalanobis distance can be used to calculate the probability of a specimen’s membership in a given group. The method requires that the number of samples in every group be greater by at least two than the number of variables used in the calculation. Hence, in order to calculate probabilities of membership in all groups, only the first four principal components could be used (because the smallest group has only six members). These four components capture 77% of the total variance in the full 30-element data set and 86% of the

Table 5.1. Principal Components Analysis of the Full Data Set.[a]

	Principal Components									
	1	2	3	4	5	6	7	8	9	10
La	-0.2197	0.2135	-0.0815	0.1014	-0.0213	-0.0526	0.0431	-0.0081	0.0807	0.0954
Lu	-0.1213	0.1172	-0.0499	-0.0087	0.0243	-0.1085	-0.1119	0.0680	-0.0280	-0.1622
Nd	-0.1914	0.2480	-0.1394	0.0738	-0.0058	-0.0777	0.1513	0.0002	-0.0477	0.0673
Sm	-0.1809	0.2348	-0.1410	0.0679	-0.0019	-0.1106	0.0963	-0.0056	-0.0074	0.0477
U	-0.1702	0.0833	0.0386	0.1304	0.0736	0.0652	0.0199	-0.2746	0.1942	-0.4023
Yb	-0.1154	0.1405	-0.1062	-0.0187	0.0283	-0.1061	-0.0840	0.1052	-0.0527	-0.1829
Ce	-0.2295	0.2298	-0.0963	0.0581	-0.0193	-0.0983	0.0519	-0.0168	0.0819	0.1123
Co	0.1911	0.2455	-0.2284	-0.2506	-0.1556	0.0018	0.0048	-0.0831	0.1135	-0.2014
Cr	0.0487	0.1112	-0.2600	-0.1052	0.0070	0.4054	-0.2000	-0.5642	0.1459	-0.1185
Cs	-0.0916	0.1926	0.2512	-0.1517	0.3567	0.2141	-0.0777	0.2445	0.3726	0.2520
Eu	-0.1085	0.2668	-0.2035	0.0137	-0.0196	-0.1288	0.2188	0.0059	-0.0472	0.1825
Fe	0.0834	0.1343	-0.0975	-0.2458	-0.0465	0.2335	-0.0047	-0.0160	0.0918	0.0306
Hf	-0.1765	0.0165	0.1518	0.0367	-0.1183	-0.1738	-0.3460	-0.1817	-0.1269	0.0863
Rb	-0.0023	0.2673	0.3731	0.0271	0.0305	0.2392	0.0491	0.2173	0.2089	-0.0622
Sb	0.0847	0.0970	-0.0236	-0.0831	0.7487	0.1007	-0.0856	-0.0245	-0.5359	-0.1342
Sc	0.0601	0.1083	-0.1295	-0.1100	-0.0331	0.1835	-0.0142	-0.1085	-0.0564	0.1724
Ta	-0.1912	0.0903	0.1666	0.0069	-0.0211	0.0076	-0.3838	-0.1359	0.0787	0.0958
Tb	-0.1634	0.2253	-0.1962	0.0709	0.1159	-0.1057	0.0504	0.1009	-0.0103	-0.1650
Th	-0.2418	0.1010	0.1963	0.0690	0.0315	0.0697	-0.1406	-0.1531	0.0111	0.1216
Zn	0.1065	0.2037	-0.0248	-0.1594	-0.0409	0.1056	0.0776	0.0307	-0.1656	0.1595
Zr	-0.1774	0.0208	0.1173	0.0796	-0.0902	-0.1040	-0.2917	-0.1936	-0.2273	-0.0449
Al	-0.0128	0.0726	-0.0038	-0.0177	-0.0743	0.1140	0.1469	-0.1243	-0.0143	0.2473
Ba	0.0904	0.2472	0.2206	0.1959	-0.4050	0.3640	0.1598	0.0656	-0.4961	-0.1036
Ca	0.3563	0.1049	-0.2906	0.7444	0.0755	0.1501	-0.3185	0.1679	0.1369	0.1095
Dy	-0.1426	0.1828	-0.1429	0.0289	0.0430	-0.0944	0.0555	0.0872	-0.0562	-0.0990
K	0.0237	0.2499	0.3864	0.1025	-0.0301	0.0688	0.0508	-0.0044	0.0041	-0.2362
Mn	0.3600	0.3206	-0.0122	-0.3228	-0.1672	-0.2726	-0.4209	0.2512	0.0237	-0.1475
Na	0.4590	0.2403	0.2912	0.1330	0.1578	-0.4535	0.2450	-0.4624	0.0870	0.1464
Ti	-0.0326	0.0506	0.0267	-0.0547	-0.0725	-0.0933	-0.2600	0.0400	-0.1988	0.3764
V	0.0526	0.0734	-0.0924	-0.0982	0.0308	0.1455	-0.0001	-0.0771	-0.0898	0.3543
Eigenvalue	0.7820	0.5296	0.2410	0.1604	0.1089	0.0932	0.0640	0.0541	0.0311	0.0253
Variance (%)	35.1033	23.7744	10.8193	7.1981	4.8866	4.1817	2.8723	2.4302	1.3951	1.1364
Cumulative (%)	35.1033	58.8777	69.6969	76.8951	81.7817	85.9633	88.8357	91.2659	92.6609	93.7974

[a] Based on variance-covariance matrix derived from a data set consisting of 30 elements measured on all pottery and clay samples ($n = 142$).

total variance in the reduced 10-element data set, so they provide a good approximation, if not a perfect picture, of the multivariate relationships among the samples.

The Mahalanobis probabilities calculated on both the full and reduced data sets generally support our group assignments, albeit with some exceptions (Table 5.4). Groups 1 and 2 show some overlap, as do Groups 3 and 4. This apparent mixing results from the lack of strong separation between adjacent groups, as well as from our inability to use a larger number of principal components in the calculations. It is also exacerbated by the fact that our probabilities are "jackknifed," i.e., they exclude each sample from the group to which it is being compared, even when the sample has been assigned to that group — a method designed to yield

Table 5.2. Group Assignments of Pottery Samples.

Group: Sample ID	Site	Drainage	Region	Type	Dominant Temper
Group 1:					
JMH006	31Hk123	Lower Little	Sandhills	Yadkin Fabric Impressed	diabase
JMH031	Doerschuk	Yadkin	Piedmont	Yadkin Fabric Impressed	diabase
JMH032	Doerschuk	Yadkin	Piedmont	Dan River Simple Stamped	granite
JMH034	Doerschuk	Yadkin	Piedmont	Jenrette Plain	quartz/granite?
JMH046	Haw River	Haw	Piedmont	Yadkin Plain	diabase/quartz
JMH047	Haw River	Haw	Piedmont	Yadkin eroded	diabase/quartz
Group 2:					
JMH003	31Ht273	Lower Little	Sandhills	Cape Fear III Fabric Impressed	sand
JMH008	31Ht269	Lower Little	Sandhills	Mt. Pleasant Cord Marked	quartz
JMH016	31Sc71	Drowning Cr.	Sandhills	New River Paddle-edge Stamped	grog
JMH033	Doerschuk	Yadkin	Piedmont	Yadkin Fabric Impressed	granite
JMH035	Doerschuk	Yadkin	Piedmont	New River Cord Marked	granite
JMH036	Doerschuk	Yadkin	Piedmont	New River Net Impressed	quartz/granite
JMH037	Doerschuk	Yadkin	Piedmont	Yadkin Check Stamped	quartz
JMH038	Doerschuk	Yadkin	Piedmont	Yadkin Cord Marked	granite/quartz
JMH039	Doerschuk	Yadkin	Piedmont	Dan River Net Impressed	granite/sand?
JMH040	Doerschuk	Yadkin	Piedmont	Yadkin Net Impressed	granite
JMH041	Haw River	Haw	Piedmont	Yadkin Paddle-edge Stamped	quartz
JMH042	Haw River	Haw	Piedmont	Yadkin Cord Marked	quartz
JMH043	Haw River	Haw	Piedmont	Yadkin Plain	quartz
JMH044	Haw River	Haw	Piedmont	Cape Fear Fabric Impressed	sand/quartz
JMH045	Haw River	Haw	Piedmont	Yadkin Plain	rock (granite?)
JMH048	Haw River	Haw	Piedmont	Yadkin Plain	rock (mafic?)
JMH049	Haw River	Haw	Piedmont	Yadkin Plain	granite
JMH050	Haw River	Haw	Piedmont	Yadkin eroded	granite
Group 3:					
JMH002	31Ht392	Lower Little	Sandhills	Hanover II Fabric Impressed	grog
JMH004	31Hk127	Lower Little	Sandhills	Hanover II Fabric Impressed	grog
JMH005	31Hk59	Lower Little	Sandhills	Hanover I Cord Marked	grog
JMH010	31Hk715	Lower Little	Sandhills	Hanover Fabric Impressed	sand/grog
JMH017	31Mr93	Lower Little	Sandhills	New River Cord Marked	sand
JMH018	31Sc87	Drowning Cr.	Sandhills	Deptford Check Stamped	sand
JMH020	31Mr241	Drowning Cr.	Sandhills	New River Cord Marked	sand
JMH021	Breece	Cape Fear	Coastal Plain	Hanover II Paddle-edge Stamped	grog
JMH022	Breece	Cape Fear	Coastal Plain	New River Fabric Impressed	sand
JMH023	Breece	Cape Fear	Coastal Plain	Hanover II Fabric Impressed	grog
JMH024	Breece	Cape Fear	Coastal Plain	Hanover II Fabric Impressed	grog/sand
JMH025	Breece	Cape Fear	Coastal Plain	Cape Fear Cord Marked	sand
JMH027	Breece	Cape Fear	Coastal Plain	Hanover I Fabric Impressed	sand
JMH028	Breece	Cape Fear	Coastal Plain	Hanover I Fabric Impressed	sand
JMH029	Breece	Cape Fear	Coastal Plain	Hanover I Fabric Impressed	sand/grog
JMH030	Breece	Cape Fear	Coastal Plain	Hanover II Fabric Impressed	grog/sand
JMH054	Kolb	Pee Dee	Coastal Plain	New River Cord Marked	sand
JMH065	Waccamaw	Waccamaw	Coastal Plain	Hanover I Fabric Impressed	clay/sand
JMH067	Waccamaw	Waccamaw	Coastal Plain	Cape Fear Fabric Impressed	sand
Group 4:					
JMH055	Kolb	Pee Dee	Coastal Plain	Yadkin Cord Marked	quartz
JMH056	Kolb	Pee Dee	Coastal Plain	New River Fabric Impressed	none visible

Table 5.2. Group Assignments of Pottery Samples (continued).

Group: Sample ID	Site	Drainage	Region	Type	Dominant Temper
JMH057	Kolb	Pee Dee	Coastal Plain	New River Cord Marked	sand
JMH058	Kolb	Pee Dee	Coastal Plain	Cape Fear Fabric Impressed	sand
JMH059	Kolb	Pee Dee	Coastal Plain	Cape Fear Fabric Impressed	sand
JMH060	Kolb	Pee Dee	Coastal Plain	Hanover I Fabric Impressed	clay/sand
JMH061	Waccamaw	Waccamaw	Coastal Plain	Thoms Creek Punctate	sand
JMH062	Waccamaw	Waccamaw	Coastal Plain	Cape Fear Fabric Impressed	sand
JMH063	Waccamaw	Waccamaw	Coastal Plain	Hanover II Fabric Impressed	grog
Group 5:					
JMH009	31Cd486	Lower Little	Sandhills	Cape Fear Cord Marked	sand
JMH011	31Mr241	Drowning Cr.	Sandhills	Hanover I Cord Marked	grog/sand
JMH012	31Mr259	Drowning Cr.	Sandhills	Hanover II Fabric Impressed	grog/sand
JMH013	31Mr241	Drowning Cr.	Sandhills	Deptford Linear Check Stamped	sand
JMH019	31Mr93	Lower Little	Sandhills	Hanover II Cord Marked	grog
JMH051	Kolb	Pee Dee	Coastal Plain	Yadkin Fabric Impressed	quartz
JMH052	Kolb	Pee Dee	Coastal Plain	Hanover Fabric Impressed	grog/quartz
JMH069	Waccamaw	Waccamaw	Coastal Plain	Cape Fear Fabric Impressed	sand
JMH070	Waccamaw	Waccamaw	Coastal Plain	Cape Fear Fabric Impressed	sand
Unassigned:					
JMH001	31Hk868	Lower Little	Sandhills	Hanover II Fabric Impressed	grog
JMH007	31Cd750	Lower Little	Sandhills	Hanover I Paddle-edge Stamped	grog/sand
JMH014	31Mr253	Drowning Cr.	Sandhills	Yadkin Fabric Impressed	sandstone
JMH015	31Mr241	Drowning Cr.	Sandhills	Sand-tempered plain	sand
JMH026	Breece	Cape Fear	Coastal Plain	Hanover II Fabric Impressed	grog
JMH053	Kolb	Pee Dee	Coastal Plain	Yadkin Cord Marked	quartz/grog
JMH064	Waccamaw	Waccamaw	Coastal Plain	Hanover II Fabric Impressed	grog
JMH066	Waccamaw	Waccamaw	Coastal Plain	Cape Fear Fabric Impressed	sand
JMH068	Waccamaw	Waccamaw	Coastal Plain	Hanover eroded	grog/sand

probabilities that are conservative. Computational details aside, the fundamental issue here is this: when groups are not widely separated in multidimensional space, specimens whose chemical compositions fall near the boundaries of these groups will show high probabilities of membership in more than one group, and which group's probability is highest can change depending on which (and how many) principal components are used in the calculation. Table 5.4 provides a good example of this pattern.

In sum, the five chemical groups we have identified for pottery samples are compositionally distinct in a general sense, but not as clearly separated at the boundaries as we would like. Even so, the groups do show a strong geographical pattern. Groups 1 and 2 include sherds from the Piedmont and Sandhills regions, while groups 3, 4, and 5 include sherds from the Coastal Plain and Sandhills. Let us now look at the geographical patterning in the clays.

Chemical Composition of Clays

Comparing the chemical composition of pottery sherds with that of "raw" clays is difficult for two reasons. First, one has to take into account the effects of temper — deliberate additions

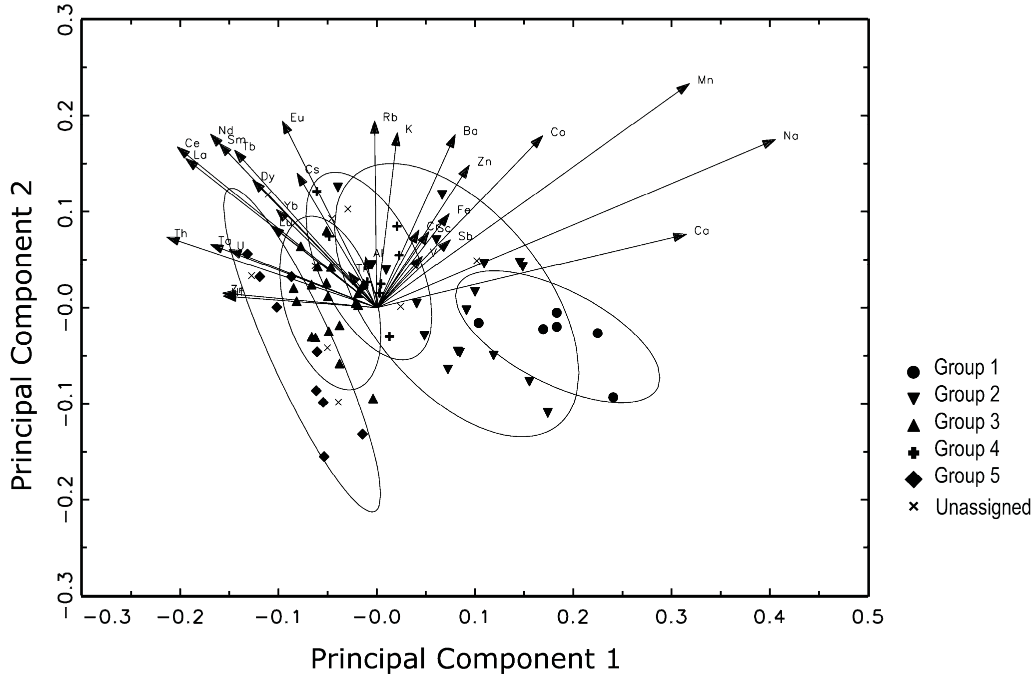


Figure 5.1. Biplot of principal components 1 and 2 derived from PCA of pottery and clay samples, based on the full data set (30 elements). Only pottery samples are shown. The 90% confidence ellipse is drawn for each group.

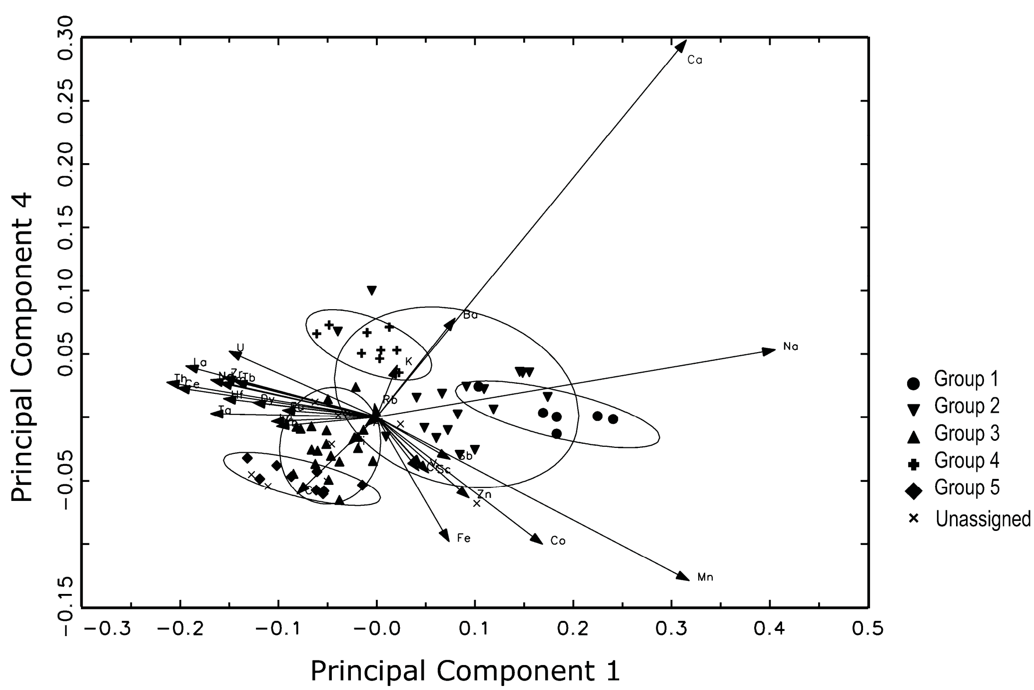


Figure 5.2. Biplot of principal components 1 and 4 derived from PCA of pottery and clay samples, based on the full data set (30 elements). Only pottery samples are shown. The 90% confidence ellipse is drawn for each group.

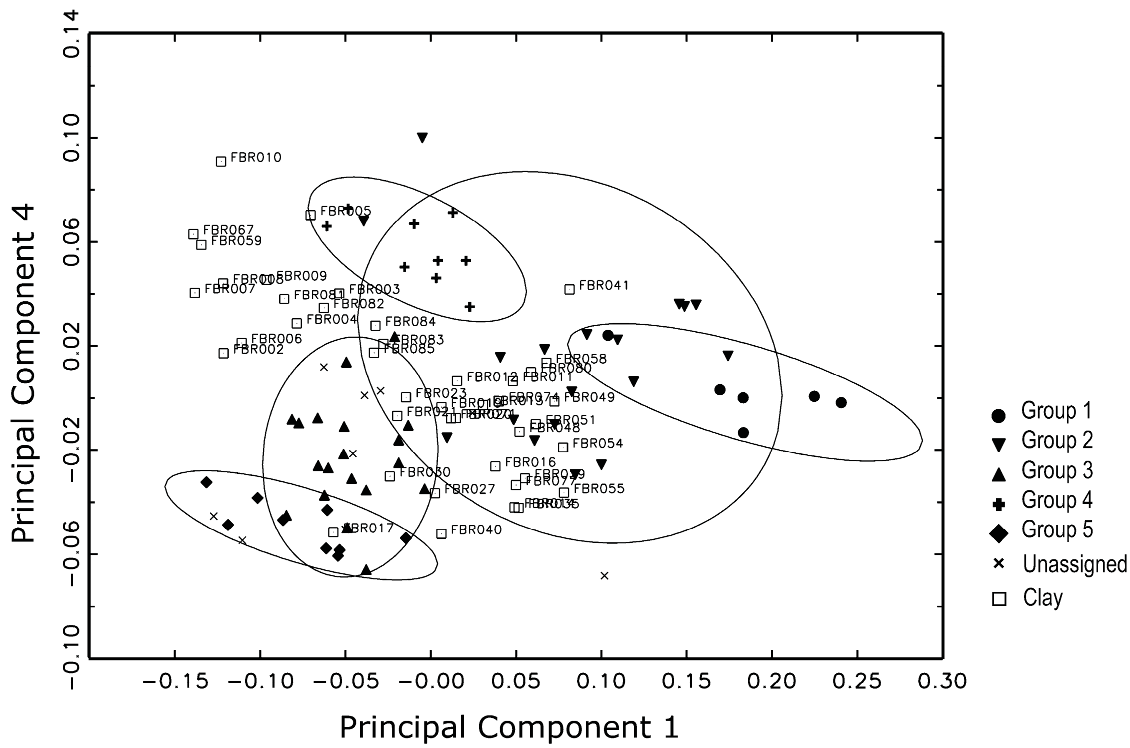


Figure 5.3. Scatter plot of principal components 1 and 4 derived from PCA of pottery and clay samples, based on the full data set (30 elements). Both pottery and clay samples are shown; clay samples are labeled individually. The 90% confidence ellipse is drawn for each group.

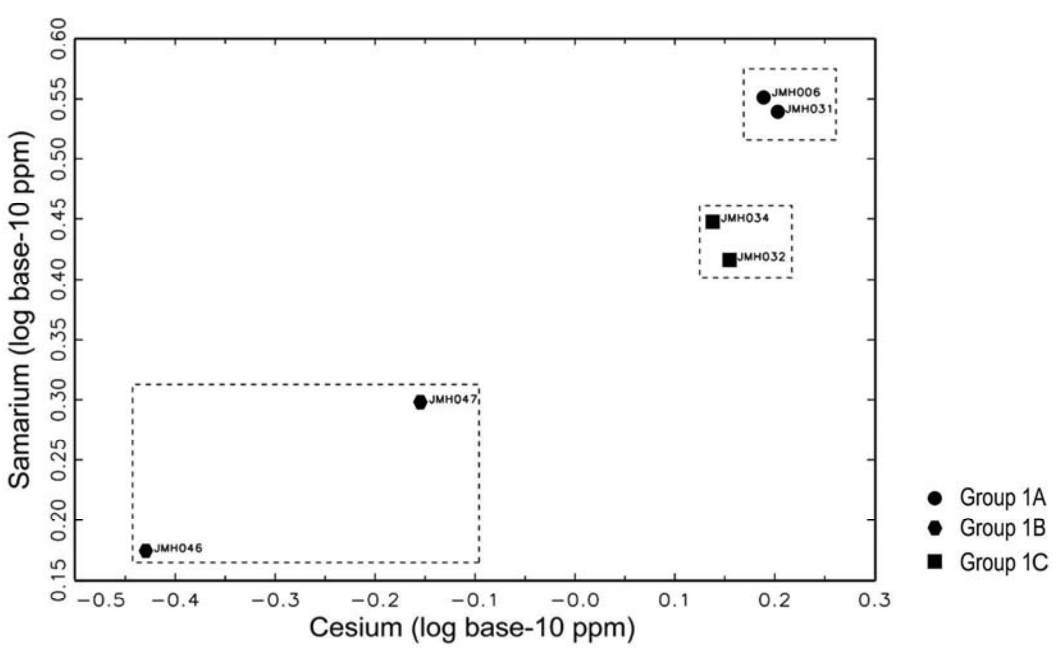


Figure 5.4. Scatter plot of Cs and Sm concentrations, illustrating possible subgroups within Group 1.

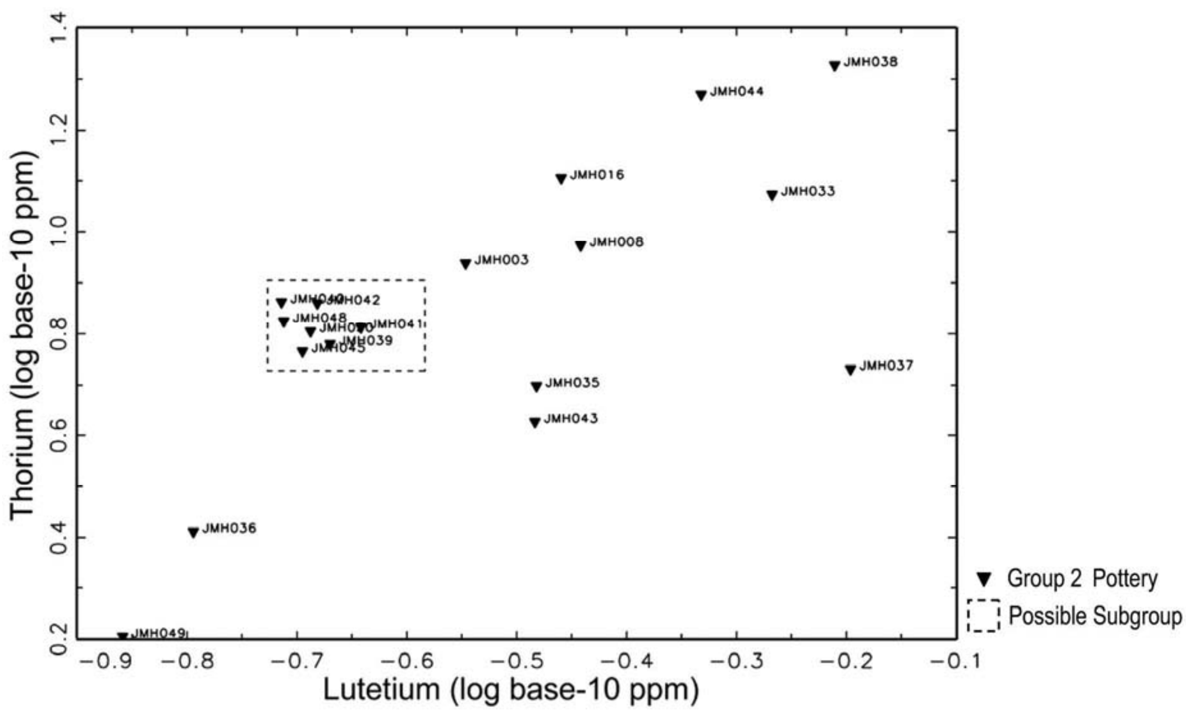


Figure 5.5. Scatter plot of Lu and Th concentrations, illustrating possible subgroups within Group 2.

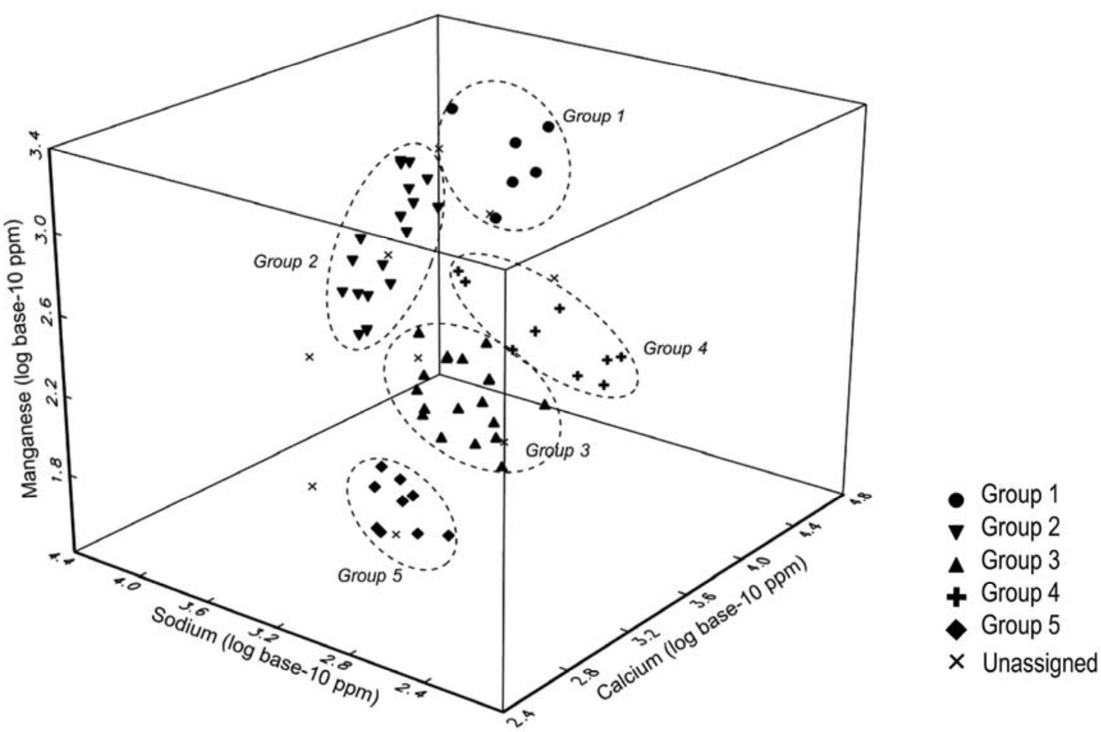


Figure 5.6. Three-dimensional scatter plot of Ca, Na, and Mn concentrations, illustrating the differences among the five compositional groups.

Table 5.3. Principal Components Analysis of the Reduced Data Set.[a]

	Principal Components									
	1	2	3	4	5	6	7	8	9	10
Lu	-0.0845	0.2447	0.1673	0.0298	0.2916	0.0509	0.1130	0.4912	-0.0587	-0.7476
Yb	-0.0719	0.2664	0.2240	-0.0171	0.3160	0.0458	0.0004	0.5841	-0.0110	0.6559
Cr	0.0811	0.1149	0.3800	-0.3620	-0.4169	-0.6122	0.2243	0.1079	0.3059	-0.0245
Eu	-0.0138	0.4210	0.3604	0.0280	0.3968	-0.1522	-0.4885	-0.4836	0.1926	-0.0412
Sc	0.0907	0.1433	0.1761	-0.1909	-0.1580	-0.1507	-0.1454	-0.0570	-0.9120	0.0088
Th	-0.2166	0.2857	0.0857	0.4054	0.1123	-0.1039	0.7314	-0.3360	-0.1420	0.0911
Ba	0.1994	0.3135	0.1772	0.6112	-0.5816	0.2083	-0.2227	0.1450	0.0680	-0.0123
Ca	0.4886	-0.5199	0.6126	0.1432	0.2039	0.1582	0.1576	-0.0544	-0.0279	-0.0021
Mn	0.5082	0.4494	-0.1089	-0.4445	-0.0348	0.4842	0.2599	-0.1398	0.0866	0.0075
Na	0.6237	0.0775	-0.4366	0.2730	0.2556	-0.5108	-0.0136	0.1110	-0.0318	0.0063
Eigenvalue	0.5334	0.1570	0.1344	0.0951	0.0601	0.0487	0.0240	0.0106	0.0071	0.0010
Variance (%)	49.7844	14.6534	12.5406	8.8784	5.6096	4.5497	2.2393	0.9871	0.6660	0.0916
Cumulative (%)	49.7844	64.4378	76.9784	85.8568	91.4663	96.0160	98.2553	99.2424	99.9084	100.0000

[a] Based on variance-covariance matrix derived from a data set consisting of 10 elements measured on all pottery and clay samples (n = 142).

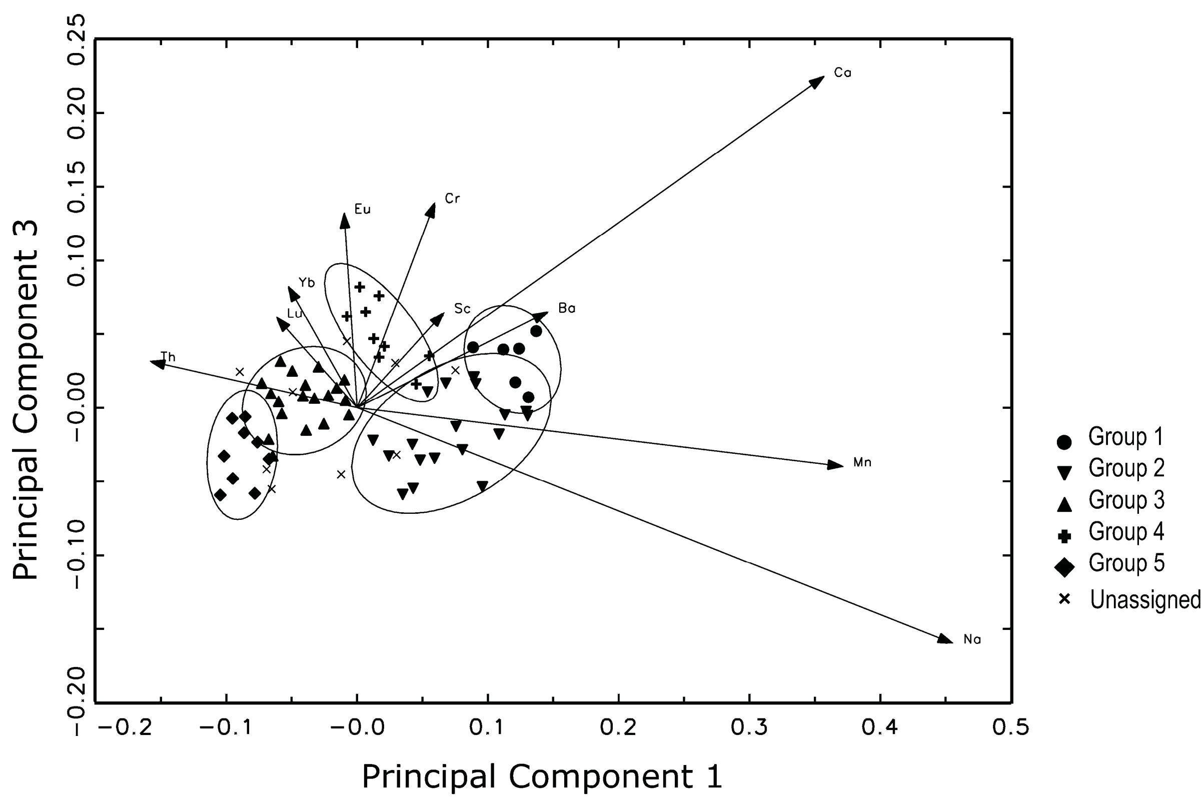


Figure 5.7. Biplot of principal components 1 and 3 derived from PCA of pottery and clay samples, based on the reduced data set (10 elements). Only pottery samples are shown. The 90% confidence ellipse is drawn for each group.

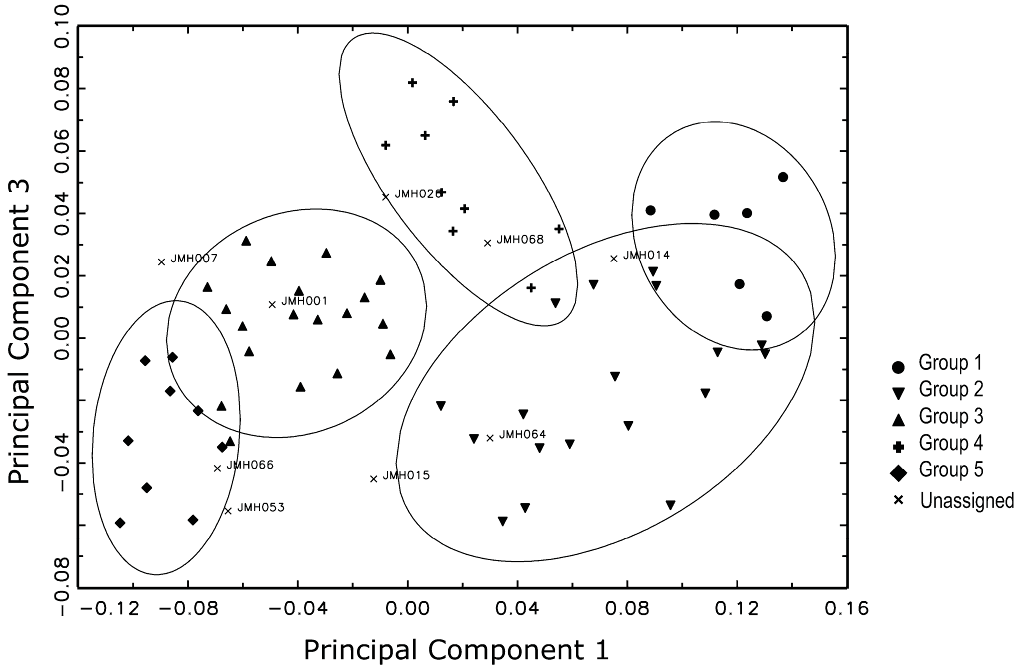


Figure 5.8. Scatter plot of principal components 1 and 3 derived from PCA of pottery and clay samples, based on the reduced data set (10 elements). Only pottery samples are shown; unassigned sherds are labeled individually. The 90% confidence ellipse is drawn for each group.

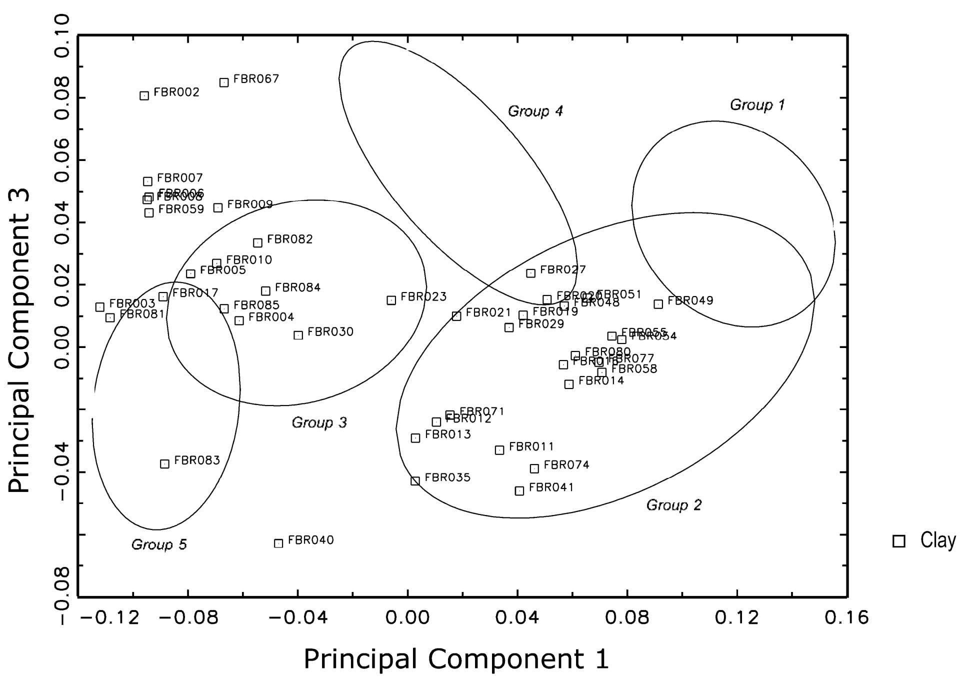


Figure 5.9. Scatter plot of principal components 1 and 3 derived from PCA of pottery and clay samples, based on the reduced data set (10 elements). Only clay samples are plotted; each is labeled individually. The 90% confidence ellipse of each pottery group is shown for comparison.

Table 5.4. Mahalanobis Probabilities of Group Membership for Pottery Samples.

Group:		Full Data Set: Probability of Group Membership[a]					Reduced Data Set: Probability of Group Membership[a]				
Sample ID	Region	1	2	3	4	5	1	2	3	4	5
Group 1:											
JMH006	Sandhills	**36.4**	16.8	0.0	0.0	0.0	**27.2**	4.5	0.0	0.0	0.0
JMH031	Piedmont	**39.5**	25.1	0.0	0.0	0.0	**16.6**	1.2	0.0	0.0	0.0
JMH032	Piedmont	**99.9**	18.4	0.0	0.0	0.0	**87.4**	0.3	0.0	0.0	0.0
JMH034	Piedmont	**44.3**	8.4	0.0	0.0	0.0	**92.9**	0.7	0.0	0.0	0.0
JMH046	Piedmont	**13.6**	8.4	0.0	0.0	0.0	**27.8**	0.6	0.0	0.0	0.0
JMH047	Piedmont	10.0	**20.3**	0.0	0.0	0.0	**28.8**	1.7	0.0	0.0	0.0
Group 2:											
JMH003	Sandhills	5.9	**66.4**	3.5	2.3	0.5	14.1	**29.3**	4.0	2.8	0.3
JMH008	Sandhills	9.9	**94.9**	2.7	28.4	0.2	13.2	**91.9**	1.3	13.5	0.2
JMH016	Sandhills	5.0	**55.1**	4.8	2.5	1.2	11.2	**52.1**	6.5	1.9	0.8
JMH033	Piedmont	22.2	**46.3**	0.0	2.9	0.1	18.4	**55.6**	0.2	9.2	0.0
JMH035	Piedmont	53.6	**54.5**	0.0	0.2	0.1	**39.1**	34.3	0.0	0.3	0.0
JMH036	Piedmont	**52.2**	10.4	0.0	0.0	0.0	**16.4**	9.4	0.0	0.1	0.0
JMH037	Piedmont	11.8	**50.1**	0.1	0.8	0.1	21.3	**26.4**	0.1	1.4	0.0
JMH038	Piedmont	**14.7**	10.8	0.0	1.7	0.0	11.2	**21.3**	0.4	6.8	0.1
JMH039	Piedmont	7.9	**86.4**	0.0	1.8	0.1	16.7	**96.5**	0.1	2.1	0.0
JMH040	Piedmont	32.6	**87.8**	0.0	0.4	0.0	19.5	**83.2**	0.0	0.4	0.0
JMH041	Piedmont	5.4	**84.5**	0.4	9.9	0.2	11.2	**93.6**	0.3	11.7	0.2
JMH042	Piedmont	2.7	**35.7**	0.2	2.1	0.6	10.0	**18.8**	0.2	2.5	0.4
JMH043	Piedmont	6.3	**71.6**	0.0	0.6	0.1	20.0	**55.5**	0.2	1.7	0.0
JMH044	Piedmont	**7.7**	0.4	0.0	0.1	0.0	**5.8**	5.5	0.0	1.0	0.1
JMH045	Piedmont	18.7	**36.2**	0.0	0.2	0.0	10.5	**49.6**	0.0	0.6	0.0
JMH048	Piedmont	17.5	**32.2**	0.0	0.3	0.0	10.8	**54.2**	0.0	0.6	0.0
JMH049	Piedmont	17.8	**32.0**	0.0	0.0	0.0	11.0	**37.3**	0.0	0.7	0.0
JMH050	Piedmont	3.6	**62.7**	0.7	4.6	0.4	10.2	**56.0**	0.2	2.2	0.4
Group 3:											
JMH002	Sandhills	5.2	1.3	**82.8**	0.4	5.2	8.0	0.7	**100.0**	0.4	1.4
JMH004	Sandhills	3.8	13.5	**73.3**	0.7	5.8	9.3	3.8	**81.8**	0.6	1.4
JMH005	Sandhills	5.1	14.5	**74.1**	1.2	3.1	11.0	12.4	**45.9**	1.2	0.5
JMH010	Sandhills	2.0	6.1	8.8	0.3	**13.7**	**6.6**	0.1	1.5	0.1	4.4
JMH017	Sandhills	2.9	0.1	**12.7**	0.1	5.3	5.0	0.6	**21.4**	0.1	1.8
JMH018	Sandhills	11.0	1.8	**43.9**	2.6	0.6	11.3	0.9	**55.6**	1.5	0.5
JMH020	Sandhills	8.8	3.2	**44.4**	1.1	2.3	10.6	3.7	**80.3**	1.4	0.6
JMH021	Coastal Plain	3.8	4.1	**37.5**	0.4	17.3	7.8	0.9	**96.0**	0.4	1.2
JMH022	Coastal Plain	**18.2**	4.2	7.9	4.8	0.2	14.8	0.2	**24.3**	7.1	0.1
JMH023	Coastal Plain	2.0	2.5	**52.9**	0.1	49.0	6.1	0.9	**78.9**	0.1	9.6
JMH024	Coastal Plain	5.2	0.3	**41.3**	0.4	4.9	7.2	0.0	**34.3**	0.4	0.4
JMH025	Coastal Plain	3.9	4.8	**65.5**	0.4	8.2	7.8	3.5	**81.5**	0.4	2.3
JMH027	Coastal Plain	2.8	3.6	**96.1**	0.3	22.0	7.0	6.2	**36.9**	0.2	8.3
JMH028	Coastal Plain	7.5	0.6	**61.6**	0.6	4.5	8.2	0.9	**41.8**	0.7	0.5
JMH029	Coastal Plain	2.8	0.9	**54.0**	0.2	23.3	6.5	0.0	**10.1**	0.1	2.3
JMH030	Coastal Plain	2.4	0.9	**76.3**	0.2	61.0	5.9	0.3	**62.1**	0.1	7.0
JMH054	Coastal Plain	7.4	11.2	**41.6**	1.3	1.5	12.8	2.1	**52.6**	1.9	0.3
JMH065	Coastal Plain	5.5	2.0	**66.9**	0.7	4.3	8.6	0.0	**29.0**	0.7	0.3
JMH067	Coastal Plain	1.7	0.6	3.5	0.1	**3.7**	5.2	0.2	**11.2**	0.1	2.1

Table 5.4. Mahalanobis Probabilities of Group Membership for Pottery Samples (continued).

Group:		Full Data Set: Probability of Group Membership[a]					Reduced Data Set: Probability of Group Membership[a]				
Sample ID	Region	1	2	3	4	5	1	2	3	4	5
Group 4:											
JMH055	Coastal Plain	32.9	10.9	5.9	**55.5**	0.0	17.2	0.0	0.6	**56.3**	0.0
JMH056	Coastal Plain	**24.5**	10.9	0.4	15.5	0.0	15.1	0.0	0.4	**54.2**	0.0
JMH057	Coastal Plain	27.9	14.0	1.3	**96.1**	0.0	18.6	0.0	0.3	**46.2**	0.0
JMH058	Coastal Plain	25.3	35.0	4.0	**87.0**	0.1	16.6	0.1	3.3	**31.5**	0.0
JMH059	Coastal Plain	15.2	1.4	2.6	**16.7**	0.0	20.0	0.0	1.0	**37.1**	0.0
JMH060	Coastal Plain	23.6	46.5	1.5	**63.2**	0.0	20.1	0.2	4.8	**98.1**	0.0
JMH061	Coastal Plain	21.4	**86.0**	2.1	57.9	0.1	18.9	23.6	4.7	**32.0**	0.1
JMH062	Coastal Plain	22.6	**66.6**	1.0	17.6	0.0	18.1	4.3	1.4	**21.1**	0.0
JMH063	Coastal Plain	20.9	4.0	1.0	**34.0**	0.0	18.0	0.0	0.3	**61.5**	0.0
Group 5:											
JMH009	Sandhills	2.1	1.8	4.5	0.1	**49.5**	4.9	1.5	1.8	0.0	**23.5**
JMH011	Sandhills	1.3	0.6	17.9	0.1	**86.2**	4.6	0.0	3.0	0.0	**15.7**
JMH012	Sandhills	3.0	0.2	2.6	0.1	**49.3**	4.4	0.5	7.9	0.0	**81.0**
JMH013	Sandhills	2.1	0.2	3.8	0.1	**43.5**	4.0	0.2	9.2	0.0	**46.4**
JMH019	Sandhills	2.3	0.4	12.3	0.1	**85.1**	4.8	0.3	8.7	0.0	**88.4**
JMH051	Coastal Plain	1.9	1.6	29.8	0.1	**66.2**	5.5	1.2	12.6	0.1	**44.1**
JMH052	Coastal Plain	1.3	0.9	6.4	0.1	**27.9**	4.5	0.2	1.3	0.0	**64.6**
JMH069	Coastal Plain	1.5	0.9	9.6	0.1	**15.0**	5.3	0.1	1.6	0.1	**53.4**
JMH070	Coastal Plain	1.2	0.1	1.9	0.0	**25.0**	4.1	0.0	0.9	0.0	**30.6**
Unassigned:											
JMH001	Sandhills	2.4	0.9	0.2	0.1	**6.8**	4.6	1.7	**8.4**	0.1	4.2
JMH007	Sandhills	**3.0**	0.0	0.7	0.0	1.3	3.8	0.0	**9.7**	0.1	2.2
JMH014	Sandhills	5.4	**7.9**	0.0	0.0	0.0	**14.0**	2.7	0.0	0.0	0.0
JMH015	Sandhills	4.5	**27.0**	0.0	0.1	0.2	6.1	**12.3**	0.0	0.1	1.1
JMH026	Coastal Plain	5.4	**13.0**	7.7	0.8	4.2	**10.1**	1.0	6.5	2.4	0.1
JMH053	Coastal Plain	1.8	2.2	46.6	0.1	**79.6**	5.3	4.0	0.3	0.0	**17.7**
JMH064	Coastal Plain	5.4	**79.0**	7.6	4.9	0.7	12.1	**67.4**	2.4	2.3	0.4
JMH066	Coastal Plain	3.4	1.1	**4.7**	0.7	0.4	**6.5**	0.1	0.2	0.1	2.6
JMH068	Coastal Plain	**19.6**	5.6	15.3	2.3	0.5	**14.2**	9.5	0.2	1.0	0.0

[a] Based on Mahalanobis distances calculated with scores on principal components 1–4. Probablilities are jackknifed for samples in each group. The highest probability of group membership for each sherd is highlighted in bold.

to the pottery's fabric that can have a strong effect on chemical composition. Second, the variability among clays can be large even within a single region, and one can never be sure that one has sampled exactly the same clays that ancient potters used. Given these issues, especially the first, we decided to examine the clays separately, comparing their composition to the pottery groups just described.

Before making these comparisons, it is important to consider the potential effects of temper. Most of the pottery sherds in the current sample are tempered predominantly with crushed quartz, sand, or grog. The first two materials alter a clay's composition differently than the third.

Quartz and sand consist almost entirely of silicon (Si), which cannot be detected by NAA. Thus, adding either of these materials to a clay has the effect of diluting all the other elements that can be detected. To the extent that a given quartz or sand might contain a few minor or trace elements in addition to Si, the concentrations of these might be enhanced or not diluted quite as much, but this would depend on the particular case. The dominant effect of quartz or sand tempering is that it significantly *decreases* the concentrations of most, if not all, the clay's elements that NAA can detect.

The chemical effects of grog are different. Because grog temper consists of crushed pottery, it is also made of clay — potentially the same type of clay to which it is added. Thus, grog is often chemically "transparent," in that it alters the composition of the raw clay very little or not at all. Exceptions might occur in cases where the grog was made from nonlocal pottery or pottery tempered with a different material, but such cases are likely to be rare.

With these considerations in mind, we computed Mahalanobis probabilities for the 42 untempered clay samples with reference to the five pottery groups just described and arranged these probabilities by the drainage in which the clay samples were collected (Table 5.5; see also Figures 5.3 and 5.9). Based on the full data set, raw clays from the Deep, Yadkin, Cape Fear, and Pee Dee drainages all show moderate to high probabilities of membership in Group 2. Clays from the Haw drainage are also most similar to Group 2, but their probabilities of membership are substantially lower. In contrast, clays from the Waccamaw and Lower Little drainages show the closest affinities to Group 1, but the probabilities of membership are so low that these clays are not really similar to the pottery specimens that comprise this group. When one computes Mahalanobis probabilities based on the reduced data set, the results are not identical (Table 5.5). The closest affinities of seven clays change from Group 2 to Group 1, and those of three other clays change from Group 2 to Group 3 (Table 5.5). In all of these cases, however, the highest probability is either quite low (i.e., not a strong match) or virtually equal to the probability of membership in Group 2 (i.e., a borderline case). Thus, the overall pattern remains similar, albeit not as consistent, with most clay samples from the Cape Fear, Pee Dee, Deep, and Yadkin drainages having strong relationships with Group 2, and virtually all the remaining clays having their closest tie (even if weak) to Group 1.

Most of the sherds in Groups 1 and 2 are tempered with quartz, sand, or granitic rock (see Table 5.2). It is therefore interesting that a number of the clays chemically resemble Group 2, despite the effects of temper. The question is, would adding temper to the raw clays produce a different pattern of chemical relationships?

To investigate this question, we mathematically "tempered" all of our clay samples with quartz (FBR086, FBR087), sand (FBR092), and granite (FBR088, FBR089) whose composition had been determined by NAA. Using the known compositions of tempers and clays, simulated sherds were created from each clay by mathematically adding 15%, 25%, and 50% of each temper. These simulated sherds were then projected into the PCA space for the full data set, and Mahalanobis probabilities were calculated with reference to the five pottery groups. None of the simulated sherds had a probability greater than 1% of belonging to any of the groups. Thus, adding temper does make a difference, but it does *not* increase the chemical similarity between any of the clays and sherds; to the contrary, many of the real tempered sherds are compositionally more similar to untempered "raw" clays than to the same clays artificially tempered with quartz, sand, or granite. This result suggests two things. First, the fact that the raw clays and tempered sherds show as much similarity as they do hints that the clays may already be somewhat mixed with a very fine-grained silica and/or granitic rock that is not easily

Table 5.5. Mahalanobis Probabilities of Group Membership for Clay Samples.

Drainage (Region): Sample ID	Full Data Set: Probability of Group Membership[a] 1	2	3	4	5	Reduced Data Set: Probability of Group Membership[a] 1	2	3	4	5
Deep (Piedmont):										
FBR058	22.6	**86.4**	0.3	1.3	0.1	21.5	**92.3**	0.2	1.2	0.0
FBR071	6.2	**69.8**	11.1	4.4	0.9	10.7	**72.0**	1.8	1.8	0.8
FBR074	6.7	**93.8**	2.6	9.8	0.4	10.3	**36.7**	0.2	2.8	0.3
FBR077	5.2	**17.7**	0.0	2.1	0.2	**11.0**	3.2	0.1	7.2	0.1
FBR080	15.0	**97.9**	0.8	6.1	0.2	17.6	**99.3**	0.9	8.9	0.1
Haw (Piedmont):										
FBR029	6.0	**13.3**	0.0	0.1	0.2	**15.2**	8.9	0.0	0.1	0.0
FBR030	2.6	**31.0**	0.8	0.3	5.6	8.4	1.9	**22.1**	0.3	3.4
FBR035	1.9	**24.9**	0.2	0.5	1.4	8.4	**47.9**	0.2	0.5	1.7
FBR040	1.3	**12.8**	0.3	0.1	6.1	5.6	**7.2**	0.0	0.1	3.4
FBR041	4.8	**16.9**	0.0	2.7	0.0	6.6	**24.6**	0.0	2.5	0.1
Yadkin (Piedmont):										
FBR048	9.2	**79.2**	0.6	1.8	0.3	23.3	**47.7**	0.1	0.6	0.0
FBR049	20.1	**79.4**	0.1	0.6	0.1	**32.0**	31.9	0.0	0.1	0.0
FBR051	12.8	**75.8**	0.2	1.0	0.2	25.7	**58.9**	0.1	0.7	0.0
FBR054	9.2	**79.8**	0.1	0.5	0.1	**22.7**	18.3	0.0	0.1	0.0
FBR055	6.1	**54.4**	0.0	0.4	0.1	**18.5**	12.5	0.0	0.2	0.0
Cape Fear (Coastal Plain):										
FBR011	6.6	**89.4**	2.9	12.0	0.2	11.0	**82.3**	0.4	3.4	0.4
FBR012	6.6	**58.5**	13.5	7.7	0.4	10.3	**43.7**	0.8	1.8	0.7
FBR013	4.2	**66.1**	4.5	4.1	0.5	10.1	**21.9**	0.8	1.3	0.8
FBR014	4.6	**35.2**	0.1	0.8	0.2	**11.9**	5.2	0.1	1.4	0.1
FBR016	7.0	**50.1**	0.5	1.2	0.3	13.5	**17.1**	0.3	2.0	0.1
Pee Dee (Coastal Plain):										
FBR019	8.1	**61.6**	0.9	5.3	0.6	14.1	**65.0**	3.3	11.3	0.2
FBR020	9.8	**47.5**	0.8	6.0	0.4	14.7	**52.2**	1.6	13.6	0.1
FBR021	7.5	**39.8**	3.2	2.6	1.2	12.1	**49.0**	13.5	3.4	0.4
FBR023	6.1	**35.0**	25.5	3.0	0.9	14.1	1.5	**58.7**	3.2	0.2
FBR027	5.8	**13.8**	0.1	1.1	0.2	**11.0**	9.5	0.3	3.1	0.1
Waccamaw (Coastal Plain):										
FBR081	**4.2**	0.0	0.0	0.3	0.0	**5.0**	0.0	0.0	0.1	0.1
FBR082	**8.8**	1.3	1.0	2.5	0.1	**9.6**	0.0	4.1	1.2	0.1
FBR083	**4.0**	0.2	0.2	0.8	0.1	**5.4**	0.0	0.0	0.1	0.3
FBR084	**6.4**	1.6	1.5	3.1	0.1	**9.8**	0.0	1.9	1.2	0.1
FBR085	**4.8**	0.4	1.0	1.1	0.1	**7.8**	0.0	0.5	0.3	0.1
Lower Little (Sandhills):										
FBR002	**8.7**	0.0	0.5	0.3	0.5	**5.4**	0.0	0.0	0.5	0.0
FBR003	**4.2**	0.0	0.0	0.2	0.0	**5.0**	0.0	0.0	0.1	0.1
FBR004	**8.7**	1.6	1.1	1.3	0.1	**8.0**	0.0	2.2	0.2	0.7
FBR005	**10.8**	0.0	0.0	3.9	0.0	**7.4**	0.0	0.1	0.7	0.0
FBR006	**7.9**	0.0	1.3	0.7	0.3	**6.4**	0.0	0.7	0.3	0.1
FBR007	**10.4**	0.0	0.1	0.8	0.1	**6.2**	0.0	1.1	0.3	0.1
FBR008	**8.2**	0.0	0.0	0.7	0.0	**6.0**	0.0	0.5	0.3	0.1
FBR009	**11.7**	0.1	0.2	2.3	0.0	**7.8**	0.0	2.0	0.7	0.1
FBR010	**12.6**	0.0	0.0	0.6	0.0	**8.4**	0.0	1.4	0.6	0.1
FBR017	**2.6**	0.0	0.0	0.0	0.4	4.6	0.0	**10.5**	0.1	0.9
FBR059	**10.7**	0.0	0.0	1.2	0.0	**6.3**	0.0	1.5	0.2	0.1
FBR067	**15.9**	0.0	0.1	4.2	0.0	**8.0**	0.0	0.2	1.9	0.0

[a] Based on Mahalanobis distances calculated with scores on principal components 1–4. Probablilities are jackknifed for samples in each group. The highest probability of group membership for each sherd is highlighted in bold.

seen or felt. Second, it raises the question of whether the sand temper in the real sherds is an artificial additive or a natural inclusion. This is a question we cannot answer here.

It is also worth noting the geographical dimension of the patterns just discussed. Group 2 sherds come exclusively from the Piedmont and Sandhills. The raw clays most similar to Group 2, on the other hand, are either from the Piedmont (Deep and Yadkin drainages) or rivers in the Coastal Plain that flow out of the Piedmont (Cape Fear, Pee Dee). Admittedly, membership probabilities for Group 2 may be somewhat inflated due to the heterogeneous nature of the group, but the similarities are so strong that it is implausible to attribute them purely to this factor. A more likely explanation is that the composition of Group 2 is characteristic of Piedmont and Piedmont-derived sediments, the latter occurring in the Coastal Plain along major rivers that carry Piedmont alluvium.

Conclusions

Based on composition, we have tentatively identified five pottery groups, two consisting mainly of sherds from the Piedmont and three mainly of sherds from the Coastal Plain. Sherds found in the Sandhills (Fort Bragg) occur in four of the five groups, clustering with pottery from both the Piedmont and the Coastal Plain. The five chemical groups identified herein correspond approximately to the petrographic groups identified by Smith in Chapter 6, and the relationship between petrographic and chemical groups will be fully explored in Chapter 8.

Clays from the Piedmont and Piedmont-derived sediments in the Coastal Plain show the greatest chemical similarities to Group 2, whose sherds (not surprisingly) are mainly from Piedmont sites. Clays collected in the Sandhills bear little chemical similarity to any of the pottery groups.

Although significant progress has been made in identifying compositional groups that may be indicative of specific drainages and regions in and around the Fort Bragg area, we stress the preliminary nature of the data. Any conclusions regarding these data should be considered carefully and supported by other lines of evidence, such as the petrographic component of this project. Future research should focus on refining the preliminary groups identified in this study with larger samples.

Notes

Acknowledgments. We acknowledge Nicole Little, Tessa Schut, and Jon Dake for their assistance with preparing the samples for irradiation.

Chapter 6

Petrography

Michael S. Smith

A petrographic analysis was conducted as part of the effort to determine how, and to what degree, pottery may have been moving into the Sandhills from surrounding regions. The sample included 70 ceramic sherds and 53 clay test tiles representing eight drainages in the Sandhills, Coastal Plain, and Piedmont (Table B.7).

The objective of the petrographic study was to establish a baseline of information about the petrological variability observed in pottery and clays from the Sandhills and surrounding regions. This was accomplished by characterizing the minerals, rock fragments, and other components identified in standard size petrographic thin sections (Figure 6.1; Appendix D). In addition, the petrographic characteristics of the sherds and clays were used to identify possible source locations for the pottery samples.

This chapter describes the results of the petrographic study and compares them with those from a previous study of Fort Bragg pottery conducted by Herbert et al. (2002). Appendix D contains a full description of the methodology and point count data for the pottery samples.

Petrographic Criteria for Characterizing Pottery and Clays

Archaeologists often use terms that are misconstrued by geologists, and vice versa. The following discussion of nomenclature and terminology is offered to circumvent this dilemma.

In this study, the materials composing the prehistoric pottery and ceramic test tiles are separated into two types, *plastic* and *aplastic*, based upon certain material properties. *Paste* refers to the entire ceramic matrix including plastic and aplastic components.

Plastic components are predominately clay minerals and generally comprise most of the sherd or test tile matrix. During firing, clay minerals respond to changes in temperature and react to produce an amorphous glass or a partially amorphous intermediate-reaction product. This vitrification process destroys or dramatically changes the optical characteristics of the materials, preventing identification of the original clay minerals. In addition, the grain size of clay is generally less than 0.01 mm and therefore below the optical resolution of the BH-2 microscope (Rice 1987:38, Figure 2.2).

Nonclay minerals and rock fragments are referred to as *aplastic* components and can be identified through petrographic analysis. Aplastic materials greater than 0.1 mm in diameter were evaluated for crystal shape (angular, subangular, subrounded, or rounded), color (clear, translucent, or colored), pleochroism (change of color upon rotation of the stage in plane-polarized light), and presence of alteration minerals (secondary minerals resulting from alteration

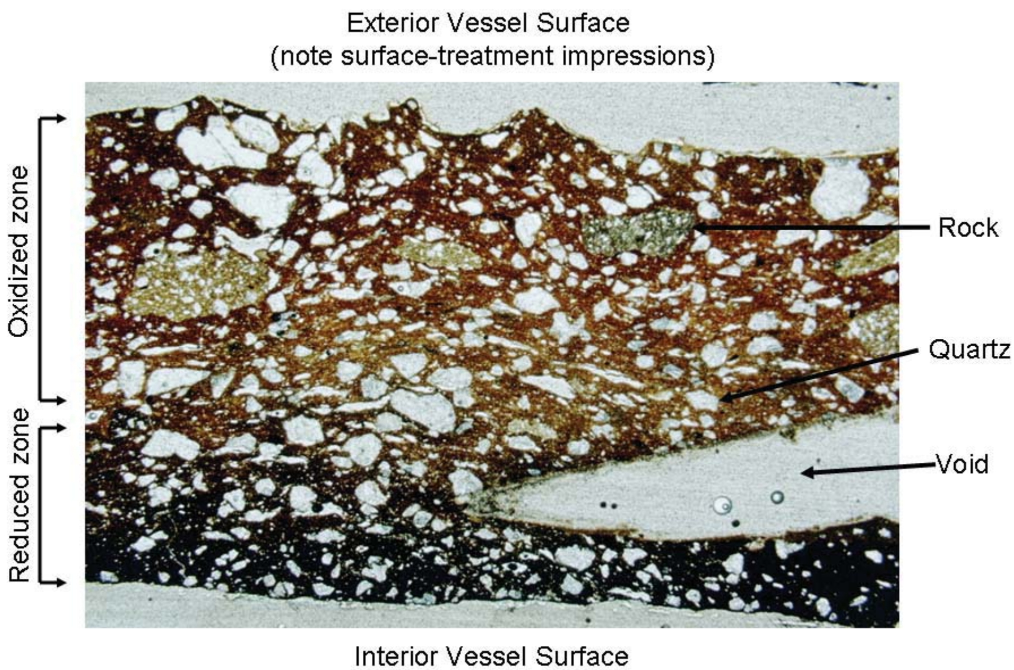


Figure 6.1. Ceramic petrographic thin section illustrating the orientation of the cross section and some common attributes analyzed in this study.

of original minerals). Opaque minerals, which appear black under plane-polarized light, were also evaluated.

Temper is generally defined by archaeologists as aplastic material added to clay to enhance the workability or firing characteristics of the paste (Rice 1987:74). It is often difficult to ascertain whether specific aplastic components of pottery have been deliberately added to enhance the workability of the paste or are present simply as naturally occurring constituents of the clay (Rice 1987; Stoltman 1989). In this study, aplastic materials with grain sizes smaller than 0.1 mm are considered to be naturally occurring components of the paste material. Aplastic materials with grain sizes greater than 0.1 mm are classified as tempering materials, although one of the goals of this study is to determine whether naturally occurring, coarse aplastic materials can be distinguished from deliberately added components.

Aplastic Component Categories

Aplastic materials were divided into three categories: mineral grains or fragments, rock fragments, and other constituents. *Mineral grains* include

- quartz,
- mica (muscovite or biotite),
- feldspar (plagioclase or K-feldspar),
- mafic minerals (pyroxene or amphibole),
- opaque minerals (generally hematite or magnetite based upon color, optical relief, and grain shape), and
- other minerals (including epidote or clinozoisite, tourmaline, and zircon).

Quartz minerals were distinguished using criteria such as monocrystalline versus polycrystalline texture, grain size, and degree of angularity and rounding. Mica was identified as either muscovite or biotite based upon mineral color and pleochroism, Michel-Levy interference colors, and extinction angle. However, the firing process often changes the color characteristics of the micas, generating a small degree of uncertainty in the identification.

Feldspar minerals were typically identified based upon the presence or absence of diagnostic twinning. A mineral exhibiting no twinning was described as feldspar. Plagioclase was identified by characteristic albite polysynthetic twinning, while lack of albite twinning or presence of "tartan plaid" intersection twinning identified K-feldspar (also termed potassium feldspar or alkali feldspar). Plagioclase and K-feldspar can also sometimes be distinguished based on alteration minerals. Because plagioclase and K-feldspar have slight chemical differences, they alter according to different chemical reactions and produce different alteration assemblages. Sericite (or "white mica") and argillite (a clay mineral) are common alteration minerals for both plagioclase and K-feldspar, but saussurite (or epidote) is only formed through the alteration of Ca-plagioclase.

Mafic minerals are generally colored in plane-polarized light and have characteristic cleavage, interference colors, and extinction angles. Pyroxene and amphibole represent two groups of mafic minerals with slight variations in chemistry and mineral properties. As with the feldspar minerals, characteristic mineral properties help discriminate one mafic group from the other. In addition, the presence of other minerals within the paste can also be used to constrain the identity of mafic minerals. For example, pyroxene would be commonly associated with plagioclase feldspar but not quartz, while amphibole would be associated with quartz, biotite or muscovite mica, and plagioclase feldspar.

Other minerals include those that have high hardness, density, or chemical resistivity to weathering. Minerals such as tourmaline are often associated with specific rock types (e.g., high-alumina granites) and might have specific applicability as "mineral tracers" in some sedimentary depositional environments.

The *rock fragment* category includes igneous, sedimentary, and metamorphic types. Rock fragments in the majority of samples include

- diabase igneous rock fragments,
- quartz + feldspar igneous rock fragments occurring with or without mafic and/or opaque minerals,
- polygranular igneous or metamorphic quartz rock fragments (sometimes with fluid inclusions and rutile needles), and
- sedimentary or metasedimentary rock fragments.

Other constituents include

- grog (with or without aplastic mineral grains),
- argillaceous clay fragments (argillaceous clay clots or hematite-stained clots), and
- charcoal or petrified wood fragments.

Grog and argillaceous clay fragments (ACF) share many morphological and optical characteristics, so distinguishing between them can be very difficult. Grog refers to fired pottery fragments deliberately added to the clay in order to enhance workability or thermal shock resistance during firing (Whitbread 1986). ACF are naturally occurring inclusions of air-dried clay (Cuomo di Caprio and Vaughan 1993); Whitbread (1986) refers to these inclusions as "argillaceous pellets." In this study, ACF are separated into two types: argillaceous clay clots and hematite-stained clay clots. Argillaceous clay clots appear as angular to subrounded fragments that are nearly indistinguishable from the surrounding paste (Figure 6.2). Indeed, these clay clots completely blend into the paste under cross-polarized light and are thus virtually impossible to detect through point counting. Nevertheless, slightly different abundances of clay minerals or aplastic mineral crystals in the argillaceous clay clots and paste produce subtle yet distinctive optical differences. In contrast, hematite-stained clay clots are iron rich and stand out as brick red or dark red ovals or lozenges with few mineral inclusions.

Firing Conditions

Firing conditions (temperature and atmosphere) can sometimes be interpreted from the color of the sherd (Rice 1987; Rye 1981; Velde and Druc 2000). Light color (e.g., light red, pink, pale rose, light tan, light greenish tan) may indicate low carbon content, high firing temperature, or oxidizing conditions, while a dark color (e.g., black, black-gray, dark gray) may indicate high carbon content, low firing temperature, and reduced (i.e., low oxygen) firing conditions. The presence of both oxidation and reduction may be recorded on a single vessel as "fire clouding" (a phenomenon caused by variations in temperature and oxidization resulting from uneven fuel and ventilation) or as differences in core and surface color in sherd cross sections. Munsell colors for sherd cores and test tile surfaces were recorded for the hand samples (see Appendixes A and B) and are noted in the petrographic analysis of thin sections.

The ceramic samples display oxidation features on the inner and outer surfaces. These features extend into the sherd for several millimeters. In some sherds there is a darker core between these oxidized zones indicating that either organics were originally present and oxidized only near the surfaces or the pot was fired in a reduced-oxygen environment and then cooled quickly. Observations and measurements of the size of the oxidized zones and the degree of oxidation to reduction were noted.

Other Observations

It was also noted that some sherds show secondary alteration in fractures and along broken edges. This mineralization is apparent as a localized color change and may have resulted from usage or burial and interaction with groundwater.

The percentage of void spaces is sometimes used as a basis for characterizing pottery types (Whitbread 1987), but it was not used in the classification of samples for this study. Nevertheless, void spaces were evaluated during point counting to assess the loss of organic inclusions (through firing or dissolution) or mineral and rock fragments (due to plucking during thin-section preparation and finishing).

Results: Ceramic Samples

The 70 pottery samples can be separated into three distinct petrographic groups based on characteristic aplastic inclusions (Table 6.1). Group I samples are characterized by the presence of diabase (pyroxene + plagioclase) rock fragments. Group II samples contain quartz + feldspar

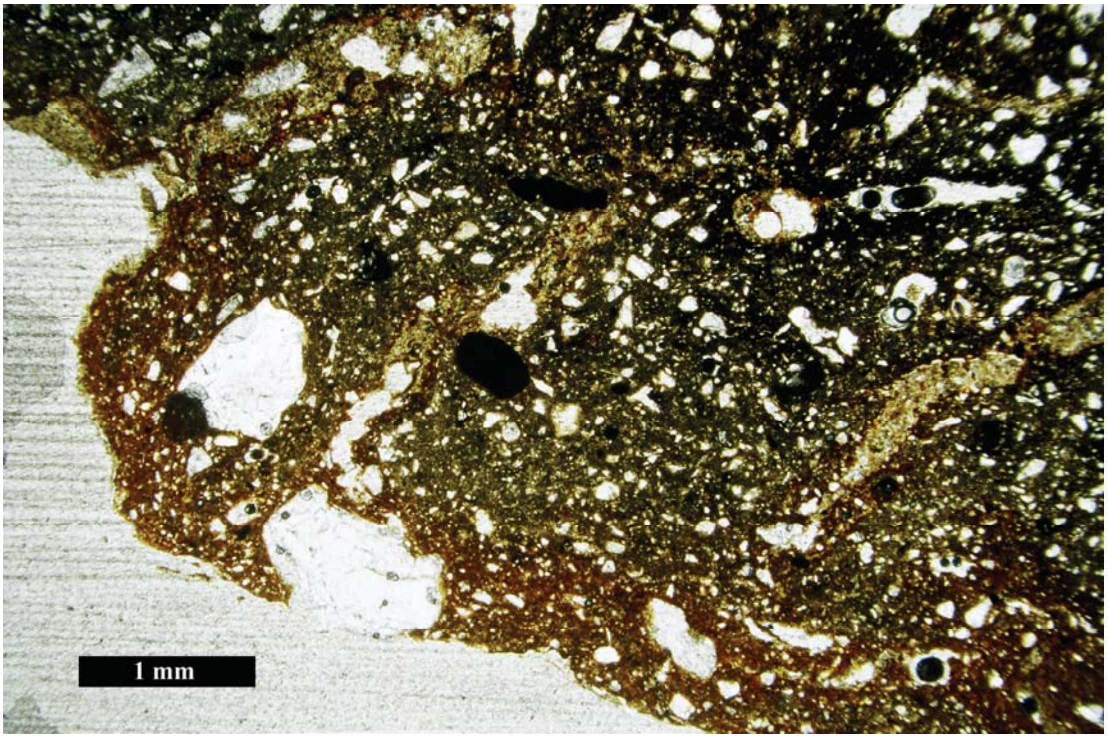


Figure 6.2. ACF in pottery sample JMH068 (plane-polarized light). Argillaceous clay clots (center, top left, and bottom right of center) are yellow brown, worm-like in appearance, and contain quartz and feldspar inclusions. Hematite-stained clay clots (center and top right of center) are reddish black and lack visible mineral inclusions. Aplastic components are mainly medium- to fine-grained quartz, feldspar, and biotite. Paste is dark golden tan to brown and is nearly isotropic in optical behavior. Note that there are aplastic components within the paste that are probably quartz and feldspar minerals.

rock fragments, quartz mineral fragments, and mafic mineral fragments. Group III samples are rich in muscovite mica, quartz mineral fragments, and quartz rock fragments and generally lack mafic minerals such as pyroxene or amphibole. Groups II and III contain samples exhibiting considerable petrographic variability, but the samples within these groups share enough general similarities that it was decided to divide the groups into subgroups rather than create additional distinct groups.

The general characteristics of the groups, subgroups, and samples are summarized below. More detailed descriptive information and point count data for the 70 sherds are included in Appendix D.

Group I

Group I contains four Middle Woodland Yadkin series sherds from the Lower Little, Haw, and Yadkin drainages (Table 6.2). These sherds are dominated by coarse to very coarse (0.5–2.0 mm) pyroxene + plagioclase diabase rock fragments (Figure 6.3). The associated mineral suite is composed mainly of pyroxene and plagioclase mineral fragments which are probably derived from the breakdown of the diabase. The pyroxene is probably a clinopyroxene (augite). The plagioclase is Ca-rich (probably labradorite).

Table 6.1. Characteristic Aplastic Inclusions in Petrographic Groups.

	Petrographic Groups				
		Group II		Group III	
Inclusions	Group I	A	B	A	B
Mineral Grains					
Pyroxene	x				
Feldspar (plagioclase or potassium)	x	x	x		
Amphibole		x	x		
Biotite		x	x		
Muscovite		x	x	x	x
Quartz (monocrystalline)		x	x	x	x
Opaque (hematite or magnetite)		x	x	x	x
Rock Fragments					
Diabase (pyroxene- and/or plagioclase-rich)	x				
Quartz + feldspar + mafic minerals		x			
Quartz + feldspar		x	x		
Quartz (polygranular) fragments		x	x	x	x
Other					
Grog				x	x
ACF - Hematite-stained clay clots				x	x
ACF - Argillaceous clay clots				x	

Group I sherds have a consistent black to black-gray color that may be a result of reduced firing. Alternatively, the dark color may be what happens when Ca-Mg-Fe-rich diabase is fired under oxidizing conditions.

Diabase fragments in sample JMH006 comprise almost 30% of the paste and range from medium to very coarse in size, allowing them to be observed in thin section without magnification. The nearly pristine condition of these fragments suggests a source close to a diabase exposure. The original vessel may have been constructed from a residual saprolite material that did not require the addition of temper.

In addition to diabase fragments, samples JMH031, JMH046, and JMH047 also have a small amount of monocrystalline quartz mineral fragments and polygranular quartz rock fragments (Figure 6.4). The presence of these different types of quartz fragments may reflect a mixing of sedimentary materials during fluvial transportation, a suggestion reinforced by the observation that the diabase fragments in JMH046 and JMH047 show signs of alteration. The polygranular quartz rock fragments in JMH031 are different in texture, appearance, and shape than the ones found in JMH046 and JMH047.

Triassic- to Jurassic-age diabase dikes have been mapped (mainly by aeromagnetic surveys) in the Piedmont of North Carolina (North Carolina Geological Survey 1985). Surface exposures of diabase can be found in the eastern Piedmont (see Chapter 2 and Figure 2.4). For comparison with the Group I sherds, diabase samples were acquired from Albemarle, where there is good outcrop exposure. The rock fragments in the Group I sherds are identical to those from

Table 6.2. Petrographic Group Assignments for Ceramic Samples.

Group: Sample ID	Site	Drainage	Region	Type
Group I:				
JMH006	31Hk123	Lower Little	Sandhills	Yadkin Fabric Impressed
JMH031	Doerschuk	Yadkin	Piedmont	Yadkin Fabric Impressed
JMH046	Haw River	Haw	Piedmont	Yadkin Plain
JMH047	Haw River	Haw	Piedmont	Yadkin eroded
Group IIA:				
JMH032	Doerschuk	Yadkin	Piedmont	Dan River Simple Stamped
JMH033	Doerschuk	Yadkin	Piedmont	Yadkin Fabric Impressed
JMH034	Doerschuk	Yadkin	Piedmont	Jenrette Plain
JMH040	Doerschuk	Yadkin	Piedmont	Yadkin Net Impressed
JMH045	Haw River	Haw	Piedmont	Yadkin Plain
JMH048	Haw River	Haw	Piedmont	Yadkin Plain
Group IIB:				
JMH014	31Mr253	Drowning Creek	Sandhills	Yadkin Fabric Impressed
JMH015	31Mr241	Drowning Creek	Sandhills	Sand-tempered Plain
JMH035	Doerschuk	Yadkin	Piedmont	New River Cord Marked
JMH036	Doerschuk	Yadkin	Piedmont	New River Net Impressed
JMH037	Doerschuk	Yadkin	Piedmont	Yadkin Check Stamped
JMH038	Doerschuk	Yadkin	Piedmont	Yadkin Cord Marked
JMH039	Doerschuk	Yadkin	Piedmont	Dan River Net Impressed
JMH041	Haw River	Haw	Piedmont	Yadkin Paddle-edge Stamped
JMH042	Haw River	Haw	Piedmont	Yadkin Cord Marked
JMH043	Haw River	Haw	Piedmont	Yadkin Plain
JMH044	Haw River	Haw	Piedmont	Cape Fear Fabric Impressed
JMH049	Haw River	Haw	Piedmont	Yadkin Plain
JMH050	Haw River	Haw	Piedmont	Yadkin eroded
JMH067	Waccamaw	Waccamaw	Coastal Plain	Cape Fear Fabric Impressed
Group IIIA:				
JMH001	31Hk868	Lower Little	Sandhills	Hanover II Fabric Impressed
JMH002	31Ht392	Lower Little	Sandhills	Hanover II Fabric Impressed
JMH003	31Ht273	Lower Little	Sandhills	Cape Fear III Fabric Impressed
JMH004	31Hk127	Lower Little	Sandhills	Hanover II Fabric Impressed
JMH005	31Hk59	Lower Little	Sandhills	Hanover I Cord Marked
JMH007	31Cd750	Lower Little	Sandhills	Hanover I Paddle-edge Stamped
JMH008	31Ht269	Lower Little	Sandhills	Mt. Pleasant Cord Marked
JMH009	31Cd486	Lower Little	Sandhills	Cape Fear Cord Marked
JMH010	31Hk715	Lower Little	Sandhills	Hanover Fabric Impressed
JMH011	31Mr241	Drowning Creek	Sandhills	Hanover I Cord Marked
JMH012	31Mr259	Drowning Creek	Sandhills	Hanover II Fabric Impressed
JMH013	31Mr241	Drowning Creek	Sandhills	Deptford Linear Check Stamped
JMH016	31Sc71	Drowning Creek	Sandhills	New River Paddle-edge Stamped
JMH019	31Mr93	Lower Little	Sandhills	Hanover II Cord Marked
JMH020	31Mr241	Drowning Creek	Sandhills	New River Cord Marked
JMH021	Breece	Cape Fear	Coastal Plain	Hanover II Paddle-edge Stamped
JMH023	Breece	Cape Fear	Coastal Plain	Hanover II Fabric Impressed

Table 6.2. Petrographic Group Assignments for Ceramic Samples (continued).

Group: Sample ID	Site	Drainage	Region	Type
JMH024	Breece	Cape Fear	Coastal Plain	Hanover II Fabric Impressed
JMH025	Breece	Cape Fear	Coastal Plain	Cape Fear Cord Marked
JMH026	Breece	Cape Fear	Coastal Plain	Hanover II Fabric Impressed
JMH027	Breece	Cape Fear	Coastal Plain	Hanover I Fabric Impressed
JMH028	Breece	Cape Fear	Coastal Plain	Hanover I Fabric Impressed
JMH029	Breece	Cape Fear	Coastal Plain	Hanover I Fabric Impressed
JMH030	Breece	Cape Fear	Coastal Plain	Hanover II Fabric Impressed
JMH053	Kolb	Pee Dee	Coastal Plain	Yadkin Cord Marked
JMH054	Kolb	Pee Dee	Coastal Plain	New River Cord Marked
JMH056	Kolb	Pee Dee	Coastal Plain	New River Fabric Impressed
JMH058	Kolb	Pee Dee	Coastal Plain	Cape Fear Fabric Impressed
JMH059	Kolb	Pee Dee	Coastal Plain	Cape Fear Fabric Impressed
JMH060	Kolb	Pee Dee	Coastal Plain	Hanover I Fabric Impressed
JMH061	Waccamaw	Waccamaw	Coastal Plain	Thoms Creek Punctate
JMH063	Waccamaw	Waccamaw	Coastal Plain	Hanover II Fabric Impressed
JMH065	Waccamaw	Waccamaw	Coastal Plain	Hanover I Fabric Impressed
Group IIIB:				
JMH017	31Mr93	Lower Little	Sandhills	New River Cord Marked
JMH018	31Sc87	Drowning Creek	Sandhills	Deptford Check Stamped
JMH022	Breece	Cape Fear	Coastal Plain	New River Fabric Impressed
JMH055	Kolb	Pee Dee	Coastal Plain	Yadkin Cord Marked
JMH057	Kolb	Pee Dee	Coastal Plain	New River Cord Marked
JMH062	Waccamaw	Waccamaw	Coastal Plain	Cape Fear Fabric Impressed
JMH064	Waccamaw	Waccamaw	Coastal Plain	Hanover II Fabric Impressed
JMH066	Waccamaw	Waccamaw	Coastal Plain	Cape Fear Fabric Impressed
JMH069	Waccamaw	Waccamaw	Coastal Plain	Cape Fear Fabric Impressed
JMH070	Waccamaw	Waccamaw	Coastal Plain	Cape Fear Fabric Impressed
Unassigned:				
JMH051	Kolb	Pee Dee	Coastal Plain	Yadkin Fabric Impressed
JMH052	Kolb	Pee Dee	Coastal Plain	Hanover Fabric Impressed
JMH068	Waccamaw	Waccamaw	Coastal Plain	Hanover eroded

Albemarle. It is thus hypothesized that the materials from which Group I samples were made came from areas of the Piedmont where diabase dikes are exposed and weathered. The Doerschuk site from which sample JMH031 was recovered is in the vicinity of the Albemarle outcrops, and the Haw River site from which samples JMH046 and JMH047 were acquired is less than 8 km away from diabase exposures in the Deep River Basin. The different appearances of the quartz rock fragments in the Doerschuk and Haw River samples are consistent with two different source locations.

Significantly, the site on Fort Bragg from which JMH006 was acquired is approximately 30 km from the nearest diabase dike, but the unaltered condition of the rock and mineral fragments in this sample suggests that they did not experience long-term chemical weathering or extensive

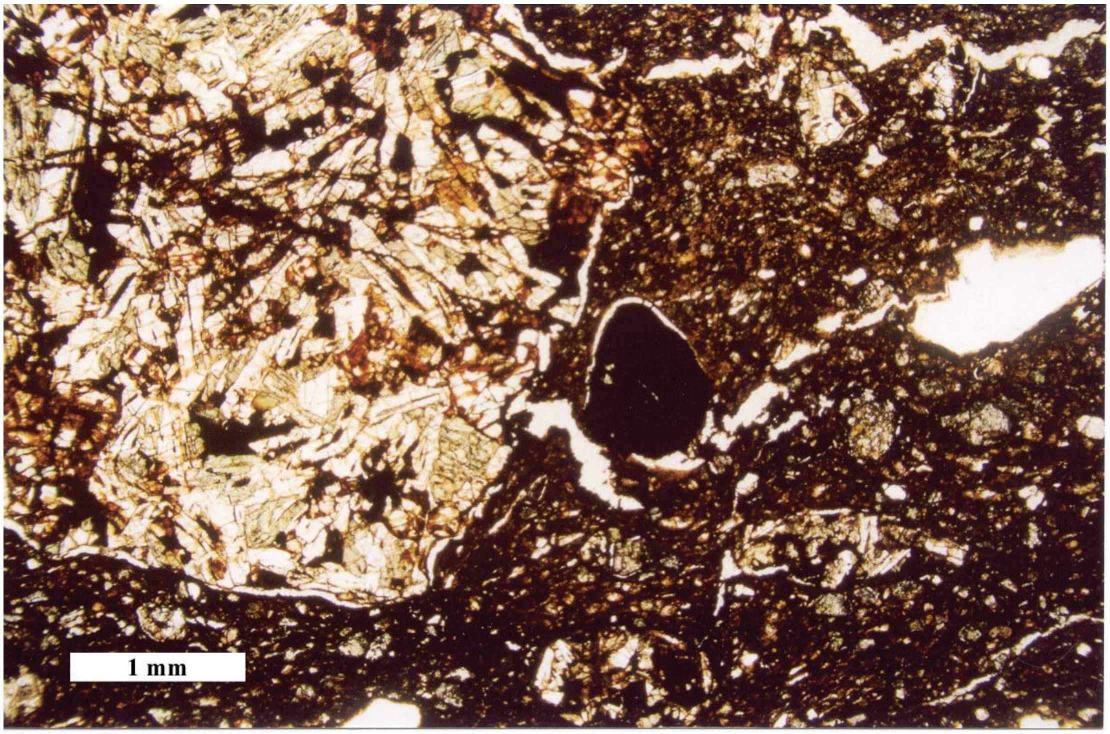


Figure 6.3. Diabase rock fragment (left) in pottery sample JMH006 (plane-polarized light). Also note the rounded grog fragment (center) with partial separation void and pyroxene and plagioclase mineral fragments.

fluvial transportation. It is therefore likely that JMH006 was manufactured some distance from the site where it was recovered.

Group II

Group II is defined by the presence of quartz + feldspar igneous rock fragments. It is divided into two subgroups based on variation in mafic mineral components (i.e., amphibole and biotite). Sherds in Group IIA contain cohesive quartz + feldspar + mafic rock fragments. Group IIB samples contain quartz + feldspar rock fragments and *individual* mafic mineral fragments, but the quartz + feldspar rock fragments do not have visible mafic components.

Group IIA. Group IIA includes six samples from the Yadkin and Haw drainages (Table 6.2). These sherds contain coarse to very coarse mineral fragments. Five of them have a consistent dark coloration, while JMH040 has a distinct black core and red outer oxidation region.

In thin section the rock fragments are of two types. One is a subangular to subrounded, polygranular quartz with sutured grain boundaries (Figure 6.5). The other rock fragment type is quartz + feldspar + mafic igneous rock (Figure 6.6).

Group IIA samples also contain coarse- to medium-grained biotite and amphibole mineral fragments that are probably derived from the quartz + feldspar + mafic rock material. Feldspar mineral fragments could also be derived from the rock fragments because both show extensive alteration to sericite and argillite (Figures 6.6–6.7).

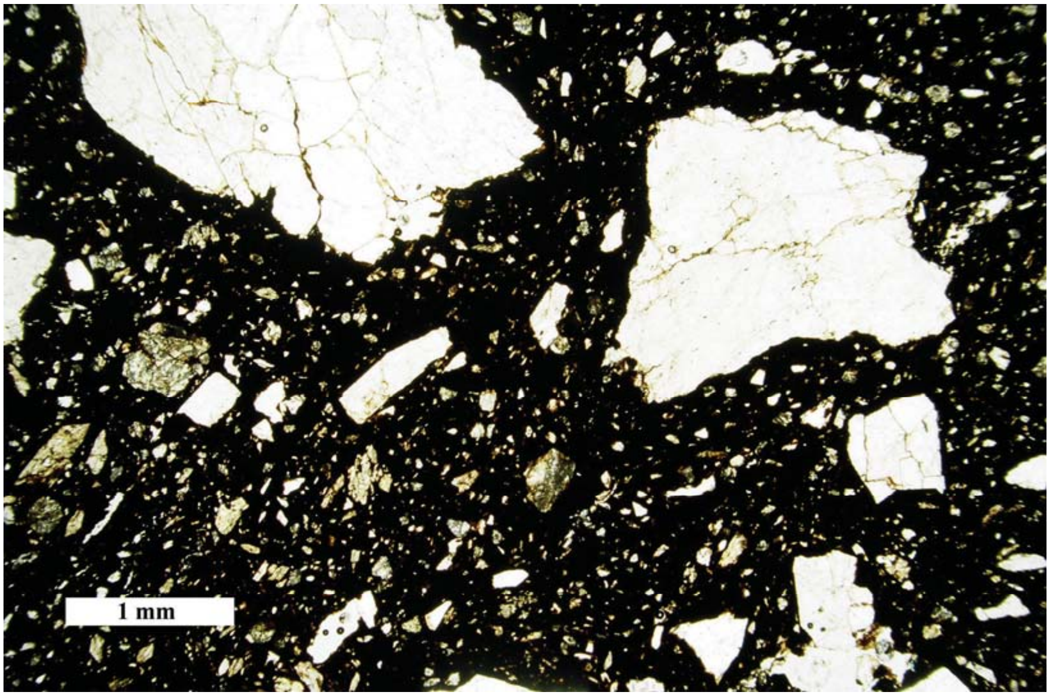


Figure 6.4. Coarse to very coarse (0.5–2.0 mm), blocky to subangular quartz mineral and rock fragments in sample JMH046 (cross-polarized light). The surrounding clay material is dominated by mafic minerals (clinopyroxene or amphibole) and also includes feldspar and quartz.

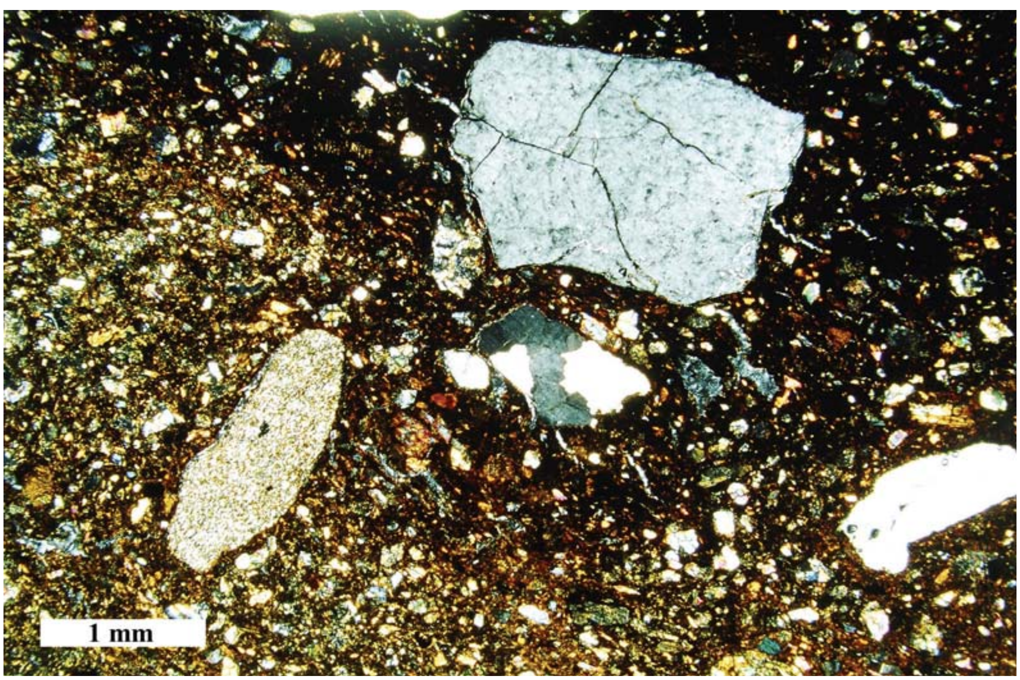


Figure 6.5. A polygranular quartz rock fragment with sutured grain boundaries (center) in sample JMH034 (cross-polarized light). Also note the very coarse, angular quartz mineral fragment (top) and the elongate, rounded sedimentary rock fragment (left of center). The paste is nearly isotropic, with fine-grained quartz, biotite, and feldspar minerals.

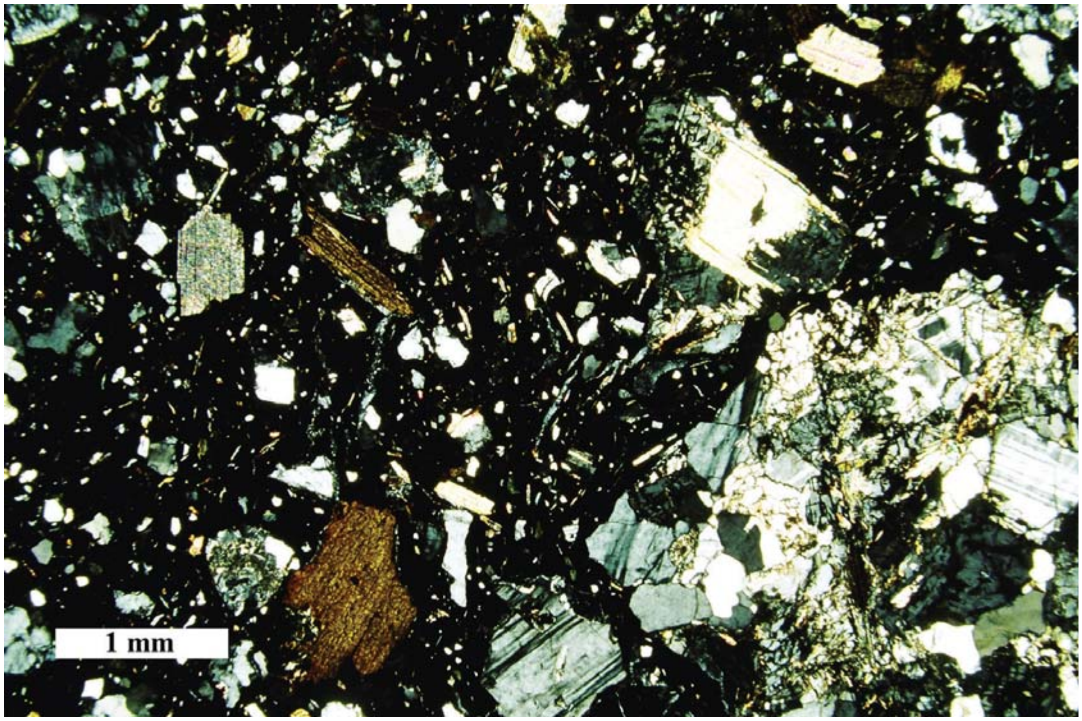


Figure 6.6. Polygranular quartz + K-feldspar (microcline) + mafic igneous rock fragments (right of center) in sample JMH033 (cross-polarized light). The feldspar displays fine-grained sericite alteration. Other aplastic inclusions include blocky, golden brown biotite crystals (left of center) and blocky microcline (twinned; bottom center).

Sample JMH034 contains what appear to be sedimentary or metasedimentary rock fragments (Figure 6.5). These fragments are subrounded to elongate (with rounded edges) and contain fine to very fine, subrounded to subangular grains of quartz and possibly feldspar. The fragments in Yadkin sample JMH034 are very similar to rock fragments from the Tillery Formation in the Piedmont. The Tillery Formation crops out along the Uwharrie River and is a thinly-laminated siltstone and claystone with horizons of metamorphic schist and phyllite. There are a number of sedimentary and metasedimentary units that could also be similar to the fragments in JMH034, however, so this is not a definitive comparison.

Finally, the four sherds from the Yadkin drainage (JMH032–JMH034, JMH040) include carbonized plant matter that appears to be wood charcoal (Figure 6.8).

Group IIB. Fourteen samples comprise Group IIB (Table 6.2). Most of the sherds are from the Doerschuk and Haw River sites. Eight are classified as Yadkin series, which by definition indicates that they are tempered with angular rock fragments.

The majority of the sherds in Group IIB are generally red-brown, and some exhibit a thin oxidation zone at the sherd edge. Four of the Group IIB sherds are very dark and resemble Group IIA sherds (JMH037–JMH038, JMH049–JMH050). Three of the samples were cut thinner than the standard 30 μm, and their color appears reddish tan to tan-yellow due to higher light transmission (JMH039, JMH041, JMH044).

The major aplastic components in Group IIB sherds are quartz + feldspar rock fragments (without mafic mineral components); polygranular quartz rock fragments; and mica, amphibole,

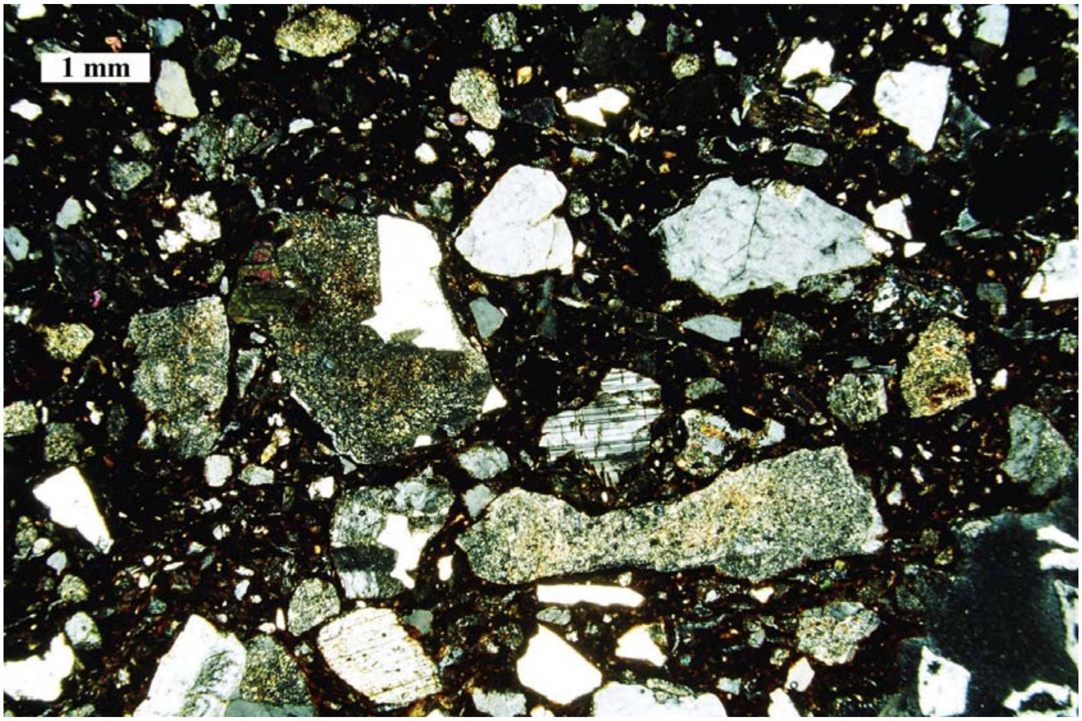


Figure 6.7. Highly-altered quartz + feldspar rock fragments (left of center) and feldspar mineral fragments (bottom center) in sample JMH048 (cross-polarized light). The feldspar in the rock and mineral fragments displays fine-grained sericite alteration. Also note the unaltered blocky plagioclase fragment (polysynthetic twinning; center).

and opaque mineral fragments. The percentage of rock and mineral fragments varies from about 15 to 30% of the paste material. Samples exhibit a range of muscovite and biotite mica content from none visible to 16%, with most samples falling in the 1–3% range.

The feldspar in the quartz + feldspar rock fragments is usually K-feldspar (microcline), but some specimens have both K-feldspar and plagioclase. The feldspar is often heavily altered, indicated by the presence of sericite, argillite, or epidote alteration minerals. In addition, many of the feldspar fragments show graphic texture. This texture occurs when granitic magma bodies cool slowly and quartz exsolves, forming tiny blebs. The presence of graphic texture and abundance of K-feldspar suggests that the rock fragments are derived from an intermediate to felsic plutonic source.

Although the quartz + feldspar rock fragments lack mafic mineral components, the presence of individual mafic mineral grains in the paste and the alteration of the feldspars suggest that the raw materials used for Group IIB and Group IIA sherds may be related. Such a scenario might result if distinct levels of the weathering profile (i.e., soil and saprolite) of an intermediate-igneous source rock (quartz + feldspar + mafic) were differentially exposed, eroded, and transported to produce clay source areas with slightly different characteristics.

Samples JMH039, JMH043, and JMH067 do not contain quartz + feldspar rock fragments but are nevertheless assigned to Group IIB based on the presence of mafic mineral fragments.

Re-examination of thin sections from the Herbert et al. (2002) prior study of pottery from Fort Bragg sites confirmed that the three Yadkin Net Impressed samples in that study (Samples 13, 16, and 17) would be included in Group IIB.

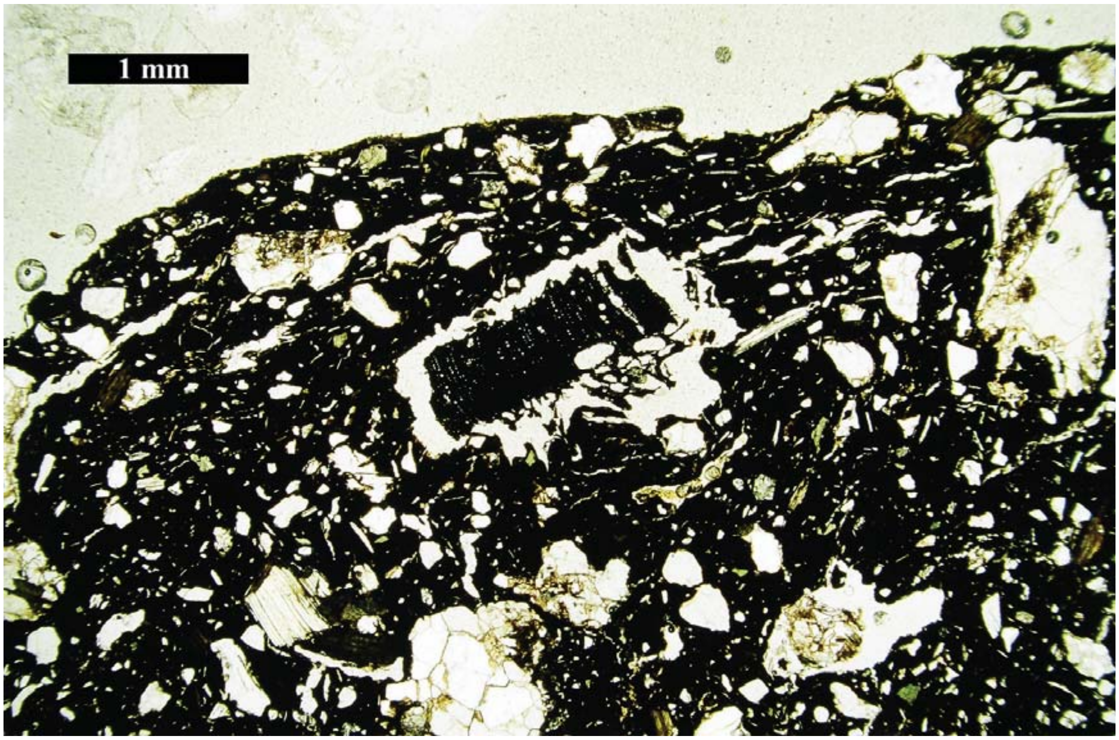


Figure 6.8. Carbonized plant fragment with separation void (center) in sample JMH034 (plane-polarized light).

Group III

The majority of Sandhills and Coastal Plain samples are assigned to Group III (Table 6.2). Sherds in this group are generally red-brown, although a few samples with sections cut thinner than 30 μm are light reddish brown to reddish brown. All of the Group III samples contain polygranular quartz rock fragments and/or a mineral association of monocrystalline quartz minerals and muscovite mica laths. The polygranular quartz rock fragments are probably derived from metamorphic rock.

Muscovite is generally found in two size distributions. In the medium- to coarse-grained size, its abundance ranges from 2–3%. In the very fine- to fine-grained size, its abundance reaches about 10%. In samples that do not have any of the medium- to coarse-grained laths (e.g., JMH007), muscovite is found in the very fine- to fine-grained fractions at an abundance of approximately 2–3%.

All mica in the very fine fraction was classified as muscovite, but effects related to firing and iron staining made it nearly impossible to obtain enough optical information to definitely state that there was no biotite. Medium- to coarse-grained biotite is present in a few samples, and it is highly possible that some of the very fine-grained mica identified as muscovite may be biotite.

Many of the Group-III specimens contain tourmaline, zircon, and/or rutile. These minerals are considered to be diagnostic constituents of soils derived from Coastal Plain sediments (Windom et al. 1971). Seven sherds in Group III also have possible sedimentary or metasedimentary rock fragments (JMH024–JMH025, JMH027, JMH029–JMH030, JMH058, and JMH064; Figure 6.9).

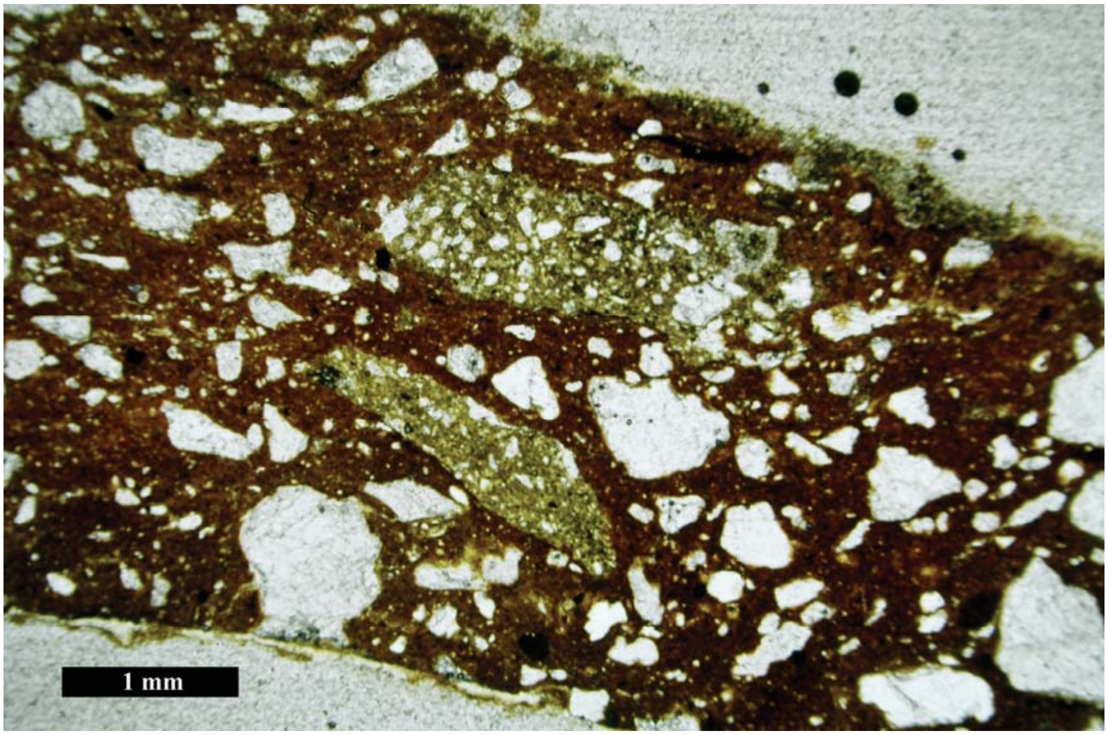


Figure 6.9. Sedimentary or metasedimentary rock fragments (center; note the finer-grained mineral inclusions) in sample JMH058 (plane-polarized light). The other aplastic fragments include coarse quartz rock fragments and medium- and fine-grained quartz and feldspar minerals.

Group III is further subdivided into two subgroups based upon the presence of argillaceous clay clots. Thirty-three samples with argillaceous clay clots make up Group IIIA, and 10 samples lacking such clots are classified as Group IIIB (Table 6.2).

Under plane-polarized light, the argillaceous clay clots appear as angular, subangular, and subrounded fragments ranging from a light yellowish-green tan to a more yellow brown with a little rust red color (Figure 6.2). They contain medium- and coarse-grained quartz, blocky feldspar, and variable amounts of mica laths embedded in a very fine-grained mass of clay, quartz, and mica. Under cross-polarized light, the interference color is dominated by quartz and feldspar inclusions (first-order gray Michel-Levy).

Unassigned

Three samples are not assigned to any of the petrographic groups described above (Table 6.2). Samples JMH051, JMH052 and JMH068 appear to have experienced partial vitrification during firing. These sherds have textures of melted rock glass, and their optical characteristics are nearly isotropic. Sample JMH051 is dominated by paste with only a few medium- to coarse-grained aplastic mineral fragments. Sample JMH052 contains quartz grains and a couple of grog fragments with fine-grained mineral inclusions. Samples JMH051 and JMH052 are too vitrified to allow point counting but probably contain quartz and clay minerals, suggesting they may be similar to Group III samples. Sample JMH068 has a very ‘swirly’ appearance, probably reflecting poorly mixed paste, and vitrification appears to have been in the clay-mineral-rich portions of the sherd.

Results: Clay Samples

The 53 clay test tiles examined in this study represent 42 untempered clay samples and 11 tempered samples. The mineralogical characteristics of the untempered samples are discussed here, and the tempered samples are treated in a subsequent section.

The following descriptions summarize the general aplastic characteristics of the clay samples by drainage and attempt to classify them according to the scheme developed for the pottery samples. In most cases it is not possible to assign clay samples to a specific petrographic subgroup as was done for the prehistoric ceramics, but most samples can be assigned to a general group (i.e., II or III). The results reveal that general regional distinctions can be seen based on differences in proportion and type of natural rock and mineral constituents.

Sandhills Samples

Twelve clay samples from the Sandhills were submitted for petrographic analysis. Seven can be tentatively assigned to Group III, one is tentatively assigned to Group IIB, and the other four could not be attributed to a defined petrographic group (Table 6.3).

Lower Little River Samples. Eleven clay test tiles representing the Lower Little drainage were fashioned into thin sections for petrographic analysis. The thin section for sample FBR002, however, exhibited so much void space that it was excluded from the study. The other ten samples exhibit considerable variability, but many can be loosely grouped into sets.

Samples FBR003–FBR005 and FBR010 were collected within 6 km of each other and are petrographically similar. Samples FBR004, FBR005, and FBR010 represent the Cretaceous-age Cape Fear Formation. Sample FBR010 is dominated by quartz mineral and quartz rock fragments (Figure 6.10). It contains very little mica and more aplastic mineral fragments than clay minerals. Sample FBR004 resembles FBR010 but has larger aplastic fragments and plagioclase feldspar. Interestingly, sample FBR005 was collected from the same location as FBR010 but appears more similar to FBR004. It contains quartz and feldspar minerals and quartz rock fragments with no visible mica (Figure 6.11). In many ways FBR005 is similar to Waccamaw sample FBR067.2 (discussed below), which has 10% sand temper added (Figure 6.12). Sample FBR003 is from a Cretaceous-age Middendorf Formation deposit and contains angular to subangular quartz mineral fragments but no quartz rock fragments. These four samples are tentatively assigned to Group III.

Samples FBR007–FBR009 form a second set of petrographically similar samples that can also tentatively be classified as Group III. Samples FBR008 and FBR009 are derived from Middendorf Formation deposits on the slopes of a broad upland terrace. Sample FBR009 is dominated by quartz and mica (mostly muscovite) mineral fragments and contains a very coarse quartz + feldspar rock fragment (Figure 6.13; cf. quartz-dominated Sample FBR010 in Figure 6.10). Sample FBR008 resembles FBR009 but includes more coarse rock fragments. Both samples fired to a brownish green color. Sample FBR007 is an alluvial sample that was collected almost 12 km from sample FBR008, but its alluvial sediments are likely derived from the same upland terrace. It also resembles sample FBR009 but contains more mica and fired to a reddish brown color.

The test tiles for Sandhills samples FBR059 and FBR067 were fired at 950°C. These two samples appear to be partially vitrified, which posed problems for analysis and precluded them

Table 6.3. Selected Petrographic Characteristics of Clay Samples.[a]

Region/Drainage: Sample ID	Mineral Grains					Rock Fragments				Other		Tentative Group Assignment
	Mafic[b]	Feldspar[c]	Mica[d]	Quartz	Opaque	Quartz	Quartz + Feldspar	Feldspar	Sedimentary	Argillaceous Clay Clots	Hematite-stained Clay Clots	
Sandhills/Lower Little:												
FBR003	-	-	-	x	-	-	-	-	-	-	-	III
FBR004	-	x (Pl)	-	xx	-	x	-	-	-	-	-	III
FBR005	-	x	-	x	-	x	-	-	-	-	-	III
FBR007	-	-	xx (Ms)	xx	-	-	x	-	-	-	-	III
FBR008	-	-	xx (Ms)	xx	-	-	x	-	-	-	-	III
FBR009	-	-	xx (Ms)	xx	-	-	x	-	-	-	-	III
FBR010	-	-	tr	xx	-	x	-	-	-	-	-	III
FBR017	-	x	-	xx	x	x	-	-	-	x	x	IIB
FBR059	-	-	-	xx	-	x	-	-	-	-	-	-
FBR067	-	x	-	x	-	-	-	-	-	-	-	-
Sandhills/Drowning Creek:												
FBR006	-	-	-	x	-	-	-	-	-	-	x	-
Coastal Plain/Cape Fear:												
FBR011	tr (Am)	x (Kfs)	x (Ms, Bt)	x	x	x	x	-	-	-	x	III
FBR012	-	x	x (Bt)	x	-	x	-	-	-	-	-	III
FBR013	-	x (Kfs)	-	xx	x	x	x	-	-	-	x	III
FBR014	-	-	x (Bt)	x	-	-	-	-	-	-	x	III
FBR016	-	x	x (Bt)	x	-	x	-	-	-	-	xx	III
Coastal Plain/Pee Dee:												
FBR019	-	-	xx (Ms)	xx	-	-	-	-	-	-	-	III
FBR020	-	-	xx (Ms)	xx	-	-	-	-	-	-	-	III
FBR021	-	-	xx (Ms)	xx	-	-	-	-	-	-	-	III
FBR023	-	-	xx (Ms)	xx	-	-	x	-	-	-	x	III
FBR027	-	-	xx (Ms)	x	-	-	-	-	-	-	x	III
Coastal Plain/Waccamaw:												
FBR081	-	x	-	xx	-	-	-	-	-	-	-	III
FBR082	-	x	-	xx	-	-	-	-	-	-	x	III
FBR083	x	x	-	xx	-	-	-	-	-	-	-	III
FBR084	-	x	-	xx	-	-	-	-	-	-	x	III
FBR085	-	x	-	xx	-	-	-	-	-	-	x	III

Table 6.3. Selected Petrographic Characteristics of Clay Samples (continued).[a]

Region/Drainage:	Mineral Grains					Rock Fragments				Other		Tentative
Sample ID	Mafic[b]	Feldspar[c]	Mica[d]	Quartz	Opaque	Quartz	Quartz + Feldspar	Feldspar	Sedimentary	Argillaceous Clay Clots	Hematite-stained Clay Clots	Group Assignment
Piedmont/Haw:												
FBR029	-	-	-		-	x	x	-	x (sandstone)	-	x	II
FBR030	-	-	-		-	x	-	-	x (sandstone)	-	-	II
FBR035	-	-	-		-	x	x	-	-	-	-	II
FBR040	-	-	-		-	x	x	-	-	-	-	II
FBR041	-	x (Pl)	-	xx	x	x	x	-	x (siltstone or sandstone)	x	-	II
Piedmont/Yadkin:												
FBR048	x	x	x	x	x	x	x	-	-	-	x	IIB
FBR049	xx	xx	-	xx	xx	x	x	x	-	-	xx	IIB
FBR051	-	-	x (Bt)	x	x	x	x	-	-	-	-	IIB
FBR054	-	x	-	x	-	x	-	-	-	-	x	III
FBR055	-	x	-	x	-	x	x	-	-	-	x	III
Piedmont/Deep:												
FBR058	x (Am)	-	-	x	-	-	x	-	-	-	x	IIB
FBR071	-	-	-	xx	-	-	-	-	-	-	x	IIB
FBR074	-	-	-	xx	-	-	x	-	x (sandstone)	-	x	IIB
FBR077	-	-	-	xx	-	-	-	-	x	-	x	IIB
FBR080	-	-	x	x	-	x	x	-	-	-	-	IIB

[a] Key: xx, abundant; x, present; tr, trace.
[b] Key: Am, amphibole.
[c] Key: Kfs, K-feldspar; Pl, plagioclase.
[d] Key: Bt, biotite; Ms, muscovite.

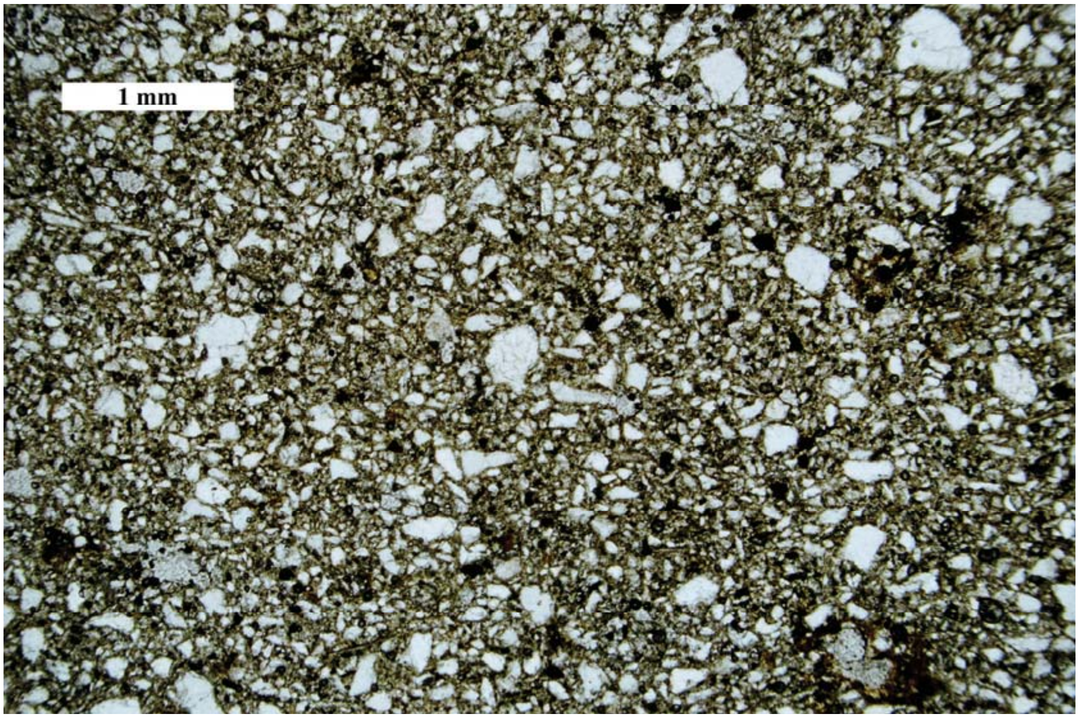


Figure 6.10. Clay sample FBR010 dominated by very fine- and fine-grained, subrounded and subangular quartz (plane-polarized light).

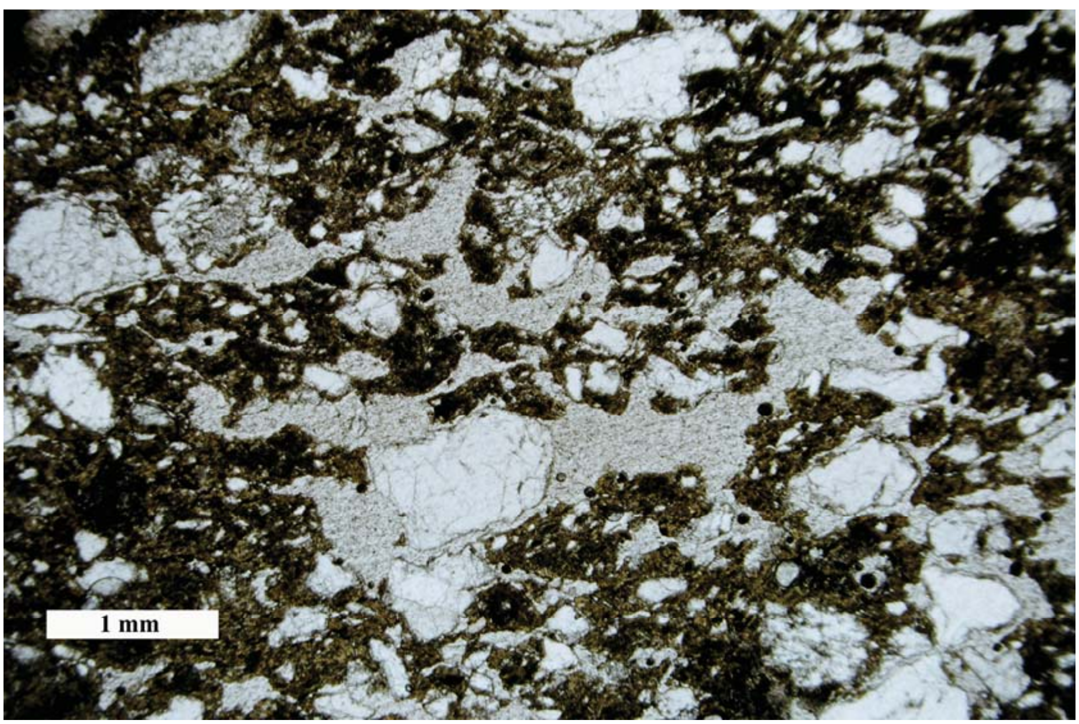


Figure 6.11. Clay sample FBR005 with coarse-grained quartz and feldspar mineral fragments and quartz rock fragments (plane-polarized light). This sample contains many voids and appears to have experienced some melting in the clay-rich portions.

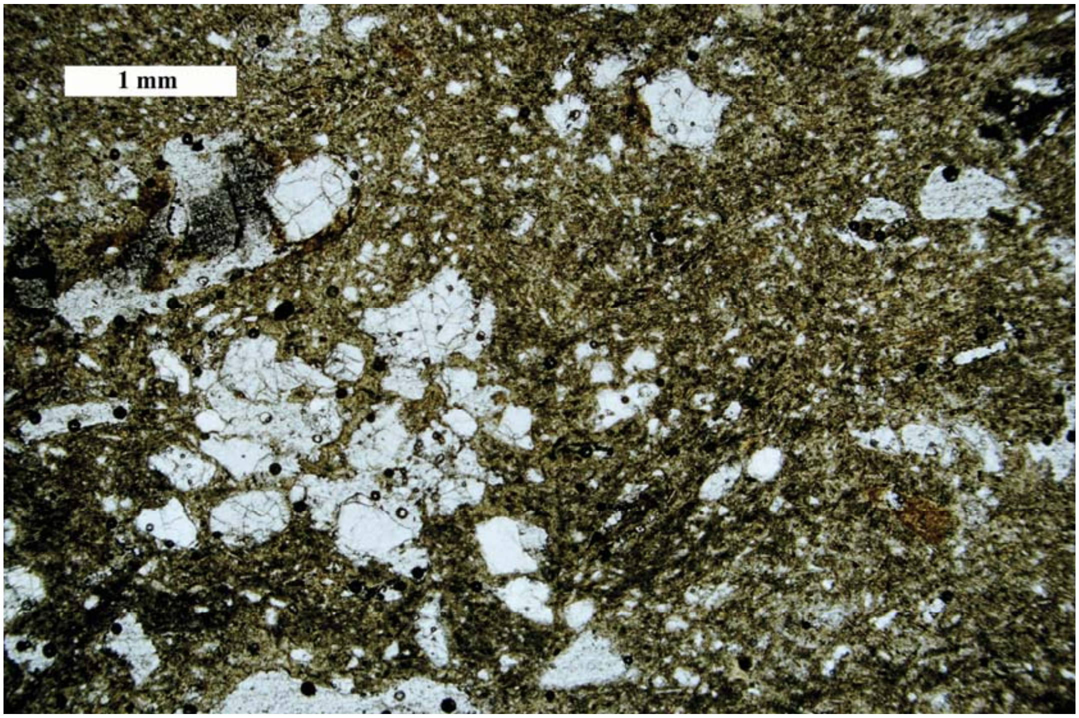


Figure 6.12. Clay sample FBR067 tempered with 10% quartz sand (test tile FBR067.2; plane-polarized light). The added sand temper makes this test tile difficult to distinguish from the untempered test tile for sample FBR005 (Figure 6.11).

from being assigned to a petrographic group. Nevertheless, they form a third set of petrographically similar samples. Sample FBR059 is dominated by quartz mineral and quartz rock fragments (Figure 6.14). Sample FBR067 is dominated by clay and contains quartz and feldspar mineral fragments (Figure 6.15).

Sample FBR017 was collected from a Middendorf Formation deposit in the eastern Sandhills, but it is more similar to Haw River sample FBR041 (discussed below) than to other Sandhills samples. Compared to sample FBR041, however, FBR017 has a greater proportion of quartz, feldspar, and opaque mineral fragments and dark red hematite-stained clay clots (Figure 6.16; cf. Figure 6.17). In addition, FBR017 contains some clasts that may be quartz-rich argillaceous clay clots or possibly sedimentary rock fragments. This petrography places FBR017 in Group IIB.

Drowning Creek. The single sample from the Drowning Creek drainage is dominated by very fine, vitrified clay minerals. Sample FBR006 has only a few hematite-stained clay clots and quartz mineral fragments (Figure 6.18). It is similar to Lower Little River sample FBR067 and can be grouped with samples FBR067 and FBR059. It cannot be assigned to a defined petrographic group.

Coastal Plain Samples

All fifteen clay samples from the Coastal Plain can be tentatively assigned to Group III (Table 6.3). Nevertheless, differences exist both between and within drainages.

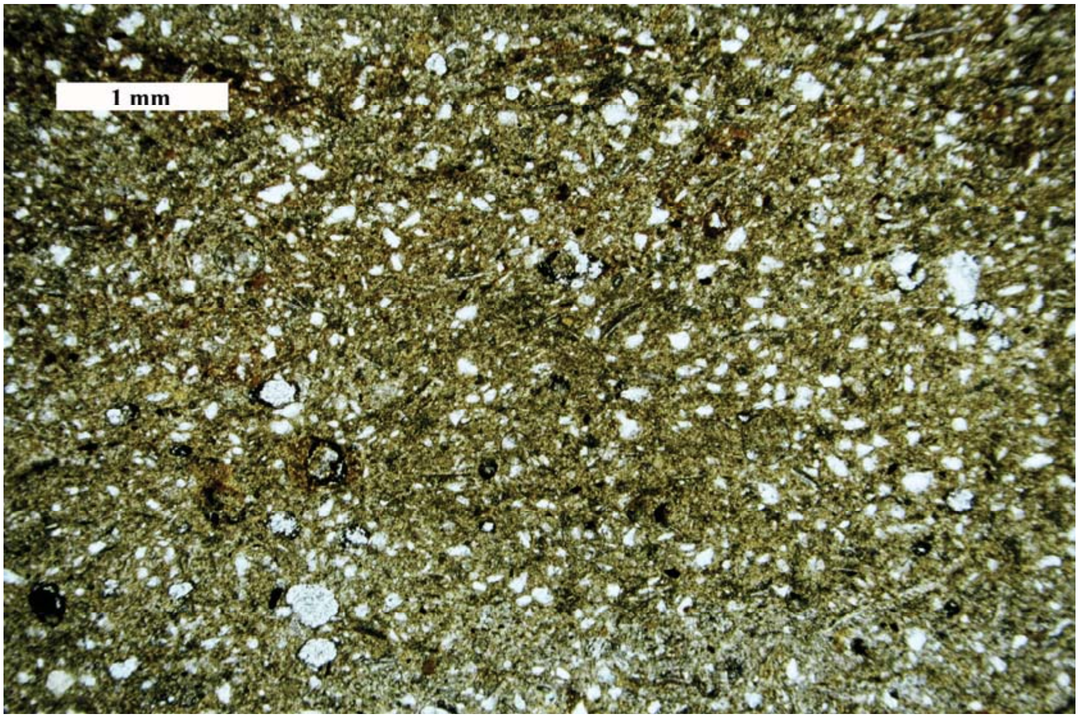


Figure 6.13. Clay sample FBR009 with very fine- and fine-grained quartz and muscovite (plane-polarized light).

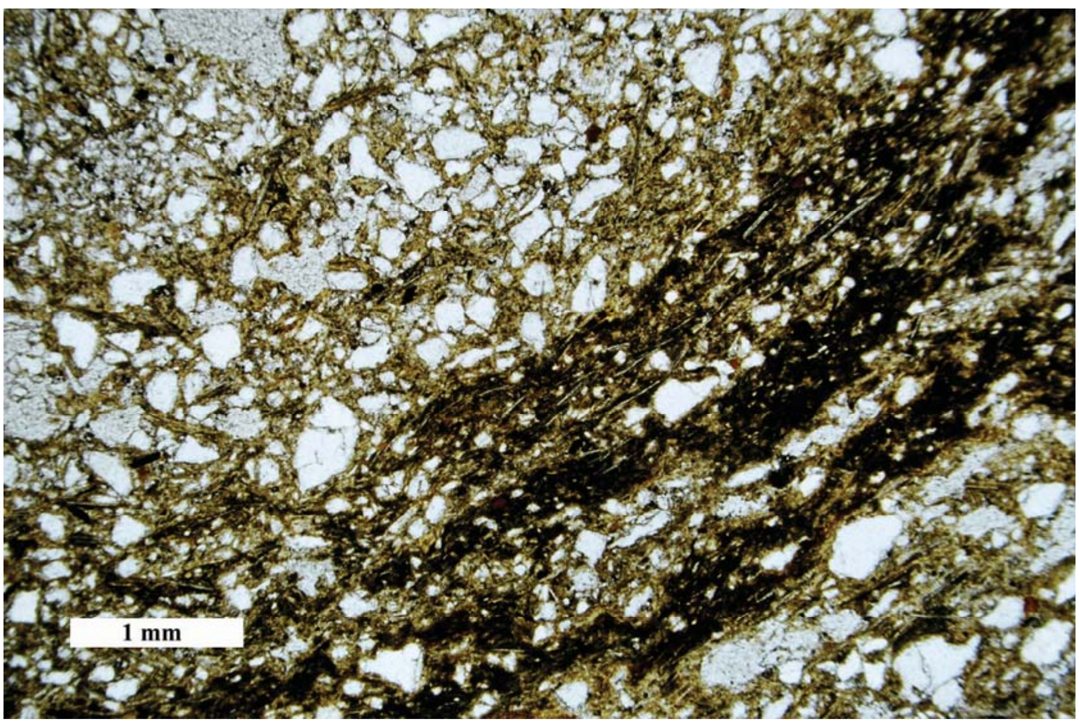


Figure 6.14. Clay sample FBR059 with fine- to coarse-grained, angular to subangular quartz mineral and rock fragments (plane-polarized light). The darker stripes are vitrified clay.

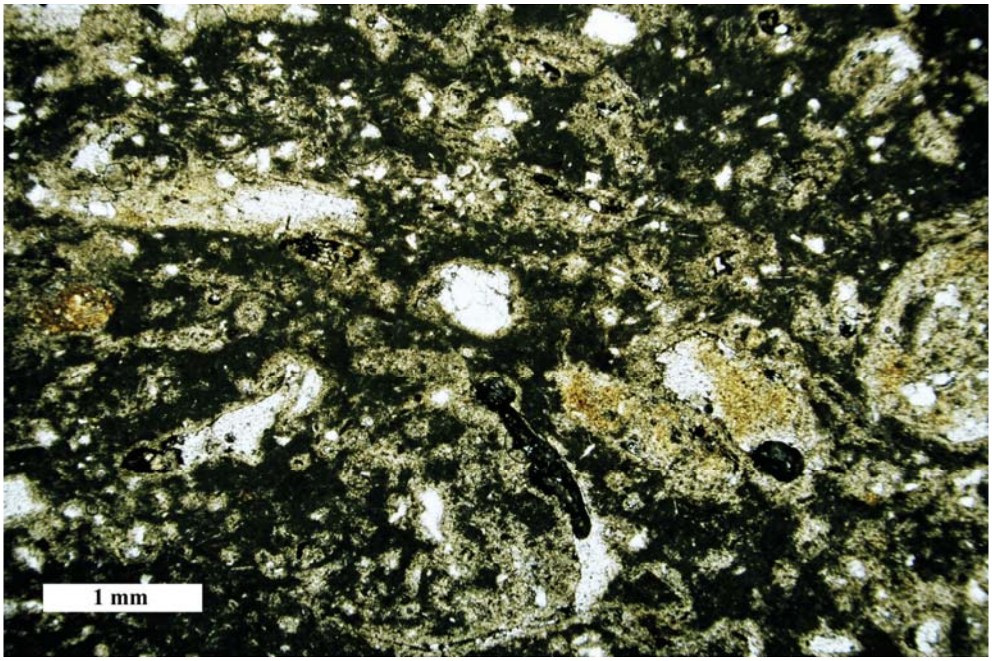


Figure 6.15. Clay sample FBR067 with fine- and medium-grained, blocky to subrounded quartz and feldspar mineral fragments (plane-polarized light). Note partially vitrified (isotropic) paste due to high firing temperature.

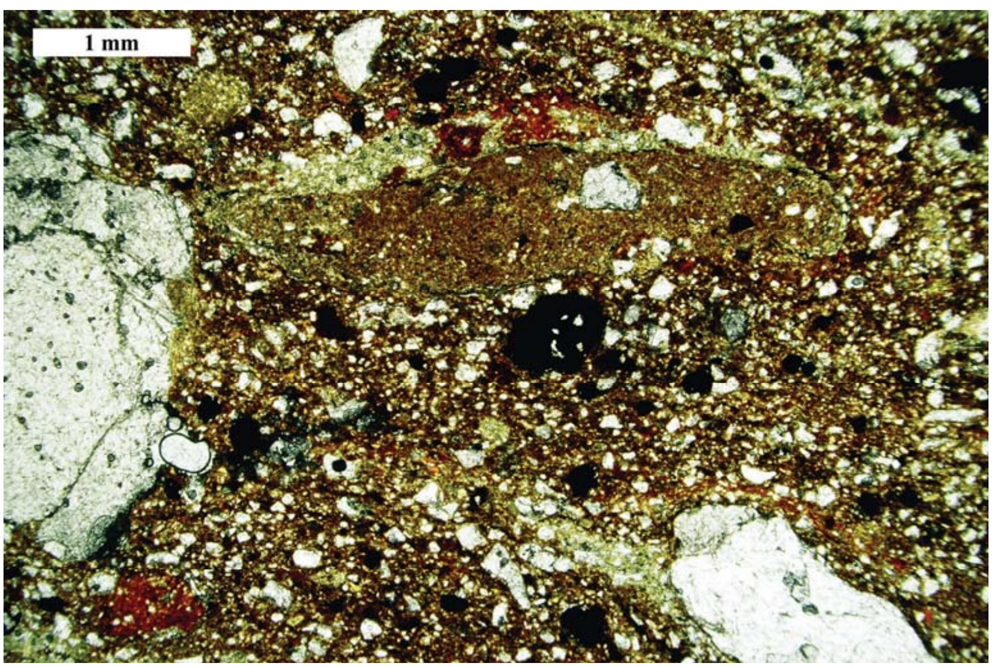


Figure 6.16. Clay sample FBR017 with fine- and medium-grained, subangular and angular quartz (left), feldspar, and opaque mineral fragments; quartz rock fragments (lower right); and dark red hematite-stained clay clots with quartz mineral inclusions (center; plane-polarized light). There are also some quartz mineral-rich argillaceous clay clots (center above large hematite-stained clay clot).

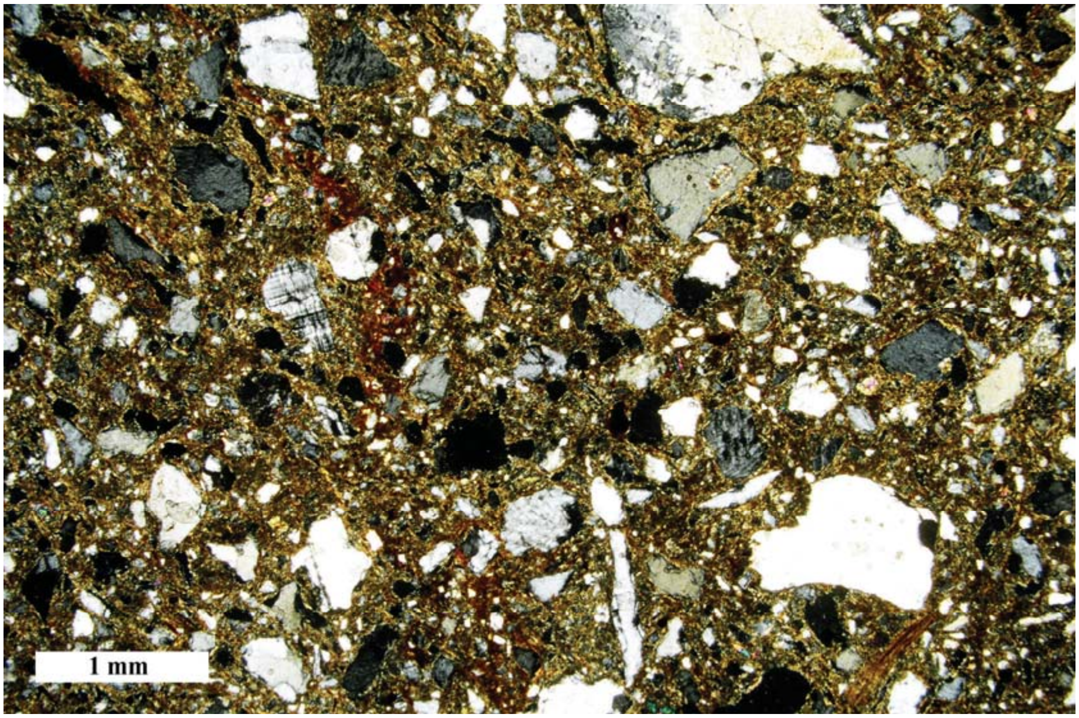


Figure 6.17. Clay sample FBR041 with fine to very coarse fragments of quartz, plagioclase, opaque minerals, an unknown high relief mineral (not very abundant), and sedimentary rock (plane-polarized light). There are also a few reddish brown argillaceous clay clots.

Cape Fear River. The five clay samples from the Cape Fear drainage exhibit variability that may be in part related to their locations within the sedimentary system. These samples represent a quartz-dominated system but vary with respect to particle size, which is a function of sorting.

Sample FBR011 is a stream bank sample with polygranular quartz and quartz + feldspar rock fragments and quartz, K-feldspar (microcline), muscovite, and biotite mineral fragments (Figure 6.19). The mica fragments occur in proportions greater than 1%. Subangular to blocky opaque minerals (approximately 1%) and one fragment of amphibole are also present. Sample FBR011 also contains small (0.2 mm in diameter), rounded, dark red hematite-stained clay clots and black opaque minerals.

Samples FBR012–FBR013 are floodplain samples. FBR012 is characterized by quartz, feldspar, and biotite minerals and quartz rock fragments. The aplastic components, however, are subordinate to the amount of clay. Sample FBR013 has abundant quartz, undifferentiated feldspar, and microcline mineral fragments and polygranular quartz and quartz + feldspar rock fragments. A few opaque minerals and red hematite-stained clay clots were observed.

Sample FBR014 is another stream bank sample with very fine-grained quartz, biotite, and a few visible hematite-stained clay clots. Sample FBR016 is from a tributary streambed and appears to be a cross between FBR014 and FBR012, but it also contains a lot of red hematite-stained clay clots.

Pee Dee River. All five Pee Dee samples include extremely fine- to very fine-grained aplastic material consisting mostly of quartz and muscovite mica. Sample FBR023 also has a few red hematite-stained clay clots and a quartz + feldspar rock fragment, while sample FBR027

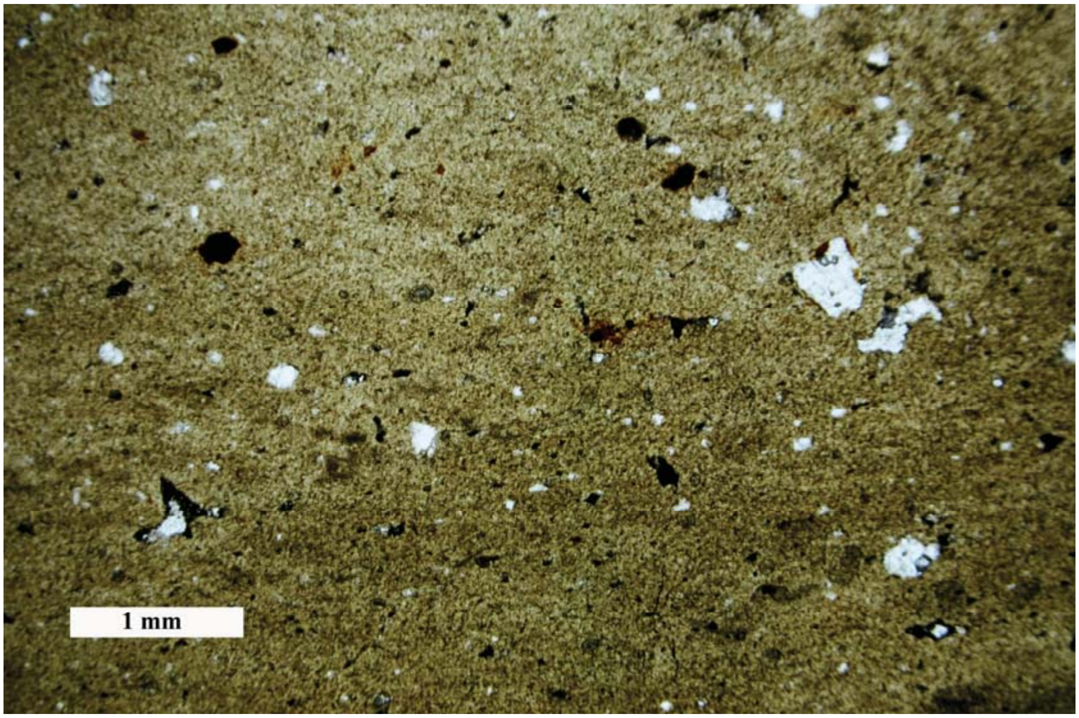


Figure 6.18. Clay sample FBR006 with very fine-grained clay, dark red-black hematite-stained clay clots, and fine- to medium-grained quartz mineral fragments (plane-polarized light).

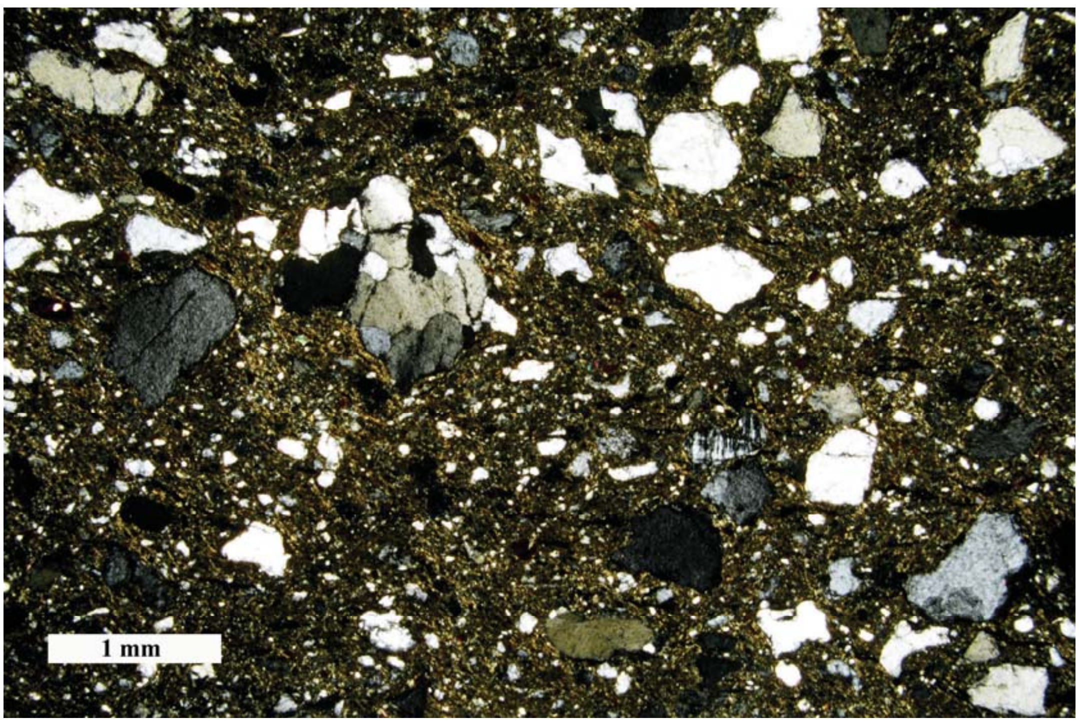


Figure 6.19. Quartz rock fragments (center) and K-feldspar (microcline) in clay sample FBR011 (cross-polarized light).

contains numerous red hematite-stained clay clots and only a few visible quartz mineral fragments (0.1 mm grain size; Figure 6.20).

Waccamaw River. All five Waccamaw clay samples are dominated by quartz minerals (i.e., sample FBR081; Figure 6.21). A few subrounded feldspar mineral fragments were observed with the quartz mineral fragments or, in the case of FBR083, with a single mafic mineral fragment. Samples FBR082, FBR084, and FBR085 also contain red hematite-stained clay clots.

Piedmont Samples

Thirteen of the 15 Piedmont samples can be tentatively assigned to Group II (Table 6.3). Two samples from the Yadkin drainage are classified as Group III.

Haw River. The five clay samples collected in the Haw drainage contain quartz rock fragments and, with the exception of FBR030, quartz + feldspar rock fragments (Figure 6.17). They consequently fall into Group II but exhibit enough variation that they can be categorized into two classes. One class includes three samples characterized by sedimentary rock fragments (FBR029, FBR030, and FBR041), while the other includes two samples lacking sedimentary rock fragments (FBR035 and FBR040).

Yadkin River. The five clay samples collected in the Yadkin drainage are quite variable. Samples FBR048, FBR049, and FBR051 are characterized by quartz rock and quartz + feldspar rock fragments and are thus classified as Group IIB (Figure 6.22). However, these three clay samples have proportionally less quartz + feldspar rock fragments than the majority of Group II pottery samples.

Yadkin samples FBR054 and FBR055 generally lack quartz + feldspar rock fragments, although a few were observed in FBR055 (Figure 6.23). These two samples are clay dominated with fine- and medium-grained quartz and feldspar mineral fragments, quartz rock, and some rounded red hematite-stained clay clots. FBR054 and FBR055 are tentatively classified as Group III. They were collected several kilometers downstream of the Group IIB samples, however, so it is possible that their quartz and feldspar mineral grains are derived from the same quartz + feldspar rock that occurs as fragments in FBR048, FBR049, and FBR051.

Deep River. All five Deep River clay samples can be assigned to Group IIB. Samples FBR058 and FBR080 were collected from the bank of the Deep River at the Carbonton hydroelectric dam. Both are clay rich and contain quartz mineral fragments. Sample FBR058 also contains amphibole and quartz + feldspar rock fragments (Figure 6.24), while sample FBR080 contains quartz rock fragments, a quartz + feldspar rock fragment, and some mica (Figure 6.25). The petrographic variability between these two samples that were collected within only a few meters of each other supports the decision to lump generally similar samples (i.e., Group IIA and IIB samples) rather than split them into distinct groups.

Samples FRB071, FBR074, and FBR077 were collected in upland settings downstream from FBR058 and FBR080. These samples contain abundant very fine quartz minerals and some red hematite-stained clay clots in varying amounts (Sample FBR071; Figure 6.26). FBR074 also contains quartz + feldspar rock fragments and quartz sandstone fragments (Figure 6.27). FBR077 has a few rounded, coarse- to very coarse-grained sedimentary or metasedimentary rock fragments, but they differ from the quartz sandstone found in FBR074.

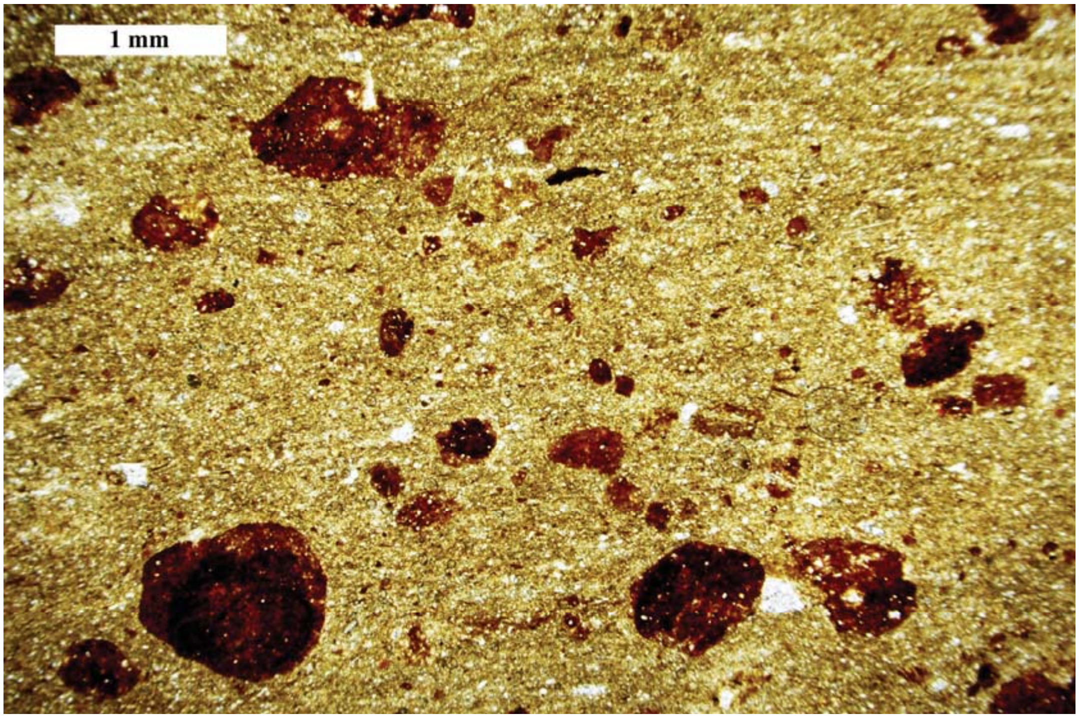


Figure 6.20. Red hematite-stained clay clots in clay sample FBR027 (plane-polarized light).

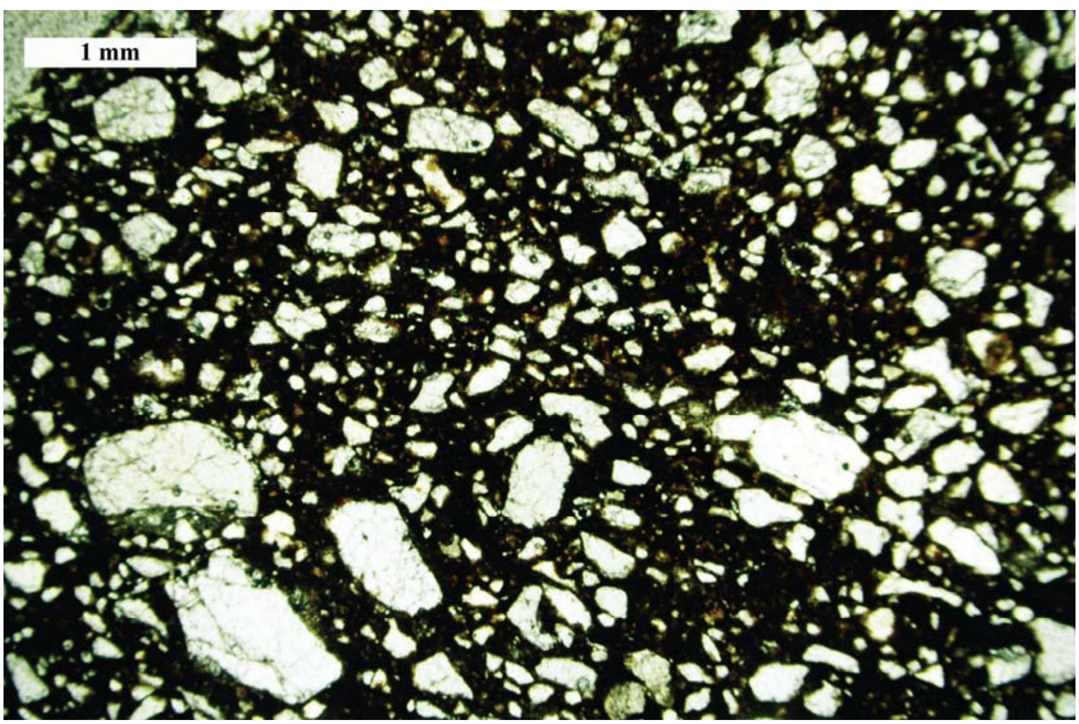


Figure 6.21. Clay sample FBR081 with subrounded to subangular quartz mineral fragments (plane-polarized light).

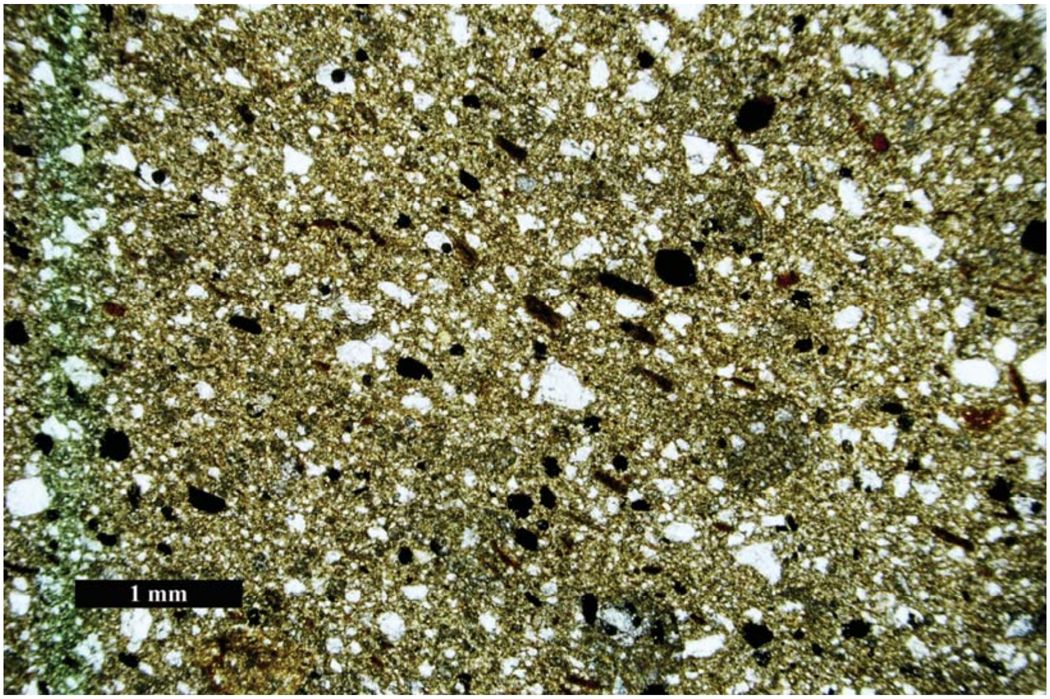


Figure 6.22. Clay sample FBR049 with subangular quartz and opaque mineral fragments and abundant fine- and medium-sized, subrounded and elliptical red hematite-stained clay clots (plane-polarized light).

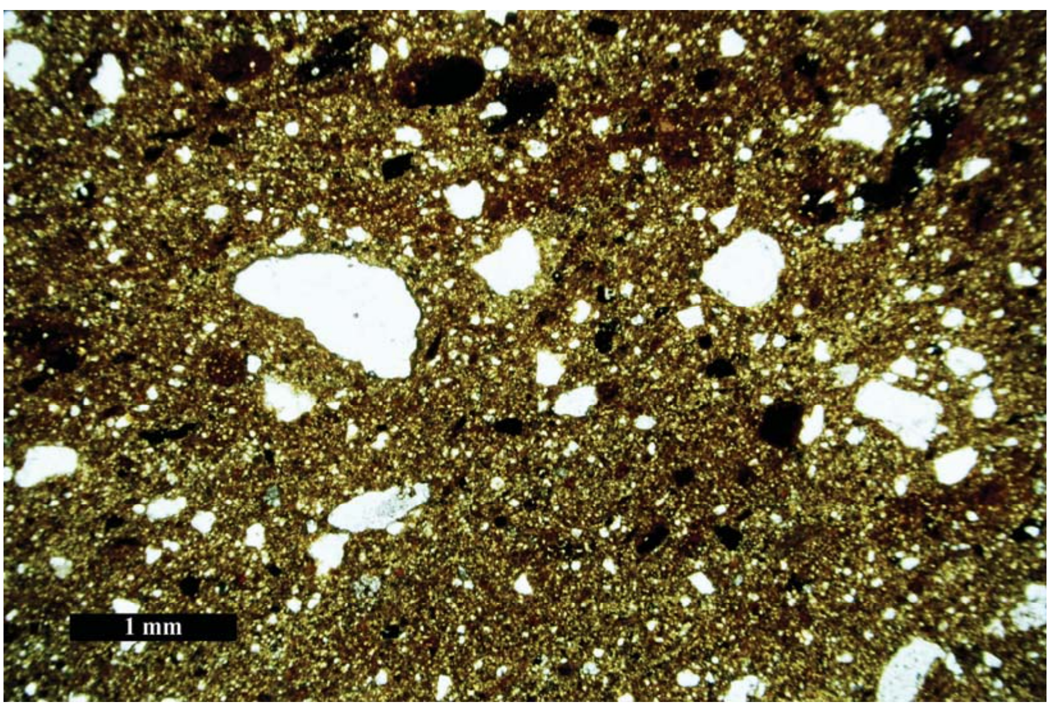


Figure 6.23. Clay sample FBR055 with fine- and medium-grained quartz and feldspar mineral fragments, quartz + feldspar rock fragments, and rounded red hematite-stained clay clots (plane-polarized light).

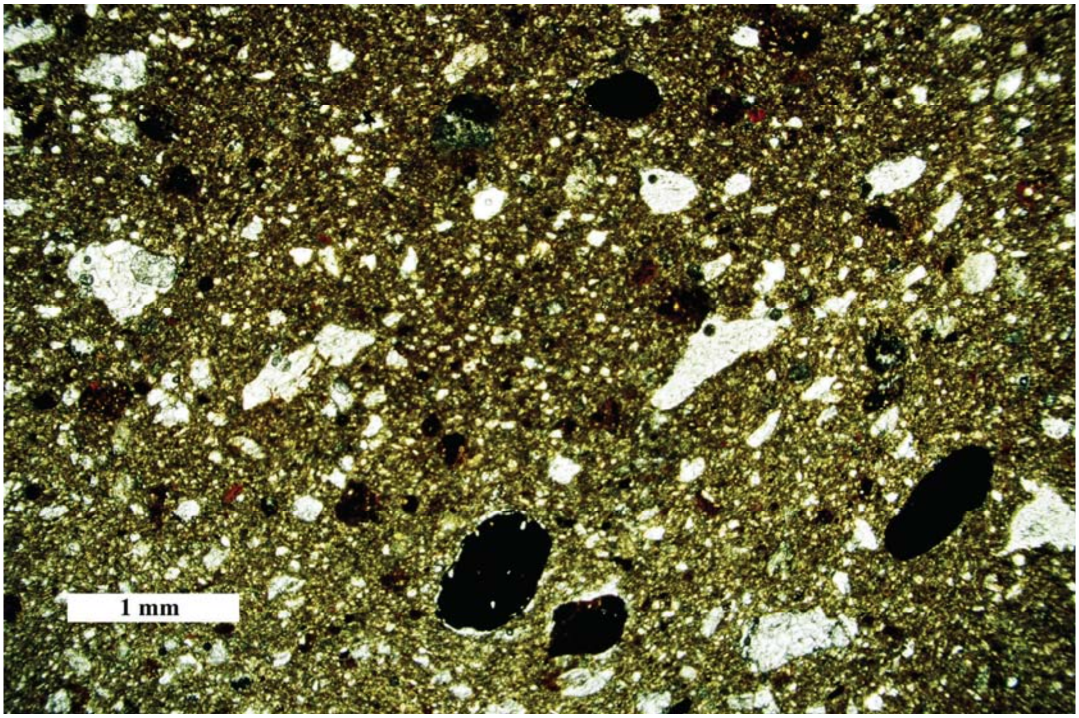


Figure 6.24. Clay sample FBR058 with fine- to medium-grained quartz mineral fragments and some rounded red hematite-stained clay clots (plane-polarized light).

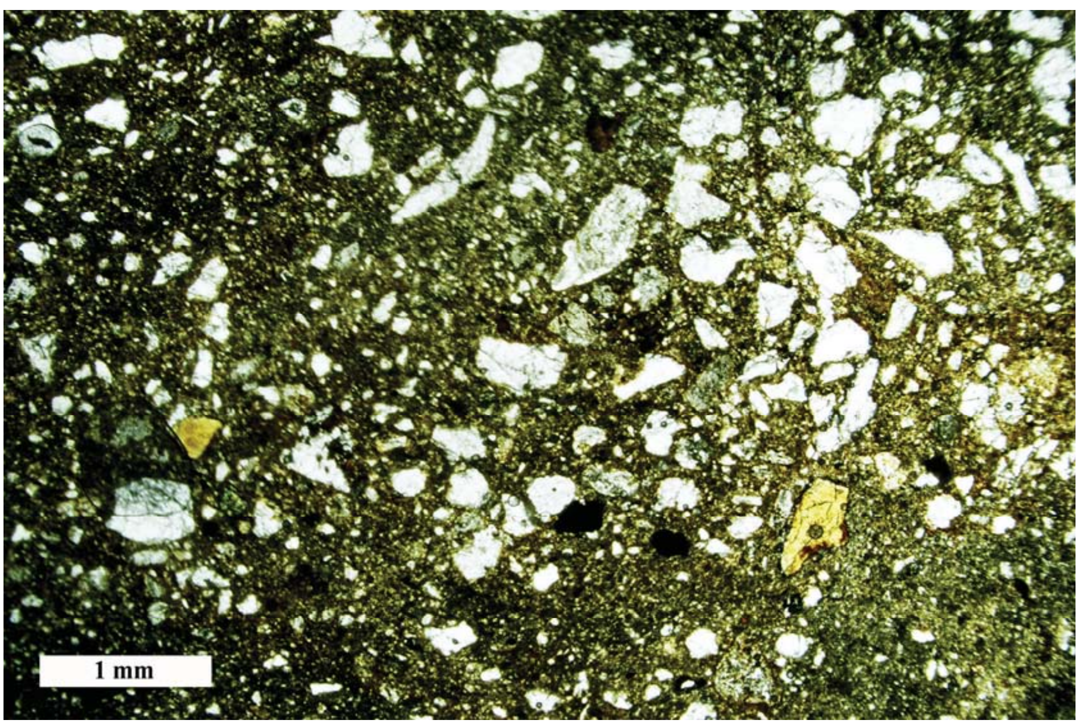


Figure 6.25. Clay sample FBR080 with subrounded quartz rock fragments and quartz mineral fragments (plane-polarized light).

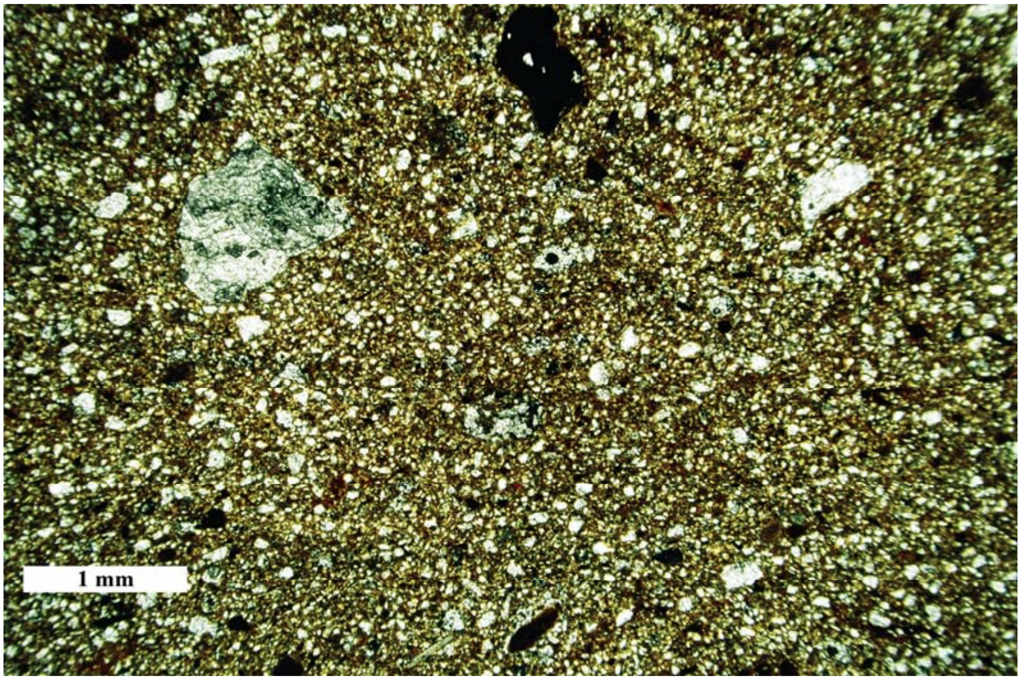


Figure 6.26. Clay sample FBR071 with abundant very fine-grained quartz minerals, red hematite-stained clay clots, and a few coarser-grained quartz mineral fragments (left of center; plane-polarized light).

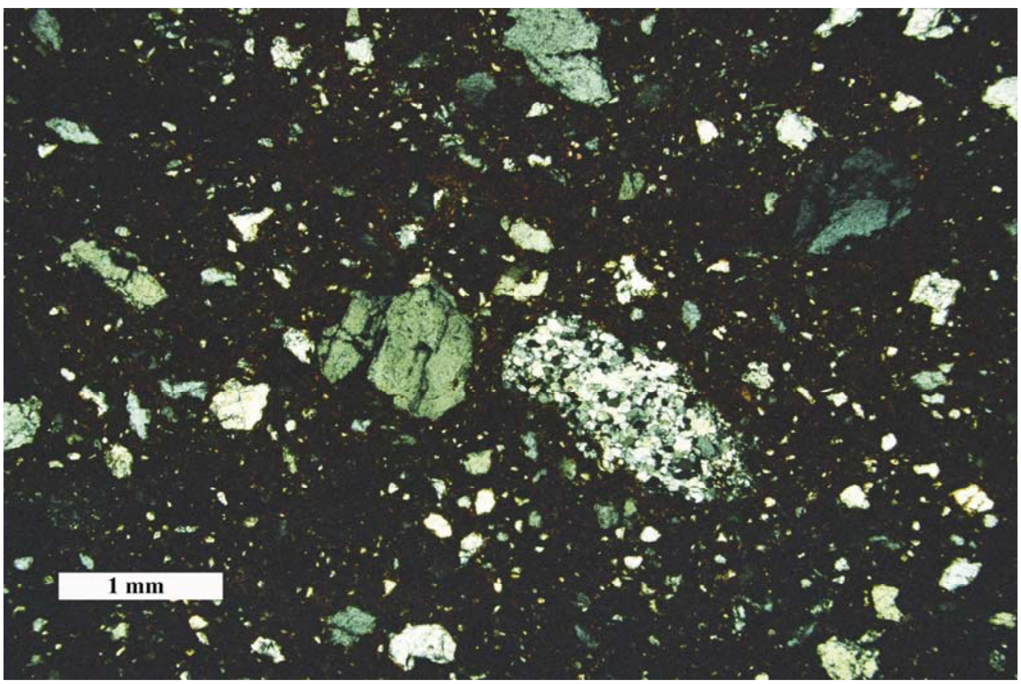


Figure 6.27. Clay sample FBR074 with coarse, polygranular metasedimentary rock fragments (center), quartz + feldspar rock fragments, and quartz mineral fragments (cross-polarized light). The dark matrix suggests reducing conditions.

Discussion

The petrographic observations demonstrate that some regional clay types can be distinguished on the basis of naturally occurring aplastic components of the matrix. This is especially true where those components include materials other than quartz rock or mineral fragments. For example, the relatively homogeneous, very fine-grained aplastic composition of the Pee Dee samples makes them quite distinct from samples representing other drainages.

It is also true, however, that certain characteristics of the samples seem to transcend regional boundaries, as revealed by similarities between samples from different regions. For example, Lower Little River sample FBR017 and Haw River sample FBR041 both have aplastic material including quartz, plagioclase, and opaque mineral fragments; polygranular quartz, quartz + feldspar, and sedimentary or metasedimentary rock fragments; and red hematite-stained clay clots (cf. Figures 6.16 and 6.17). They are difficult to tell apart petrographically and, if represented in ceramic sherds, would be grouped together based on the presence of similar aplastic components. Likewise, Yadkin samples FBR054 and FBR055 have aplastic compositions comparable to that of Deep River sample FBR058 (cf. Figures 6.23 and 6.24).

The Question of Added Temper

Distinguishing between naturally occurring aplastic particles and material purposefully added to clay to alter its character has long challenged archaeological ceramicists. In order to improve our ability to distinguish between natural rock or mineral inclusions and materials added as temper, 11 tempered test tiles were examined and compared with prehistoric pottery samples (Table 6.4).

This comparison was complicated by the fact that the test tiles and sherds were fired under different conditions. The tiles were uniformly oxidized by electric kiln firing, while many of the prehistoric ceramic sherds were fired in a reduced atmosphere. Consequently, the sherds have black or darkened matrices that make identification of diagnostic inclusions difficult and direct comparisons with clay tiles challenging. Nevertheless, some similarities between clay and pottery samples were recognizable and may provide clues as to whether pottery inclusions are natural or added.

Grog versus ACF

Some of the test tiles revealed optically distinct macroscopic textural and compositional features that were classified as ACF. The observation that these fragments occur naturally in the clay tiles indicates that it is necessary to attempt to evaluate how to separate them from grog, as these two types of inclusions share many morphological and optical traits that make them difficult to distinguish. For example, Pee Dee clay sample FBR027 includes brick red hematite-stained clay clots that look similar to grog particles (Figure 6.20). In addition to these red clay clots, argillaceous clay clots were also observed in some of the samples. In such cases, differences in texture and microstructure between argillaceous clay clots and the surrounding clay matrix can be very subtle or indistinguishable. Thin skins of hematite-rich precipitate (or possibly oxidized surfaces) sometimes form on the outside of these fragments, affecting hydration and resulting in incomplete mixing of argillaceous clay clots with the clay matrix. Roundness, internal particle orientation, and presence or absence of shrink rims can be used to

Table 6.4. Tempered Test Tiles Analyzed.

Sample ID	Drainage	Temper (Weight %)
FBR040.4	Haw	10% weathered granitic rock (FBR088)
FBR040.5	Haw	10% weathered granitic rock (FBR089)
FBR040.6	Haw	10% weathered metavolcanic rock (FBR090)
FBR040.7	Haw	10% fresh diabase (FBR091)
FBR040.8	Haw	10% Deep River quartz (FBR086)
FBR049.5	Yadkin	10% fresh diabase (FBR091)
FBR023.3	Pee Dee	10% local grog[a]
FBR023.4	Pee Dee	10% nonlocal grog[b]
FBR011.2	Cape Fear	10% nonlocal grog[b]
FBR011.3	Cape Fear	10% local grog[a]
FBR012.2	Cape Fear	10% nonlocal grog[b]

[a] Local grog was made by crushing fired test tiles fashioned from the sample clay.

[b] Nonlocal grog was made by crushing unprovenienced sherds.

distinguish argillaceous clay clots from grog, but these characteristics are not always consistently associated with one or the other (Cuomo di Caprio and Vaughan 1993).

The ability to distinguish between purposefully added grog and natural inclusions has important implications for identification and classification of prehistoric ceramics. It is especially important given that grog-tempered pottery is a key artifact type used to identify the Middle Woodland Hanover phase in the Sandhills and Coastal Plain.

While this problem deserves much more attention, this study was primarily concerned with identifying the characteristics of inclusions that would allow sherds to be linked with clay source areas. Accordingly, the problem of identifying grog is discussed briefly in the context of test tiles made from two Coastal Plain clays to which grog was added.

To determine what grog might look like in Pee Dee clay, grog-tempered test tiles made from sample FBR023 were examined. Local grog (i.e., crushed, fired test tile made from the same clay) in test tile FBR023.3 is distinguishable by slight color and texture differences, internal particle orientation different from the matrix, particle angularity, and presence of shrink rim (Figure 6.28).

A similar test was made using a Cape Fear clay sample tempered with local grog (FBR011.3). This test tile was nearly indistinguishable from untempered samples. However, when the same clay was tempered with nonlocal grog (FBR011.2), the added component was easily recognized due to the compositional differences and a pronounced color contrast between the grog and clay matrix (Figure 6.29).

Mineral and Rock Fragments

In many of the samples observed in this study, it is also possible to recognize subtle differences between mineral and rock fragments added as temper and those occurring naturally

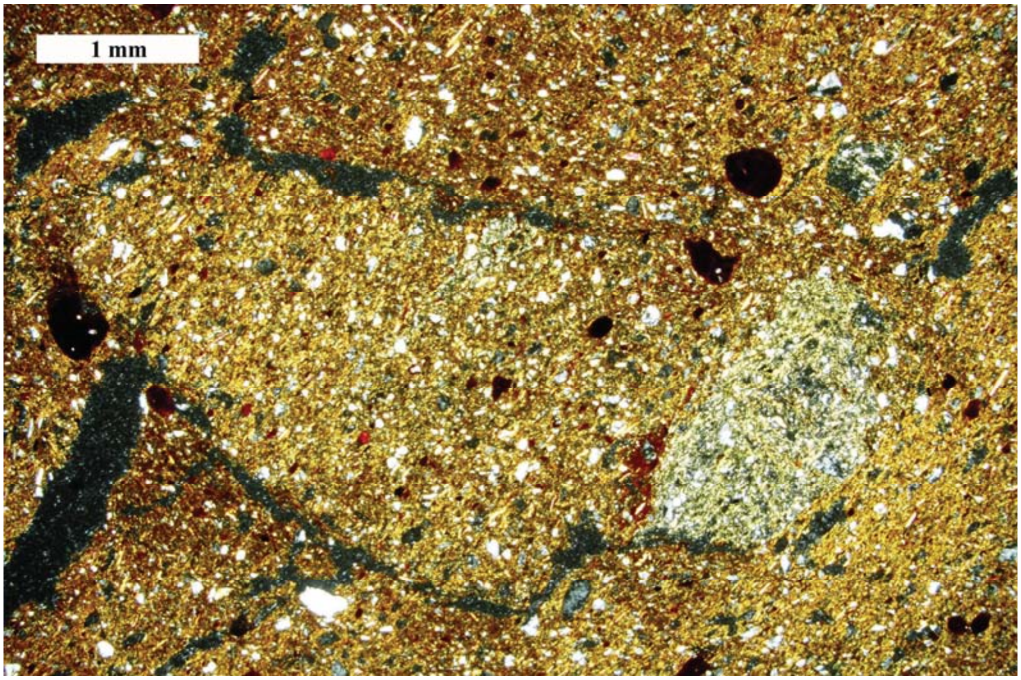


Figure 6.28. Clay sample FBR023 tempered with local grog (test tile FBR023.3; plane-polarized light). The coarse grog particle (center) has a slightly different color, texture, and orientation of inclusions than the surrounding matrix. Also note the particle's angularity and shrink rim.

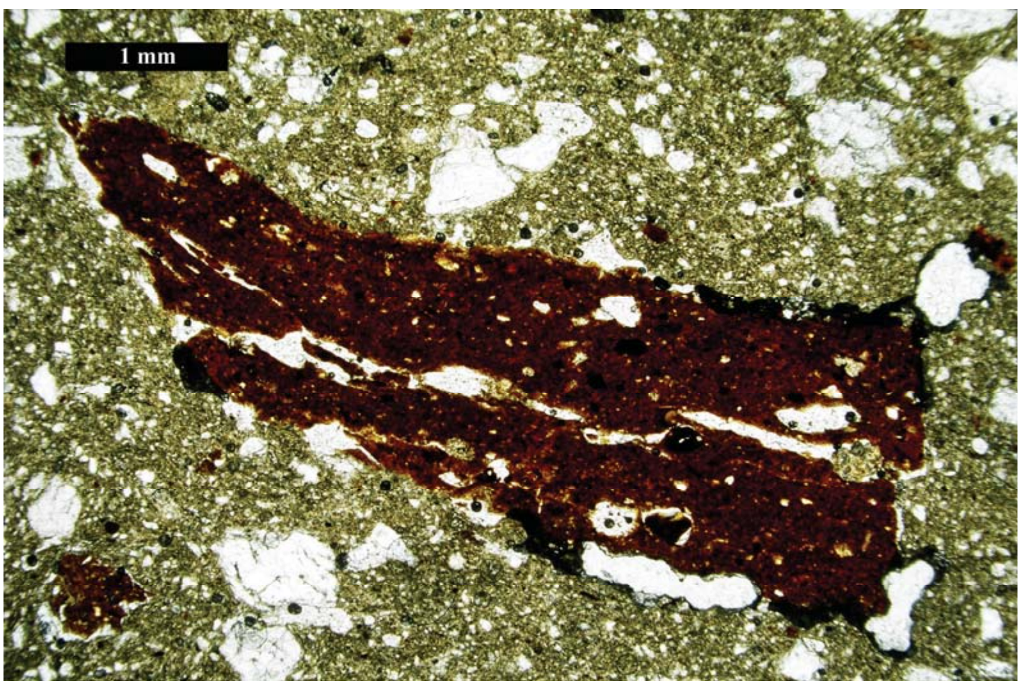


Figure 6.29. Clay sample FBR011 tempered with nonlocal grog (test tile FBR011.2; plane-polarized light). Note the distinct color and textural differences between the added grog fragment and the surrounding clay body.

in the clay. Often, the initial clue is the large size and angularity of rock fragments. Large (> 2 mm), angular rock fragments are unusual natural inclusions in raw clay samples dug for the purpose of making pottery. However, the distinction between temper and natural inclusions must be made on a case-by-case basis.

It is especially difficult to separate natural fragments from added rock and mineral fragments when they are of the same type. For example, quartz-rich Haw River clay sample FBR040 tempered with crushed quartz (test tile FBR040.8) was nearly impossible to distinguish from the untempered sample unless very large (4–7 mm) quartz temper fragments were in the field of view (Figure 6.30; Table 6.4).

On the other hand, a distinctive added temper is often identifiable. If rock fragments in a sample include characteristic minerals (e.g., amphibole, mica, or tourmaline) while the finer-grained aplastic material is found to be devoid of these materials, deliberate addition of the rock fragments would be implied. Crushed igneous and metavolcanic rock tempers were clearly distinguishable in test tiles FBR040.4, FBR040.5, FBR040.6, and FBR040.7 (Figure 6.31; Table 6.4). Nevertheless, it can still be difficult (if not impossible) to identify temper in clays exhibiting a lot of natural variation.

Quartz. In some test tiles, quartz temper was identifiable. The quartz used as temper was monocrystalline vein quartz, while the quartz fragments occurring naturally in most clays are polycrystalline. These differences are obvious in the flat sections of the thin-section pucks examined at 10× magnification.

Differences in particle size or angularity may also help distinguish quartz temper from natural inclusions. The quartz used to temper test tiles was crushed and added without winnowing or sorting. The resulting temper included every particle size from powder to pebble, was notably angular, and commonly included thin flakes and splinters (shapes not likely in the naturally occurring sample).

In theory, then, pottery tempered with quartz prepared by crushing should be distinguishable from pottery with naturally occurring quartz (grit) by the presence of flakes in the prepared-temper samples. In practice, flakes are difficult to capture in thin section, as the sample sections are very thin and the chances of sectioning a flake in a manner that reveals a characteristic profile is low. This factor increases the importance of properly defining the range of sizes and shapes that distinguish natural and artificial tempering. Had the test tiles been point-counted to produce quantitative data, they likely would have exhibited a bimodal distribution with the naturally occurring material (0.5–1.5 mm) comprising one mode and the added granule- and pebble-sized particles (> 2.0 mm) comprising another, with few particles in intermediate sizes.

Diabase. In an effort to determine whether the diabase fragments observed in the four Group I pottery samples are natural inclusions or purposefully added temper, two test tiles tempered with crushed diabase rock were examined. One test tile was made from a Haw River clay sample (FBR040.7; Figure 6.32), while the other was made from a Yadkin sample (FBR049.5).

Test tile FBR040.7 appears similar to Group I pottery sample JMH031 from the Doerschuk site, except that the test tile includes fewer and more rounded quartz mineral fragments. JMH031 includes approximately 20% diabase rock fragments in a paste composed of clay minerals and greater than 30% medium to very coarse, subangular to angular, quartz mineral fragments. These characteristics suggest the addition of diabase material to a coarse quartz-rich paste material. Alternatively, the sherd could represent a clay source derived from two different parent materials concentrated in one area, but this is an unlikely scenario.

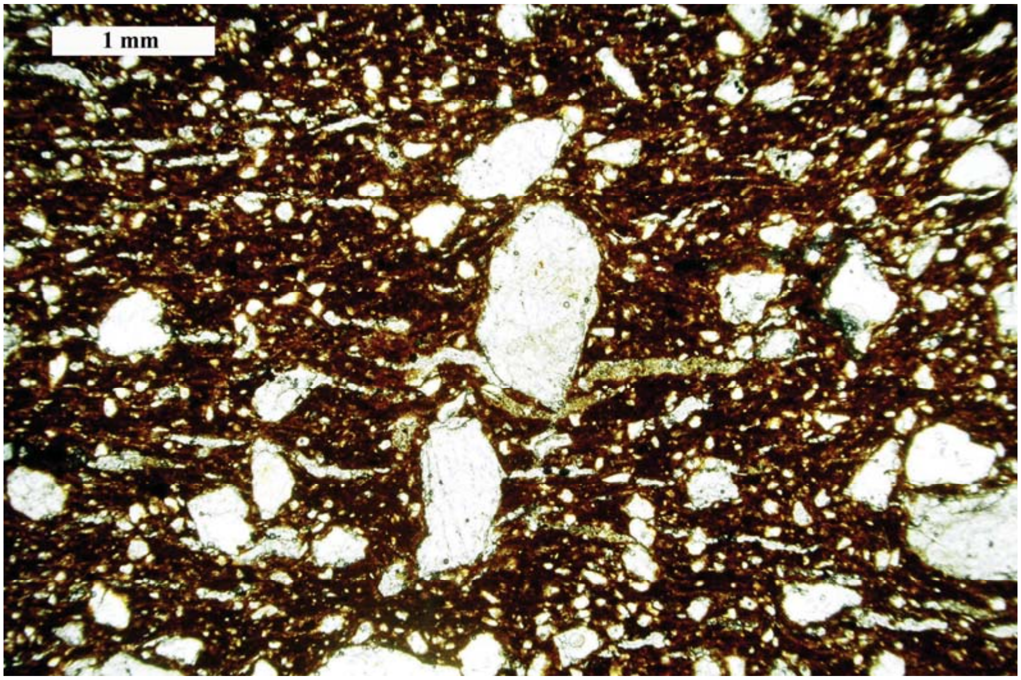


Figure 6.30. Clay sample FBR040 tempered with crushed quartz fragments (test tile FBR040.8; plane-polarized light). In this view, added quartz temper is indistinguishable from natural inclusions.

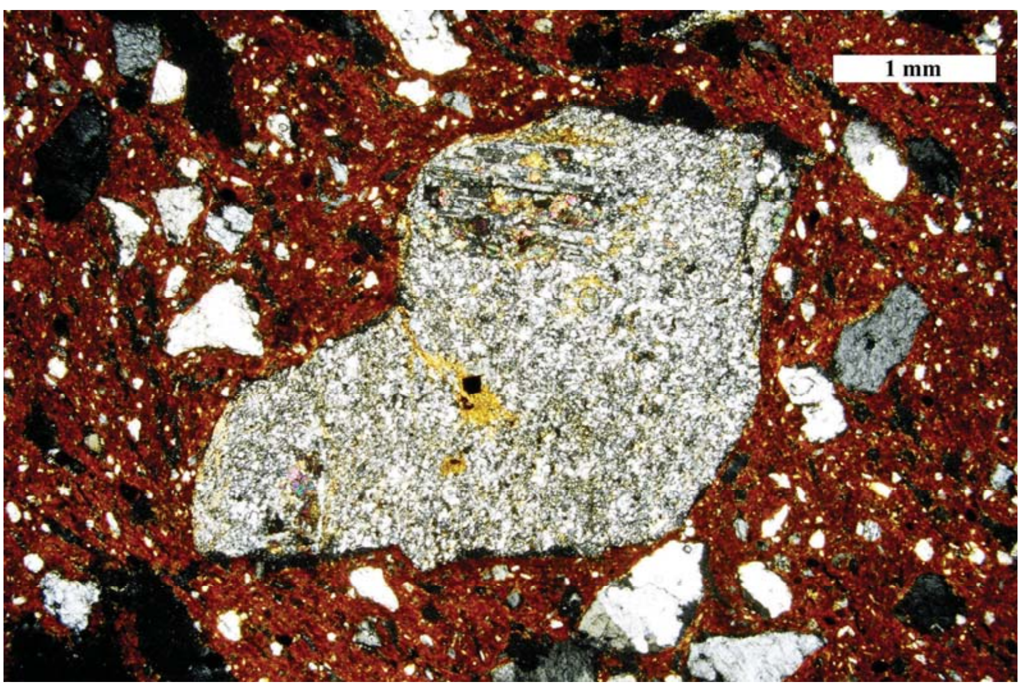


Figure 6.31. Clay sample FBR040 tempered with metavolcanic rock fragments (test tile FBR040.6; cross-polarized light). Note the coarse metavolcanic rock fragment (center) with plagioclase phenocrysts in a fine crystalline groundmass of quartz and muscovite mica. This rock fragment has experienced sericite alteration.

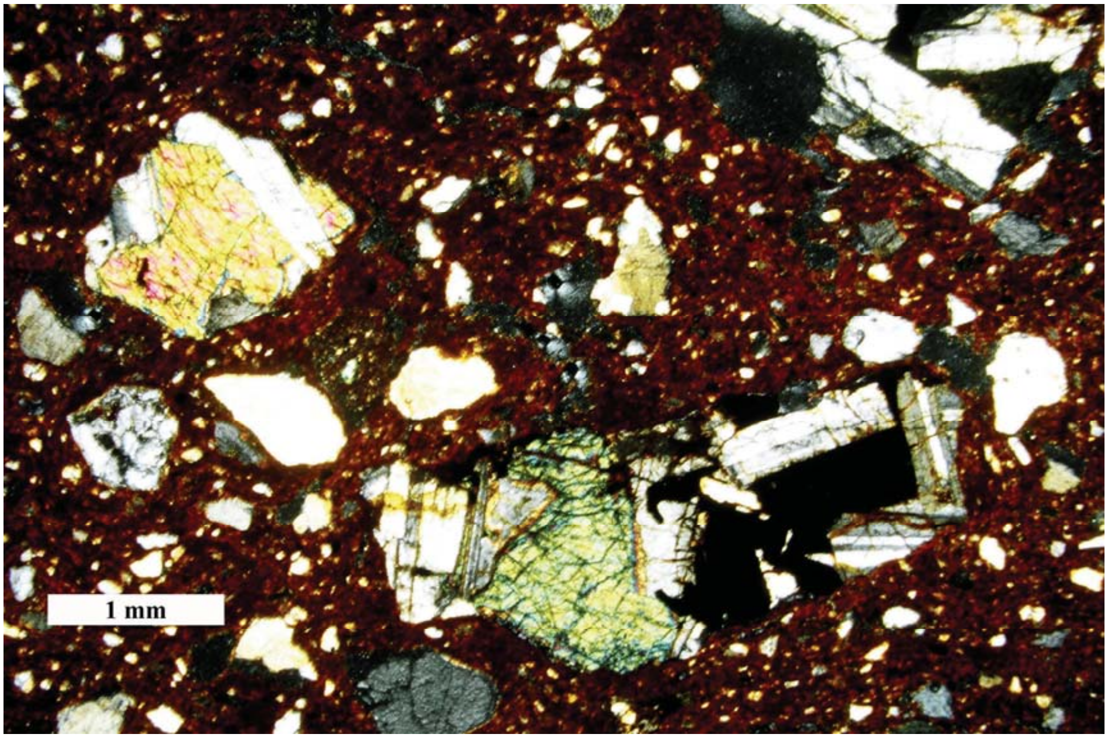


Figure 6.32. Clay sample FBR040 tempered with unweathered diabase rock fragments (test tile FBR040.7; cross-polarized light). Note the coarse plagioclase-pyroxene rock fragment (bottom center) and quartz mineral and rock fragments (gray or clear subangular and subrounded grains).

Group I pottery sample JMH046 from the Haw River site contrasts with JMH031. Sample JMH046 is composed of coarse to very coarse, blocky to angular quartz mineral and rock fragments in a paste dominated by mafic minerals (Figure 6.4). Because it is not likely that mafic material and quartz would be found in the same location, it is likely that the quartz was added as temper. Crushed quartz temper in test tile FBR040.8 made from Haw River clay approximates the type and angularity of the larger quartz fragments found in JMH046, but the test tile does not adequately represent the mafic paste composition of the sherd. None of the clay test tiles examined for this study have a mafic paste like that of sherd JMH046.

Group I sherd JMH047 is similar in some ways to JMH046, but the largest aplastic inclusions include not only quartz but also amphibole (or clinopyroxene) and heavily altered plagioclase rock fragments. The paste also contains fragments of amphibole (or clinopyroxene) and feldspar but not quartz, suggesting the quartz fragments have been intentionally added.

Finally, neither of the two test tiles tempered with crushed diabase replicates the distribution of aplastic material found in sherd JMH006. Diabase fragments in sample JMH006 comprise almost 30% of the paste and are nearly pristine, suggesting the vessel was constructed from a residual saprolitic clay that was not intentionally tempered.

Conclusions

In summary, three distinct petrographic groups are represented in the ceramic sample and appear to reflect regional differences in resources. Groups I and II generally consist of sherds from the Piedmont, while Group III consists of sherds from the Coastal Plain and Sandhills. Similar patterning in the clay data suggests that the majority of sherds were probably constructed with resources from the same general region in which they were found.

Chapter 7

Feldspar and Clay Mineralogy

Theresa E. McReynolds, Sheldon A. Skaggs, and Paul A. Schroeder

To refine our understanding of the differences between clay-resource regions, 42 clay samples were analyzed by X-ray diffraction (XRD; Table B.6; Figure 7.1). The primary purpose of the analyses was to identify variability in mineral assemblages that could explain the geochemical patterns described in Chapter 5. An additional objective was to evaluate the relationship between mineralogy and the performance characteristics evaluated in Chapter 4.

X-Ray Diffraction

Plastic soils are typically mixtures of one or more clay minerals and nonclay minerals such as feldspar, quartz, and micas (Klein and Hurlbut 1993:512). Most of the nonclay components are identifiable in thin section, but clay minerals are so small (< 2 μm in spherical diameter) that they can only be recognized on the basis of their crystalline structures. Four groups of clay minerals are distinguished according to their three-dimensional arrangements of atoms: (1) the kaolin group (including kaolinite, halloysite, nacrite, and dickite); (2) the smectite group (including montmorillonite, nontronite, saponite, sauconite, and vermiculite); (3) illite; and (4) chlorite (including clinoclore and chamosite). Any two of these clay mineral groups can also occur together in mixed layers.

XRD is uniquely capable of detecting the structural differences among clay mineral groups in unfired samples. In XRD analysis, a powdered sample is exposed to a monochromatic beam of X-rays. When the beam hits a mineral's crystal lattice, the X-rays constructively and destructively interfere or diffract. The angles at which the X-rays diffract vary with the distance (d-spacing) between adjacent planes of atoms in the crystal, resulting in a distinctive diffraction pattern for every crystalline mineral. The measured angles of diffraction can be used to calculate the d-spacing (d) according to Bragg's law:

$$n\lambda = 2d\sin\theta \qquad (1)$$

where n is an integer representing the order of the diffracted beam, λ is the wavelength of the incident beam, and θ is the angle between the diffracted beam and the crystallographic plane. Once the d-spacing is known, the mineral can be identified through comparison with standard reference materials (Flohr 1997; Stanjek and Häusler 2004).

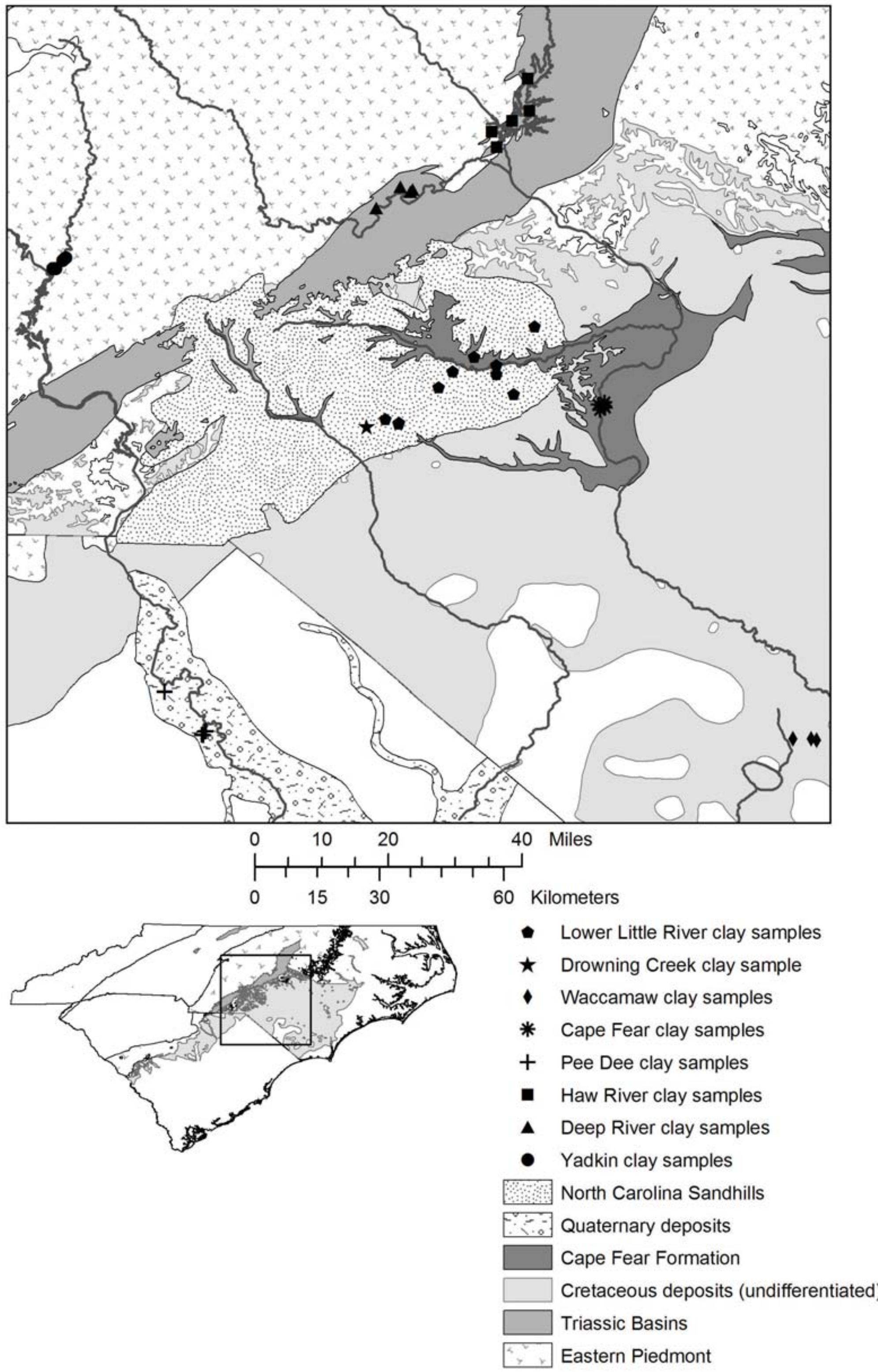


Figure 7.1. Locations of 42 clay samples analyzed by XRD (North Carolina Geological Survey 1998; South Carolina Geological Survey 2005; United States Geological Survey 2002).

Although standard XRD does not provide quantitative compositional data, several semi-quantitative methods can be applied to determine the relative proportions of minerals in a sample (Hurst et al. 1997). One such method, the Mineral Intensity Factor 100% approach (MIF), uses integrated diffraction peak intensities and reference intensity ratios to roughly estimate the *comparative* weight fraction of each mineral, assuming that the identified minerals constitute 100% of the sample (see Kahle et al. 2002 for a detailed description of this method). Although MIF has been criticized when represented as a quantitative technique (Kahle et al. 2002), it is an acceptable method of achieving semi-quantitative results for the purpose of comparing a similar suite of samples within a single study.

Methodology

Samples were air-dried and ground in a ball mill. Clay-sized particles (i.e., equivalent spherical diameter of 2 µm or less) were separated by allowing the larger fraction to settle in a column of water. In some cases, calcium phosphate chemicals were added to reduce flocculation and allow the particles to remain dispersed. The clay-sized fraction was then coated onto glass slides for preferred orientation and ethylene-glycol saturated analyses.

The specimens were analyzed on a Scintag XDS-2000 diffractometer using CoK_{α} radiation. Randomly-oriented (bulk) samples were run at a continuous scan rate of 1.00 degree per minute over a range of 2.00–70.00 degrees; counts were collected for 0.600 seconds at step increments of 0.010 degrees. Preferred orientation and ethylene-glycol saturated specimens were scanned at a continuous rate of 0.50 degrees per minute over a range of 2.00–36.00 degrees, with counts collected for 1.2 seconds.

Diffraction patterns for all three specimens (i.e., bulk, air-dried preferred orientation, and ethylene glycolated) were combined to qualitatively assess the abundance of ten minerals or mineral groups in each sample: quartz, lepidocrocite, gibbsite, plagioclase, K-feldspar, amphibole, the 7Å kaolin group, the 10Å illite/mica group, the 14Å hydroxy-interlayered vermiculite/chlorite/smectite group, and expandable (smectitic) clays.

The MIF procedure was applied to the bulk data to obtain semi-quantitative measurements of quartz, lepidocrocite, gibbsite, plagioclase, K-feldspar, amphibole, and total clay minerals. It was also applied to the preferred orientation data to assess the percentages of the 14Å, 10Å, and 7Å clay minerals relative to each other. Finally, the preferred orientation estimates were applied to the total clay mineral measurement from the bulk data to calculate semi-quantitative measurements for each of the three clay mineral groups.

Results

Qualitative analysis of bulk mineralogy suggests that clays from the same drainage basin generally exhibit similar mineral compositions (Table 7.1). Individual drainages cannot be differentiated on the basis of bulk mineral composition, but feldspar (i.e., plagioclase and K-feldspar) mineralogy does help discriminate between regions. With a few exceptions, clays from drainages originating in the Piedmont contain plagioclase and/or K-feldspar while those from drainages restricted to the Coastal Plain do not.

Table 7.2 presents the results of semi-quantitative analysis for 39 samples. All values represent the estimated proportions of minerals relative to each other and should not be confused

Table 7.1. Qualitative bulk mineralogy.[a]

Region/Drainage: Sample ID	Quartz	Lepidocrocite	Gibbsite	Plagioclase	K-feldspar	Amphibole	Clay Minerals 14Å Group	10Å Illite/Mica	7Å Kaolin Group	Expandable (Smectitic)
Sandhills/Lower Little:										
FBR002	xx		x				x	x	x	
FBR003	xx		x				x	x	x	
FBR004	xx			x				x	x	x
FBR005	xx		tr	x			x	x	x	
FBR007	xx		x				x	x	x	tr
FBR008	xx						tr	x	x	
FBR009	xx							x	x	
FBR010	xx			x			x	x	x	tr
FBR017	xx	x					x	x	x	x
FBR059	xx						x	x	xx	
FBR067	xx						x	x	xx	
Sandhills/Drowning Cr:										
FBR006	xx						x	x	xx	
Coastal Plain/Waccamaw:										
FBR081	xx	x					x		x	tr
FBR082	xx						x	x	x	x
FBR083	xx						x		x	
FBR084	xx						x		x	x
FBR085	xx				tr		x		x	x
Coastal Plain/Cape Fear:										
FBR011	xx			x	x		x	x	x	tr
FBR012	xx			x	x		x	x	x	x
FBR013	xx			x	x		x	x	x	tr
FBR014	xx			x	x		x	x	x	x
FBR016	xx			tr	tr		x	x	x	x
Coastal Plain/Pee Dee:										
FBR019	xx	x	x	x	x		x	tr	x	
FBR020	xx		tr	x	x		x	x	x	
FBR021	xx		tr	x	x		x	x	x	
FBR023	xx			tr	tr		x	x	x	tr

Table 7.1. Qualitative bulk mineralogy (continued).[a]

Region/Drainage: Sample ID	Quartz	Lepidocrocite	Gibbsite	Plagioclase	K-feldspar	Amphibole	Clay Minerals 14Å Group	10Å Illite/Mica	7Å Kaolin Group	Expandable (Smectitic)
FBR027	xx			tr	tr		x	x	x	
Piedmont/Haw:										
FBR029	xx			tr			x		x	x
FBR030	xx			tr			x	xx	x	
FBR035	xx			x	x		x	xx		x
FBR040	xx				x		x	tr		
FBR041	xx			x	x		x			x
Piedmont/Deep:										
FBR058	xx			x	tr	tr	x	x	x	tr
FBR071	xx			x			x	x	x	x
FBR074	xx			x			x	x	x	x
FBR077	xx			x			x	x	x	tr
FBR080	xx			x	tr		x	x	x	
Piedmont/Yadkin:										
FBR048	xx			x	tr		x	x	x	
FBR049	xx			x			x	x	x	
FBR051	xx			x		tr	x	x	x	
FBR054	xx			x		tr	x	x	x	
FBR055	xx			x		tr	x	x	x	

[a] Key: xx, abundant; x, minor; tr, trace.

Table 7.2. Semi-quantitative mineralogy.[a]

	Nonclay Minerals[b]						Clay Minerals[c]		
							14Å	10Å	7Å
Region/Drainage: Sample ID	Quartz (%)	Lepidocrocite (%)	Gibbsite (%)	Plagioclase (%)	K-feldspar (%)	Amphibole (%)	Group (%)	Illite/Mica (%)	Kaolin Group (%)
Sandhills/Lower Little:									
FBR002	84.9	0.0	3.6	0.0	0.0	0.0	4.3	4.3	2.8
FBR003	87.5	0.0	3.3	0.0	0.0	0.0	2.0	3.0	4.1
FBR004	88.2	0.0	0.0	1.2	0.0	0.0	8.9	0.4	1.2
FBR005	90.8	0.0	1.0	2.2	0.0	0.0	3.1	0.0	3.0
FBR007	82.8	0.0	1.2	0.0	0.0	0.0	1.4	8.4	6.2
FBR008	94.4	0.0	0.0	0.0	0.0	0.0	0.0	3.2	2.5
FBR009	86.3	0.0	0.0	0.0	0.0	0.0	0.0	8.2	5.5
FBR010	94.0	0.0	0.0	3.1	0.0	0.0	0.8	0.3	1.7
FBR017	77.1	12.6	0.0	0.0	0.0	0.0	9.3	0.0	1.0
FBR059	94.7	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.7
FBR067	49.8	0.0	0.0	0.0	0.0	0.0	14.3	0.8	35.0
Sandhills/Drowning Cr:									
FBR006	63.9	0.0	0.0	0.0	0.0	0.0	1.4	8.4	26.3
Coastal Plain/Waccamaw:									
FBR081	93.1	5.3	0.0	0.0	0.0	0.0	1.2	0.0	0.5
FBR082	96.5	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.4
FBR084	87.2	0.0	0.0	0.0	0.0	0.0	11.1	0.7	0.9
FBR085	82.5	0.0	0.0	0.0	0.6	0.0	13.5	2.5	0.9
Coastal Plain/Cape Fear:									
FBR011	70.1	0.0	0.0	7.2	16.0	0.0	4.8	0.0	1.9
FBR012	90.9	0.0	0.0	1.8	4.6	0.0	2.3	0.0	0.4
FBR013	89.8	0.0	0.0	2.2	2.4	0.0	3.4	1.2	1.0
FBR016	89.3	0.0	0.0	0.8	3.9	0.0	4.2	0.4	1.4
Coastal Plain/Pee Dee:									
FBR019	72.1	2.3	10.5	1.8	6.0	0.0	4.2	0.7	2.3
FBR020	69.3	0.0	14.5	1.8	3.9	0.0	6.2	1.0	3.3
FBR021	70.3	0.0	9.6	1.2	4.9	0.0	10.2	0.0	3.9

Table 7.2. Semi-quantitative mineralogy (continued).[a]

	Nonclay Minerals[b]						Clay Minerals[c]		
							14Å	10Å	7Å
Region/Drainage: Sample ID	Quartz (%)	Lepidocrocite (%)	Gibbsite (%)	Plagioclase (%)	K-feldspar (%)	Amphibole (%)	Group (%)	Illite/Mica (%)	Kaolin Group (%)
FBR023	84.4	0.0	0.0	0.3	1.7	0.0	4.2	2.5	6.9
FBR027	74.6	0.0	0.0	1.3	2.5	0.0	13.9	1.9	5.8
Piedmont/Haw:									
FBR029	97.2	0.0	0.0	0.5	0.0	0.0	0.6	1.2	0.5
FBR030	88.3	0.0	0.0	1.2	0.0	0.0	9.7	0.0	0.8
FBR035	88.2	0.0	0.0	0.9	4.1	0.0	2.4	3.6	0.8
FBR040	91.2	0.0	0.0	0.0	2.5	0.0	3.9	2.1	0.3
FBR041	87.9	0.0	0.0	0.9	2.3	0.0	6.8	1.9	0.3
Piedmont/Deep:									
FBR058	90.6	0.0	0.0	2.4	0.0	0.0	4.3	0.8	2.0
FBR071	88.1	0.0	0.0	5.1	0.0	0.0	1.9	0.0	4.8
FBR074	82.5	0.0	0.0	9.3	0.0	0.0	4.3	3.1	0.7
FBR077	90.1	0.0	0.0	4.8	0.0	0.0	4.7	0.3	0.0
FBR080	95.6	0.0	0.0	2.7	1.3	0.0	0.2	0.2	0.0
Piedmont/Yadkin:									
FBR048	90.1	0.0	0.0	4.4	0.0	0.0	4.8	0.5	0.2
FBR051	89.7	0.0	0.0	4.2	0.0	0.4	3.1	1.1	1.5
FBR054	92.8	0.0	0.0	3.4	0.6	0.3	1.9	0.0	1.1
FBR055	91.5	0.0	0.0	2.7	0.0	0.0	3.9	0.0	1.9

[a] All values represent the estimated proportions of minerals relative to each other.
[b] Based on bulk data.
[c] Based on bulk and preferred orientation data.

with absolute concentrations. Samples FBR014, FBR049, and FBR083 (from the Cape Fear, Yadkin, and Waccamaw drainages, respectively) have been omitted because of concerns regarding artifacts attributed to effects of preferred orientation on the diffraction patterns.

To facilitate identification of patterning in the semi-quantitative data, relative proportions of minerals were plotted on ternary diagrams in various combinations. Displaying the data this way reveals some general patterns with respect to feldspar and clay mineralogy.

Feldspar Mineralogy

It is not possible to demonstrate clear distinctions among individual drainages on the basis of semi-quantitative data for only 39 samples, but some differentiation is evident on the basis of feldspar mineralogy (Figure 7.2). Samples from the Haw drainage do not exhibit any patterning in feldspar mineralogy and are consequently not considered in much of the following discussion. The lack of grouping in the Haw River data may reflect the heterogeneous nature of the collection sites: FBR029 is from the Slate Belt; FBR030 is from the Deep River Triassic Basin; and FBR035, FBR040, and FBR041 are from the shores of man-made Jordan Lake.

Piedmont samples contain high relative proportions of plagioclase compared to Coastal Plain samples (Figure 7.2). Samples from drainages restricted to the Coastal Plain generally lack feldspar minerals entirely, while Coastal Plain samples collected from drainages originating in the Piedmont exhibit mixed mineralogies with intermediate proportions of plagioclase and relatively high K-feldspar contents.

The patterning in Figure 7.2 makes sense given the geological characteristics of the Piedmont and Coastal Plain regions (Chapter 2). Plagioclase phenocrysts are common in metamorphic rocks of the Carolina Slate Belt (Stoddard 2006), so we would expect Piedmont sediments derived from these rocks to be plagioclase-rich. We would also expect alluvial sediments from Coastal Plain rivers with Piedmont origins to contain some redeposited plagioclase. The K-feldspar in the Cape Fear samples presumably comes from the Cretaceous Cape Fear Formation, which is characterized by K-feldspar-rich quartz sands (Figure 7.1; Sohl and Owens 1991:193). It is not clear why the Pee Dee samples collected from Quaternary deposits also contain high relative proportions of K-feldspar, although the Pee Dee River may pick up alkali sediments as it traverses Cretaceous deposits north of the collection area. Another possible explanation is that the K-feldspar was contributed by aeolian sediments, as has been demonstrated elsewhere in the southeastern U.S. (Schroeder et al. 1997).

Three Lower Little River samples (FBR004, FBR005, FBR010) exhibit high relative proportions of plagioclase and are therefore exceptions to the aforementioned patterns. These three anomalous samples were collected from the Cape Fear Formation, whereas all other Lower Little River samples were collected from the Middendorf Formation. The Cape Fear Formation generally contains more plagioclase than the Middendorf (Sohl and Owens 1991:193, 198), but it is puzzling that these three samples do not also contain the K-feldspar that characterizes the Cape Fear Formation. Again, the explanation may involve some sort of aeolian process.

Clay Mineralogy

The clay mineralogy data suggest additional trends (Figure 7.3). The 14Å hydroxy-interlayered vermiculite/chlorite/smectite minerals dominate the clay mineralogy of most samples, although many Sandhills specimens are relatively enriched in 7Å kaolin-group minerals. With the exception of the Sandhills samples, Coastal Plain clays tend to be very rich in

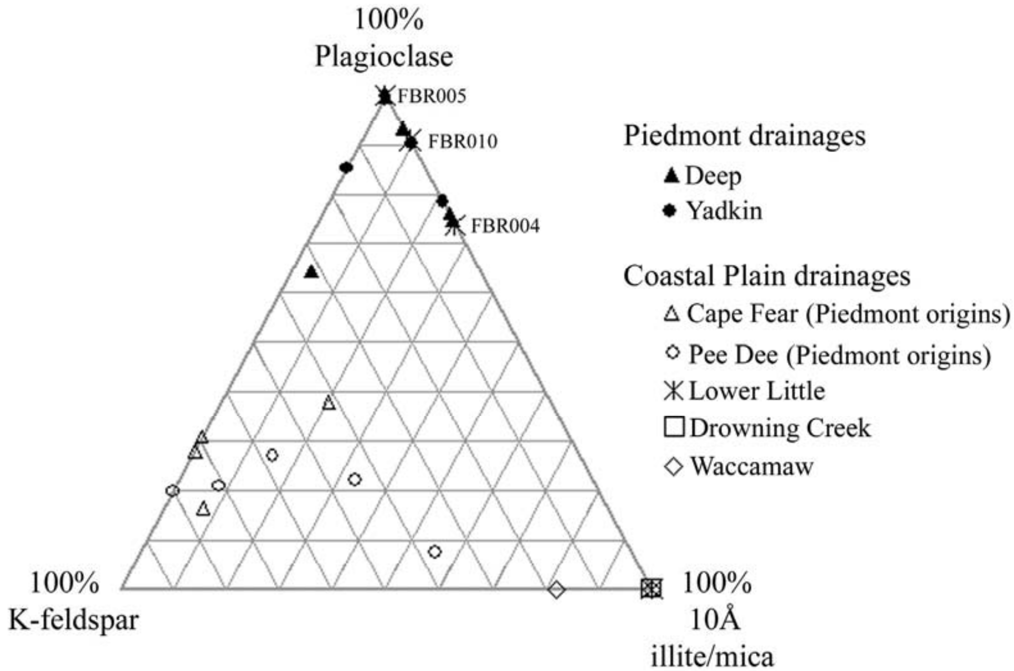


Figure 7.2. Clay samples plotted according to relative proportions of plagioclase, K-feldspar, and the 10Å illite/mica group minerals and arrayed by drainage. The labeled samples are discussed in the text. Samples from the Haw drainage do not exhibit any grouping in feldspar mineralogy and are not displayed.

14Å minerals and poor in 10Å illite/mica minerals. Piedmont clays, especially those from the Deep River Triassic basin, generally have low proportions of 7Å minerals.

The aforementioned patterns are consistent with the geology of the study area (Chapter 2). In general, Coastal Plain clays are rich in smectite-group minerals while Piedmont clays tend to be rich in kaolinite (Neiheisel and Weaver 1967; Steponaitis et al. 1996; Windom et al. 1971). It therefore makes sense that the Coastal Plain samples are relatively enriched in 14Å minerals, with those from Piedmont-spanning drainages exhibiting slightly higher proportions of 7Å minerals than those from the Waccamaw drainage. Most of the Sandhills samples that seem to be exceptions to the general rule come from the Middendorf Formation, which contains more kaolinite and illite than smectite in some areas (Heron 1960; Sohl and Owens 1991:196).

Piedmont clays that are rich in 14Å minerals and relatively deficient in kaolin-group minerals also seem to be exceptions to what we would expect to find. However, the 14Å mineral group includes hydroxy-interlayered vermiculite and chlorite, both of which are found in the Carolina Slate Belt. Furthermore, smectite-rich clays are common in the Deep River Triassic basin and in the vicinity of metagabbro intrusions, which are abundant in the area where the Yadkin samples were collected (Buol 2003; Olive et al. 1989; Schroeder and West 2005).

Discussion

A principal objective of the XRD analyses was to determine if mineralogical variability could account for the geochemical patterns identified in Chapter 5. An additional objective was

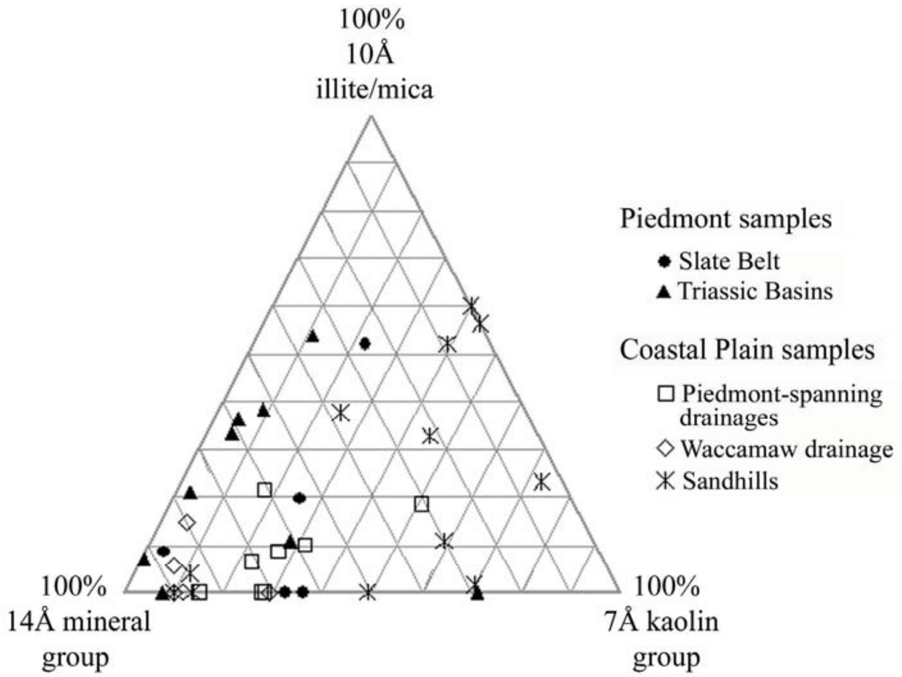


Figure 7.3. Clay samples plotted according to relative proportions of 10Å, 14Å, and 7Å minerals and arrayed by physiographic region.

to ascertain the extent to which clay mineralogy influences workability and other physical properties (see Chapter 4) that presumably formed the basis upon which prehistoric potters selected their clay resources.

Geochemistry

Neutron activation analysis data indicate that clay samples from Piedmont drainages (Deep, Yadkin) or Coastal Plain drainages originating in the Piedmont (Cape Fear, Pee Dee) have the greatest chemical similarity to Ca-rich Group 2 pottery (see Table 5.5, left side). Petrographic analyses (Chapter 6) suggest that the source of the Ca in these samples is plagioclase-rich igneous rocks from the Piedmont, and the results of the XRD analyses support this hypothesis. Our data confirm that clay samples from Piedmont-spanning drainages are generally enriched in plagioclase relative to samples from Coastal Plain drainages (Figure 7.2, Table 7.1).

Physical Properties

Prehistoric potters selected clay resources on the basis of physical properties such as workability, shrinkage, and the hardness of ceramics made from them (Rice 1987:53). Identifying the relationship between these physical properties and mineralogy could therefore help us understand why potters selected resources from particular areas. It could also help us predict additional locations where suitable resources are likely to be found. Mineralogical trends in the performance data consequently merit consideration.

Workability. Smectitic clays are generally more plastic than kaolinite-rich clays (Rice 1987:60), and indeed our good and moderately lean samples typically contain higher proportions of 14Å minerals than our lean samples (Figure 7.4). As explained in Chapter 4, however, our sample of lean clays does not represent the entire study area: lean materials were collected in the Sandhills region only. Furthermore, lean clays make up the majority of that region's samples. Thus the apparent mineralogical distinction between lean and more workable samples may simply reflect mineralogical differences between the Sandhills and other regions. The fact that the clay mineralogy data do not help discriminate between moderately lean and good samples supports the idea that the pattern in Figure 7.4 may be spurious. Nonetheless, it is interesting to note that the most workable sample from the Sandhills is also the richest in 14Å clay minerals (FBR017).

Better separation between moderately lean and good samples is achieved when feldspar mineralogy is considered (Figure 7.5). In general, good clays contain proportionally more K-feldspar and less plagioclase than moderately lean clays. Even the Haw River samples, which demonstrate no regional patterning with respect to feldspar mineralogy, fit this general pattern. Three good Haw River samples (FBR035, FBR040, and FBR041) are K-feldspar-rich and plagioclase-poor, while two moderately lean samples (FBR029 and FBR030) are plagioclase-rich and lack K-feldspar. Before a definite relationship between feldspar mineralogy and workability of Carolina clays can be posited, however, additional samples, including representative lean ones, should be analyzed to discredit the possibility that the pattern in Figure 7.5 is fortuitous.

Hardness. The relationship between feldspar mineralogy and ceramic hardness resembles the relationship between feldspar and workability: hard samples tend to contain proportionally more K-feldspar and less plagioclase than soft samples (Figure 7.6). This is not surprising given that most clay samples with good workability also yielded hard test tiles (see Chapter 4). K-feldspar can act as a flux, and modern potters often add it to their clays to lower the temperature at which sintering begins, increase fired strength, and reduce porosity (Rice 1987:75). It is possible that K-feldspar had a similar effect on some of our samples, especially those that were fired at 950ºC and show evidence of vitrification.

Drying Shrinkage. Kaolinite- and illite-rich clays typically shrink less during drying than smectitic clays (Goffer 1980:Table 8.3; Rice 1987:Table 2.7), and this observation holds true for many of our samples (Figure 7.7). Clays exhibiting high shrinkage values also tend to contain low proportions of plagioclase (Figure 7.8). Plagioclase occurs in many of our samples as relatively coarse inclusions and thus presumably reduces shrinkage by increasing pore space.

Conclusions

The XRD data help explain the geochemical patterning discussed by Speakman, Glascock, and Steponaitis in Chapter 5. They also suggest that K-feldspar and 14Å clay minerals may have a positive effect on workability. If this conclusion is valid, additional workable samples are likely to be found in areas characterized by these minerals. In particular, suitable raw materials may have been available just east of the Sandhills in the K-feldspar-rich Cape Fear Formation. We therefore recommend that future efforts to find suitable clays near the Sandhills should focus on the portion of the Lower Little drainage that cuts through the Cape Fear Formation.

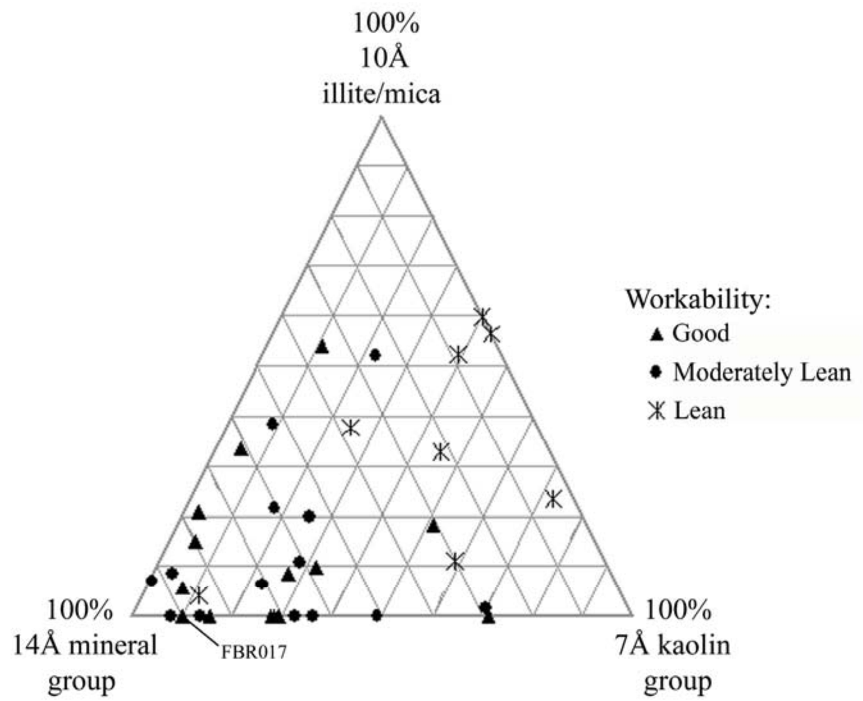


Figure 7.4. Clay samples plotted according to relative proportions of 10Å, 14Å, and 7Å minerals and arrayed by workability. The labeled sample is discussed in the text.

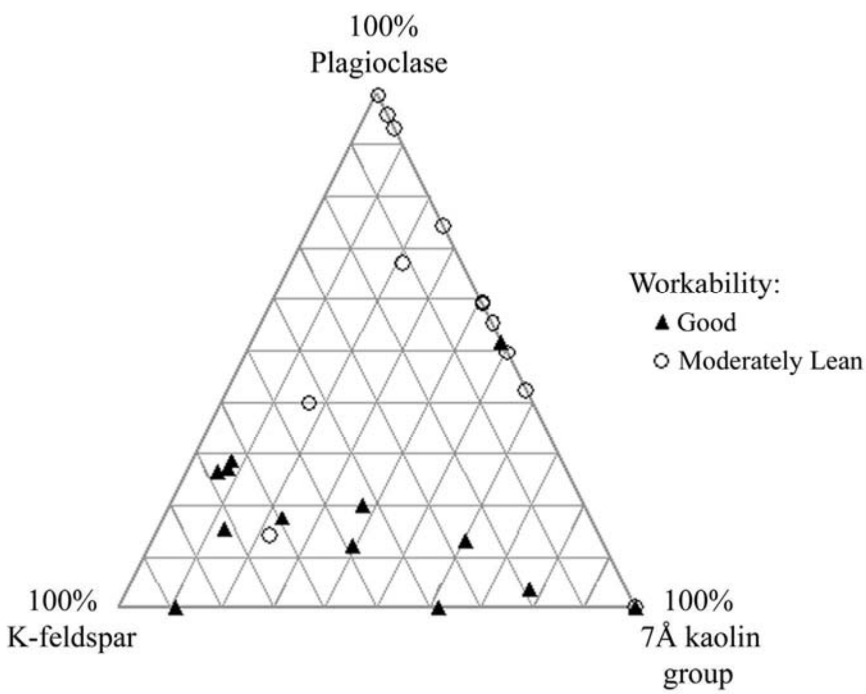


Figure 7.5. Good and moderately lean clay samples plotted according to relative proportions of plagioclase, K-feldspar, and 7Å minerals.

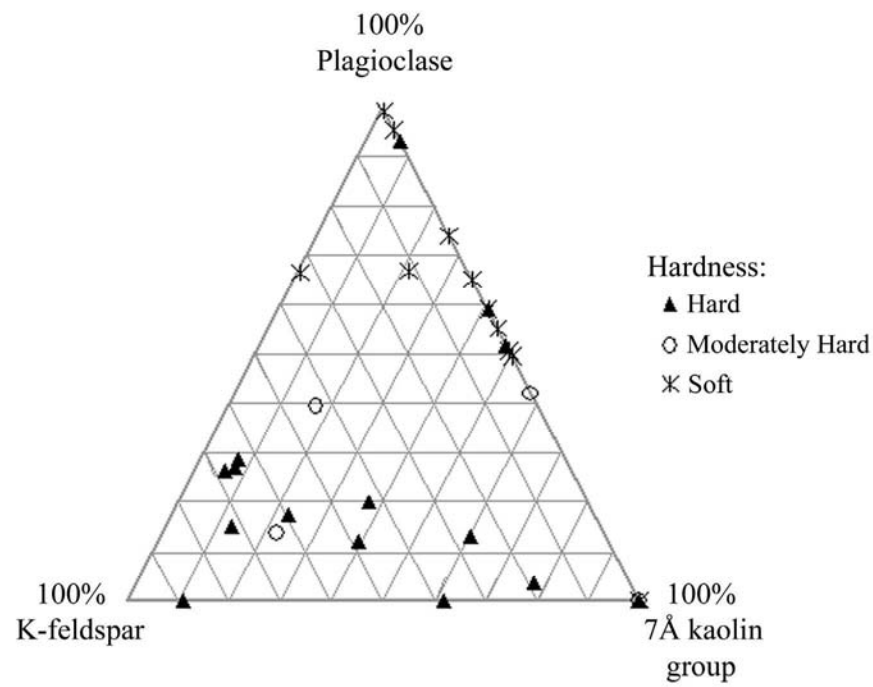


Figure 7.6. Clay samples plotted according to relative proportions of plagioclase, K-feldspar, and 7Å minerals and arrayed according to hardness.

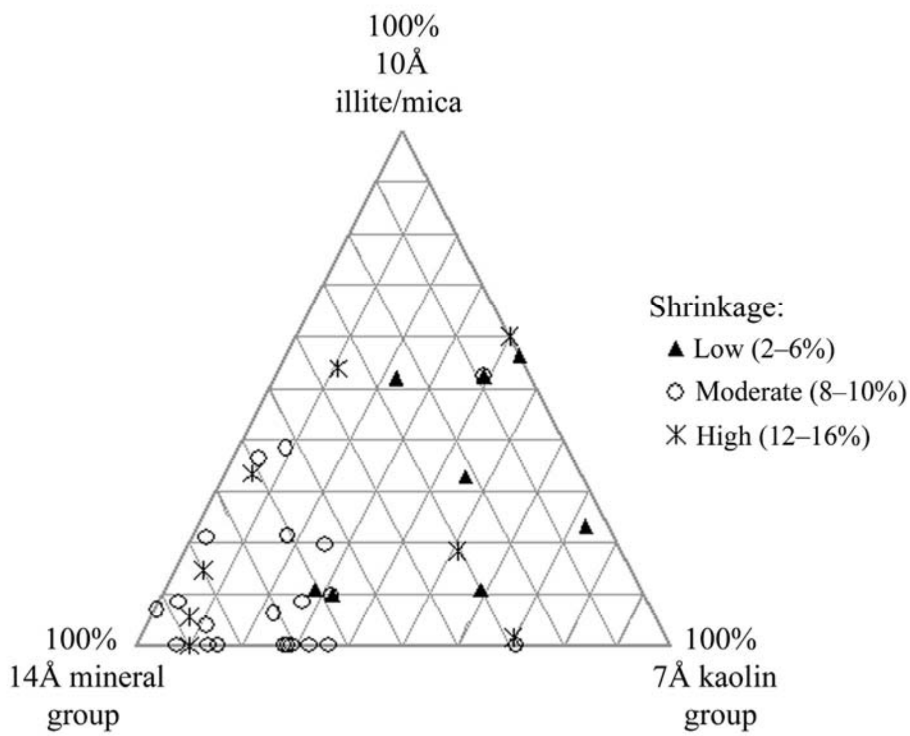


Figure 7.7. Clay samples plotted according to relative proportions of 10Å, 14Å, and 7Å minerals and arrayed according to linear drying shrinkage.

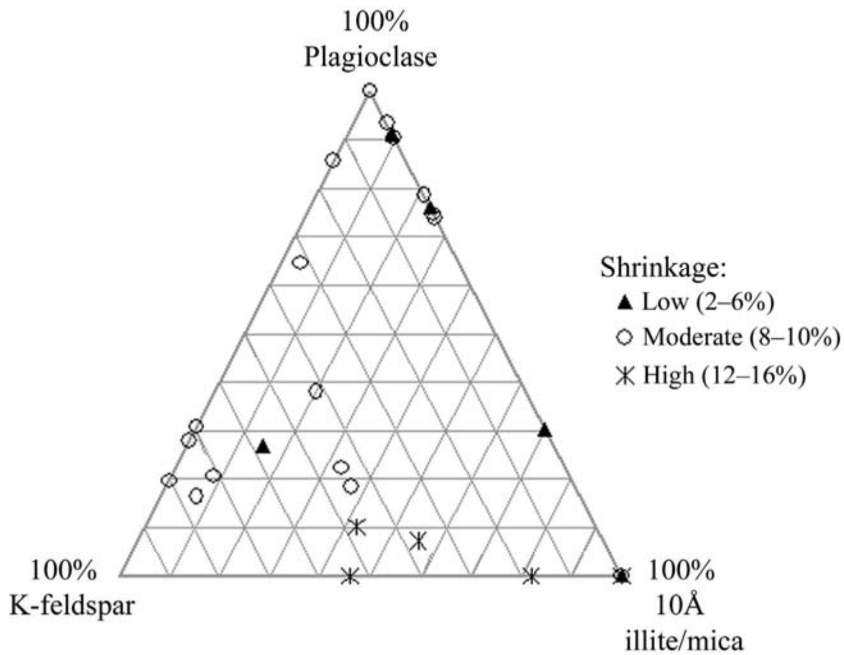


Figure 7.8. Clay samples plotted according to relative proportions of plagioclase, K-feldspar, and 10Å minerals and arrayed according to linear drying shrinkage.

Notes

Acknowledgments. We thank Charles W. Rovey for advice on applying the MIF procedure to the preferred-orientation data.

Chapter 8

Conclusions

Joseph M. Herbert and Theresa E. McReynolds

The goal of this study has been to identify the regional sources of raw materials used to manufacture Woodland-era ceramic vessels found on archaeological sites in and around the North Carolina Sandhills. To this end, pottery and clay samples from the Sandhills and adjacent regions of the Coastal Plain and Piedmont were collected and compared. The preceding chapters describe the results of analyses that reveal regional variation in the physical, geochemical, and mineralogical characteristics of the samples. This concluding chapter reviews the results of these various studies and brings in an additional line of evidence, the National Geochemical Survey database (United States Geological Survey 2004). The collective data are then evaluated in order to assign artifacts to geographic sources and address the archaeological implications of the study.

Clay Performance Trials

McReynolds and Herbert's performance trials in Chapter 4 assessed the suitability of 84 clay samples for making low-fired earthenware. The goal was to determine if serviceable clays would have been locally available to prehistoric potters in the Sandhills, and if not, to identify the nearest suitable resource area. On a more fundamental level, the research endeavored to clarify why Woodland potters selected particular resources and production techniques rather than others. A primary objective was thus to gain some understanding of the performance characteristics of the samples in order to recognize the technical and economic factors that may have influenced whether or not specific resources were selected for pottery making.

Workability tests designed to assess plasticity, stiffness, and strength allowed samples to be qualitatively described as lean, moderately lean, good, or fat. Replication experiments involved building and, in a few cases, drying and firing coil-built ceramic vessels. The results revealed that even clays exhibiting good workability and no excessive cracking, warping, or shrinkage during laboratory drying and firing still might not have the right combination of strength and plasticity for making pots.

In general, Sandhills samples performed worst while Coastal Plain samples from the Waccamaw and Pee Dee drainages performed best (Figure 8.1). The very best samples, however, came from the lower Haw drainage of the Piedmont. It is therefore unlikely that Sandhills materials were used to fashion the pottery found on Fort Bragg. More suitable resources are available to the north in the lower Haw drainage, to the east in the middle Cape Fear drainage, and to the south in the Waccamaw and Pee Dee drainages.

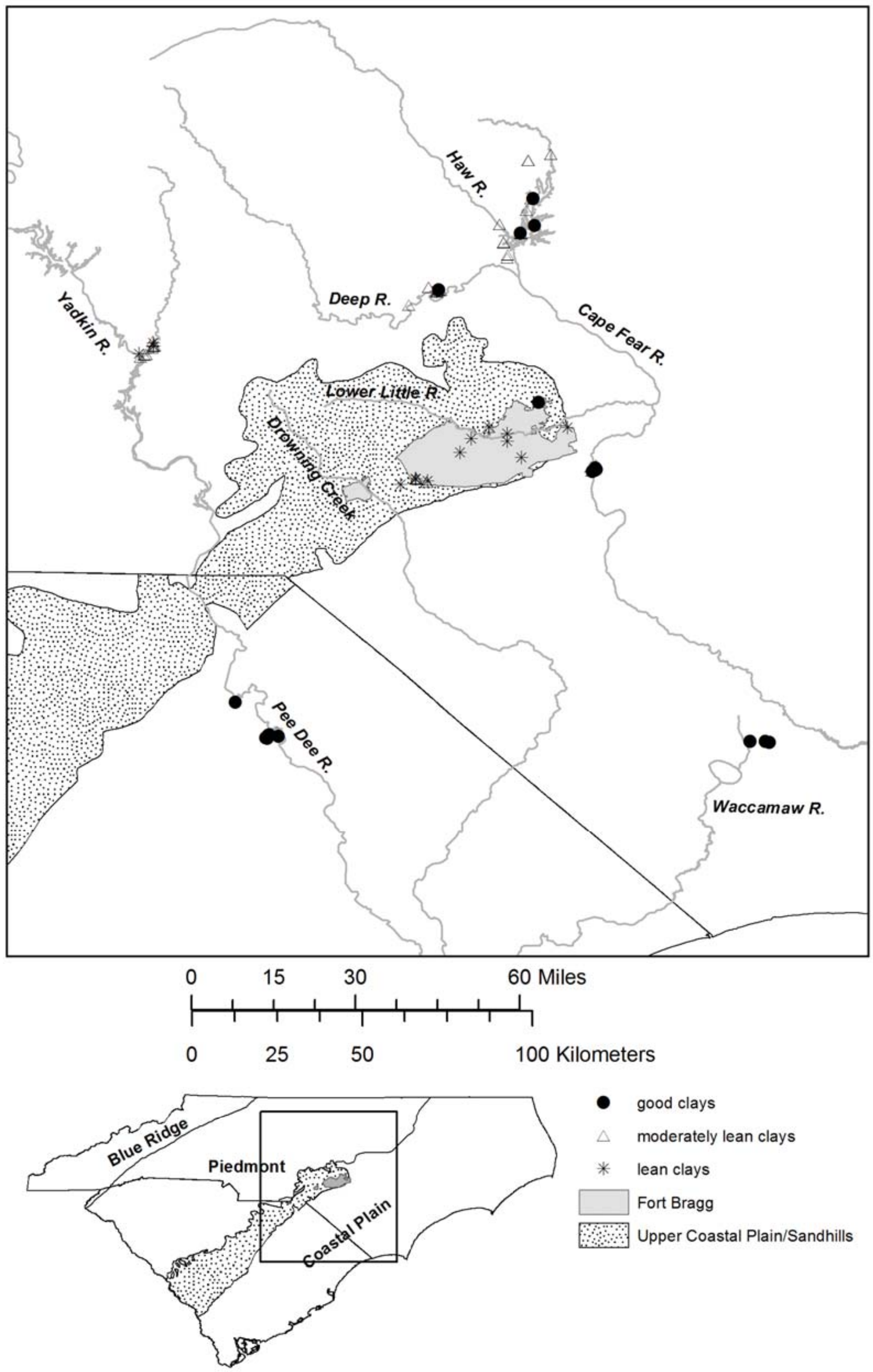


Figure 8.1. Clay sample locations and workability classes (United States Geological Survey 2002).

Neutron Activation Analysis

In Chapter 5, Speakman, Glascock, and Steponaitis described the elemental compositions of the ceramic and clay samples. Neutron activation analysis (NAA) provided elemental concentration values for 30 detectable elements in 70 ceramic samples and 42 clay samples, and these data were explored through standard statistical procedures to assess the similarities and differences among regions. Principal components analysis of the data set generated five chemical groups. Calcium (Ca), sodium (Na), and manganese (Mn) play an important role in discriminating the groups. Indeed, the groups are clearly visible in a simple scatter plot of Ca versus Na (Figure 8.2). Sixty-one of the 70 pottery specimens were assigned to a specific group, and the remaining nine were left unassigned (Table 8.1). A clear pattern emerged from the data indicating that the chemical signatures of Piedmont pottery samples are distinct from those of Coastal Plain samples. The NAA results can be summarized as follows:

- Piedmont pottery samples are assigned to Groups 1 and 2. Most fall into the latter, which is characterized by relatively high Ca, Na, and Mn concentrations. Petrographic analyses (Chapter 6) suggest that the Ca in these pottery samples comes from plagioclase mineral and rock fragments, some of which may have been added as temper.

- Coastal Plain pottery samples are assigned to Groups 3, 4, and 5. All of the assigned Breece site sherds from the middle Cape Fear drainage belong to Group 3 and have intermediate Ca and Na concentrations and low Mn concentrations. Most samples from the Kolb and Waccamaw sites in the Coastal Plain are assigned to Groups 4 and 5. Group 4 is characterized by high Ca concentrations and intermediate Na and Mn concentrations, while Group 5 exhibits low Ca and Mn concentrations and intermediate Na concentrations.

- Significantly, the Sandhills pottery samples exhibit the greatest chemical heterogeneity. Sandhills sherds are assigned to Groups 1, 2, 3, and 5.

If the chemical differences between Piedmont and Coastal Plain pottery samples reflect differences in local resources, then two possibilities exist for explaining the chemical heterogeneity exhibited in Sandhills pottery: (1) either local clay materials in the Sandhills are highly variable, with some similar to Piedmont resources and others similar to Coastal Plain resources, or (2) some or all of the pottery found in the Sandhills was made with resources procured from the Piedmont and Coastal Plain.

The chemical analysis of clay samples supports the latter possibility. Twenty of the 42 samples exhibited moderate to high probabilities of membership in the pottery groups (Table 8.2). Piedmont clays tend to be similar to the pottery in Group 2, as do Coastal Plain clays collected from alluvial deposits along the Pee Dee and Cape Fear Rivers, which originate in the Piedmont. In contrast, clay samples collected elsewhere in the Coastal Plain and in the Sandhills show low probabilities of membership in any of the pottery groups. Sandhills clays seem to be less chemically diverse than Sandhills pottery and quite distinct from Piedmont materials, suggesting a cultural interpretation for the diversity of chemical groups represented in the pottery from Fort Bragg.

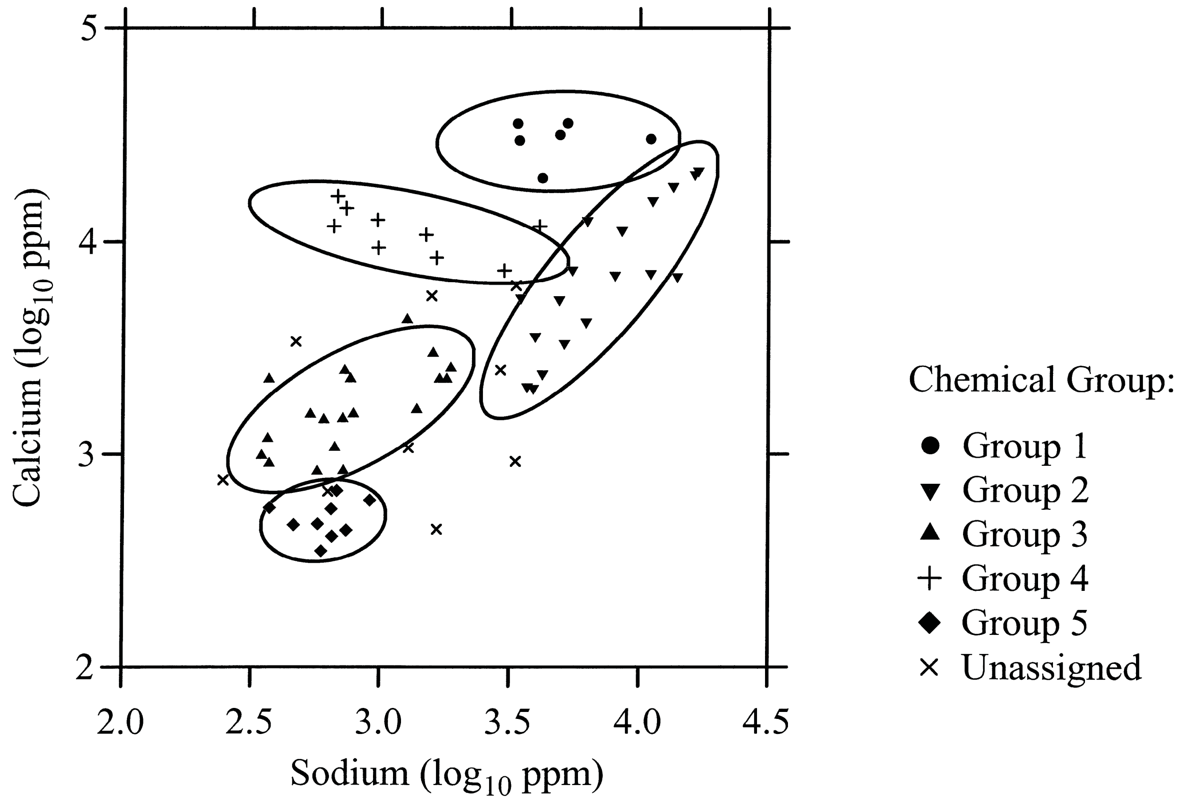


Figure 8.2. Scatter plot of Na and Ca concentrations for pottery samples, showing chemical groups. Confidence ellipses are drawn at the 80% level.

The chemical data for the clays make sense from a geological standpoint: the clays similar to Group 2 represent Piedmont sources and alluvium from Coastal Plain rivers that originate in the Piedmont. Nonetheless, comparing the clay data with the pottery data yields some surprising results. In particular, the discrepancies between Coastal Plain pottery samples (mostly in Groups 3–5) and clays (mostly similar to Group 2) raise the possibility that many of the sherds from the Breece, Kolb, and Waccamaw sites were not made from local resources. We defer a full discussion of the complex chemical relationship between pottery and clays until later in this chapter when we can consider it in combination with other lines of evidence.

Petrography

In Chapter 6, Smith reported the results of petrographic analysis of 70 archaeological pottery sherds and 53 clay test tiles. On the basis of these mineralogical data, the pottery and clay samples were assigned to three distinct petrographic groups. Group I samples have diabase (pyroxene + plagioclase) rock fragments. Group II samples contain quartz + feldspar rock fragments, quartz mineral fragments, and mafic mineral fragments. Group III samples include muscovite mica and quartz and generally lack mafic minerals. Groups II and III are divided into

Table 8.1. Assignment of Pottery Samples to Chemical Groups.[a]

Region: Drainage	Chemical Group 1	2	3	4	5	Unassigned	Total
Sandhills:							
Lower Little	1	2	5		2	2	12
Drowning Creek		1	2		3	2	8
Coastal Plain:							
Cape Fear			9			1	10
Pee Dee			1	6	2	1	10
Waccamaw			2	3	2	3	10
Piedmont:							
Haw	2	8					10
Yadkin	3	7					10
	6	18	19	9	9	9	70

[a] Based on NAA. Group assignments taken from Table 5.4.

subgroups based on variation in mafic mineral components and the presence of argillaceous clay clots, respectively.

Sixty-seven of the 70 pottery specimens could be assigned to a specific petrographic group (Table 8.3). As with the chemical data, a clear pattern emerges indicating that the mineralogical characteristics of Piedmont pottery samples are different from those of Coastal Plain samples. The petrographic data can be summarized as follows:

- Piedmont pottery samples contain Ca-rich plagioclase, pyroxene, and amphibole and are assigned to petrographic Groups I or II. Most fall into Group IIB, characterized by quartz + feldspar rock fragments without mafic mineral components.

- With one exception, Coastal Plain pottery samples are assigned to quartz-rich Group III. Most contain argillaceous clay clots and are classified in Group IIIA.

- Interestingly, most Sandhills pottery samples also fall into petrographic Group III.

These petrographic data may reflect differences in local Piedmont and Coastal Plain resources. Indeed, the petrographic analysis of clay samples bolsters this hypothesis (Table 8.4). Thirty-eight of the 42 clay samples could be tentatively assigned to a petrographic group, and with few exceptions the clay data mirror the pottery data: most Piedmont clay samples fall into Group II, while Coastal Plain and Sandhills clay samples fall into Group III.

In contrast to the chemical data, then, the petrographic data indicate that Sandhills sherds are mineralogically similar to Coastal Plain samples but generally distinct from Piedmont samples. We will explore this apparent contradiction below in light of additional mineralogical and chemical data.

Table 8.2. Affinities of Clay Samples to Chemical Groups.[a]

Region: Drainage	Most Similar Chemical Group[b] 1	2	3	4	5	No Similar Group[c]	Total
Sandhills:							
Lower Little	-	-	-	-	-	12	12
Coastal Plain:							
Cape Fear	-	5	-	-	-	-	5
Pee Dee	-	4	-	-	-	1	5
Waccamaw	-	-	-	-	-	5	5
Piedmont:							
Haw	-	2	-	-	-	3	5
Yadkin	-	5	-	-	-	-	5
Deep	-	4	-	-	-	1	5
	0	20	0	0	0	22	42

[a] Based on NAA, full data set (Table 5.5).
[b] Mahalanobis probability of membership is moderate to high (greater than 20%).
[c] Mahalanobis probability of membership is low for all groups (less than 20%).

X-Ray Diffraction

In Chapter 7, McReynolds, Skaggs, and Schroeder described the mineralogy of clay samples as determined by X-ray diffraction (XRD). They used the Mineral Intensity Factor 100% approach (MIF) to obtain semi-quantitative measurements of quartz, lepidocrocite, gibbsite, plagioclase, K-feldspar, amphibole, and clay minerals in 39 samples.

The resulting data help explain the geochemical patterns seen in the NAA data (Chapter 5). They confirm that the high Ca content of chemical Group 2 samples comes from plagioclase derived from Piedmont rocks. They also suggest that clay samples exhibiting good workability and superior hardness contain proportionally more K-feldspar than less suitable samples.

National Geochemical Survey

The National Geochemical Survey (NGS) database contains concentration values for 40 elements detected in stream-sediment samples from across the United States. These data were reported by a variety of agencies employing standardized sampling techniques and analytical methods, including NAA and inductively coupled plasma-atomic emission spectrometry (ICP-AES; United States Geological Survey 2004). Although the NGS data are not comparable to the geochemical data reported here in absolute terms, as the methods and standards of data collection were different, the data can be compared in a general way by looking at patterns of relative abundance. The NGS samples for North Carolina (n = 646) and South Carolina (n = 1,335) are comprehensive and allowed us to generate element distribution maps demonstrating significant geochemical distinctions among the Piedmont, Coastal Plain, and Sandhills regions (Figures 8.3–

Table 8.3. Assignment of Pottery Samples to Petrographic Groups.[a]

Region: Drainage	Petrographic Group I	IIA	IIB	IIIA	IIIB	Unassigned	Total
Sandhills:							
Lower Little	1	-	-	10	1	-	12
Drowning Creek	-	-	2	5	1	-	8
Coastal Plain:							
Cape Fear	-	-	-	9	1	-	10
Pee Dee	-	-	-	6	2	2	10
Waccamaw	-	-	1	3	5	1	10
Piedmont:							
Haw	2	2	6	-	-	-	10
Yadkin	1	4	5	-	-	-	10
	4	6	14	33	10	3	70

[a] Based on petrography. Group assignments taken from Table 6.2.

Table 8.4. Assignment of Clay Samples to Petrographic Groups.[a]

Region: Drainage	Petrographic Group I	II	III	Unassigned	Total
Sandhills:					
Lower Little	-	1	7	4	12
Coastal Plain:					
Cape Fear	-	-	5	-	5
Pee Dee	-	-	5	-	5
Waccamaw	-	-	5	-	5
Piedmont:					
Haw	-	5	-	-	5
Yadkin	-	3	2	-	5
Deep	-	5	-	-	5
	0	14	24	4	42

[a] Based on petrography. Group assignments taken from Table 6.3.

8.7). Comparing these maps to the data reported in Chapter 5 reveals general agreement between the two data sets, indicating that the NGS data can provide an additional line of evidence to inform the assignment of pottery artifacts to specific source areas.

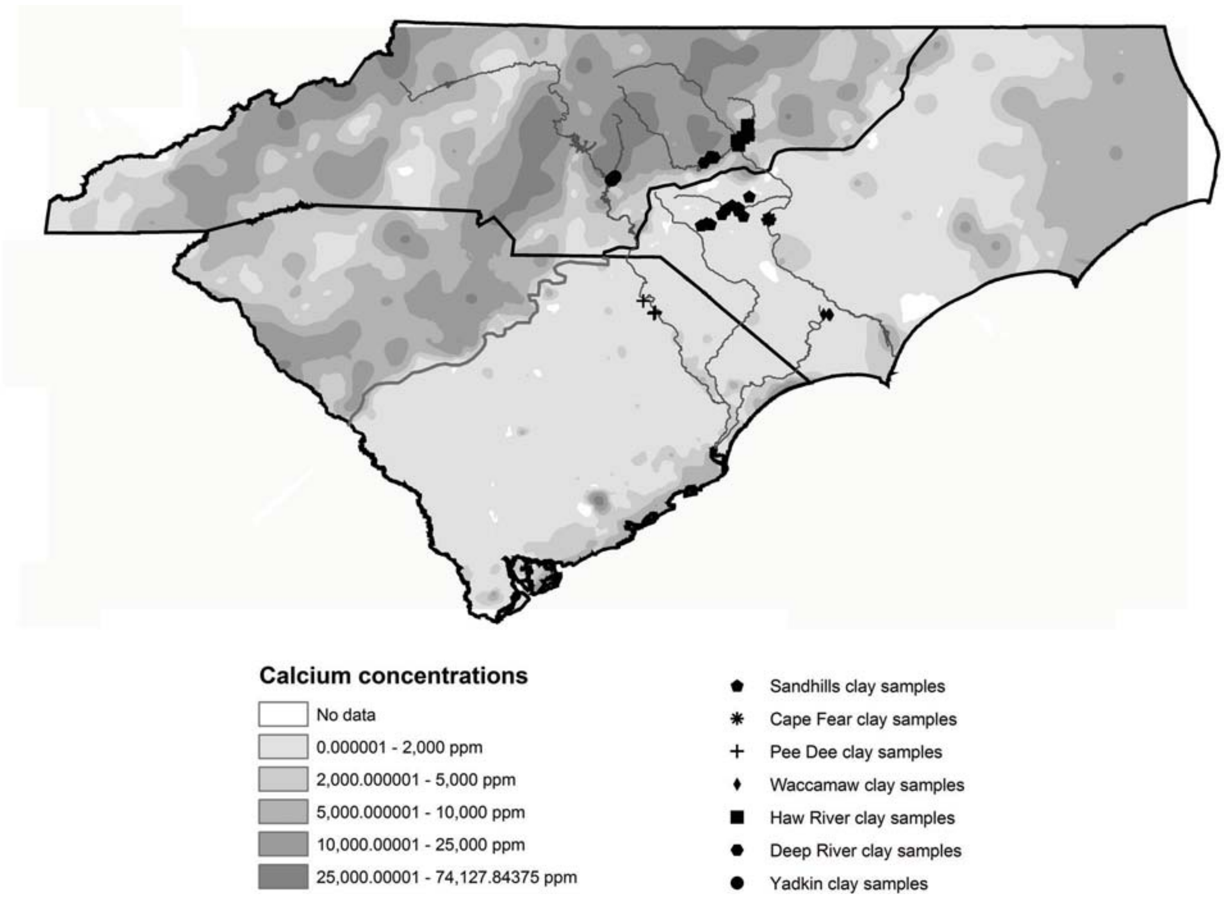


Figure 8.3. Interpolated Ca concentration map prepared by kriging ICP-AES data found in the National Geochemical Survey database (United States Geological Survey 2002, 2004).

The NGS data demonstrate that the Piedmont and Coastal Plain are clearly distinguishable with respect to concentrations of Ca, Na, and Mn, the same three elements that play the largest roles in defining the five chemical groups identified in Chapter 5 (Figures 8.3–8.5). In particular, the Slate Belt region of the Piedmont has very high concentrations of these three elements relative to the Coastal Plain. The Sandhills region is further distinguished by high concentrations of samarium (Sm) and thorium (Th) relative to the lower Coastal Plain and Piedmont regions (Figures 8.6–8.7).

The NAA data on our clay samples reveal similar patterns. In general, the highest average concentrations of Ca, Na, and Mn are found in Piedmont samples from the Yadkin and Deep drainages, while the lowest average concentrations of these three elements are found in samples from the Sandhills (Table 8.5). Sandhills samples also exhibit the highest Sm and Th concentrations. Notably, clays from the Piedmont-originating Cape Fear and Pee Dee drainages exhibit higher relative concentrations of Ca, Na, and Mn than the NGS data predict. However, these discrepancies are easily explained: the NGS database primarily includes samples from low-order streams containing only local sediments, while the clay samples analyzed for this study represent higher-order rivers with sediments transported from far upstream.

General similarities between the NGS sediment data and our clay data indicate that, despite its small size, our clay sample reflects at least some of the regional differences in elemental

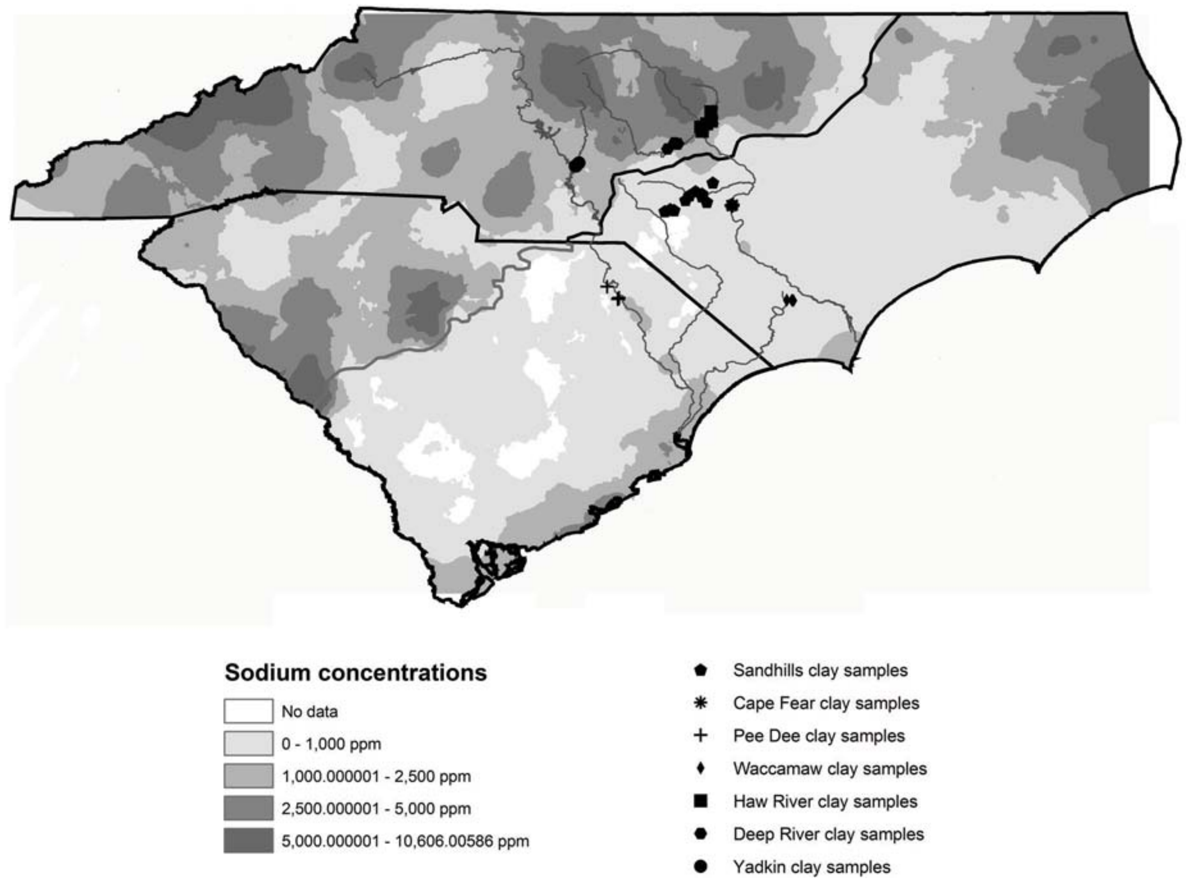


Figure 8.4. Interpolated Na concentration map prepared by kriging NAA data found in the National Geochemical Survey database (United States Geological Survey 2002, 2004).

composition. Concentration values for Ca, Na, Mn, Sm, and Th may be especially useful for discriminating among regions, and we draw upon these results in the following discussion.

Discussion

The various lines of evidence point to broad geographic source areas that correspond to the Piedmont and Coastal Plain physiographic provinces. The following discussion integrates the evidence to help us better understand the relationships between pottery and clay samples from each region. We then propose the most likely geographic area of origin for each of the 70 pottery samples.

Based solely on the pottery samples, there appears to be a relatively unambiguous relationship between chemical and petrographic group assignments (Table 8.6). With the exception of four samples, the data reveal the following general patterns:

- Petrographic Group I is associated with chemical Group 1. Three of the four pottery samples assigned to these groups are from Piedmont sites, while the fourth is from the Lower Little drainage in the Sandhills.

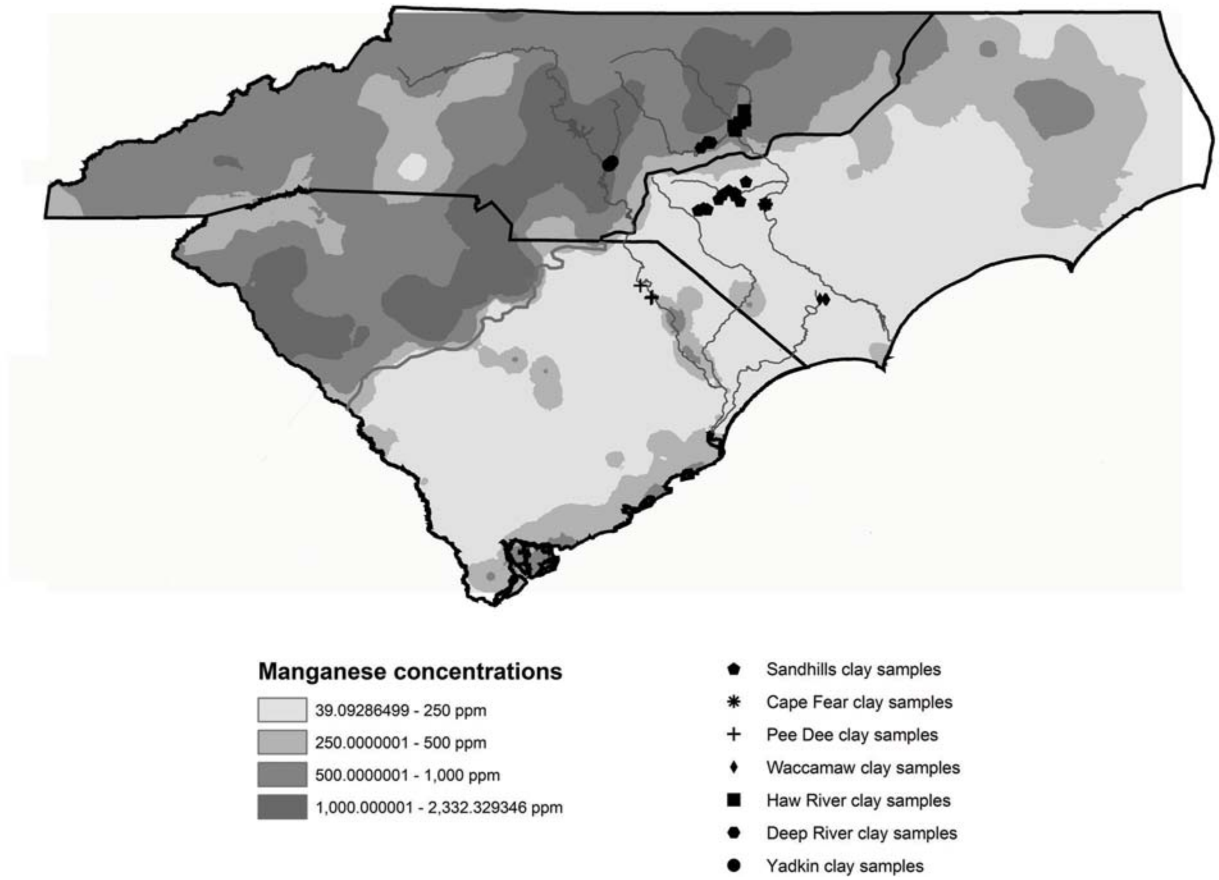


Figure 8.5. Interpolated Mn concentration map prepared by kriging ICP-AES data found in the National Geochemical Survey database (United States Geological Survey 2002, 2004).

- Petrographic Groups IIA and IIB are primarily associated with chemical Groups 1 and 2. Samples assigned to these groups are from Piedmont sites.

- Petrographic Groups IIIA and IIIB are primarily associated with chemical Groups 3, 4, and 5. Samples assigned to these groups represent sites in the Coastal Plain and Sandhills.

If these patterns reflect the use of local resources, the clay data should exhibit similar patterns. Accordingly, Piedmont clay samples should classify as petrographic Group I or II and chemical Group 1 or 2, while Coastal Plain samples should classify as petrographic Group III and chemical Group 3, 4, or 5. In fact, the relationship between petrographic and chemical group assignments for the clay samples is more complicated. As predicted, Piedmont clay samples are assigned to petrographic Group II and chemical Group 2, and Coastal Plain samples are assigned to petrographic Group III (Tables 8.2 and 8.4). Contrary to predictions, however, most Coastal Plain clay samples fall into chemical Group 2 (Table 8.2).

Although the assignment of Coastal Plain clay samples to chemical Group 2 is unexpected, it makes sense when the XRD data are considered. The seemingly problematic clay samples generally represent Coastal Plain drainages with Piedmont origins, and the XRD data suggest

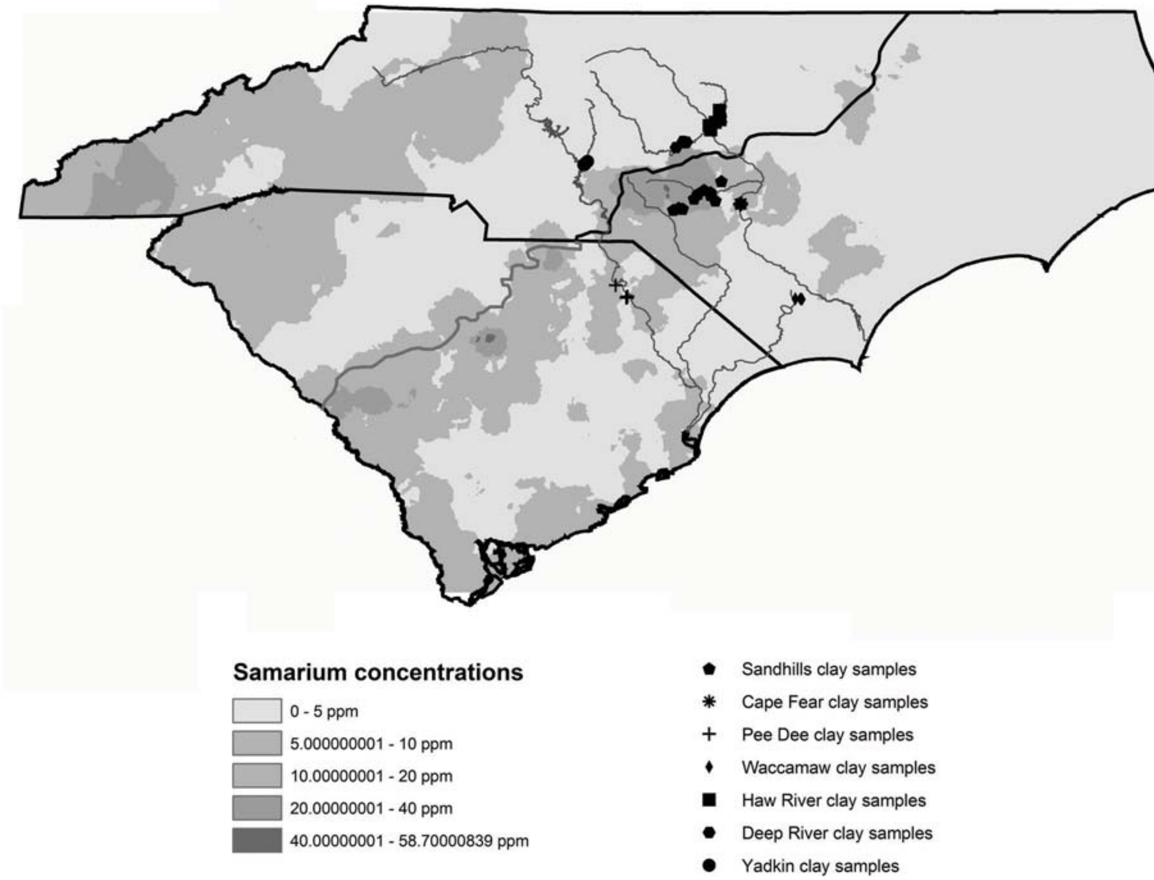


Figure 8.6. Interpolated Sm concentration map prepared by kriging NAA data found in the National Geochemical Survey database (United States Geological Survey 2002, 2004).

Piedmont-derived, Ca-rich plagioclase is responsible for the chemical Group 2 classification. Clay samples from drainages restricted to the Coastal Plain lack plagioclase and show little chemical similarity to any of the pottery groups.

These results indicate that the petrographic data let us broadly distinguish between Piedmont (Group II) and Coastal Plain (Group III) samples. The chemical data, on the other hand, allow discrimination between resources from the Piedmont and drainages originating in the Piedmont (Groups 1–2) and those from drainages restricted to the Coastal Plain (Groups 3–5). With this in mind, we now consider the pottery samples from each region and attempt to attribute them to specific geographic areas of origin.

Piedmont Pottery Samples

Most Piedmont pottery samples are assigned to chemical Group 2 and petrographic Group II. As discussed previously, our Piedmont clay samples are chemically most similar to Group 2 and typically assigned to petrographic Group II. The most straightforward reading of this evidence is that pottery found at the Doerschuk and Haw River sites was generally made from local resources (Table 8.7).

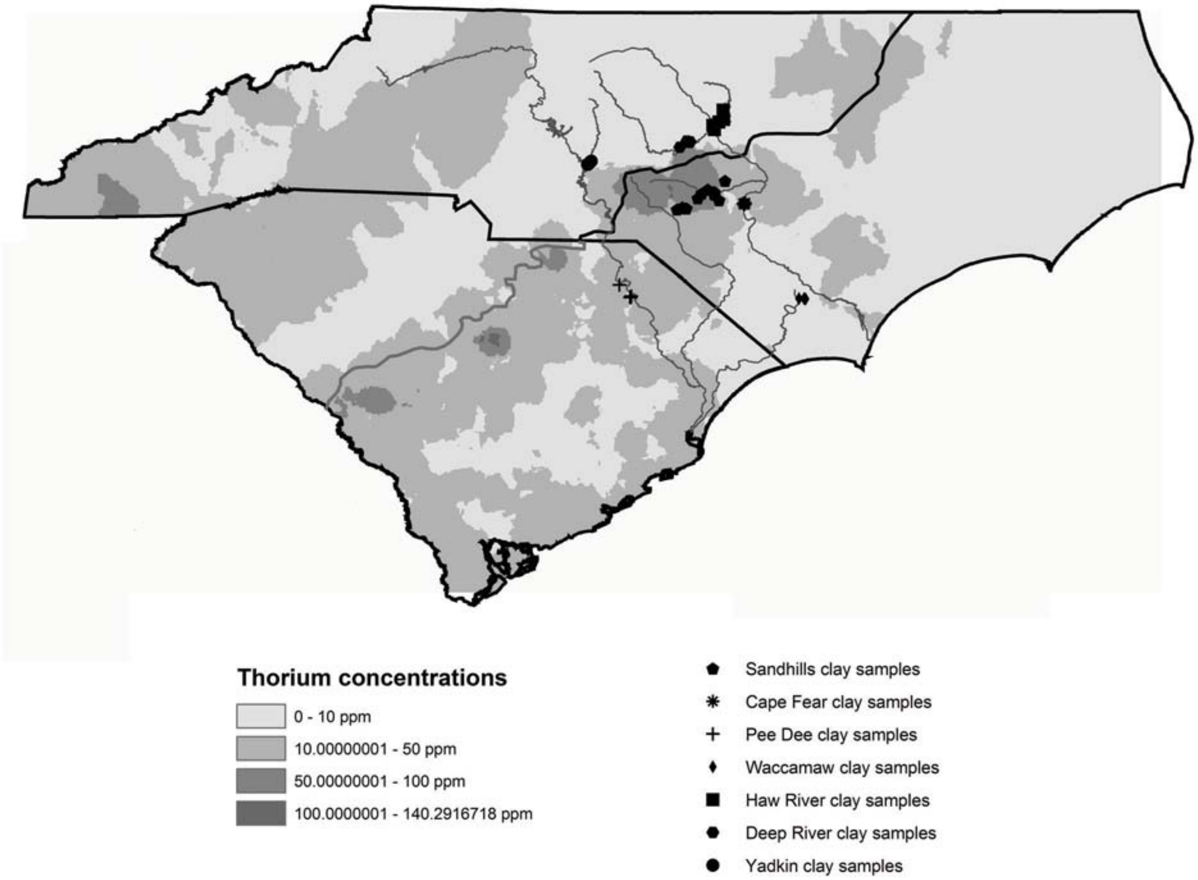


Figure 8.7. Interpolated Th concentration map prepared by kriging NAA data found in the National Geochemical Survey database (United States Geological Survey 2002, 2004).

Table 8.5. Mean Concentrations of Select Elements in Clay Samples by Drainage.[a]

Region: Drainage	Ca (ppm)	Na (ppm)	Mn (ppm)	Sm (ppm)	Th (ppm)
Sandhills:					
Lower Little	106.9	386.4	54.60	9.4510	14.8333
Drowning Creek	0.0	391.2	31.81	8.1630	22.4766
Coastal Plain:					
Cape Fear	2182.3	4293.9	668.20	4.6340	8.5305
Pee Dee	2628.0	3281.3	575.20	7.9030	13.1709
Waccamaw	3160.0	460.2	55.00	3.5350	8.0947
Piedmont:					
Haw	2670.3	3103.5	361.30	2.7830	10.9907
Yadkin	7809.6	3568.0	1431.40	4.9690	5.8311
Deep	4448.7	7230.6	511.60	5.5740	7.9631

[a] Based on NAA. Data from Tables C.1–C.3.

Table 8.6. Cross Tabulation of Chemical and Petrographic Groups for Pottery Samples.[a]

	Chemical Group				
Petrographic Group	1	2	3	4	5
I	4	-	-	-	-
IIA	2	4	-	-	-
IIB	-	11	1	-	-
IIIA	-	3	15	6	5
IIIB	-	-	3	3	2

[a] The dotted lines divide predominantly Piedmont groups from predominantly Coastal Plain groups. Generally, the upper left quadrant contains pottery made in the Piedmont, the lower left quadrant contains pottery made in the Coastal Plain from Piedmont-derived alluvial clays, and the lower right quadrant contains pottery made in the Coastal Plain from other kinds of clays.

Five Piedmont pottery samples are assigned to chemical or petrographic groups that are not similar to any of the clay samples we collected (JMH031, JMH032, JMH034, JMH046, JMH047; see Table 8.7). In three of these cases (JMH031, JMH046, JMH047), diabase inclusions account for the petrographic Group I assignment. Because the crushed diabase in these sherds was probably added as temper, the chemical differences between the pottery and local clays are to be expected. Smith's comparison of the inclusions with diabase from the eastern Piedmont suggests that these three samples were made from locally obtained Piedmont resources (Chapter 6).

In the cases of samples JMH032 and JMH034 from the Doerschuk site, stylistic evidence suggests Piedmont sources. These pottery samples are typologically classified as Dan River Simple Stamped and Jenrette Plain, respectively. Both types are associated with the Piedmont Dan and Eno River basins, about 80–120 km northeast of the Doerschuk site. Because the Group II petrographic assignments for these sherds are also consistent with Piedmont sources, a Piedmont origin is proposed for both samples.

In addition, Ca, Na, Mn, Sm, and Th concentration values for these five samples are consistent with Piedmont origins. As the NGS data for Piedmont sediments predict, the samples exhibit relatively high concentrations of Ca, Na, and Mn and relatively low concentrations of Sm and Th.

Coastal Plain Pottery Samples

The complex relationship between chemical and petrographic group assignments for Coastal Plain clays makes it more difficult to attribute pottery samples to specific source areas. Petrographic Group III assignments for most sherds are consistent with Coastal Plain origins, but the chemical data are problematic. None of the 30 Coastal Plain sherds match local clay samples

Table 8.7. Proposed Source Assignments for Piedmont Pottery Samples.

Sample ID	Site	Drainage	Pottery Type	Period	Chemical Group	Petrographic Group	Proposed Source Area
JMH031	Doerschuk	Yadkin	Yadkin Fabric Impressed	Middle Woodland	1	I	Piedmont
JMH032	Doerschuk	Yadkin	Dan River Simple Stamped	Late Woodland	1	IIA	Piedmont (Dan or Eno drainage?)
JMH033	Doerschuk	Yadkin	Yadkin Fabric Impressed	Middle Woodland	2	IIA	Piedmont
JMH034	Doerschuk	Yadkin	Jenrette Plain (Bruton?)	Contact	1	IIA	Piedmont (Dan or Eno drainage?)
JMH035	Doerschuk	Yadkin	New River Cord Marked	Early Woodland	2	IIB	Piedmont
JMH036	Doerschuk	Yadkin	New River Net Impressed	Early Woodland	2	IIB	Piedmont
JMH037	Doerschuk	Yadkin	Yadkin Check Stamped	Middle Woodland	2	IIB	Piedmont
JMH038	Doerschuk	Yadkin	Yadkin Cord Marked	Middle Woodland	2	IIB	Piedmont
JMH039	Doerschuk	Yadkin	Dan River Net Impressed	Late Woodland	2	IIB	Piedmont
JMH040	Doerschuk	Yadkin	Yadkin Net Impressed	Middle Woodland	2	IIA	Piedmont
JMH041	Haw River	Haw	Yadkin Paddle-edge Stamped	Middle Woodland	2	IIB	Piedmont
JMH042	Haw River	Haw	Yadkin Cord Marked	Middle Woodland	2	IIB	Piedmont
JMH043	Haw River	Haw	Yadkin Plain	Middle Woodland	2	IIB	Piedmont
JMH044	Haw River	Haw	Cape Fear Fabric Impressed	Middle Woodland	2	IIB	Piedmont
JMH045	Haw River	Haw	Yadkin Plain	Middle Woodland	2	IIA	Piedmont
JMH046	Haw River	Haw	Yadkin Plain	Middle Woodland	1	I	Piedmont
JMH047	Haw River	Haw	Yadkin eroded	Middle Woodland	1	I	Piedmont
JMH048	Haw River	Haw	Yadkin Plain	Middle Woodland	2	IIA	Piedmont
JMH049	Haw River	Haw	Yadkin Plain	Middle Woodland	2	IIB	Piedmont
JMH050	Haw River	Haw	Yadkin eroded	Middle Woodland	2	IIB	Piedmont

Table 8.8. Proposed Source Assignments for Coastal Plain Pottery Samples.

Sample ID	Site	Drainage	Pottery Type	Period	Chemical Group	Petrographic Group	Proposed Source Area
JMH021	Breece	Cape Fear	Hanover II Paddle-edge Stamped	Middle Woodland	3	IIIA	Coastal Plain
JMH022	Breece	Cape Fear	New River Fabric Impressed	Early Woodland	3	IIIB	Coastal Plain
JMH023	Breece	Cape Fear	Hanover II Fabric Impressed	Middle-Late Woodland	3	IIIA	Coastal Plain
JMH024	Breece	Cape Fear	Hanover II Fabric Impressed	Middle-Late Woodland	3	IIIA	Coastal Plain
JMH025	Breece	Cape Fear	Cape Fear Cord Marked	Middle Woodland	3	IIIA	Coastal Plain
JMH026	Breece	Cape Fear	Hanover II Fabric Impressed	Middle Woodland	-	IIIA	Coastal Plain
JMH027	Breece	Cape Fear	Hanover I Fabric Impressed	Middle Woodland	3	IIIA	Coastal Plain
JMH028	Breece	Cape Fear	Hanover I Fabric Impressed	Middle Woodland	3	IIIA	Coastal Plain
JMH029	Breece	Cape Fear	Hanover I Fabric Impressed	Middle Woodland	3	IIIA	Coastal Plain
JMH030	Breece	Cape Fear	Hanover II Fabric Impressed	Middle-Late Woodland	3	IIIA	Coastal Plain
JMH051	Kolb	Pee Dee	Yadkin Fabric Impressed	Middle Woodland	5	-	Coastal Plain
JMH052	Kolb	Pee Dee	Yadkin/Hanover Fabric Impressed (with grog)	Middle Woodland	5	-	Coastal Plain
JMH053	Kolb	Pee Dee	Yadkin Cord Marked	Middle Woodland	-	IIIA	Coastal Plain
JMH054	Kolb	Pee Dee	New River Cord Marked	Early Woodland	3	IIIA	Coastal Plain
JMH055	Kolb	Pee Dee	Yadkin Cord Marked	Middle Woodland	4	IIIB	Coastal Plain
JMH056	Kolb	Pee Dee	New River Fabric Impressed	Early Woodland	4	IIIA	Coastal Plain
JMH057	Kolb	Pee Dee	New River Cord Marked	Early Woodland	4	IIIB	Coastal Plain
JMH058	Kolb	Pee Dee	Cape Fear Fabric Impressed	Late Middle Woodland	4	IIIA	Coastal Plain
JMH059	Kolb	Pee Dee	Cape Fear Fabric Impressed	Late Middle Woodland	4	IIIA	Coastal Plain
JMH060	Kolb	Pee Dee	Hanover I Fabric Impressed	Middle Woodland	4	IIIA	Coastal Plain
JMH061	Waccamaw	Waccamaw	Thoms Creek Punctate	Early Woodland	4	IIIA	Coastal Plain
JMH062	Waccamaw	Waccamaw	Cape Fear Fabric Impressed	Late Middle Woodland	4	IIIB	Coastal Plain
JMH063	Waccamaw	Waccamaw	Hanover II Fabric Impressed	Late Woodland	4	IIIA	Coastal Plain
JMH064	Waccamaw	Waccamaw	Hanover II Fabric Impressed	Late Woodland	-	IIIB	Coastal Plain
JMH065	Waccamaw	Waccamaw	Hanover I Fabric Impressed	Middle Woodland	3	IIIA	Coastal Plain
JMH066	Waccamaw	Waccamaw	Cape Fear Fabric Impressed	Late Middle Woodland	-	IIIB	Coastal Plain
JMH067	Waccamaw	Waccamaw	Cape Fear Fabric Impressed	Late Middle Woodland	3	IIB	-
JMH068	Waccamaw	Waccamaw	Hanover eroded	Middle Woodland	-	-	-
JMH069	Waccamaw	Waccamaw	Cape Fear Fabric Impressed	Late Middle Woodland	5	IIIB	Coastal Plain
JMH070	Waccamaw	Waccamaw	Cape Fear Fabric Impressed	Late Middle Woodland	5	IIIB	Coastal Plain

with respect to both chemistry and mineralogy. Nevertheless, the available data may be used to propose general source areas for most Coastal Plain sherds (Table 8.8).

The Breece site pottery samples are all assigned to chemical Group 3 and petrographic Group III, suggesting a single, Coastal Plain source (Table 8.8). However, because all five clay samples collected near the Breece site are most similar to chemical Group 2, it is likely that the source used by prehistoric potters lies outside the site's immediate environs.

One possible nearby source for the Breece site pottery samples is suggested by the nineteenth-century manufacture of stoneware from sedimentary clay mined at the "Poe & Bros." yard in Fayetteville (Ries 1897:110–111). Although the Poe clay bed was primarily used for brickmaking, some portion contained very smooth clay without iron stains that was used for pottery making. The Poe clay mine was not discovered during this study, but its general location indicates the presence of good quality clay about 10 km from the Breece site.

Most pottery samples from the Kolb and Waccamaw sites are assigned to petrographic Group III and chemical Groups 3, 4, or 5 (Table 8.8). This suggests pottery found at these two sites was constructed from Coastal Plain resources, and stylistic evidence generally supports this conclusion. Six Kolb sherds and all of the Waccamaw sherds are classified to Coastal Plain pottery types.

Four Kolb sherds were classified to the Yadkin series on the basis of crushed-quartz temper (JMH051–JMH053, JMH055). The Yadkin series is typically found in the Piedmont and occasionally in the Sandhills. Nevertheless, the geochemical and petrographic characteristics of these four specimens are consistent with Coastal Plain resources. Interestingly, samples JMH051 and JMH052 are geochemically and petrographically distinct from the other Kolb sherds, indicating that they were likely made from different resources. It is not difficult to imagine the significance of the Pee Dee River as a prehistoric transportation corridor, and it may be that both pots and pottery making traditions moved along this major waterway.

Clearly, the exact source locations for the resources used to make most of the Kolb and Waccamaw pottery were not identified in this study. Although it is possible that constituents of sand or grog added as temper may have influenced the chemical composition of the pottery samples, a more likely explanation is that the specific clay sources that were used prehistorically are not represented by the clay samples collected for this study.

Sandhills Pottery Samples

Sandhills pottery samples exhibit more mineralogical and chemical variability than Sandhills clays, which are primarily assigned to petrographic Group III. It is tempting to speculate that the seven pottery samples classified as chemical Group 3 and petrographic Group III were made with local Sandhills materials, but it is important to recall that this study did not identify a single suitable clay sample in the Sandhills region despite intensive searching (see Chapter 4). Moreover, Sm and Th concentrations for Sandhills sherds are not as elevated as would be expected if they were made from Sandhills resources.

Petrographic assignments to Group III suggest that most Sandhills pottery samples were made from Coastal Plain resources, and stylistic attributes support this conclusion (Table 8.9). The 12 samples assigned to chemical Groups 3 or 5 almost certainly came from the Coastal Plain. Samples JMH003, JMH008, and JMH016 are classified as chemical Group 2 and may have come from Coastal Plain drainages originating in the Piedmont or from the Piedmont itself, but the former interpretation is favored given that they are classified to series characteristic of the

Table 8.9. Proposed Source Assignments for Sandhills Pottery Samples.

Sample ID	Site	Drainage	Pottery Type	Period	Chemical Group	Petrographic Group	Proposed Source Area
JMH001	31Hk868	Lower Little	Hanover II Fabric Impressed	Middle-Late Woodland	-	IIIA	Coastal Plain
JMH002	31Ht392	Lower Little	Hanover II Fabric Impressed	Middle-Late Woodland	3	IIIA	Coastal Plain
JMH003	31Ht273	Lower Little	Cape Fear III Fabric Impressed	Middle-Late Woodland	2	IIIA	Coastal Plain (Piedmont drainage)
JMH004	31Hk127	Lower Little	Hanover II Fabric Impressed	Middle-Late Woodland	3	IIIA	Coastal Plain
JMH005	31Hk59	Lower Little	Hanover I Cord Marked	Middle Woodland	3	IIIA	Coastal Plain
JMH006	31Hk123	Lower Little	Yadkin Fabric Impressed	Middle Woodland	1	I	Piedmont
JMH007	31Cd750	Lower Little	Hanover I Paddle-edge Stamped	Early Woodland	-	IIIA	Coastal Plain
JMH008	31Ht269	Lower Little	Mount Pleasant Cord Marked	Middle Woodland	2	IIIA	Coastal Plain (Piedmont drainage)
JMH009	31Cd486	Lower Little	Cape Fear Cord Marked	Middle Woodland	5	IIIA	Coastal Plain
JMH010	31Hk715	Lower Little	Hanover Fabric Impressed	Middle Woodland	3	IIIA	Coastal Plain
JMH011	31Mr241	Drowning Creek	Hanover I Cord Marked	Middle Woodland	5	IIIA	Coastal Plain
JMH012	31Mr259	Drowning Creek	Hanover II Fabric Impressed	Middle-Late Woodland	5	IIIA	Coastal Plain
JMH013	31Mr241	Drowning Creek	Deptford Linear Check Stamped	Middle Woodland	5	IIIA	Coastal Plain
JMH014	31Mr253	Drowning Creek	Yadkin Fabric Impressed	Middle Woodland	-	IIB	Piedmont
JMH015	31Mr241	Drowning Creek	Sand-Tempered Plain	Early-Middle Woodland	-	IIB	Piedmont
JMH016	31Sc71	Drowning Creek	New River Paddle-edge Stamped	Early Woodland	2	IIIA	Coastal Plain (Piedmont drainage)
JMH017	31Mr93	Lower Little	New River Cord Marked	Early Woodland	3	IIIB	Coastal Plain
JMH018	31Sc87	Drowning Creek	Deptford Check Stamped	Middle Woodland	3	IIIB	Coastal Plain
JMH019	31Mr93	Lower Little	Hanover II Cord Marked	Middle-Late Woodland	5	IIIA	Coastal Plain
JMH020	31Mr241	Drowning Creek	New River Cord Marked	Early Woodland	3	IIIA	Coastal Plain

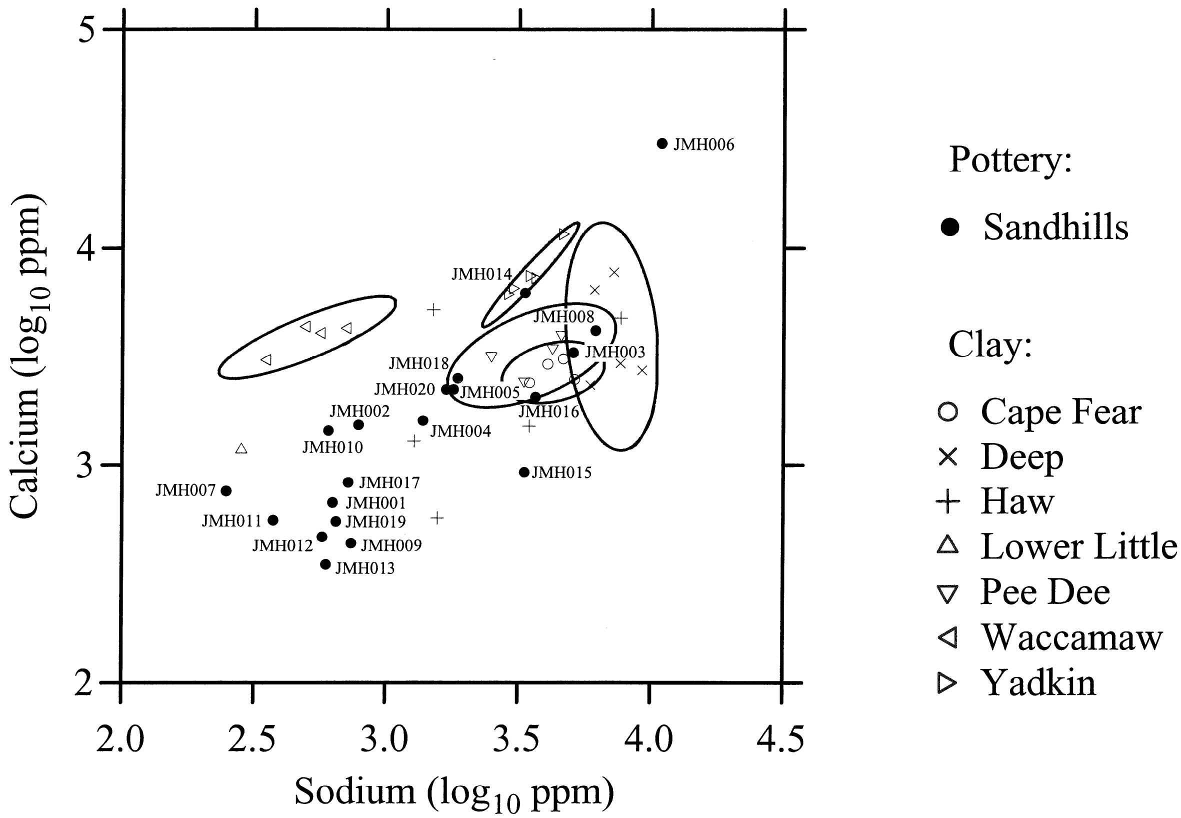


Figure 8.8. Scatter plot of Na and Ca concentrations, comparing Sandhills pottery with clay samples. Sandhills pottery specimens are labeled. Confidence ellipses are shown for clay samples from the Cape Fear, Deep, Pee Dee, Waccamaw, and Yadkin drainages.

Coastal Plain. In addition, when Ca and Na concentrations are considered, these three samples cluster with clay samples from the Cape Fear and Pee Dee drainages (Figure 8.8).

Samples JMH001 and JMH007 are assigned to petrographic Group III but could not be assigned to a chemical group. When Ca and Na concentrations for Sandhills samples are plotted, however, these two samples resemble other Group 5 pottery samples (Figure 8.8). Given that JMH001 and JMH007 also exhibit Hanover stylistic attributes, they may reasonably be attributed to Coastal Plain resources.

Three Sandhills samples are mineralogically similar to Piedmont samples (JMH006, JMH014, and JMH015). It is very likely that Group 1 sherd JMH006 was originally made in the Piedmont. Like the other three Group-I sherds attributed to Piedmont resources, JMH006 is classified as Yadkin series and tempered with crushed-diabase rock, the nearest source of which is approximately 30 km from the Fort Bragg site where this sherd was found. Petrographic Group IIB samples JMH014 and JMH015 were not assigned to a chemical group, but Na and Ca concentrations suggest that they were also made from Piedmont resources. Sample JMH014 clusters with clay samples from the Yadkin drainage and is classified as Yadkin series. The amount of Na in JMH015 suggests it resembles other Group-2 pottery samples (Figure 8.8).

In summary, the data suggest that 3 of the 20 Sandhills pottery samples were probably imported from the Piedmont (JMH006, JMH014, and JMH015). The other Sandhills sherds appear to reflect Coastal Plain resources, most likely obtained outside of the Sandhills region.

Conclusions

The chemical and mineralogical characteristics of pottery found on Piedmont sites generally reflect Piedmont resources, and the characteristics of pottery found on Coastal Plain sites generally reflect Coastal Plain resources. Based on the convergent results of NAA and petrographic analyses of Piedmont pottery and clays, we conclude that potters at the Haw River and Doerschuk sites primarily used locally available resources. Sherds from Coastal Plain sites could not be associated with particular clay resources, but most could be linked to the Coastal Plain region.

Interestingly, the chemical and mineralogical homogeneity of pottery samples from the Breece site suggests a clay source in the immediate vicinity of the site, but the NAA results reveal an unexpected chemical distinction between the sherds (Group 3) and local clays (similar to Group 2). This anomaly suggests that alluvial clays from the Cape Fear drainage were not often being used to make the pottery found at the Breece site, but rather that pottery vessels made from Coastal Plain resources were being transported to the site from other areas. The clay bed accessed by the nineteenth-century Poe mine suggests that good clay resources may be found nearby, but the current study cannot preclude the possibility that the Breece site occupants procured clays from Coastal Plain sources much farther afield.

The presence of several distinct chemical and petrographic groups among the Kolb and Waccamaw sherds suggests that potters in these areas utilized clays from multiple locations. Most of these resources appear to have come from the Coastal Plain, although a few Kolb pottery samples suggest stylistic influence from the Piedmont. Additional study may help determine whether potters at the Kolb and Waccamaw sites used several different clays from the same general region or exploited resources from more than one region.

Finally, the results of clay performance trials, geochemical analyses, and mineralogical analyses all suggest that most of the archaeological pottery found at Fort Bragg sites was fashioned from Piedmont or Coastal Plain sources and subsequently transported into the Sandhills region. We were unable to locate serviceable clay resources in the North Carolina Sandhills, and the results of NAA and petrographic analyses indicate that most Fort Bragg pottery samples more closely resemble Coastal Plain and Piedmont resources than local Sandhills materials. The available evidence indicates that Coastal Plain clays may be better represented among the Sandhills sherds than Piedmont clays, but at least three pottery samples appear to have been fashioned from Piedmont resources.

Overall, these results suggest that pottery circulated over broad regions, implying that the acquisition of clay materials from distant sources was a routine feature of Woodland-period subsistence in the Sandhills. Such materials could have been obtained through high levels of residential mobility, exchange, or both, and future studies should be designed to evaluate the specific strategies Woodland people used to obtain pots. If pottery vessels were routinely transported into the Sandhills by mobile Woodland people, we would expect to primarily find small, light, multipurpose vessels on archaeological sites. Research should be undertaken to determine if this expectation is warranted by ethnographic analogy to mobile pottery making societies and substantiated by archaeological evidence from Fort Bragg.

Additional studies are also needed to expand the number and stylistic range of pottery samples such that temporal variations in acquisition strategies can be assessed. Likewise, unanswered questions regarding the variation and quality of clay resources could be addressed by collecting more clay samples at greater distances from the pottery-sample sites. Results of the XRD data suggest that workable clays might be found where the Lower Little River dissects the

Cape Fear Formation just east of Fort Bragg. Certainly the nineteenth-century commercial Poe pottery at Fayetteville represents a clay source that was not included in this study sample. Collecting a broader spectrum of clay samples, including lean ones from the Piedmont and Coastal Plain, would fill gaps in the database.

Nevertheless, the overarching conclusion reached in this study is well supported by the data. Although it is often assumed that serviceable clay is ubiquitously distributed across the landscape, clay resources with adequate plasticity and strength for fashioning coil-built pots are hard to find. In fact, it appears that they may be largely absent from some regions such as the Sandhills. It therefore seems likely that Woodland potters would have held serviceable clay resources in high regard, passing information about their locations from generation to generation and considering the costs of clay acquisition when deciding where to take up residence. We hope this study will encourage future research that will lead to a better understanding of the importance of clay resources and how the acquisition of those resources may have influenced economic activities and social relations during the Woodland period.

Notes

Acknowledgments. We thank Vin Steponaitis for reviewing multiple drafts of this chapter, offering suggestions for improvement, and providing editorial assistance.

Appendix A

Pottery Sample Descriptions

Joseph M. Herbert

Each pottery specimen analyzed was selected on the basis of its potential to reveal information about taxonomic relationships, in addition to providing samples for chemical and mineral analyses. Preference was given to larger sherds with distinct temper and surface treatment characteristics.

Table A.1 describes the provenience of the 70 samples. Table A.2 includes the paste and temper characteristics, and Table A. 3 lists the surface treatment characteristics. Assignment of sherds to typological classes followed regional precedents (Herbert 2003; Herbert et al. 2002).

Each sherd was cut into three sections with a dremel tool fitted with a carborundum disk. Although not measured or recorded, sherds presented very different degrees of stubbornness in yielding to the saw, the difficulty being positively related to hardness (possibly a useful measure in future studies). One section was submitted for NAA, a second section was submitted to a commercial firm for the preparation of thin sections for petrographic analysis, and a third section was reserved for comparative purposes. Two different thin-sectioning firms were used, and the quality of results varied significantly. Pottery samples JMH001–JMH050 were embedded in epoxy blocks, and the quality of thin sections prepared from these samples was excellent. Pottery samples JMH051–JMH070 were vacuum impregnated with epoxy but not embedded in blocks. The quality of these thin sections left a great deal to be desired.

Photomicrographs were made of the flat sections of pucks from which thin sections were cut, thereby providing remarkably distinct images of sherd cross sections (Figures A.1–A.7). Photographs were made with a 35 mm SLR camera body mounted on an Olympus SE40 binocular microscope with incident light provided by Fostec EKE fiber-optics, using Fuji T-64 slide film, subsequently scanned at 600 dpi. Puck surfaces were wetted before photographing, greatly enhancing color and contrast definition, but in some cases dried so quickly that portions of the images appear washed out. Degrees of absorption were also influenced by epoxy impregnation, which partially penetrated the ceramic sample preventing absorption. Some specimens with partial epoxy impregnation appear to have a dark horizontal band across their centers (the absorbent portion) approximately where one might expect to see a reduced core, but this color and contrast difference has nothing to do with firing temperature or atmosphere.

Table A.1. Descriptive Information for Pottery Samples: Provenience.

Sample ID	Site	Accession Number[a]	Drainage	Region	UTM Northing	UTM Easting	Pottery Series	Pottery Type
JMH001	31Hk868	522n778e	Lower Little	Sandhills	3888676	661414	Hanover II	Fabric Impressed
JMH002	31Ht392	990498p72	Lower Little	Sandhills	3899986	677604	Hanover II	Fabric Impressed
JMH003	31Ht273	990484p263	Lower Little	Sandhills	3902386	682724	Cape Fear III	Fabric Impressed
JMH004	31Hk127	19p782	Lower Little	Sandhills	3891176	670004	Hanover II	Fabric Impressed
JMH005	31Hk59	19p752.1	Lower Little	Sandhills	3887216	653924	Hanover I	Cord Marked
JMH006	31Hk123	19p1038	Lower Little	Sandhills	3891296	668844	Yadkin	Fabric Impressed
JMH007	31Cd750	97968p98	Lower Little	Sandhills	3889636	686304	Hanover I	Paddle-edge Overstamped
JMH008	31Ht269	990483p452	Lower Little	Sandhills	3903546	682454	Mount Pleasant	Cord Marked
JMH009	31Cd486	980102p505	Lower Little	Sandhills	3895076	674014	Cape Fear	Cord Marked
JMH010	31Hk715	990794p22	Lower Little	Sandhills	3880315	662064	Hanover	Fabric Impressed
JMH011	31Mr241	980239p35	Drowning Creek	Sandhills	3879546	640234	Hanover I	Cord Marked
JMH012	31Mr259	990790	Drowning Creek	Sandhills	3881026	640664	Hanover II	Fabric Impressed
JMH013	31Mr241	980239	Drowning Creek	Sandhills	3879546	640234	Deptford	Linear Check
JMH014	31Mr253	990789p9	Drowning Creek	Sandhills	3880906	640924	Yadkin	Fabric Impressed
JMH015	31Mr241	980239p77	Drowning Creek	Sandhills	3879546	640234	Woodland	Sand-tempered Plain
JMH016	31Sc71	19p598.1	Drowning Creek	Sandhills	3875426	641129	New River	Paddle-edge Overstamped
JMH017	31Mr93	980237p37	Lower Little	Sandhills	3894431	671714	New River	Cord Marked
JMH018	31Sc87	96123p6	Drowning Creek	Sandhills	3875702	641599	Deptford	Check Stamped
JMH019	31Mr93	980237p36	Lower Little	Sandhills	3894431	671714	Hanover II	Cord Marked
JMH020	31Mr241	92604	Drowning Creek	Sandhills	3879546	640234	New River	Cord Marked
JMH021	Breece	2103p4.1	Cape Fear	Coastal Plain	3885236	695604	Hanover II	Paddle-edge Overstamped
JMH022	Breece	2103p4.2	Cape Fear	Coastal Plain	3885236	695604	New River	Fabric Impressed
JMH023	Breece	2103p4.3	Cape Fear	Coastal Plain	3885236	695604	Hanover II	Fabric Impressed
JMH024	Breece	2103p4.4	Cape Fear	Coastal Plain	3885236	695604	Hanover II	Fabric Impressed
JMH025	Breece	2103p4.5	Cape Fear	Coastal Plain	3885236	695604	Cape Fear	Cord Marked
JMH026	Breece	2103p4.6	Cape Fear	Coastal Plain	3885236	695604	Hanover II	Fabric Impressed
JMH027	Breece	2103p4.7	Cape Fear	Coastal Plain	3885236	695604	Hanover I	Fabric Impressed
JMH028	Breece	2103p4.8	Cape Fear	Coastal Plain	3885236	695604	Hanover I	Fabric Impressed
JMH029	Breece	2103p4.9	Cape Fear	Coastal Plain	3885236	695604	Hanover I	Fabric Impressed
JMH030	Breece	2103p4.10	Cape Fear	Coastal Plain	3885236	695604	Hanover II	Fabric Impressed
JMH031	Doerschuk	488p14.1	Yadkin	Piedmont	3917576	584484	Yadkin	Fabric Impressed
JMH032	Doerschuk	488p14.2	Yadkin	Piedmont	3917576	584484	Dan River	Simple Stamped

Table A.1. Descriptive Information for Pottery Samples: Provenience (continued).

Sample ID	Site	Accession Number[a]	Drainage	Region	UTM Northing	UTM Easting	Pottery Series	Pottery Type
JMH033	Doerschuk	488p14.3	Yadkin	Piedmont	3917576	584484	Yadkin	Fabric Impressed
JMH034	Doerschuk	488p14.4	Yadkin	Piedmont	3917576	584484	Jenrette	Plain (possibly Bruton)
JMH035	Doerschuk	488p14.5	Yadkin	Piedmont	3917576	584484	New River	Cord Marked
JMH036	Doerschuk	488p14.6	Yadkin	Piedmont	3917576	584484	New River	Net Impressed
JMH037	Doerschuk	488p14.7	Yadkin	Piedmont	3917576	584484	Yadkin	Check Stamped
JMH038	Doerschuk	488p14.8	Yadkin	Piedmont	3917576	584484	Yadkin	Cord Marked
JMH039	Doerschuk	488p14.9	Yadkin	Piedmont	3917576	584484	Dan River	Net Impressed
JMH040	Doerschuk	488p14.10	Yadkin	Piedmont	3917576	584484	Yadkin	Net Impressed
JMH041	Haw River	2309p67.1	Haw	Piedmont	3951596	673884	Yadkin	Paddle-edge Stamped
JMH042	Haw River	2309p67.2	Haw	Piedmont	3951596	673884	Yadkin	Cord Marked
JMH043	Haw River	2309p299.1	Haw	Piedmont	3951596	673884	Yadkin	Plain
JMH044	Haw River	2309p67.3	Haw	Piedmont	3951596	673884	Cape Fear	Fabric Impressed
JMH045	Haw River	2309p67.4	Haw	Piedmont	3951596	673884	Yadkin	Plain
JMH046	Haw River	2309p67.5	Haw	Piedmont	3951596	673884	Yadkin	Plain
JMH047	Haw River	2309p299.2	Haw	Piedmont	3951596	673884	Yadkin/Hanover	eroded
JMH048	Haw River	2309p299.3	Haw	Piedmont	3951596	673884	Yadkin	Plain
JMH049	Haw River	2309p299.4	Haw	Piedmont	3951596	673884	Yadkin	Plain
JMH050	Haw River	2309p299.5	Haw	Piedmont	3951596	673884	Yadkin	eroded
JMH051	Kolb	Feat 99-32	Pee Dee	Coastal Plain	3951596	673884	Yadkin	Fabric Impressed
JMH052	Kolb	Feat 99-32	Pee Dee	Coastal Plain	3951596	673884	Yadkin/Hanover	Fabric Impressed
JMH053	Kolb	Feat 99-32	Pee Dee	Coastal Plain	3951596	673884	Yadkin/Hanover	Cord Marked
JMH054	Kolb	Feat 99-32	Pee Dee	Coastal Plain	3951596	673884	New River	Cord Marked
JMH055	Kolb	Feat 99-32	Pee Dee	Coastal Plain	3951596	673884	Yadkin	Cord Marked
JMH056	Kolb	Feat 96-106	Pee Dee	Coastal Plain	3951596	673884	New River	Paddle-edge Stamped
JMH057	Kolb	surface	Pee Dee	Coastal Plain	3951596	673884	New River	Cord Marked
JMH058	Kolb	Feat 02-22	Pee Dee	Coastal Plain	3951596	673884	Cape Fear	Fabric Impressed
JMH059	Kolb	Feat 99-32	Pee Dee	Coastal Plain	3951596	673884	Cape Fear	Fabric Impressed
JMH060	Kolb	Feat 02-22	Pee Dee	Coastal Plain	3951596	673884	Hanover I	Fabric Impressed
JMH061	Waccamaw	960p7	Waccamaw	Coastal Plain	3796473	733147	Thoms Creek	Punctate (random)
JMH062	Waccamaw	960p7	Waccamaw	Coastal Plain	3796473	733147	Cape Fear	Fabric Impressed
JMH063	Waccamaw	960p7	Waccamaw	Coastal Plain	3796473	733147	Hanover II	Fabric Impressed
JMH064	Waccamaw	960p7	Waccamaw	Coastal Plain	3796473	733147	Hanover II	Fabric Impressed

Table A.1. Descriptive Information for Pottery Samples: Provenience (continued).

		Accession			UTM			
Sample ID	Site	Number[a]	Drainage	Region	Northing	Easting	Pottery Series	Pottery Type
JMH065	Waccamaw	960p7	Waccamaw	Coastal Plain	3796473	733147	Hanover I	Fabric Impressed
JMH066	Waccamaw	960p7	Waccamaw	Coastal Plain	3796473	733147	Cape Fear	Fabric Impressed
JMH067	Waccamaw	960p7	Waccamaw	Coastal Plain	3796473	733147	Cape Fear	Fabric Impressed
JMH068	Waccamaw	960p7	Waccamaw	Coastal Plain	3796473	733147	Hanover	eroded
JMH069	Waccamaw	960p7	Waccamaw	Coastal Plain	3796473	733147	Cape Fear	Fabric Impressed
JMH070	Waccamaw	960p7	Waccamaw	Coastal Plain	3796473	733147	Cape Fear	Fabric Impressed

[a] Accession numbers were not available for pottery samples from the Kolb site.

Table A.2. Descriptive Information for Pottery Samples: Paste and Temper Characteristics.

Sample ID	Pottery Type	Temper		Characteristics
		Type	Amount	
JMH001	Hanover II Fabric Impressed	grog	25–50%	Paste is reddish brown (2.5YR4/4); thin oxidation rind, otherwise fired high; grog is 1–2 mm in moderately high proportion, pale brown; quartz sand is .5–1 mm in moderate proportion, subangular, clear, smoky, and rose.
JMH002	Hanover II Fabric Impressed	grog	< 25%	Paste is black (2.5Y2.5); very thin oxidation rind, fired high but in reduced atmosphere; grog is 1–2 mm in low proportion, pale brown or reddish brown; background sand is very fine.
JMH003	Cape Fear III Fabric Impressed	sand	< 25%	Paste is reddish brown (2.5YR4/4); thin rind of complete oxidation, exterior half lighter brown partial oxidation; quartz sand is .5–1 mm in moderate proportion, subrounded; two long flat sections reveal no grog, although grog was identified by petrographer.
JMH004	Hanover II Fabric Impressed	grog	> 50%	Paste is black (2.5Y2.5); moderate (1 mm) oxidation rind, fired high but in reduced atmosphere; "grog" (1–2 mm) is apparent in high proportion on the surface as more highly oxidized pale brown or reddish brown colored clots, but in flat section no grog is evident as clots are identical in color to matrix and show no boundaries; background sand is coarse (.5–1 mm) subangular quartz in low proportion.
JMH005	Hanover I Cord Marked	grog	< 25%	Paste is red (2.5YR5/8); pale brown grog is granule size (2–4 mm) in moderate proportion; very coarse subangular quartz sand is present in moderate proportion; core and surfaces look well oxidized, but sherd is moderately soft, suggesting low firing temperature.
JMH006	Yadkin Fabric Impressed	diabase	25–50%	Paste is dark, weak red (2.5YR4/2); very thin oxidation rind; granule-sized diabase fragments visible macroscopically and in flat section in high proportion.
JMH007	Hanover I Paddle-edge Stamped	grog/sand	25–50%	Paste grades from reddish brown (2.5YR5/3) to light red (2.5YR6/6); darker interior but no reduced core; cross section looks mottled with pale brown (probably grog) to red (probably natural hematite) lumps; grog is in moderate to high proportion; very fine quartz and possibly polymineralic metaigneous rock sand 0–.5 mm in low to moderate proportion; despite being red and having loads of hematite, this sherd is very porous and soft, suggesting low firing temperature.

Table A.2. Descriptive Information for Pottery Samples: Paste and Temper Characteristics (continued).

Sample ID	Pottery Type	Temper Type	Temper Amount	Characteristics
JMH008	Mount Pleasant Cord Marked	quartz	< 25%	Paste is light reddish brown (2.5YR6/3); no reduced core; occasional rounded quartz granules; mottled with pale brown lumps, some of which may be grog, but no boundary voids are observable and the color of lumps is very nearly the same as the matrix; sherd is soft and porous.
JMH009	Cape Fear Cord Marked	sand	25–50%	Paste is light red (2.5YR6/6) homogeneous; no reduced core; slightly darker reduced rind (1 mm thick) on the interior; medium to very coarse subangular quartz in moderate proportion; grog was noted in petrography, but only a couple very red hematite clots are visible in this cross section; sherd is hard, red throughout, probably fired high.
JMH010	Hanover Fabric Impressed	sand/grog	25–50%	Paste is light reddish brown (5YR6/3); subrounded quartz sand in coarse to very coarse size is present in moderate proportion (10–15%); grog appears as rounded granule size particles that have indistinct boundaries apparent on the basis of color that is redder or paler brown than surrounding matrix; sherd is soft and very porous, with many large voids indicating advanced state of disintegration, so probably fired at low temperature.
JMH011	Hanover I Cord Marked	grog/sand	25–50%	Paste is red (2.5YR5/6); core and surfaces are oxidized the same, looking well oxidized, no reduced core; pale brown, blocky grog particles are granule size (2–4 mm) in moderate proportion (15–20%); coarse (.5–1 mm) subrounded quartz sand is present in low proportion (5%); sherd is relatively hard and porosity is low.
JMH012	Hanover II Fabric Impressed	grog/sand	25–50%	Paste is black (7.5YR2.5/1) on the interior half of the wall (note carbon particle in lower right) and red (2.5YR5/6) on the exterior half; granule- and pebble-sized grog particles (upper left) in moderate proportion (about 15%), reddish brown and tempered with medium sand; fine sand (less than .5 mm) is in moderate proportion (about 10%) throughout the matrix; this sherd is very hard and porosity is quite low.
JMH013	Deptford Linear Check Stamped	sand	< 25%	Paste is black (7.5YR2.5/1) in the core and red (2.5YR5/6) on both interior (1 mm) and exterior (2.5 mm); very coarse (1–2 mm) subangular quartz sand is present in low proportion (3%), and very fine sand (less than .5 mm) is present in low proportion (perhaps 5%) as "background."
JMH014	Yadkin Fabric Impressed	sandstone	< 25%	Paste is red (2.5YR5/6) throughout; pebble-sized polycrystalline quartz (ferric sandstone?); large grog particle (center) is pale brown; this sherd is hard.

Table A.2. Descriptive Information for Pottery Samples: Paste and Temper Characteristics (continued).

Sample ID	Pottery Type	Temper Type	Temper Amount	Characteristics
JMH015	Sand-tempered Plain	sand	25–50%	Paste is weak red (2.5YR4/2) in core and interior, but light red (2.5YR6/6) in the outer 1.5 mm; subrounded quartz sand of medium (.5–1 mm) to very coarse (1–2 mm) size in moderately high proportion (about 20%).
JMH016	New River Paddle-edge Stamped	grog	< 25%	Paste is reddish grey (2.5YR5/1), somewhat lighter on the exterior 2.3 mm and near black on the interior 3 mm; the color of the grog is very close to the color of the matrix; subangular coarse (1–2 mm) quartz sand in low proportion (5%); sherd is soft and porous, apparently fired at low temperature.
JMH017	New River Cord Marked	sand	25–50%	Paste is dark reddish gray (2.5YR3/1) in the core and red (2.5YR6/6) on the exterior and interior 2 mm and throughout in one portion of the flat section; medium to very coarse subangular quartz sand in moderate proportion; grog was noted in petrography, but there is no doubt that, lacking petrography, this sherd would be classified as sand tempered as no grog was evident in the flat section or across either face of sherd.
JMH018	Deptford Check Stamped	sand	< 25%	Paste is black in core and pale brown within a thin rind about 1 mm thick; subangular quartz sand of medium (.25–.5 mm) and coarse (.5–1 mm) size in moderate proportion (about 15%).
JMH019	Hanover II Cord Marked	grog	< 25%	Paste is red (2.5YR6/4) in exterior half and dark reddish gray (2.5YR4/1) on the interior half; very large chunks (up to 9 mm) of crushed pottery are visible in the broken cross section; medium and coarse sand is also present in low proportion (about 5%).
JMH020	New River Cord Marked	sand	< 25%	Paste is red (2.5YR5/6) in most of the cross section with some pockets of dark reddish gray (2.5YR4/1) reduced core; medium and coarse subrounded quartz and feldspar sand in low proportion (about 5%); grog temper also appears to be present in low proportion.
JMH021	Hanover II Paddle-edge Stamped	grog	< 25%	Paste is black in core and pale brown within a thin rind about 1 mm thick; grog particles occur in low proportion and are reduced like the core, so are difficult to see, although they appear to have a higher proportion of sand oriented differently than that in the matrix; temper also includes medium and coarse sand in very low proportion (3%); sherd is soft and porous.

Table A.2. Descriptive Information for Pottery Samples: Paste and Temper Characteristics (continued).

Sample ID	Pottery Type	Temper		Characteristics
		Type	Amount	
JMH022	New River Fabric Impressed	sand	25–50%	Paste is black (7.5YR2.5/1) throughout, although surfaces are pale brown; coarse and very coarse subrounded quartz sand in moderately high proportion (20–25%).
JMH023	Hanover II Fabric Impressed	grog	< 25%	Paste is dark gray (7.5YR5/1) to black (7.5YR2.5/1) on the interior two-thirds and light brown (7.5YR6/4) on the exterior one-third of the core; pebble-sized (2–5 mm) and smaller grog particles are light reddish brown (2.5YR7/3) or pale brown and occur in moderately low proportion (3–5%); fine and larger quartz sand is present in very low proportion (less than 3%).
JMH024	Hanover II Fabric Impressed	grog/sand	< 25%	Paste is light reddish brown (2.5YR6/4) to reddish brown (2.5YR5/3) with interior being only slightly darker than exterior; medium to coarse (up to 2 mm) light brown grog particles are present in moderately low proportion (about 5%); medium to coarse sand is also present in moderately low proportion (about 5%); red argillaceous clots are common throughout.
JMH025	Cape Fear Cord Marked	sand	< 25%	Paste is light red (2.5YR6/6) and only slightly darker on the interior; medium to coarse (up to 1 mm) angular quartz sand; grog was noted in petrography but is ambiguous in the flat section — note that grog-like particle in photo is in poorly welded coil void.
JMH026	Hanover II Fabric Impressed	grog	< 25%	Paste is red (2.5YR5/6) on the exterior half of the core and gray (5YR5/1) on the interior half; grog particles up to 1 cm, typically light brown, are present throughout; subangular quartz sand up to 1 mm is present in moderate proportion (about 5%); sherd is relatively soft and porous.
JMH027	Hanover I Fabric Impressed	sand	< 25%	Paste is light reddish brown (5YR6/4) over two-thirds of the exterior core and black (5YR2.5/1) on the interior; subangular quartz sand up to very coarse size (1–2 mm) in moderate proportion (15–20%); grog particles up to 4 mm in low proportion (less than 5%).
JMH028	Hanover I Fabric Impressed	sand	< 25%	Paste is light reddish brown (5YR5/4) on the exterior half of core and dark reddish gray (5YR4/2) on the interior half; subangular quartz sand in mixed sizes in moderate proportion (10–15%); grog particles up to 4 mm in low proportion (3–5%); sherd is moderately hard and porous.

Table A.2. Descriptive Information for Pottery Samples: Paste and Temper Characteristics (continued).

Sample ID	Pottery Type	Temper		Characteristics
		Type	Amount	
JMH029	Hanover I Fabric Impressed	sand/grog	< 25%	Paste is pink (5YR7/4) throughout except for a 1 mm rind of black (5YR2.5/1) on the interior; subrounded quartz sand up to coarse (.5–1 mm) size; grog up to 4 mm in moderate proportion (about 10%).
JMH030	Hanover II Fabric Impressed	grog/sand	25–50%	Paste is pink (5YR7/4) throughout except for a 1 mm rind of black (5YR2.5/1) on the interior; grog up to 4 mm in size in moderate proportion (about 10%); subrounded quartz sand up to coarse (.5–1 mm) size.
JMH031	Yadkin Fabric Impressed	diabase	25–50%	Paste is black (5YR2.5/1) throughout (obviously fired in reduced atmosphere); subangular and angular particles of quartz, quartzite, and feldspar up to pebble size (greater than 4 mm) with most pieces in the very coarse and granule size range, occurring in moderate proportion (about 20%).
JMH032	Dan River Simple Stamped	granite	25–50%	Paste is black (5YR2.5/1) throughout (obviously fired in reduced atmosphere); subangular and angular particles of quartz, quartzite, and feldspar up to very coarse range (looks like crushed rock consisting of many size grades from very small to 2 mm), occurring in moderately high proportion (greater than 20%); given the temper attributes, classification as Yadkin may also be appropriate.
JMH033	Yadkin Fabric Impressed	granite	25–50%	Paste is black (5YR2.5/1) throughout (obviously fired in reduced atmosphere); subangular and angular particles of polymineralic (quartz, quartzite, and feldspar) rock from very small to 2 mm, occurring in moderately high proportion (greater than 20%).
JMH034	Jenrette Plain	quartz/ granite?	25–50%	Paste is gray (5YR5/1) to dark gray (5YR4/1), the core being slightly darker than the interior and exterior; subangular quartz up to very coarse size; possibly angular polymineralic rock (probably granitic) also in mixed size grades up to very coarse size.
JMH035	New River Cord Marked	granite	25–50%	Paste is gray (5YR5/1); subangular particles of granitic rock in mixed size grades with far more fine and medium particles than larger, occurring in high proportion (30% or more).
JMH036	New River Net Impressed	quartz/ granite	25–50%	Paste is gray (5YR5/1); subangular particles of quartz up to coarse size; polymineralic rock (granitic) in mixed size grades with far more fine and medium particles than larger, occurring in high proportion (30% or more).

Table A.2. Descriptive Information for Pottery Samples: Paste and Temper Characteristics (continued).

Sample ID	Pottery Type	Temper		Characteristics
		Type	Amount	
JMH037	Yadkin Check Stamped	quartz	25–50%	Paste is dark gray (5YR4/1) to very dark gray (5YR3/1); very thin oxidized rind of light brown (7.5YR6/4); angular quartz particles mostly in the very coarse and granule size range, occurring in moderate proportion (about 15%).
JMH038	Yadkin Cord Marked	granite/ quartz	< 25%	Paste is black (5YR2.5/1); oxidized surface is yellowish red (5YR4/6) and core tends to be lighter on the exterior half, but no distinct oxidized zone in cross section; angular crushed rock (granitic) from fine to granule size with most particles in the medium and coarse size range; grog was noted in petrography, but none visible in the 10× view of the flat section.
JMH039	Dan River Net Impressed	granite/ sand?	< 25%	Paste is pink (5YR7/3) on the exterior half and very dark gray (5YR4/1) on the interior half; fine to coarse particles of granitic rock (sand?) with quartz, plagioclase, K-feldspar and biotite, occurring in high proportion (greater than 30%); the vast majority of particles are in the medium and fine size grade, giving the sherd a very smooth feel; sherd is very hard with low porosity; originally classified as Dan River, but the temper also suggests Yadkin.
JMH040	Yadkin Net Impressed	granite	< 25%	Paste is black, except for a thin (1.5 mm) rind of reddish brown (5YR5/2) on the exterior; crushed weathered granitic rock (including quartz, feldspars, and biotite) ranging in size grades up to granule but mostly in the medium and coarse size, occurring in high proportion (greater than 30%).
JMH041	Yadkin Paddle-edge Stamped	quartz	25–50%	Paste is light gray (5YR7/1) throughout, except for a very thin rind of darker gray on both interior and exterior; crushed quartz in granule and pebble size range in moderate proportion (about 20%); many quartz flakes attest to the method of preparation; moderate amount of medium and fine feldspar.
JMH042	Yadkin Cord Marked	quartz	< 25%	Paste is reddish brown (5YR6/2) with slightly lighter red in the exterior half and darker gray in the interior half of the core; crushed quartz up to pebble size in moderate proportion; the paste also incorporates a high frequency of fine- and medium-sized feldspar particles suggesting, perhaps, a saprolite source for the clay.

Table A.2. Descriptive Information for Pottery Samples: Paste and Temper Characteristics (continued).

Sample ID	Pottery Type	Temper Type	Temper Amount	Characteristics
JMH043	Yadkin Plain	quartz	25–50%	Paste is yellowish red (5YR6/6) on the exterior half and reddish gray (5YR5/2) to black (5YR2.5/1) on the interior; subangular quartz in very coarse and occasionally granule size in moderate proportion (10–15%).
JMH044	Cape Fear Fabric Impressed	sand/ quartz	25–50%	Paste is white 2.5Y8/1 with a slightly redder thin zone on the interior and exterior surfaces; subangular to subrounded polygranular quartz in very coarse size, occurring in moderate proportion (10%); fine and medium feldspar particles seem to be present but there is not much color contrast.
JMH045	Yadkin Plain	rock (granite?)	25–50%	Paste is black (2.5Y2.5/1) throughout; surfaces are oxidized reddish brown; quartz and feldspar (granitic rock?) in coarse size (.5–1 mm), occurring in moderately high proportion (about 25%).
JMH046	Yadkin Plain	diabase/ quartz	25–50%	Paste is black (2.5Y2.5/1) throughout; surfaces are oxidized reddish brown; rock in fine and medium size (0–.5 mm), occurring in moderate proportion (about 10–15%); angular crushed quartz in very coarse size in moderate proportion (10%).
JMH047	Yadkin/Hanover eroded	diabase/ quartz	25–50%	Paste is pinkish gray (5YR7/2) in the exterior half and gray (5YR5/1) in the interior half; angular quartz in the granule-size grade occurring in moderate proportion (15%) with a background of fine and medium feldspar fragments in moderate proportion.
JMH048	Yadkin Plain	rock (mafic?)	25–50%	Paste is dark reddish gray (5YR4.2) and black (2.5Y2.5/1) on the interior; crushed rock in medium to very coarse size grades, occurring in high proportion (30% or more).
JMH049	Yadkin Plain	granite	25–50%	Paste is mostly very dark gray (5YR4/1) with a thin reddish gray (5YR5/2) band along the exterior and interior; polymineralic rock with quartz, plagioclase, K-feldspar, and biotite in medium- and very-coarse-sized grades, occurring in moderate proportion (20%).
JMH050	Yadkin eroded	granite	25–50%	Paste is dark gray (5YR4/1) except for a small band of reddish gray (5YR5/2) on the interior and exterior; medium and coarse polymineralic rock (quartz, plagioclase, K-feldspar) in moderate proportion (20%); large quartz particles in the very coarse and granule-sized grade in low proportion (3%).

Table A.2. Descriptive Information for Pottery Samples: Paste and Temper Characteristics (continued).

Sample ID	Pottery Type	Temper		Characteristics
		Type	Amount	
JMH051	Yadkin Fabric Impressed	quartz	25–50%	Paste is dark gray (5YR3/1) on the exterior and interior with a more oxidized core of light reddish brown (5YR6/3); moderately abundant quartz pebbles (many pieces 5–7 mm), some are subangular but there are definitely angular particles and even flakes, in moderately low proportion (5–10%).
JMH052	Yadkin/Hanover Fabric Impressed	grog/ quartz	25–50%	Paste is dark gray (5YR3/1) on the interior half and reddish brown (5YR6/3) in the exterior half; large grog particles deform interior surface; a few pieces of pebble-sized (4.5 mm) angular quartz.
JMH053	Yadkin/Hanover Cord Marked	quartz/ grog	25–50%	Paste is dark gray (5YR3/1) on the interior half and reddish brown (5YR6/3) in the exterior half; angular and subangular quartz and quartzite fragments up to 4 mm, some black mineral inclusions in quartz (possibly tourmaline); grog up to 3 mm; paste also includes fine micaceous sand.
JMH054	New River Cord Marked	sand	25–50%	Paste is black (5YR2.5/1) throughout with a thin (1 mm) oxidized band and surface that is yellowish red (5YR4/6) on the exterior; sand and grit (mostly quartz) about 1 mm with some larger pieces up to 3 mm, occurring in moderate density; possible grog particles in granule size occur in low proportion.
JMH055	Yadkin Cord Marked	quartz	> 50%	Paste is dark gray (5YR4/1) on the interior and exterior and gray (5YR6/1) in the center of the core; subangular and angular quartz particles in very coarse and granule size, occurring in moderate proportion; a few quartz particles appear to be flakes, suggesting crushing; paste is fine micaceous sand and also includes fine particles of what appears to be feldspar or weathered granite; also thin lamellar voids such as those seen in shell-tempered ware.
JMH056	New River Fabric Impressed	-	-	No specimen portion remained for examination; temper, if tempered, is not visible; two cavities in the cross-section break suggest that large (6 mm) temper particles (probably quartz pebbles) have been plucked from the matrix.
JMH057	New River Cord Marked	sand	25–50%	Water-worn, subrounded quartz grains up to granule size (1–5 mm), including crystal, rose, and smoky, occurring in moderate proportion; some feldspar and polycrystalline rock with feldspar in low proportion.

Table A.2. Descriptive Information for Pottery Samples: Paste and Temper Characteristics (continued).

Sample ID	Pottery Type	Temper		Characteristics
		Type	Amount	
JMH058	Cape Fear Fabric Impressed	sand	< 25%	Paste is dark reddish gray (5YR4/2) with a black (5YR2.5/1) interior zone; background inclusion of fine sand (less than .5 mm) in moderate proportion; subangular quartz in very coarse size range in low proportion (less than 5%); metasiltstone fragment.
JMH059	Cape Fear Fabric Impressed	sand	< 25%	Paste is dark gray in the core, with a light reddish brown (5YR6/4) zone in the exterior 1.5 mm and a black zone (5YR2.5/1) on the interior; temper, if any, is very coarse subangular quartz sand (1–2 mm) in low proportion; because piece is small, we may be missing larger grains of quartz temper.
JMH060	Hanover I Fabric Impressed	clay/sand	< 25%	Paste is reddish yellow (5YR6/6) in the exterior zone and throughout most of the core, with reddish gray (5YR5/2) in the interior 1.5 mm zone; a few very large (5 mm) lumps of clay and grog; subrounded quartz granules (1–4 mm).
JMH061	Thoms Creek Punctate	sand	25–50%	No remaining specimen; abundant medium subrounded quartz sand; some clay particles are included but they appear to be incidental.
JMH062	Cape Fear Fabric Impressed	sand	25–50%	Paste is yellowish red (5YR5/6) throughout with a very thin zone of reddish brown (5YR5/3) in the interior and exterior; very coarse quartz sand (1–2 mm) in moderate density; paste is well mixed and well compacted; fired relatively high although sherd is soft; well oxidized throughout.
JMH063	Hanover II Fabric Impressed	grog	25–50%	Paste core is reduced dark reddish brown (5YR3/2) throughout with a thin black zone on the interior; exterior oxidized; grog particles about 4–5 mm in moderate density; background of sparse medium quartz sand in moderate proportion (5–10%).
JMH064	Hanover II Fabric Impressed	grog	25–50%	Paste core is reduced dark reddish brown (5YR3/2) throughout with a thin black zone on the interior; surfaces oxidized or weathered to reddish brown; grog (up to 4 mm) obvious as it is very oxidized in comparison to reduced sherd core; sand in fine and medium size grades, occurring in low proportion.
JMH065	Hanover I Fabric Impressed	clay/sand	< 25%	Paste is reddish brown (5YR5/2) in the interior and exterior zones and dark gray (5YR4/1) in the core; clay is 1–4 mm in moderate proportion; sand is medium subrounded quartz in low proportion; interior surface is well smoothed — nearly floated — nearly obscuring temper.

Table A.2. Descriptive Information for Pottery Samples: Paste and Temper Characteristics (continued).

Sample ID	Pottery Type	Temper		Characteristics
		Type	Amount	
JMH066	Cape Fear Fabric Impressed	sand	25–50%	Core is black and interior and exterior are similarly oxidized to buff color; medium, coarse, and very coarse quartz sand in moderate proportion (about 20%); occasional small clay particles suggest incidental inclusion.
JMH067	Cape Fear Fabric Impressed	sand	< 25%	Paste is dark gray (5YR4/1) in the core and reddish brown (5YR5/4) in the interior and exterior zones; medium, coarse, and very coarse sand in low proportion; some rock inclusions appear to be quartz and micaceous schist, very soft and full of mica.
JMH068	Hanover eroded	grog/sand	25–50%	No remnant specimen; large (3–5mm) grog particles in moderate proportion; background of medium quartz sand.
JMH069	Cape Fear Fabric Impressed	sand	25–50%	Paste is reddish yellow (5YR6/6) throughout with thin slightly reduced reddish brown zones in interior and exterior; medium, coarse, and very coarse quartz sand in moderate proportion (15%).
JMH070	Cape Fear Fabric Impressed	sand	25–50%	Paste is dark gray (5YR4/1) throughout with thin, slightly reduced black zones on interior and slightly oxidized reddish brown zone on the exterior; medium, coarse, and very coarse sand in moderate proportion.

Table A.3. Descriptive Information for Pottery Samples: Surface Treatment Characteristics.

Sample ID	Pottery Series	Surface Treatment		Characteristics
		Exterior	Interior	
JMH001	Hanover II	Fabric Impressed; medium weft-faced[a]	Smoothed	Fabric is rigid warp, weft 1 mm; warp 3 mm (total width), impressions are parallel, oblique to rim (top left to bottom right). Vessel is medium open-mouthed jar/bowl, 18 cm orifice, height about 12–14 cm; one mend hole 4.25 cm from rim; lip is flattened by stamping with fabric-wrapped paddle, interior is well smoothed.
JMH002	Hanover II	Fabric Impressed; medium weft-faced[a]	Smoothed	Surface treatment of rigid warp (3 mm) interwoven with cordage weft (1 mm) is overstamped, ambiguous. A Hanover Fabric Impressed sherd from this site was TL dated AD 1084±124 (Herbert et al. 2002).
JMH003	Cape Fear III	Fabric Impressed; medium weft-faced[a]	Smoothed	Surface treatment appears to be overstamped fabric, but impressions are weak, not clear; sherd is thin, 5.4 mm, and hard, apparently fired high.
JMH004	Hanover II	Fabric Impressed; medium weft-faced[a]	Smoothed	Surface treatment of rigid warp (3 mm), but weakly executed so that impressions are not clear.
JMH005	Hanover I	Cord Marked; parallel, S-twist	Smoothed	Surface treatment is oblique overstamped cord (about 2 mm diameter).
JMH006	Yadkin	Fabric Impressed; flexible warp[b]	Smoothed	Surface treatment is overstamped fabric impressed (1 mm weft, 3–4 mm warp, possibly flexible).
JMH007	Hanover I	Paddle-edge Stamped	Smoothed	Surface impressions are weak, but former identification as overstamped paddle-edge seems plausible.
JMH008	Mount Pleasant	Cord Marked; perpendicular/oblique	Smoothed	Surface treatment is perpendicular overstamped cord marked. A Yadkin Net Impressed sherd from this site was TL dated AD 118±233 (Herbert et al. 2002).
JMH009	Cape Fear	Cord Marked; parallel, Z-twist	Smoothed	Surface is cord marked, parallel to oblique, cordage is 1 mm diameter, Z-6 twist/cm. A Cape Fear Cord Marked sherd from this site was TL dated 278±370 BC (Herbert et al. 2002).
JMH010	Hanover	Fabric Impressed; medium weft-faced[a]	Smoothed	Surface treatment is fabric impressed, warps about 4 mm, wefts 5–7 mm.

Table A.3. Descriptive Information for Pottery Samples: Surface Treatment Characteristics (continued).

Sample ID	Pottery Series	Surface Treatment: Exterior	Surface Treatment: Interior	Characteristics
JMH011	Hanover I	Cord Marked; parallel, S-twist	Smoothed	Surface treatment is cord marked, parallel, 1.3 mm diameter, S-3 twist/cm.
JMH012	Hanover II	Fabric Impressed; medium weft-faced[a]	Smoothed	Surface treatment is fabric impressing, weft about 1 mm diameter and rigid warp about 6 mm.
JMH013	Deptford	Linear Check Stamped	Smoothed	Surface treatment is linear check stamping, checks are 3.5-×-2.5 mm size.
JMH014	Yadkin	Fabric Impressed; medium weft-faced[a]	Smoothed	Surface treatment is smoothed-over fabric impressed.
JMH015		Smoothed	Smoothed	Surface treatment is smoothed-over fabric impressed (perhaps), but quite eroded.
JMH016	New River	Paddle-edge Stamped	Smoothed	Surface treatment originally identified as knot-roughened net impressed, but is overstamped (very messy) cord-wrapped paddle edge, especially evident on flattened stamped lip of rim section. Rim section suggests vessel with 18 cm orifice, and if the slope of the stamped lip is an indication, the vessel was a jar with a constricted neck (on upper one-third of vessel).
JMH017	New River	Cord Marked; parallel	Smoothed	Surface treatment is parallel cord marked, with cordage (1 mm diameter, S-4 twist/cm) widely spaced about 2–3 mm apart.
JMH018	Deptford	Square Check Stamped	Smoothed	Surface treatment is recorded as check stamped, but the piece left for comparison and photo is too small to see this.
JMH019	Hanover II	Cord Marked; perpendicular/oblique, Z-twist	Smoothed	This sherd is part of vessel that has been TL dated AD 435±314. Vessel form is probably globular jar with constricted mouth, orifice is about 30 cm diameter. Surface treatment is clearly overstamped perpendicular cord marked; this treatment is exceptionally clear and deeply impressed, cordage is 1.5 mm diameter, Z-4 twists/cm; perpendicular (vertical) to the lip; lip is stamped flat with cord-wrapped paddle.
JMH020	New River	Cord Marked; parallel, S-twist	Smoothed	Surface treatment is cord-marked parallel, cordage diameter is about 2 mm (S-4 twists/cm).

Table A.3. Descriptive Information for Pottery Samples: Surface Treatment Characteristics (continued).

Sample ID	Pottery Series	Surface Treatment: Exterior	Surface Treatment: Interior	Characteristics
JMH021	Hanover II	Paddle-edge Stamped	Smoothed	Surface treatment is either fabric or cleanly executed cord-wrapped paddle edge. This is a rim sherd from a jar with an everted rim and modestly flared, well smoothed lip; orifice is about 14 cm.
JMH022	New River	Fabric Impressed; flexible warp[b]	Scraped	Surface treatment is fabric impressing of weft-faced interlacing of 1.5 mm weft cordage over 3 mm flexible warp; there is some suggestion of twined lacing on 3-mm centers rather than interlacing to create weft-face fabric.
JMH023	Hanover II	Fabric Impressed; flexible warp[b]	Smoothed	Surface treatment is fabric impressed, flexible warp, with weft cordage diameter of about 1.5 mm, applied diagonally to the rim. This is a rim sherd of a large (orifice approximately 32 cm), straight-walled, open-mouthed jar; lip is flattened by paddling and then smoothed over.
JMH024	Hanover II	Fabric Impressed; flexible warp[b]	Smoothed	Surface treatment is fabric impressed, flexible warp, with weft cordage diameter of about 1.5 mm, applied diagonally to the rim (unusual in being oriented upper right to lower left), carefully and boldly impressed with no smoothing or smudging over; rim is paddled flat. Vessel form appears to be medium-sized (orifice diameter of approximately 20 cm), straight-walled, open-mouthed jar.
JMH025	Cape Fear	Cord Marked; perpendicular/oblique, S-twist	Smoothed	Surface treatment is perpendicular overstamped cord marking (cordage is approximately 1 mm diameter, S-4 twist/cm), spaced approximately 5 mm, overstamped nearly 90 degrees.
JMH026	Hanover II	Fabric Impressed; medium weft-faced[a]	Smoothed	Surface treatment is fabric impressing of textile with weft cordage (S-twist) of 1.5% interlaced over flexible warp.
JMH027	Hanover I	Fabric Impressed; flexible warp[b]	Smoothed	Surface treatment is fabric impressed weft-faced interwoven wefts (approximately 1 mm) over flexible warps.
JMH028	Hanover I	Fabric Impressed; medium weft-faced[a]	Smoothed	Surface treatment is fabric impressed, 1.5 mm diameter weft and flexible warp. This appears to be a rim, although the sherd segment is very narrow, and the lip is rather ambiguous. At this point, the remaining portion of the sherd does not appear to have an intact lip, although two horizontal paddle-edge impressions were clearly impressed as a decorative element under the rim, or at the throat of the vessel.

Table A.3. Descriptive Information for Pottery Samples: Surface Treatment Characteristics (continued).

Sample ID	Pottery Series	Surface Treatment: Exterior	Surface Treatment: Interior	Characteristics
JMH029	Hanover I	Fabric Impressed; fine weft-faced[c]	Smoothed	Surface treatment is fabric-impressed weft-faced interwoven textile with wefts (approximately 1 mm) interwoven over flexible warps.
JMH030	Hanover II	Fabric Impressed; fine weft-faced[c]	Smoothed	Surface treatment is fabric-impressed weft-faced interwoven textile with wefts (approximately 1 mm) interwoven over flexible warps. (Appears to me that JMH029 and JMH030 are the same vessel.)
JMH031	Yadkin	Fabric Impressed; medium weft-faced[a]	Smoothed	Surface treatment is fabric impressing fine weft (less than 1 mm) interlaced over rigid warp of about 3 mm. Interior appears to be well smoothed with clay floated over rough temper particles. This piece is a rim sherd reflecting a straight-necked jar with an orifice of about 18 cm. The lip is well formed and rounded. Exterior decoration consists of paddle-edge stamping diagonal to vessel lip. Although classified as Yadkin, there is much about this sherd that suggests Late Woodland provenance — its very clean execution, fine-weft rigid-warp fabric, and subangular particles suggest possible non-Yadkin classification.
JMH032	Dan River	Simple Stamped; narrow land	Smoothed	Surface treatment is simple stamping, overstamped perpendicular; lands are 2 mm wide, spaced 2 mm; originally identified as New River, but reclassified as Dan River by Steve Davis.
JMH033	Yadkin	Fabric Impressed; fine weft-faced[c]	Scraped	Surface treatment is fabric-impressed fine weft (less than 1 mm) interwoven over rigid warp (2–3 mm) applied horizontally on the rim. This is a rim of a jar (perhaps a collared neck) with a slightly everted rim (paddle-edge stamped down the interior, about 26 mm) and a flattened stamped lip. Vessel orifice is about 20 cm.
JMH034	Jenrette	Burnished	Smoothed	The surface is burnished on the exterior and smoothed on the interior. The exterior is yellowish red, which is very different from every other sherd in the Doerschuk sample, suggesting that a slip may have been applied. According to Steve Davis, this sherd is similar to those found at the Mitchum site and should be classified as Jenrette Plain and placed very late in the occupation history of the site (note that this sherd is burnished, not simply smoothed).
JMH035	New River	Cord Marked; parallel, Z-twist	Smoothed	Surface treatment is cord marked, parallel, with occasional cord impressions superimposed over the stamped pattern.

Table A.3. Descriptive Information for Pottery Samples: Surface Treatment Characteristics (continued).

Sample ID	Pottery Series	Surface Treatment: Exterior	Surface Treatment: Interior	Characteristics
JMH036	New River	Net Impressed; knotted, open weave[d]	Smoothed	Surface treatment is net impressed with cordage being fine (less than 1 mm) and spaces between knots of about 4–6 mm.
JMH037	Yadkin	Check Stamped	Smoothed	The surface treatment appears to be check stamping, consisting of relatively small, slightly rectangular checks (roughly 4-×-6 mm) impressed very deeply (in wet surface).
JMH038	Yadkin	Cord Marked; parallel, S-twist	Smoothed	Surface treatment is parallel cord marked; width of cordage is about 2 mm and spaced about 2.5 mm; smoothing-over obliterated most cord structure, but appears to be S-3 twists/cm. This was originally classified as New River, but reclassified as Yadkin based on the temper attributes.
JMH039	Dan River	Net Impressed; knotted, closed weave[e]	Smoothed	Very well-smoothed interior. Surface treatment is knotted net impressed; knot structure is not evident and net spacing appears to be about 2.5 mm.
JMH040	Yadkin	Net Impressed; knotted, open weave[d]	Smoothed	Surface treatment is net impressed; cordage diameter is 1 mm; S-5 twists/cm; knots about 4 mm apart.
JMH041	Yadkin	Paddle-edge Stamped	Smoothed	Surface treatment was originally recorded as paddle-edge, but the remaining piece is not adequate to confirm this; looks very much like check stamped.
JMH042	Yadkin	Cord Marked; parallel, S-twist	Smoothed	Surface treatment is cord marked; cord diameter is 2.5 mm, S-3 twists/cm.
JMH043	Yadkin	Smoothed	Smoothed	Surface treatment is plain, very well smoothed on exterior and interior; this would necessarily be partial burnishing.
JMH044	Cape Fear	Fabric Impressed; medium weft-faced[a]	Smoothed	The remaining sherd is so small that the surface treatment is not visible, but originally identified as Cape Fear Fabric Impressed.
JMH045	Yadkin	Smoothed	Smoothed	Surface is smoothed inside and out.
JMH046	Yadkin	Smoothed	Smoothed	Surface is smoothed on the exterior, but large quartz particles stand in relief on the interior surface.
JMH047	Yadkin/Hanover	eroded stamped	Smoothed	Surface is smoothed inside and out.

Table A.3. Descriptive Information for Pottery Samples: Surface Treatment Characteristics (continued).

Sample ID	Pottery Series	Surface Treatment: Exterior	Surface Treatment: Interior	Characteristics
JMH048	Yadkin	Smoothed	Smoothed	Surface treatment on both interior and exterior is very smooth, burnished to a slight or moderate degree, but not polished.
JMH049	Yadkin	eroded stamped	Smoothed	Surface treatment is not clear in this small fragment.
JMH050	Yadkin	eroded stamped	Smoothed	
JMH051	Yadkin	Fabric Impressed; coarse weft-faced[f] / Paddle-edge Stamped	Smoothed	Surface treatment is paddle-edge stamped or coarse fabric; warp is 7 mm; weft is 1.5 mm, Z-twist, spaced 1 mm; exterior core oxidized, interior reduced.
JMH052	Yadkin/Hanover	Fabric Impressed; medium weft-faced[a]	Smoothed	Surface treatment is weft-faced fabric; warps are about 7 mm and wefts about 1.5 mm; S-twist.
JMH053	Yadkin/Hanover	Smoothed-over Stamped	Smoothed	Surface is smoothed-over stamped; cord marked, parallel (oblique) 1.3 mm diameter, S-4 twists/cm. Sherd appears to be from basal area, probably cooking vessel. Some large (9 mm) lacunae in cross section suggest organic oxidized during firing.
JMH054	New River	Cord Marked; parallel, S-twist	Smoothed	Surface treatment is cord marking; cordage is 1.5 mm; S-twist; parallel or oblique arrangement; most cord impressions are smoothed over; interior is well smoothed.
JMH055	Yadkin	Cord Marked; parallel, S-twist	Smoothed	Surface is cord marked; cordage is less than 1 mm; S-twist; parallel arrangement; less than 1 mm space between; well smoothed interior, exterior very cleanly executed.
JMH056	New River	Fabric Impressed; spaced weft, overstamped[g] / Paddle-edge Stamped; S-twist	Smoothed	Surface is perpendicular overstamped fabric or, more likely, perpendicular overstamped cord-wrapped paddle. Cordage is 1.5 mm, S-twist, spaced about 1.5 mm.
JMH057	New River	Cord Marked; perpendicular/oblique, Z-twist	Smoothed	Surface treatment is perpendicular overstamped cord marked; cords are 1.5 mm, Z-twist, spaced 4 mm apart; overstamping is perpendicular, oblique.

Table A.3. Descriptive Information for Pottery Samples: Surface Treatment Characteristics (continued).

Sample ID	Pottery Series	Surface Treatment: Exterior	Surface Treatment: Interior	Characteristics
JMH058	Cape Fear	Fabric Impressed; fine weft-faced[c]	Smoothed	Surface treatment is fabric impressed, very fine (less than 1 mm) cordage weft widely spaced (3–4 mm) over wide (4 mm) non-cordage warp. Interior is very well smoothed. Sherd is moderately absorbent and relatively soft.
JMH059	Cape Fear	Fabric Impressed; medium weft-faced[a]	Smoothed	Surface is weft-faced fabric impressed; weft cordage is 1.5–2.0mm, S-twist; warp is non-cordage, about 7.0 mm; space between wefts is about 1 mm. This context radiocarbon dated to AD 740±40.
JMH060	Hanover I	Fabric Impressed; flexible warp[b]	Smoothed	Surface treatment is fabric impressed, flexible warp; cordage weft is S-twist, 1.5–2.0 mm; closely packed weft; interior is well smoothed and reduced.
JMH061	Thoms Creek	Smoothed	Smoothed	Surface treatment is plain smoothed and there are three possible punctations. Punctate tool was partially hollowed reed.
JMH062	Cape Fear	Paddle-edge Stamped	Smoothed	Surface treatment is paddle-edge stamped, possibly decorative as area between impressions is neatly smoothed; warp is 5 mm; weft is 1.5–2.0 mm. Interior is very well smoothed. This would type as Cape Fear Fabric Impressed, although paddle-edge stamped.
JMH063	Hanover II	Fabric Impressed; medium weft-faced[a]	Fabric Impressed	Surface is fabric impressed; weft-faced over non-cordage warps. Warps are 3–4 mm and weft about 1 mm. This is a rim sherd; straight neck, slightly flaring lip with paddle-edge stamping on the interior. Lip is flattened by paddling with fabric stamp. Overall, sherd is thin and rather soft.
JMH064	Hanover II	Fabric Impressed; medium weft-faced[a]	Smoothed	Surface is overstamped fabric impressed with warps of 4–5 mm and wefts of about 1.5 mm. There appear to be some cordage segments aligned parallel to the warp, but impressions are too faint to make out what is going on. Sherd seems soft.
JMH065	Hanover I	Fabric Impressed; flexible warp[b]	Smoothed	Surface is fabric impressed, flexible warp is 3–4 mm and weft is about 1 mm. This is the rim of a large bowl, with slightly incurved neck, well-thinned to rounded lip. Vessel appears to have been fired at low temperature, is soft, cracking apart, with poorly kneaded clay.

Table A.3. Descriptive Information for Pottery Samples: Surface Treatment Characteristics (continued).

		Surface Treatment		
Sample ID	Pottery Series	Exterior	Interior	Characteristics
JMH066	Cape Fear	Fabric Impressed; medium weft-faced[a]	Smoothed	Surface is impressed with weft-faced fabric on non-cordage warp (about 4 mm) and medium weft (about 1 mm). This is a rim sherd from a medium jar with orifice circumference of about 24 cm; rim appears to be straight and the lip is slightly flared, thinned, and very cleanly executed.
JMH067	Cape Fear	None	Smoothed	Surface is too badly eroded to determine precisely, but remnant paddle-edge or fabric impressions are just visible; this is a rim of a medium-sized bowl (22 cm) with incurvate neck and narrow rounded lip.
JMH068	Hanover	None	Smoothed	No surface treatment visible because of extreme erosion. Sherd is poorly mixed and kneaded, fired very low; falling apart.
JMH069	Cape Fear	Fabric Impressed; flexible warp[b] / Paddle-edge Stamped	Fabric Impressed	Surface treatment is fabric impressed or overstamped paddle-edge stamped. This is the rim of a very large jar; straight neck; flattened-stamped lip with slight stamping of the paddle edge down the interior.
JMH070	Cape Fear	Fabric Impressed; fine weft-faced[c]	Smoothed	Surface is impressed with weft-faced fabric executed on rigid non-cordage warp (3–4 mm), weft is narrow (1 mm). Warps (or paddle) are aligned obliquely to the lip (upper left to lower right). Sherd is very soft. Rim is straight; lip is stamped flat; interior is smoothed.

[a] Weft diameter 1–2 mm, interwoven over non-cordage warp.
[b] Coarse to medium weft-faced, interwoven over cordage or fiber warp.
[c] Weft diameter less than 1 mm, interwoven over non-cordage warp.
[d] Space greater than 5 mm.
[e] Space less than 5 mm.
[f] Weft diameter greater than 2 mm, interwoven over non-cordage warp.
[g] Coarse to fine weft, spaced on non-cordage warp.

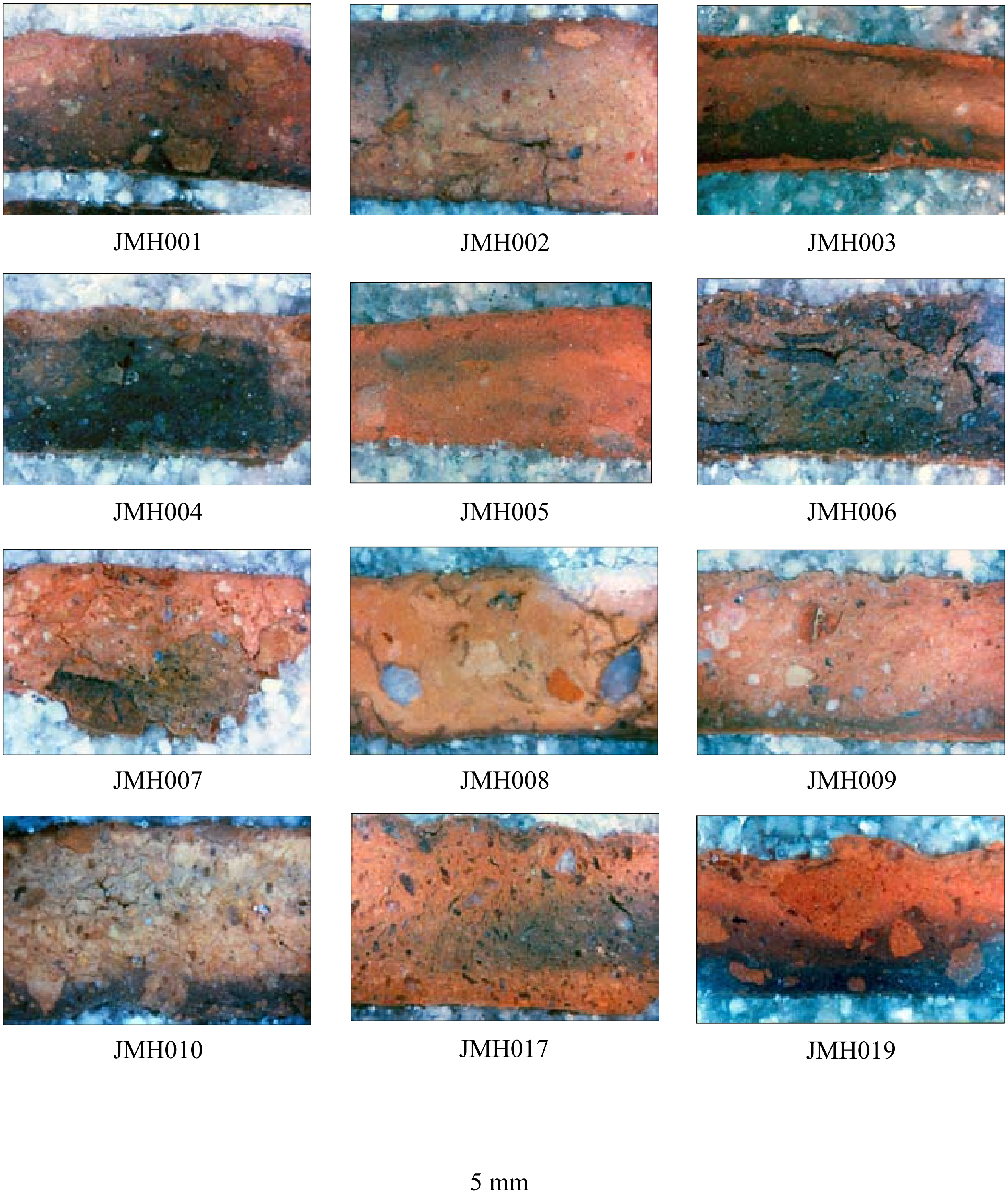
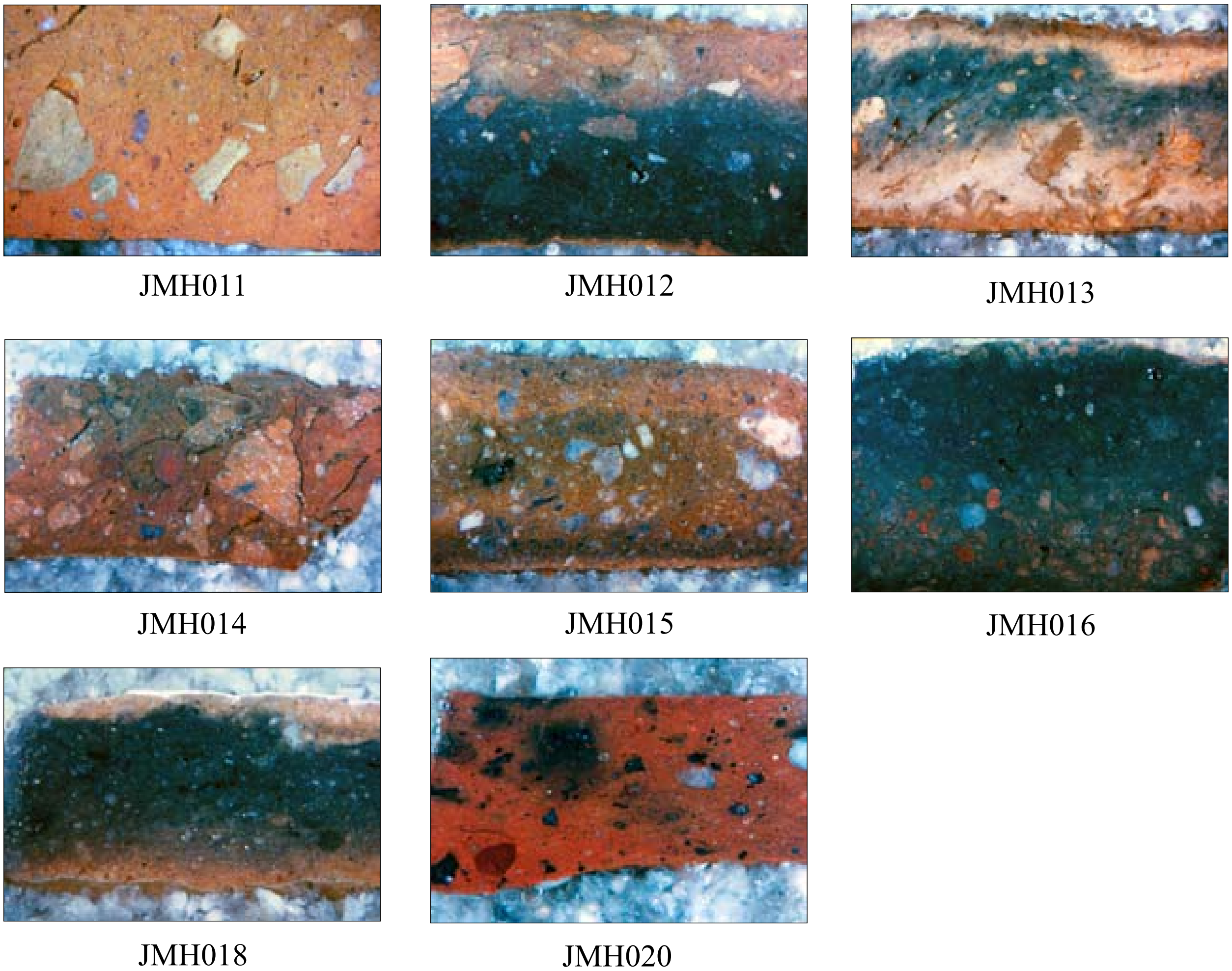
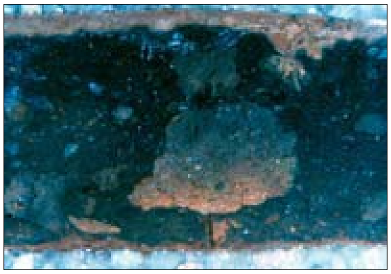


Figure A.1. Cross sections of pottery samples from Fort Bragg sites in the Lower Little drainage.

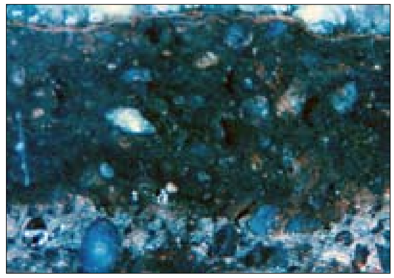


5 mm

Figure A.2. Cross sections of pottery samples from Fort Bragg sites in the Drowning Creek drainage.



JMH021



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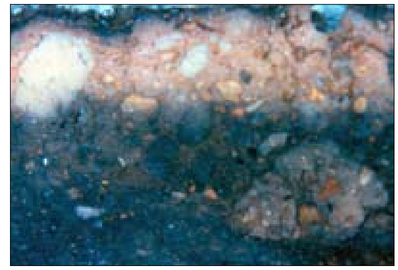
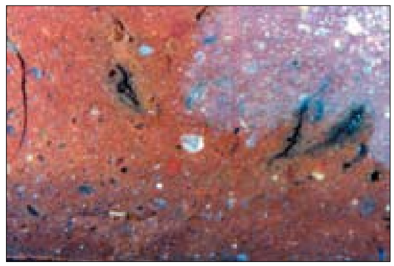


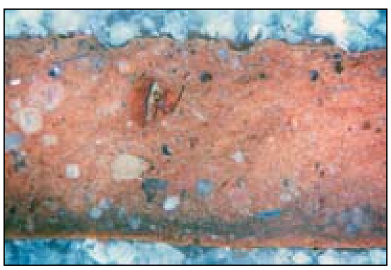
JMH023

JMH024



JMH025

JMH026



JMH027

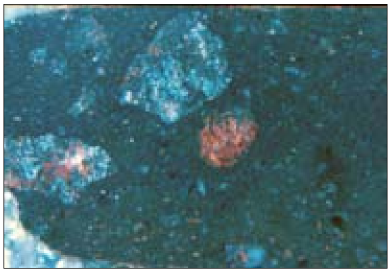
JMH028

JMH029

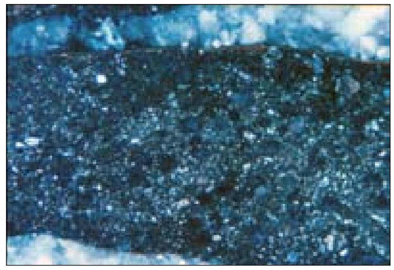
JMH030

5 mm

Figure A.3. Cross sections of pottery samples from the Breece site in the Cape Fear drainage.



JMH031



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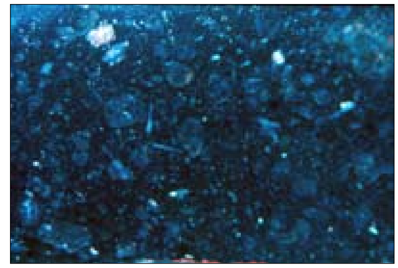

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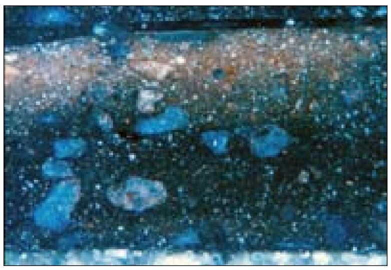

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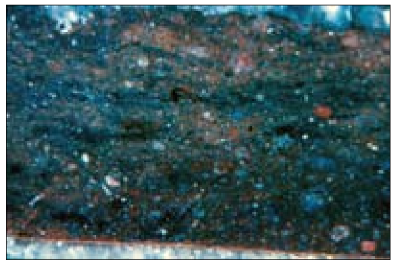

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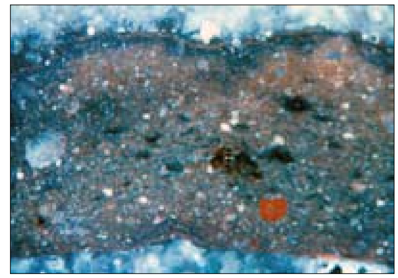

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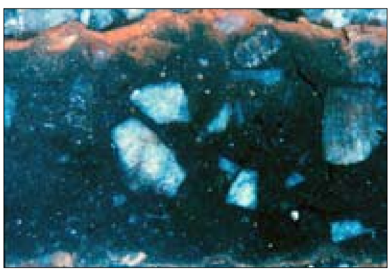
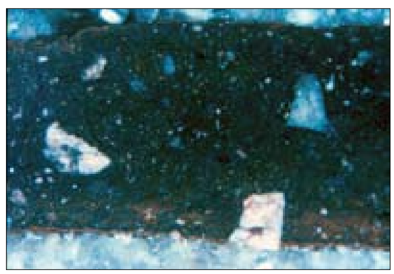


JMH037



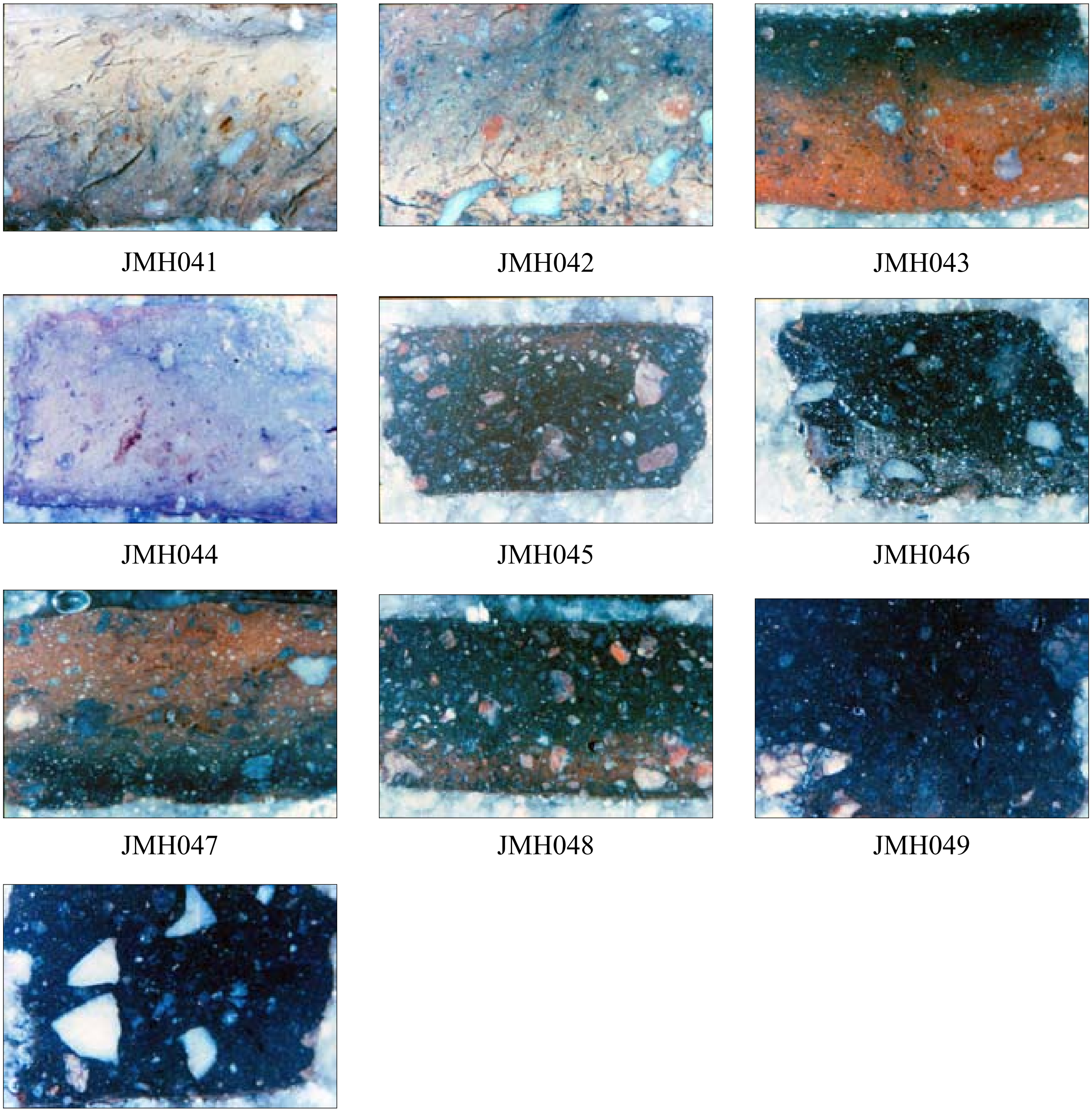
JMH038

JMH039

JMH040

5 mm

Figure A.4. Cross sections of pottery samples from the Doerschuk site in the Yadkin drainage.

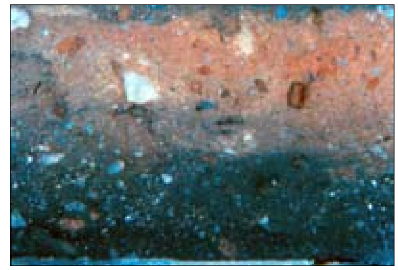


5 mm

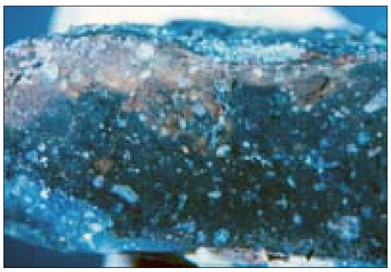
Figure A.5. Cross sections of pottery samples from the Haw River site in the Haw drainage.

JMH051

JMH052



JMH053



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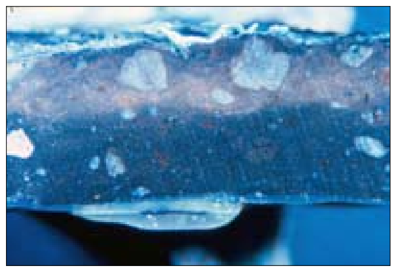

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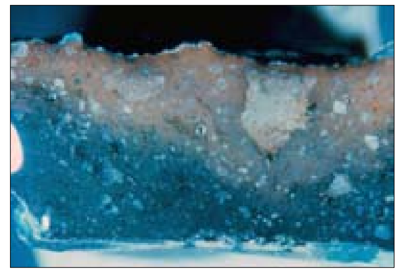
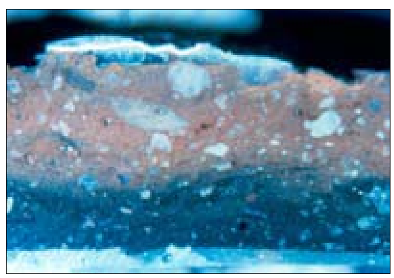
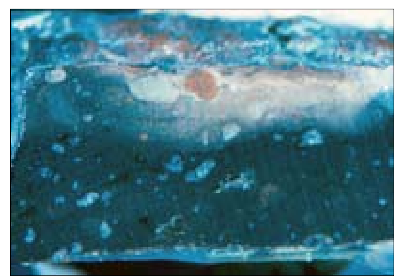


JMH056

JMH057



JMH058



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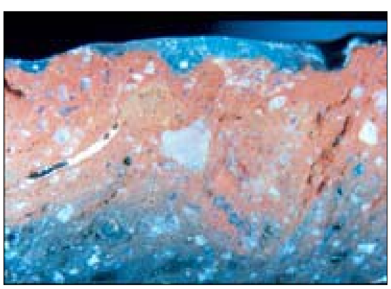
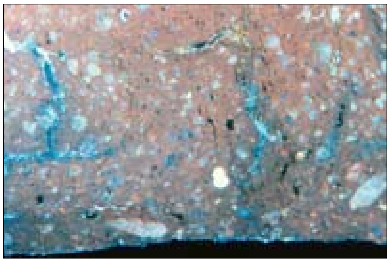


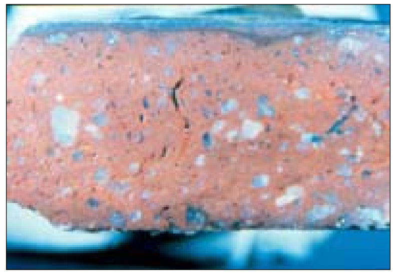
JMH060

5 mm

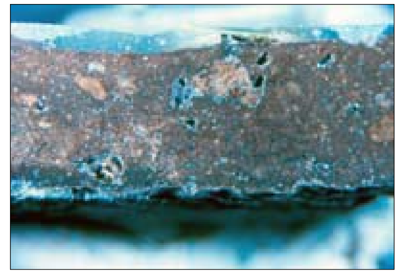
Figure A.6. Cross sections of pottery samples from the Kolb site in the Pee Dee drainage.



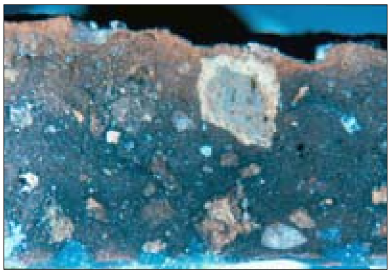
JMH061



JMH062

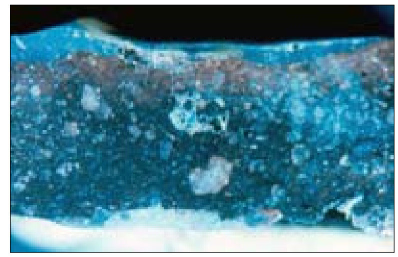


JMH063

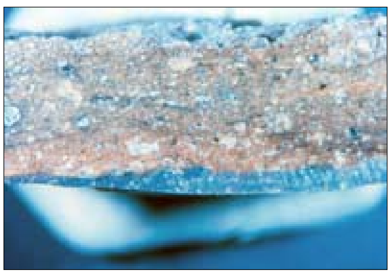


JMH064

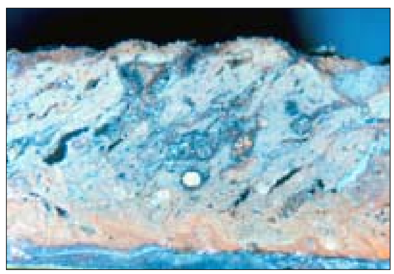
JMH065



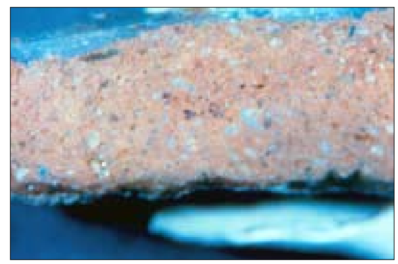
JMH066



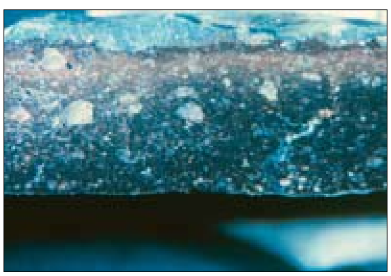
JMH067



JMH068



JMH069



JMH070

5 mm

Figure A.7. Cross sections of pottery samples from the Waccamaw site in the Waccamaw drainage.

Appendix B

Clay Sample Descriptions

Theresa E. McReynolds and Joseph M. Herbert

The sampling strategy and procedures for collecting clay samples are fully described in Chapter 4, as are the field and laboratory performance tests designed to evaluate the suitability of the samples for making low-fired earthenware. Tables B.1–B.7 present the resulting data.

Tables B.1 and B.2 describe the provenience and physical properties, respectively, of the 84 clay samples collected for this study. The drying and firing behavior of the 62 samples from which 10-×-10-×-1-cm test tiles were fashioned are summarized in Tables B.3 and B.4, and Table B.5 contains observations made during replication experiments. The 42 samples submitted for NAA, XRD, and petrographic analyses are listed in Tables B.6 and B.7.

A commercial firm prepared thin sections of the fired test tiles. Photographs were made of the flat sections of pucks using a 35mm SLR camera body mounted on an Olympus SE40 binocular microscope with incident light provided by Fostec EKE fiber-optics (Figures B.1–B.4). All puck surfaces were wetted before photographing, but some dried unevenly. Moisture absorption was influenced by partial penetration of epoxy, and as a result some samples appear to have a dark horizontal band across their centers approximately where one might expect to see a reduced core; however, this dark band has nothing to do with firing temperature or atmosphere.

Table B. 1. Descriptive Information for Clay Samples: Provenience.

Sample ID	Drainage	Nearest Site(s)[a]	UTM[b] Northing	UTM[b] Easting	Sample Type	Geographic Setting
FBR001	Lower Little	31Cd750	3896570	0688812	transported	upland setting
FBR002	Lower Little	31Cd750/31Hk127[c]	3887458	0677832	transported	upland setting
FBR003	Lower Little	31Cd486/31Mr93/ 31Hk127/31Hk123	3892165	0674316	transported	upland setting
FBR004	Lower Little	31Cd486/31Mr93/ 31Hk127/31Hk123/ 31Ht392	3894404	0674308	transported (alluvial)	stream bank
FBR005	Lower Little	31Mr93/31Cd486/ 31Hk127/31Hk123	3896330	0669883	transported (alluvial)	floodplain
FBR006	Drowning Creek	31Sc87/31Sc71/ 31Mr241/31Mr253/ 31Mr259/31Hk59/ 31Hk715[c]	3879046	0648897	transported	road cut in upland setting
FBR007	Lower Little	31Hk715/31Hk59	3880183	0655285	transported (alluvial)	stream bank
FBR008	Lower Little	31Hk868/31Ht269/ 31Hk127	3888792	0662959	transported (marine)	upland setting
FBR009	Lower Little	31Hk123/31Hk127/ 31Hk868/31Mr93	3892747	0665640	transported	upland setting
FBR010	Lower Little	31Mr93/31Cd486/ 31Hk127/31Hk123	3896332	0669869	transported (alluvial)	floodplain
FBR011	Cape Fear	Breece	3884406	0695950	transported (alluvial)	stream bank
FBR012	Cape Fear	Breece	3884925	0695785	transported (alluvial)	floodplain
FBR013	Cape Fear	Breece	3885783	0695881	transported (alluvial)	floodplain
FBR014	Cape Fear	Breece	3883886	0694988	transported (alluvial)	stream bank
FBR015	Cape Fear	Breece	3884023	0694950	transported (alluvial)	streambed
FBR016	Cape Fear	Breece	3885187	0694580	transported (alluvial)	streambed
FBR017	Lower Little	31Ht269/31Ht273/ 31Ht392	3903843	0681641	transported (alluvial)	stream bank
FBR018	Lower Little	31Ht269/31Ht273/ 31Ht392	3903844	0681603	transported (alluvial)	stream bank
FBR019	Pee Dee	Kolb	3805454	0618115	transported (lacustrine)	swampy pond edge
FBR020	Pee Dee	Kolb	3805299	0617891	transported (alluvial)	swampy floodplain

Table B. 1. Descriptive Information for Clay Samples: Provenience (continued).

			UTM[b]			
Sample ID	Drainage	Nearest Site(s)[a]	Northing	Easting	Sample Type	Geographic Setting
FBR021	Pee Dee	Kolb	3804557	0617277	transported (alluvial)	swampy floodplain
FBR022	Pee Dee	Kolb	3804963	0620363	transported (alluvial)	swampy floodplain
FBR023	Pee Dee	Kolb[c]	3814785	0609741	transported (lacustrine)	oxbow bank
FBR024	Pee Dee	Kolb	3805177	0620459	transported (alluvial)	riverbank
FBR025	Pee Dee	Kolb	3806036	0620260	transported (alluvial)	riverbank
FBR026	Pee Dee	Kolb	3806380	0620093	transported (alluvial)	swampy upper river terrace
FBR027	Pee Dee	Kolb	3804425	0617564	transported (alluvial)	stream bank
FBR028	Haw	Haw River	3950457	0672311	transported (alluvial)	floodplain
FBR029	Haw	Haw River	3950470	0672279	transported (alluvial)	floodplain
FBR030	Haw	Haw River	3946847	0673360	transported (lacustrine)	lakeshore
FBR031	Haw	Haw River	3945995	0673247	transported (alluvial)	streambed
FBR032	Haw	Haw River	3955697	0671194	transported (alluvial)	stream bank
FBR033	Haw	Haw River	3955697	0671194	transported (alluvial)	stream bank
FBR034	Haw	Haw River	3953162	0676533	transported (lacustrine)	lakeshore
FBR035	Haw	Haw River	3953225	0676289	transported	shallow basin near lake
FBR036	Haw	Haw River	3953225	0676289	transported	shallow basin near lake
FBR037	Haw	Haw River[c]	3960071	0677576	transported	muddy basin near lake
FBR038	Haw	Haw River[c]	3963409	0678625	transported (lacustrine)	lakeshore
FBR039	Haw	Haw River[c]	3963491	0679059	transported (lacustrine)	lakeshore
FBR040	Haw	Haw River[c]	3963491	0679059	transported (lacustrine)	lake bottom
FBR041	Haw	Haw River[c]	3955654	0679577	transported (lacustrine)	lakeshore
FBR042	Haw	Haw River[d]	3974555	0677701	transported (alluvial)	stream bank
FBR043	Haw	Haw River[d]	3974619	0677779	transported (alluvial)	floodplain
FBR044	Haw	Haw River[d]	3976552	0683043	transported (alluvial)	stream bank
FBR045	Haw	Haw River[d]	3976465	0683045	transported (alluvial)	swampy floodplain
FBR046	Yadkin	Doerschuk	3920259	0588642	transported (alluvial)	stream bank
FBR047	Yadkin	Doerschuk	3919683	0588766	transported (alluvial)	riverbank
FBR048	Yadkin	Doerschuk	3918363	0588424	transported (alluvial)	riverbank
FBR049	Yadkin	Doerschuk	3919007	0589049	transported (alluvial)	stream bank
FBR050	Yadkin	Doerschuk	3918787	0588793	transported (alluvial)	riverbank
FBR051	Yadkin	Doerschuk	3918787	0588793	transported (alluvial)	riverbank
FBR052	Yadkin	Doerschuk	3918739	0588663	transported (alluvial)	stream bank

Table B. 1. Descriptive Information for Clay Samples: Provenience (continued).

Sample ID	Drainage	Nearest Site(s)[a]	UTM[b] Northing	UTM[b] Easting	Sample Type	Geographic Setting
FBR053	Yadkin	Doerschuk	3916353	0587073	transported (alluvial)	stream bank
FBR054	Yadkin	Doerschuk	3916353	0587073	transported (alluvial)	stream bank
FBR055	Yadkin	Doerschuk	3916289	0586491	transported (alluvial)	floodplain
FBR056	Yadkin	Doerschuk	3915713	0585659	transported (alluvial)	riverbank
FBR057	Yadkin	Doerschuk	3916505	0585337	transported (alluvial)	floodplain
FBR058	Deep	-	3931674	0649907	transported (alluvial)	riverbank
FBR059	Lower Little	31Hk715/31Hk59	3879989	0655185	transported (lacustrine?)	stream bank/ former mill pond
FBR060	Lower Little	31Hk715/31Hk59	3879989	0655174	transported (lacustrine?)	stream bank/ former mill pond
FBR061	Lower Little	31Hk715/31Hk59	3879978	0655123	transported (alluvial)	stream bank
FBR062	Lower Little	31Hk59	3880798	0652464	transported	wetland
FBR063	Lower Little	31Hk59	3880738	0652444	transported	wetland
FBR064	Lower Little	31Hk59	3880834	0652511	transported	wetland
FBR065	Lower Little	31Hk59	3880845	0652672	transported	wetland
FBR066	Lower Little	31Hk59	3880842	0652357	transported	wetland
FBR067	Lower Little	31Hk59	3880990	0652542	transported	wetland
FBR068	Deep	-	3936119	0657466	transported (lacustrine)?	pond (clay pit?) edge
FBR069	Deep	-	3936306	0656984	sedentary	clay pit in upland setting
FBR070	Deep	-	3936306	0656984	sedentary	clay pit in upland setting
FBR071	Deep	-	3936306	0656984	sedentary	clay pit in upland setting
FBR072	Deep	-	3935791	0656593	sedentary	clay pit in upland setting
FBR073	Deep	-	3935791	0656593	sedentary	clay pit in upland setting
FBR074	Deep	-	3935781	0656546	sedentary	clay pit in upland setting
FBR075	Deep	-	3935750	0656557	sedentary	clay pit in upland setting
FBR076	Deep	-	3935703	0656548	sedentary	road cut in upland setting
FBR077	Deep	-	3936918	0654570	sedentary	clay pit in upland setting
FBR078	Deep	-	3936921	0654541	sedentary	clay pit in upland setting
FBR080	Deep	-	3931674	0649907	transported (alluvial)	riverbank
FBR081	Waccamaw	Waccamaw[c]	3805824	0738743	transported (alluvial)	floodplain
FBR082	Waccamaw	Waccamaw[c]	3805737	0735133	transported (alluvial)	roadside ditch in floodplain
FBR083	Waccamaw	Waccamaw[c]	3805762	0735128	transported (alluvial)	roadside ditch in floodplain

Table B. 1. Descriptive Information for Clay Samples: Provenience (continued).

			UTM[b]			
Sample ID	Drainage	Nearest Site(s)[a]	Northing	Easting	Sample Type	Geographic Setting
FBR084	Waccamaw	Waccamaw[c]	3805587	0739824	transported (alluvial)	floodplain
FBR085	Waccamaw	Waccamaw[c]	3805587	0739824	transported (alluvial)	streambed

[a] Refers to the nearest archaeological site(s) from which pottery samples were drawn for this study.
[b] NAD 1927 datum.
[c] Nearest site(s) more than 7.5 km away.
[d] Nearest site more than 15 km away.

Table B.2. Descriptive Information for Clay Samples: Physical Properties.

Sample ID	Drainage	Plastic Munsell Color	Description	Plasticity Ranking[a]	Stiffness Ranking[b]	Strength Ranking[c]	Workability	Test Tiles (*n*)
FBR001	Lower Little	7.5YR5/6 strong brown	silty clay	weakly plastic	could not form loop	weak	lean	1
FBR002	Lower Little	2.5YR4/6 red	clayey silt; some grit	weakly plastic	could not form loop	weak	lean	1
FBR003	Lower Little	5YR5/6 yellowish red	sandy and clayey silt; some grit	weakly plastic	could not form loop	weak	lean	1
FBR004	Lower Little	10YR6/8 brownish yellow	slightly silty clay; blocky structure; some organics	weakly plastic	moderately stiff	moderately strong	lean	1
FBR005	Lower Little	2.5Y2.5/1 black	silty clay; some fine sand and grit	moderately plastic	stiff	weak	moderately lean	1
FBR006	Drowning Creek	5Y8/1 white	clay; blocky structure	weakly plastic	could not form loop	weak	lean	1
FBR007	Lower Little	10YR6/6 brownish yellow	silty clay	weakly plastic	moderately stiff	weak	lean	1
FBR008	Lower Little	2.5YR8/2 pinkish white	clay; blocky structure	weakly plastic	could not form loop	moderately strong	lean	1
FBR009	Lower Little	8/10Y8/1 light greenish gray	silty clay; large clay lumps	weakly plastic	could not form loop	weak	lean	1
FBR010	Lower Little	2.5Y5/1 gray	clayey silt; some fine sand and organics	weakly plastic	moderately stiff	moderately strong	lean	1
FBR011	Cape Fear	2.5Y5/2 grayish brown	clay; some medium sand, grit, and organics	plastic	stiff	strong	good	3

Table B.2. Descriptive Information for Clay Samples: Physical Properties (continued).

Sample ID	Drainage	Plastic Munsell Color	Description	Plasticity Ranking[a]	Stiffness Ranking[b]	Strength Ranking[c]	Workability	Test Tiles (n)
FBR012	Cape Fear	2.5Y6/4 light yellowish brown	clay; some fine sand, gravel, and organics	plastic	stiff	strong	good	3
FBR013	Cape Fear	2.5Y6/4 light yellowish brown	clay; some fine sand and grit	plastic	stiff	weak	moderately lean	3
FBR014	Cape Fear	7.5YR4/4 brown	clay; some very fine sand	plastic	stiff	strong	good	2
FBR015	Cape Fear	5Y4/2 olive gray	clay; some fine and medium sand	plastic	moderately stiff	moderately strong	moderately lean	-
FBR016	Cape Fear	10YR6/4 light yellowish brown	clay; some organics	plastic	moderately stiff	weak	moderately lean	2
FBR017	Lower Little	10YR5/6 yellowish brown	clay; some fine sand and organics	plastic	stiff	strong	good	3
FBR018	Lower Little	2.5Y6/4 light yellowish brown	silty clay	weakly plastic	stiff	weak	moderately lean	-
FBR019	Pee Dee	2.5Y6/4 light yellowish brown	clay; some fine sand, grit, and organics	plastic	stiff	strong	good	4
FBR020	Pee Dee	2.5Y6/6 olive yellow	clay; some grit and organics	plastic	stiff	strong	good	3
FBR021	Pee Dee	10YR5/1 gray	clay; some fine sand and organics	plastic	stiff	strong	good	3

Table B.2. Descriptive Information for Clay Samples: Physical Properties (continued).

Sample ID	Drainage	Plastic Munsell Color	Description	Plasticity Ranking[a]	Stiffness Ranking[b]	Strength Ranking[c]	Workability	Test Tiles (*n*)
FBR022	Pee Dee	2.5Y5/4 light olive brown	clay; some fine and medium sand and organics	plastic	stiff	moderately strong	good	3
FBR023	Pee Dee	2.5Y6/6 olive yellow	clay; some very fine sand, clay lumps, and organics	plastic	stiff	strong	good	4
FBR024	Pee Dee	2.5Y6/4 light yellowish brown	clay; some grit, fine sand, and clay lumps	plastic	moderately stiff	strong	fat?	3
FBR025	Pee Dee	2.5Y4/2 dark grayish brown	micaceous clay; some fine sand and small clay lumps	plastic	moderately stiff	strong	fat?	3
FBR026	Pee Dee	2.5Y6/6 olive yellow	clay; some fine sand, grit, and organics	moderately plastic	moderately stiff	moderately strong	moderately lean	3
FBR027	Pee Dee	10YR5/4 yellowish brown	clay; some grit, clay lumps, and organics	plastic	moderately stiff	strong	good	3
FBR028	Haw	2.5Y6/4 light yellowish brown	slightly silty clay; some fine sand, grit, quartz gravels and pebbles, and organics	plastic	moderately stiff	strong	moderately lean	2
FBR029	Haw	10YR6/4 light yellowish brown	silty clay; abundant gravels and pebbles	moderately plastic	moderately stiff	weak	moderately lean	1
FBR030	Haw	10YR6/4 light yellowish brown	clay; some grit, gravels, pebbles, and organics	weakly plastic	soft	moderately strong	moderately lean	3
FBR031	Haw	2.5Y6/6 olive yellow	clay; some fine sand and quartz gravels and pebbles	plastic	soft	moderately strong	moderately lean	-

Table B.2. Descriptive Information for Clay Samples: Physical Properties (continued).

Sample ID	Drainage	Plastic Munsell Color	Description	Plasticity Ranking[a]	Stiffness Ranking[b]	Strength Ranking[c]	Workability	Test Tiles (n)
FBR032	Haw	2.5Y4/2 dark grayish brown	silty clay; some grit	plastic	soft	moderately strong	moderately lean	-
FBR033	Haw	10YR4/2 dark grayish brown	silty clay; some grit and organics	plastic	soft	strong	moderately lean	-
FBR034	Haw	10YR6/6 brownish yellow	clay; some fine sand, grit, and organics	moderately plastic	stiff	weak	moderately lean	1
FBR035	Haw	7.5YR6/6 reddish yellow	clay; some fine sand and organics	plastic	stiff	moderately strong	good	4
FBR036	Haw	2.5Y7/4 pale yellow	very sandy clay; some organics	moderately plastic	stiff	moderately strong	moderately lean	3
FBR037	Haw	10YR5/3 brown	clayey silt; some fine sand, grit, and organics	moderately plastic	moderately stiff	weak	moderately lean	1
FBR038	Haw	10YR6/6 brownish yellow	clay; some very fine sand and organics	moderately plastic	stiff	moderately strong	moderately lean	1
FBR039	Haw	5Y8/2 pale yellow	clay; some very fine sand and organics	plastic	stiff	moderately strong	good	4
FBR040	Haw	2.5Y6/6 olive yellow	clay; some fine sand and organics	plastic	stiff	strong	good	8
FBR041	Haw	2.5Y7/3 pale yellow	very sandy clay; some organics	plastic	moderately stiff	moderately strong	good	2
FBR042	Haw	5Y7/2 light gray	very sandy clay	plastic	soft	moderately strong	moderately lean	1

Table B.2. Descriptive Information for Clay Samples: Physical Properties (continued).

Sample ID	Drainage	Plastic Munsell Color	Description	Plasticity Ranking[a]	Stiffness Ranking[b]	Strength Ranking[c]	Workability	Test Tiles (*n*)
FBR043	Haw	10YR5/4 yellowish brown	micaceous clay; blocky structure; some fine to medium sand and organics	moderately plastic	stiff	weak	moderately lean	3
FBR044	Haw	2.5Y7/3 pale yellow	clay; some very fine sand and organics	moderately plastic	moderately stiff	moderately strong	moderately lean	1
FBR045	Haw	10YR5/4 yellowish brown	very silty clay; some fine sand and organics	plastic	moderately stiff	weak	moderately lean	1
FBR046	Yadkin	5Y5/2 olive gray	silty clay; some fine and medium sand and organics	moderately plastic	soft	weak	moderately lean	-
FBR047	Yadkin	2.5Y5/4 light olive brown	very silty clay; some fine sand and organics	moderately plastic	soft	moderately strong	lean	-
FBR048	Yadkin	5Y5/2 olive gray	silty clay; some very fine sand and organics	moderately plastic	soft	moderately strong	moderately lean	1
FBR049	Yadkin	5Y5/1 gray	clay; some silt, very fine sand, and organics	plastic	soft	moderately strong	moderately lean	5
FBR050	Yadkin	5Y4/2 olive gray	very silty clay; fine sand and abundant organics	weakly plastic	could not form loop	weak	lean	-
FBR051	Yadkin	5Y5/2 olive gray	very silty clay; some fine sand and abundant organics	plastic	soft	moderately strong	moderately lean	1
FBR052	Yadkin	2.5Y4/3 olive brown	silty clay; some fine sand and organics	moderately plastic	soft	weak	moderately lean	-
FBR053	Yadkin	2.5Y5/4 light olive brown	silty clay; some fine sand	moderately plastic	moderately stiff	weak	moderately lean	-

Table B.2. Descriptive Information for Clay Samples: Physical Properties (continued).

Sample ID	Drainage	Plastic Munsell Color	Description	Plasticity Ranking[a]	Stiffness Ranking[b]	Strength Ranking[c]	Workability	Test Tiles (*n*)
FBR054	Yadkin	5Y5/3 olive	silty clay; some fine sand	moderately plastic	soft	moderately strong	moderately lean	1
FBR055	Yadkin	5Y5/2 olive gray	silty clay; some fine sand and organics	moderately plastic	soft	moderately strong	moderately lean	1
FBR056	Yadkin	2.5Y5/4 light olive brown	very silty and sandy clay; some organics	moderately plastic	soft	moderately strong	moderately lean	-
FBR057	Yadkin	5Y4/2 olive gray	silty clay; some fine sand and organics	moderately plastic[d]	soft[d]	strongd	lean	-
FBR058	Deep	10YR5/4 yellowish brown	silty clay; blocky structure; some fine sand, grit, clay lumps, and organics	moderately plastic	moderately stiff	moderately strong	moderately lean	1
FBR059	Lower Little	2.5Y7/2 light gray	fine micaceous sand	moderately plastic	moderately stiff	weak	moderately lean	1
FBR060	Lower Little	2.5Y7/2 light gray	fine micaceous sand	moderately plastic	moderately stiff	weak	moderately lean	-
FBR061	Lower Little	2.5Y2.5/1 black	organic-rich silt	moderately plastic	soft	strong	moderately lean	-
FBR062	Lower Little	2.5Y2.5/1 black	organic-rich silt	moderately plastic	soft	strong	moderately lean	-
FBR063	Lower Little	2. 4/1/5PB dark bluish gray	clayey silt; some micaceous sand and organics	weakly plastic	moderately stiff	weak	lean	-
FBR064	Lower Little	2.5Y3/1 very dark gray	organic-rich silt	moderately plastic	soft	strong	moderately lean	-

Table B.2. Descriptive Information for Clay Samples: Physical Properties (continued).

Sample ID	Drainage	Plastic Munsell Color	Description	Plasticity Ranking[a]	Stiffness Ranking[b]	Strength Ranking[c]	Workability	Test Tiles (n)
FBR065	Lower Little	2.5Y4/1 dark gray	organic-rich silt	moderately plastic	soft	strong	moderately lean	-
FBR066	Lower Little	2.5Y5/1 gray	clay; some fine sand, silt, and organics	weakly plastic	soft	weak	lean	1
FBR067	Lower Little	2.5Y5/1 gray	clay; soft; some silt, a very small amount of fine sand, and abundant organics	moderately plastic	moderately stiff	weak	moderately lean	2
FBR068	Deep	7.5YR5/6 strong brown	slightly silty clay; blocky structure; hard; iron films on ped faces	weakly plastic	stiff	moderately strong	moderately lean	-
FBR069	Deep	7.5YR4/6 strong brown	silty or loamy clay; some organics	plastic	stiff	weak	moderately lean	1
FBR070	Deep	2.5YR4/2 weak red	silty clay; very coarse clay lumps	plastic	stiff	moderately strong	good	1
FBR071	Deep	7.5YR5/4 brown	clay; some silt	plastic	moderately stiff	moderately strong	good	1
FBR072	Deep	5YR3/4 dark reddish brown	silty clay; many sands, gravels, and small cobbles; some organics	weakly plastic	soft	weak	lean	1
FBR073	Deep	2.5YR4/4 reddish brown	clay; abundant clay lumps	weakly plastic	moderately stiff	weak	lean	-
FBR074	Deep	7.5YR4/6 strong brown	very sandy clay; some gravels	plastic	stiff	weak	moderately lean	1
FBR075	Deep	7.5YR5/6 strong brown	clay; some organic matter	plastic	moderately stiff	weak	moderately lean	1

Table B.2. Descriptive Information for Clay Samples: Physical Properties (continued).

Sample ID	Drainage	Plastic Munsell Color	Description	Plasticity Ranking[a]	Stiffness Ranking[b]	Strength Ranking[c]	Workability	Test Tiles (n)
FBR076	Deep	2.5YR4/2 weak red	clay; blocky structure; clay lumps and gravels	plastic	soft	weak	moderately lean	-
FBR077	Deep	2.5YR4/2 weak red	clay; clay lumps, gravels, and organics	plastic	stiff	weak	moderately lean	1
FBR078	Deep	2.5YR4/2 weak red	gritty clay; some gravels and fine organics	moderately plastic	moderately stiff	weak	moderately lean	-
FBR080	Deep	2.5Y4/2 dark grayish brown	clay	plastic	soft	moderately strong	fat?	1
FBR081	Waccamaw	2.5Y5/4 light olive brown	sandy clay; organics	moderately plastic	stiff	moderately strong	good	1
FBR082	Waccamaw	5Y5/2 olive gray	clay; some very fine sand	plastic	stiff	moderately strong	good	1
FBR083	Waccamaw	5Y4/2 olive gray	clay; some fine to medium sand and organics	plastic	stiff	moderately strong	good	1
FBR084	Waccamaw	2.5Y6/3 light yellowish brown	clay; some fine sand	plastic	stiff	moderately strong	good	1
FBR085	Waccamaw	2.5Y6/3 light yellowish	clay; some fine to medium sand and organics	plastic	stiff	moderately strong	good	1

[a] The plasticity ranking is based on the results of the coil test. Plastic samples did not crack when coiled, moderately-plastic samples cracked, and weakly plastic samples broke into multiple segments.
[b] The stiffness ranking is based on the results of the loop test. Stiff samples retained their shapes during the test, moderately-stiff samples sagged, and soft samples collapsed. Samples which could not be formed into a loop could not be tested.
[c] The strength ranking is based on the results of the ball test. Strong samples did not crack when compressed, moderately-strong samples cracked slightly, and weak samples cracked extensively.
[d] This sample was too soft to work until sand was added to stiffen it. Performance test results are therefore based on the sand-tempered sample.

Table B.3. Descriptive Information for Clay Samples: Drying Behavior.

Sample ID: Tile Number	Temper (Weight %)	Dry Munsell Color	Linear Drying Shrinkage (%)	Plastic Weight (g)	Dry Weight (g)	Water of Plasticity (%)	Post-Drying Observations
FBR001:							
1	-	10YR7/6 yellow	6	-	108.5	-	moderate warping
FBR002:							
1	-	2.5YR4/8 red	-	-	-	-	crumbled during drying; could not be weighed, measured, or fired
FBR003:							
1	-	5YR7/6 reddish yellow	2	-	145.9	-	minor warping; began to crumble during oven-drying
FBR004:							
1	-	10YR7/3 very pale brown	10	-	122.4	-	minor warping
FBR005:							
1	-	2.5Y4/0 dark gray	4	-	118.5	-	minor warping
FBR006:							
1	-	5YR8/1 white	6	-	92.5	-	moderate warping
FBR007:							
1	-	10YR8/4 very pale brown	8	-	109.9	-	moderate warping
FBR008:							
1	-	5YR8/1 white	6	-	128.4	-	moderate warping
FBR009:							
1	-	5Y8/1 white	12	-	100.7	-	moderate warping

Table B.3. Descriptive Information for Clay Samples: Drying Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Dry Munsell Color	Linear Drying Shrinkage (%)	Plastic Weight (g)	Dry Weight (g)	Water of Plasticity (%)	Post-Drying Observations
FBR010:							
1	-	5YR7/1 light gray	4	-	148.6	-	minor warping
FBR011:							
1	-	10YR7/2 light gray	8	167.1	138.1	21.0	minor warping
2	10% nonlocal grog[a]	10YR7/2 light gray	8	-	141.8	-	moderate warping
3	10% local grog[b]	2.5Y6/2 light brownish gray	8	183.9	139.6	31.7	minor warping
FBR012:							
1	-	10YR6/4 light yellowish brown	10	175.7	134.3	30.8	moderate warping
2	10% nonlocal grog[a]	2.5Y6/4 light yellowish brown	10	-	127.4	-	moderate warping
3	15% local grog[b]	2.5Y6/4 light yellowish brown	10	174.6	131.2	33.1	minor warping
FBR013:							
1	-	2.5Y6/4 light yellowish brown	10	177.6	136.4	30.2	minor warping; minor cracking
2	10% nonlocal grog[a]	2.5Y7/4 pale yellow	8	-	134.1	-	moderate warping; cracking
3	15% local grog[b]	2.5Y7/2 light gray	8	174.4	136.1	28.1	moderate warping; minor cracking
FBR014:							
1	-	10YR6/4 light yellowish brown	10	173.0	124.8	38.6	moderate warping; minor cracking
2	15% local grog[b]	10YR6/4 light yellowish brown	8	173.7	126.0	37.9	moderate warping; cracking

Table B.3. Descriptive Information for Clay Samples: Drying Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Dry Munsell Color	Linear Drying Shrinkage (%)	Plastic Weight (g)	Dry Weight (g)	Water of Plasticity (%)	Post-Drying Observations
FBR016:							
1	-	10YR7/3 very pale brown	10	172.4	125.1	37.8	moderate warping; minor cracking
2	15% local grog[b]	2.5Y7/4 pale yellow	8	170.2	125.6	35.5	moderate warping; minor cracking
FBR017:							
1	-	10YR6/6 brownish yellow	16	158.4	102.6	54.4	significant warping; minor cracking
2	10% local grog[b]	10YR6/6 brownish yellow	12	163.7	110.4	48.3	moderate warping; cracking
3	10% Lower Little sand (FBR092)	10YR6/8 brownish yellow	12	175.8	120.1	46.4	moderate warping
FBR019:							
1	-	10YR8/1 white	8	174.2	125.3	39.0	moderate warping
2	10% unprovenienced sand A[c]	10YR8/1 white	8	173.3	128.0	35.4	moderate warping
3	20% unprovenienced sand A[c]	10YR8/1 white	8	178.5	133.8	33.4	moderate warping
4	10% local grog[b]	10YR8/1 white	8	181.4	133.5	35.9	minor warping; cracking
FBR020:							
1	-	2.5Y7/4 pale yellow	6	181.9	131.0	38.9	moderate warping
2	10% local grog[b]	10YR8/2 white	8	191.7	138.4	38.5	minor warping; cracking
3	15% Jordan Lake sand	10YR8/1 white	8	205.1	153.8	33.4	moderate warping; cracking

Table B.3. Descriptive Information for Clay Samples: Drying Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Dry Munsell Color	Linear Drying Shrinkage (%)	Plastic Weight (g)	Dry Weight (g)	Water of Plasticity (%)	Post-Drying Observations
FBR021:							
1	-	2.5Y6/2 light brownish gray	10	156.4	100.8	55.2	moderate warping
2	15% Jordan Lake sand	10YR6/1 gray	10	163.4	108.4	50.7	moderate warping; minor cracking
3	10% local grog[b]	10YR6/1 gray	10	181.1	118.1	53.3	moderate warping; cracking
FBR022:							
1	-	10YR8/2 white	8	171.8	122.3	40.5	moderate warping
2	15% unprovenienced sand A[c]	10YR8/1 white	6	188.4	144.2	30.7	minor warping; minor cracking
3	15% local grog[b]	10YR8/1 white	6	186.9	136.7	36.7	minor warping; minor cracking
FBR023:							
1	-	2.5Y7/4 pale yellow	12	169.1	118.9	42.2	moderate warping; minor cracking
2	15% unprovenienced sand D[d]	2.5Y7/4 pale yellow	10	159.4	119.0	33.9	minor warping; minor cracking
3	10% local grog[b]	10YR7/4 very pale brown	10	160.6	114.6	40.1	moderate warping; minor cracking
4	10% nonlocal grog[a]	2.5Y7/4 pale yellow	10	167.5	122.0	37.3	minor warping
FBR024:							
1	-	2.5Y7/4 pale yellow	8	184.1	139.0	32.4	moderate warping

Table B.3. Descriptive Information for Clay Samples: Drying Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Dry Munsell Color	Linear Drying Shrinkage (%)	Plastic Weight (g)	Dry Weight (g)	Water of Plasticity (%)	Post-Drying Observations
2	15% unprovenienced sand D[d]	2.5Y7/4 pale yellow	6	192.7	154.3	24.9	minor warping
3	10% local grog[b]	10YR7/4 very pale brown	6	185.0	142.2	30.1	minor warping; minor cracking
FBR025:							
1	-	10YR7/2 light gray	8	156.7	104.3	50.2	moderate warping; minor cracking
2	10% local grog[b]	10YR7/1 light gray	6	168.5	117.4	43.5	moderate warping; minor cracking
3	15% unprovenienced sand D[d]	10YR7/1 light gray	8	178.7	129.5	38.0	moderate warping; cracking
FBR026:							
1	-	2.5Y7/4 pale yellow	10	165.8	111.1	49.2	moderate warping
2	15% unprovenienced sand D[d]	2.5Y7/4 pale yellow	8	191.6	141.3	35.6	minor warping; minor cracking
3	10% local grog[b]	2.5Y7/4 pale yellow	8	164.7	114.7	43.6	minor warping; minor cracking
FBR027:							
1	-	10YR7/3 very pale brown	10	167.9	114.0	47.3	moderate warping
2	10% local grog[b]	10YR7/3 very pale brown	8	167.5	117.0	43.2	moderate warping; minor cracking
3	15% unprovenienced sand A[c]	10YR7/3 very pale brown	8	168.9	121.8	38.7	moderate warping; minor cracking

Table B.3. Descriptive Information for Clay Samples: Drying Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Dry Munsell Color	Linear Drying Shrinkage (%)	Plastic Weight (g)	Dry Weight (g)	Water of Plasticity (%)	Post-Drying Observations
FBR028:							
1	-	2.5Y7/6 yellow	6	184.9	142.1	30.1	moderate warping
2	20% Jordan Lake sand	10YR7/6 yellow	6	193.3	150.9	28.1	moderate warping; cracking
FBR029:							
1	>30% natural[e]	2.5Y7/4 pale yellow	4	205.4	166.1	23.7	minor warping; minor cracking
FBR030:							
1	>20% natural[e]	10YR8/6 yellow	8	175.1	127.2	37.7	moderate warping; minor cracking
2	5% Jordan Lake sand	10YR7/6 yellow	8	185.5	136.8	35.6	moderate warping; minor cracking
3	10% Jordan Lake sand	10YR7/6 yellow	8	194.4	149.3	30.2	moderate warping; minor cracking
FBR034:							
1	-	10YR7/4 very pale brown	10	177.9	128.8	38.1	moderate warping
FRB035:							
1	-	7.5YR5/6 strong brown	16	164.1	106.8	53.7	significant warping
2	10% Jordan Lake sand	7.5YR5/6 strong brown	12	168.5	116.0	45.3	moderate warping
3	15% Jordan Lake sand	7.5YR5/6 strong brown	12	175.9	126.9	38.6	moderate warping
4	10% Richmond County quartz (FBR087)	7.5YR6/6 reddish yellow	10	197.6	145.3	36.0	moderate warping; minor cracking
FBR036:							
1	-	2.5Y7/4 pale yellow	10	186.6	145.7	28.1	moderate warping

Table B.3. Descriptive Information for Clay Samples: Drying Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Dry Munsell Color	Linear Drying Shrinkage (%)	Plastic Weight (g)	Dry Weight (g)	Water of Plasticity (%)	Post-Drying Observations
2	10% Richmond County quartz (FBR087)	10YR8/1 white	8	202.8	165.7	22.4	moderate warping; minor cracking
3	15% Jordan Lake sand	10YR8/1 white	8	203.9	167.2	21.9	moderate warping; minor cracking
FBR037:							
1	-	10YR6/3 pale brown	6	203.2	166.3	22.2	moderate warping
FBR038:							
1	-	10YR6/4 light yellowish brown	14	169.4	119.1	42.2	moderate warping
FBR039:							
1	-	10YR7/1 light gray	10	176.3	129.0	36.7	moderate warping
2	5% Jordan Lake sand	10YR7/1 light gray	10	176.2	133.4	32.1	moderate warping
3	10% Jordan Lake sand	10YR7/1 light gray	8	184.4	142.1	29.8	moderate warping
4	10% Richmond County quartz (FBR087)	5Y7/2 light gray	10	193.5	149.1	29.8	moderate warping; minor cracking
FBR040:							
1	-	10YR6/4 light yellowish brown	12	169.3	119.1	42.1	moderate warping
2	10% Richmond County quartz (FBR087)	10YR7/4 very pale brown	10	172.7	127.8	35.1	moderate warping; minor cracking
3	15% Jordan Lake sand	10YR7/4 very pale brown	10	201.9	152.3	32.6	minor warping; minor cracking

Table B.3. Descriptive Information for Clay Samples: Drying Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Dry Munsell Color	Linear Drying Shrinkage (%)	Plastic Weight (g)	Dry Weight (g)	Water of Plasticity (%)	Post-Drying Observations
4	10% weathered granitic rock (FBR088)	10YR6/6 brownish yellow	8	185.9	139.6	33.2	minor warping
5	10% weathered granitic rock (FBR089)	10YR6/6 brownish yellow	10	167.7	121.3	38.3	minor warping
6	10% weathered metavolcanic rock (FBR090)	10YR6/6 brownish yellow	10	174.3	126.6	37.7	minor warping
7	10% fresh diabase (FBR091)	10YR6/6 brownish yellow	10	171.5	124.6	37.6	minor warping
8	10% Deep River quartz (FBR086)	10YR6/6 brownish yellow	12	171.4	124.0	38.2	moderate warping
FBR041:							
1	-	10YR8/1 white	10	192.7	152.2	26.6	moderate warping
2	10% Richmond County quartz (FBR087)	10YR8/1 white	8	199.7	163.3	22.3	moderate warping; cracking
FBR042:							
1	-	2.5Y7/2 light gray	8	190.8	153.8	24.1	moderate warping
FBR043:							
1	-	10YR6/4 light yellowish brown	12	189.9	141.1	34.6	minor warping
2	10% Richmond County quartz (FBR087)	10YR6/4 light yellowish brown	8	193.2	149.6	29.1	minor warping; minor cracking
3	15% Morgan Creek sand	10YR6/4 light yellowish brown	8	188.9	145.8	29.6	moderate warping; cracking

Table B.3. Descriptive Information for Clay Samples: Drying Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Dry Munsell Color	Linear Drying Shrinkage (%)	Plastic Weight (g)	Dry Weight (g)	Water of Plasticity (%)	Post-Drying Observations
FBR044:							
1	-	2.5Y7/2 light gray	8	180.6	140.4	28.6	moderate warping
FBR045:							
1	-	10YR7/2 light gray	10	175.2	129.6	35.2	moderate warping
FBR048:							
1	-	10YR8/1 white	8	167.1	118.9	40.5	minor warping; minor cracking
FBR049:							
1	-	2.5Y6/2 light brownish gray	8	184.5	139.1	32.6	minor warping; minor cracking
2	10% Richmond County quartz (FBR087)	2.5Y6/2 light brownish gray	6	178.9	137.6	30.0	moderate warping
3	10% weathered granitic rock (FBR089)	2.5Y6/2 light brownish gray	6	181.7	139.3	30.4	minor warping
4	10% weathered metavolcanic rock (FBR090)	2.5Y6/2 light brownish gray	6	178.6	137.6	29.8	moderate warping
5	10% fresh diabase (FBR091)	2.5Y6/2 light brownish gray	4	181.5	137.3	32.2	moderate warping
FBR051:							
1	-	10YR7/3 very pale brown	8	165.9	113.9	45.7	minor warping
FBR054:							
1	-	2.5Y6/4 light yellowish brown	8	187.2	141.9	31.9	moderate warping

Table B.3. Descriptive Information for Clay Samples: Drying Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Dry Munsell Color	Linear Drying Shrinkage (%)	Plastic Weight (g)	Dry Weight (g)	Water of Plasticity (%)	Post-Drying Observations
FBR055:							
1	-	10YR6/4 light yellowish brown	8	182.1	132.7	37.2	minor warping
FBR058:							
1	-	10YR7/3 very pale brown	6	184.5	147.8	24.8	minor warping
FBR059:							
1	-	2.5Y8/2 white	8	173.1	130.2	32.9	minor warping
FBR066:							
1	-	7.5YR7/0 light gray	8	-	91.8	-	moderate warping
FBR067:							
1	-	7.5YR6/0 gray	12	121.8	60.4	101.7	significant warping
2	10% Lower Little sand (FBR092)	7.5YR6/0 gray	10	135.7	71.6	89.5	moderate warping
FBR069:							
1	-	10YR6/6 brownish yellow	8	176.0	139.7	26.0	moderate warping
FBR070:							
1	-	5YR5/2 reddish gray	10	155.0	120.8	28.3	no warping or cracking
FBR071:							
1	-	7.5YR5/4 brown	8	172.0	136.5	26.0	moderate warping
FBR072:							
1	-	5YR5/4 reddish brown	4	187.0	153.6	21.7	minor warping

Table B.3. Descriptive Information for Clay Samples: Drying Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Dry Munsell Color	Linear Drying Shrinkage (%)	Plastic Weight (g)	Dry Weight (g)	Water of Plasticity (%)	Post-Drying Observations
FBR074:							
1	-	-	8	184.0	149.3	23.2	minor warping
FBR075:							
1	-	10YR6/4 light yellowish brown	8	178.0	143.4	24.1	minor warping
FBR077:							
1	-	5YR6/3 light reddish brown	8	162.0	126.0	28.6	moderate warping
FBR080:							
1	-	10YR7/2 light gray	8	179.8	134.4	33.8	moderate warping
FBR081:							
1	-	2.5Y5/4 light olive brown	10	193.0	155.5	24.1	minor warping
FBR082:							
1	-	5Y6/2 light olive gray	12	174.6	129.7	34.6	minor warping
FBR083:							
1	-	5Y5/3 olive	10	196.7	156.0	26.1	minor warping
FBR084:							
1	-	5Y6/3 pale olive	12	163.8	115.9	41.3	moderate warping
FBR085:							
1	-	2.5Y6/4 light yellowish brown	14	172.3	124.0	39.0	moderate warping

[a] Nonlocal grog was made by crushing unprovenienced sherds.
[b] Local grog was made by crushing fired test tiles fashioned from the sample clay.
[c] Unprovenienced sand A is a well-sorted, subrounded coarse quartz sand with occasional dark mineral inclusions.

Table B.3. Descriptive Information for Clay Samples: Drying Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Dry Munsell Color	Linear Drying Shrinkage (%)	Plastic Weight (g)	Dry Weight (g)	Water of Plasticity (%)	Post-Drying Observations

[d] Unprovenienced sand D is a mixture of subrounded and subangular coarse quartz sand, gravels, and pebbles.

[e] This sample contains abundant natural gravels and pebbles that function as temper. No additional tempering materials were added.

Table B.4. Descriptive Information for Clay Samples: Firing Behavior.

Sample ID: Tile Number	Temper (Weight %)	Firing Temperature (°C)	Post-firing Munsell Color	Linear Firing Shrinkage (%)	Post-firing Weight (g)	Firing Weight Loss (%)	Total Weight Loss (%)[a]	Post-firing Hardness	Post-firing Observations
FBR001:									
1	-	≤950	5YR7/8 reddish yellow	-2.1	101.2	6.7	-	very soft	broke into three pieces during firing
FBR002:									
1	-	-	-	-	-	-	-	very soft	could not be fired
FBR003:									
1	-	≤950	5YR7/8 reddish yellow	0.0	138.5	5.1	-	soft	moderate warping; broke during handling
FBR004:									
1	-	≤950	5YR7/6 reddish yellow	-2.2	116.6	4.7	-	very soft	
FBR005:									
1	-	≤950	7.5YR8/2 pinkish white	0.0	107.8	9.0	-	moderately hard	became crumbly
FBR006:									
1	-	≤950	7.5YR8/2 pinkish white	2.1	81.3	12.1	-	moderately hard	
FBR007:									
1	-	≤950	5YR7/6 reddish yellow	0.0	99.3	9.6	-	moderately hard	
FBR008:									
1	-	≤950	5YR8/2 pinkish white	0.0	119.1	7.2	-	hard	
FBR009:									
1	-	≤950	7.5YR8/2 pinkish white	0.0	91.6	9.0	-	soft	
FBR010:									
1	-	≤950	7.5YR8/2 pinkish white	-2.1	143.3	3.6	-	very soft	

Table B.4. Descriptive Information for Clay Samples: Firing Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Firing Temperature (°C)	Post-firing Munsell Color	Linear Firing Shrinkage (%)	Post-firing Weight (g)	Firing Weight Loss (%)	Total Weight Loss (%)[a]	Post-firing Hardness	Post-firing Observations
FBR011:									
1	-	893	10YR8/4 very pale brown	0.0	132.3	4.2	20.8	hard	
2	10% nonlocal grog[b]	893	10YR8/4 very pale brown	0.0	135.9	4.2	-	hard	minor cracking
3	10% local grog[c]	893	7.5YR8/6 reddish yellow	0.0	131.4	5.9	28.5	hard	
FBR012:									
1	-	893	2.5YR5/8 red	-2.2	127.7	4.9	27.3	hard	
2	10% nonlocal grog[b]	893	2.5YR5/8 red	0.0	121.5	4.6		hard	
3	15% local grog[c]	893	5YR6/8 reddish yellow	0.0	124.7	5.0	28.6	hard	moderate warping
FBR013:									
1	-	893	5YR7/8 reddish yellow	2.2	130.4	4.4	26.6	moderately hard	moderate warping
2	10% nonlocal grog[b]	893	5YR6/8 reddish yellow	0.0	128.7	4.0	-	soft	
3	15% local grog[c]	893	5YR7/8 reddish yellow	0.0	130.6	4.0	25.1	soft	
FBR014:									
1	-	893	5YR6/6 reddish yellow	0.0	117.0	6.3	32.4	moderately hard	
2	15% local grog[c]	893	5YR7/6 reddish yellow	0.0	118.0	6.3	32.1	soft	
FBR016:									
1	-	893	5YR6/6 reddish yellow	0.0	117.6	6.0	31.8	moderately hard	

Table B.4. Descriptive Information for Clay Samples: Firing Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Firing Temperature (°C)	Post-firing Munsell Color	Linear Firing Shrinkage (%)	Post-firing Weight (g)	Firing Weight Loss (%)	Total Weight Loss (%)[a]	Post-firing Hardness	Post-firing Observations
2	15% local grog[c]	893	5YR7/6 reddish yellow	0.0	118.1	6.0	30.6	soft	
FBR017:									
1	-	893	2.5YR5/6 red	0.0	97.3	5.2	38.6	hard	
2	10% local grog[c]	893	2.5YR5/8 red	0.0	103.8	6.0	36.6	hard	
3	10% Lower Little sand (FBR092)	≤950	2.5YR5/8 red	-2.3	114.1	5.0	35.1	hard	
FBR019:									
1	-	893	7.5YR7/6 reddish yellow	0.0	116.9	6.7	32.9	hard	minor cracking
2	10% unprovenienced sand A[d]	893	5YR7/4 pink	0.0	120.5	5.9	30.5	hard	minor cracking
3	20% unprovenienced sand A[d]	893	5YR7/6 reddish yellow	0.0	126.6	5.4	29.1	moderately hard	minor cracking
4	10% local grog[c]	893	5YR7/6 reddish yellow	0.0	124.7	6.6	31.3	hard	
FBR020:									
1	-	893	5YR6/6 reddish yellow	2.1	122.1	6.8	32.9	hard	minor cracking
2	10% local grog[c]	893	5YR7/6 reddish yellow	2.2	127.4	7.9	33.5	hard	
3	15% Jordan Lake sand	893	5YR7/6 reddish yellow	0.0	142.8	7.2	30.4	hard	

Table B.4. Descriptive Information for Clay Samples: Firing Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Firing Temperature (°C)	Post-firing Munsell Color	Linear Firing Shrinkage (%)	Post-firing Weight (g)	Firing Weight Loss (%)	Total Weight Loss (%)[a]	Post-firing Hardness	Post-firing Observations
FBR021:									
1	-	893	10YR8/3 very pale brown	0.0	91.4	9.3	41.6	hard	minor cracking
2	15% Jordan Lake sand	893	7.5YR8/4 pink	0.0	99.1	8.6	39.4	hard	
3	10% local grog[c]	893	7.5YR8/4 pink	0.0	106.6	9.7	41.1	hard	
FBR022:									
1	-	893	5YR7/4 pink	2.2	113.7	7.0	33.8	hard	minor cracking
2	15% unprovenienced sand A[d]	893	5YR7/6 reddish yellow	2.1	134.6	6.7	28.6	hard	
3	15% local grog[c]	893	5YR7/6 reddish yellow	0.0	127.5	6.7	31.8	hard	moderate warping
FBR023:									
1	-	893	5YR6/6 reddish yellow	0.0	111.3	6.4	34.2	hard	
2	15% unprovenienced sand D[e]	893	2.5YR6/8 light red	0.0	111.9	6.0	29.8	hard	
3	10% local grog[c]	893	5YR6/8 reddish yellow	2.2	106.7	6.9	33.6	hard	
4	10% nonlocal grog[b]	≤950	5YR6/8 reddish yellow	0.0	112.9	7.5	32.6	hard	
FBR024:									
1	-	893	5YR6/6 reddish yellow	0.0	131.5	5.4	28.6	hard	minor cracking

Table B.4. Descriptive Information for Clay Samples: Firing Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Firing Temperature (°C)	Post-firing Munsell Color	Linear Firing Shrinkage (%)	Post-firing Weight (g)	Firing Weight Loss (%)	Total Weight Loss (%)[a]	Post-firing Hardness	Post-firing Observations
2	15% unprovenienced sand D[e]	893	5YR6/6 reddish yellow	0.0	146.3	5.2	24.1	hard	
3	10% local grog[c]	893	5YR6/8 reddish yellow	0.0	133.9	5.8	27.6	hard	
FBR025:									
1	-	893	7.5YR7/4 pink	2.2	96.1	7.9	38.7	moderately hard	
2	10% local grog[c]	893	7.5YR8/4 pink	2.1	108.6	7.5	35.5	hard	
3	15% unprovenienced sand D[e]	893	7.5YR8/4 pink	0.0	119.9	7.4	32.9	soft	
FBR026:									
1	-	893	2.5YR6/8 light red	0.0	104.4	6.0	37.0	hard	minor cracking
2	15% unprovenienced sand D[e]	893	5YR7/8 reddish yellow	0.0	132.9	5.9	30.6	moderately hard	moderate warping; cracking
3	10% local grog[c]	893	2.5YR6/8 light red	0.0	107.5	6.3	34.7	hard	cracking
FBR027:									
1	-	893	5YR7/6 reddish yellow	0.0	104.5	8.3	37.8	hard	minor cracking
2	10% local grog[c]	893	5YR7/6 reddish yellow	0.0	107.1	8.5	36.1	hard	
3	15% unprovenienced sand A[d]	893	5YR7/6 reddish yellow	0.0	112.1	8.0	33.6	soft	

Table B.4. Descriptive Information for Clay Samples: Firing Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Firing Temperature (°C)	Post-firing Munsell Color	Linear Firing Shrinkage (%)	Post-firing Weight (g)	Firing Weight Loss (%)	Total Weight Loss (%)[a]	Post-firing Hardness	Post-firing Observations
FBR028:									
1	-	893	5YR6/8 reddish yellow	0.0	136.9	3.7	26.0	moderately hard	minor cracking
2	20% Jordan Lake sand	893	5YR6/8 reddish yellow	0.0	146.4	3.0	24.3	soft	
FBR029:									
1	>30% natural[f]	893	5YR7/8 reddish yellow	0.0	160.9	3.1	21.7	soft	
FBR030:									
1	>20% natural[f]	893	5YR6/8 reddish yellow	0.0	119.9	5.7	31.5	hard	
2	5% Jordan Lake sand	893	5YR6/8 reddish yellow	0.0	129.9	5.0	30.0	moderately hard	
3	10% Jordan Lake sand	893	5YR7/8 reddish yellow	-2.2	142.6	4.5	26.6	soft	
FBR034:									
1	-	893	5YR6/6 reddish yellow	0.0	123.2	4.3	30.7	hard	
FRB035:									
1	-	893	2.5YR4/8 red	0.0	102.1	4.4	37.8	hard	
2	10% Jordan Lake sand	893	2.5YR4/8 red	0.0	111.8	3.6	33.6	hard	
3	15% Jordan Lake sand	893	2.5YR5/8 red	0.0	122.3	3.6	30.5	hard	minor cracking
4	10% Richmond County quartz (FBR087)	893	5YR6/8 reddish yellow	0.0	137.4	5.4	30.5	hard	

Table B.4. Descriptive Information for Clay Samples: Firing Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Firing Temperature (°C)	Post-firing Munsell Color	Linear Firing Shrinkage (%)	Post-firing Weight (g)	Firing Weight Loss (%)	Total Weight Loss (%)[a]	Post-firing Hardness	Post-firing Observations
FBR036:									
1	-	893	7.5YR6/6 reddish yellow	0.0	142.5	2.2	23.6	hard	minor cracking
2	10% Richmond County quartz (FBR087)	893	7.5YR6/6 reddish yellow	0.0	160.3	3.3	21.0	hard	
3	15% Jordan Lake sand	893	7.5YR7/6 reddish yellow	0.0	161.5	3.4	20.8	hard	
FBR037:									
1	-	893	5YR6/6 reddish yellow	0.0	161.8	2.7	20.4	soft	minor cracking
FBR038:									
1	-	893	5YR6/6 reddish yellow	0.0	113.9	4.4	32.8	hard	
FBR039:									
1	-	893	7.5YR7/4 reddish yellow	0.0	124.3	3.6	29.5	hard	
2	5% Jordan Lake sand	893	10YR7/4 very pale brown	0.0	128.5	3.7	27.1	hard	
3	10% Jordan Lake sand	893	10YR7/4 very pale brown	0.0	137.4	3.3	25.5	hard	minor cracking
4	10% Richmond County quartz (FBR087)	893	7.5YR7/4 pink	0.0	141.7	5.0	26.8	hard	
FBR040:									
1	-	893	2.5YR5/8 red	0.0	113.7	4.5	32.8	hard	
2	10% Richmond County quartz (FBR087)	893	5YR6/8 reddish yellow	0.0	121.8	4.7	29.5	moderately hard	

Table B.4. Descriptive Information for Clay Samples: Firing Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Firing Temperature (°C)	Post-firing Munsell Color	Linear Firing Shrinkage (%)	Post-firing Weight (g)	Firing Weight Loss (%)	Total Weight Loss (%)[a]	Post-firing Hardness	Post-firing Observations
3	15% Jordan Lake sand	893	5YR6/8 reddish yellow	0.0	145.9	4.2	27.7	moderately hard	
4	10% weathered granitic rock (FBR088)	≤950	5YR6/8 reddish yellow	0.0	134.0	4.0	27.9	hard	
5	10% weathered granitic rock (FBR089)	≤950	5YR6/8 reddish yellow	0.0	115.9	4.5	30.9	hard	
6	10% weathered diabase (FBR090)	≤950	5YR5/8 yellowish red	0.0	121.1	4.3	30.5	hard	
7	10% fresh diabase (FBR091)	≤950	5YR5/8 yellowish red	0.0	119.0	4.5	30.6	hard	
8	10% Deep River quartz (FBR086)	≤950	5YR5/8 yellowish red	-2.3	118.5	4.4	30.9	hard	
FBR041:									
1	-	893	7.5YR6/6 reddish yellow	0.0	147.4	3.2	23.5	hard	minor cracking
2	10% Richmond County quartz (FBR087)	893	7.5YR7/6 reddish yellow	0.0	157.5	3.6	21.1	moderately hard	
FBR042:									
1	-	893	10YR7/6 yellow	-2.2	149.5	2.8	21.6	moderately hard	
FBR043:									
1	-	893	5YR6/6 reddish yellow	0.0	133.9	5.1	29.5	hard	moderate warping; minor cracking

Table B.4. Descriptive Information for Clay Samples: Firing Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Firing Temperature (°C)	Post-firing Munsell Color	Linear Firing Shrinkage (%)	Post-firing Weight (g)	Firing Weight Loss (%)	Total Weight Loss (%)[a]	Post-firing Hardness	Post-firing Observations
2	10% Richmond County quartz (FBR087)	893	5YR6/6 reddish yellow	0.0	141.1	5.7	27.0	hard	moderate warping
3	15% Morgan Creek sand	893	5YR6/8 reddish yellow	0.0	137.0	6.0	27.5	hard	
FBR044:									
1	-	893	7.5YR7/6 reddish yellow	0.0	135.9	3.2	24.8	moderately hard	minor cracking
FBR045:									
1	-	893	7.5YR7/6 reddish yellow	-2.2	123.4	4.8	29.6	hard	minor cracking
FBR048:									
1	-	893	7.5YR7/6 reddish yellow	0.0	111.9	5.9	33.0	soft	moderate warping
FBR049:									
1	-	893	10YR7/4 very pale brown	-2.2	132.5	4.7	28.2	moderately hard	
2	10% Richmond County quartz (FBR087)	≤950	7.5YR8/4 pink	0.0	131.0	4.8	26.8	moderately hard	
3	10% weathered granitic rock (FBR089)	≤950	7.5YR7/4 pink	-2.1	132.5	4.9	27.1	moderately hard	
4	10% weathered diabase (FBR090)	≤950	7.5YR7/4 pink	0.0	130.7	5.0	26.8	moderately hard	
5	10% fresh diabase (FBR091)	≤950	7.5YR7/4 pink	2.1	130.5	5.0	28.1	moderately hard	

Table B.4. Descriptive Information for Clay Samples: Firing Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Firing Temperature (°C)	Post-firing Munsell Color	Linear Firing Shrinkage (%)	Post-firing Weight (g)	Firing Weight Loss (%)	Total Weight Loss (%)[a]	Post-firing Hardness	Post-firing Observations
FBR051:									
1	-	≤950	7.5YR7/6 reddish yellow	0.0	105.3	7.6	36.5	soft	
FBR054:									
1	-	≤950	7.5YR7/6 reddish yellow	-2.2	135.3	4.7	27.7	soft	
FBR055:									
1	-	≤950	5YR7/8 reddish yellow	0.0	124.8	6.0	31.5	soft	
FBR058:									
1	-	≤950	7.5YR6/6 reddish yellow	0.0	141.0	4.6	23.6	soft	minor cracking
FBR059:									
1	-	≤950	7.5YR8/4 pink	-2.2	122.4	6.0	29.3	very soft	
FBR066:									
1	-	≤950	7.5YR8/2 pinkish white	0.0	81.4	11.3		soft	minor cracking
FBR067:									
1	-	≤950	5YR8/1 white	-2.3	50.8	15.9	58.3	very soft	
2	10% Lower Little sand (FBR092)	≤950	5YR8/1 white	4.4	61.4	14.2	54.8	very soft	
FBR069:									
1	-	≤950	5YR6/8 reddish yellow	-2.2	133.7	4.3	24.0	hard	
FBR070:									
1	-	≤950	2.5YR6/6 light red	0.0	113.6	6.0	26.7	hard	no warping or cracking

Table B.4. Descriptive Information for Clay Samples: Firing Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Firing Temperature (°C)	Post-firing Munsell Color	Linear Firing Shrinkage (%)	Post-firing Weight (g)	Firing Weight Loss (%)	Total Weight Loss (%)[a]	Post-firing Hardness	Post-firing Observations
FBR071:									
1	-	≤950	5YR6/8 reddish yellow	0.0	131.2	3.9	23.7	hard	
FBR072:									
1	-	≤950	2.5YR6/6 light red	0.0	147.5	4.0	21.1	hard	
FBR074:									
1	-	≤950	5YR6/8 reddish yellow	-2.2	143.3	4.0	22.1	hard	
FBR075:									
1	-	≤950	5YR6/8 reddish yellow	-2.2	138.4	3.5	22.2	moderately hard	
FBR077:									
1	-	≤950	2.5YR6/6 light red	-2.2	119.4	5.2	26.3	soft	
FBR080:									
1	-	≤950	7.5YR7/6 reddish yellow	2.2	126.4	6.0	29.7	soft	
FBR081:									
1	-	≤950	5YR6/8 reddish yellow	0.0	150.3	3.3	22.1	soft	moderate warping
FBR082:									
1	-	≤950	7.5YR7/6 reddish yellow	0.0	122.6	5.5	29.8	hard	
FBR083:									
1	-	≤950	5YR7/8 reddish yellow	0.0	149.2	4.4	24.1	hard	
FBR084:									
1	-	≤950	7.5YR7/6 reddish yellow	0.0	108.8	6.1	33.6	hard	

Table B.4. Descriptive Information for Clay Samples: Firing Behavior (continued).

Sample ID: Tile Number	Temper (Weight %)	Firing Temperature (°C)	Post-firing Munsell Color	Linear Firing Shrinkage (%)	Post-firing Weight (g)	Firing Weight Loss (%)	Total Weight Loss (%)[a]	Post-firing Hardness	Post-firing Observations
FBR085:									
1	-	≤950	5YR6/6 reddish yellow	0.0	117.8	5.0	31.6	hard	

[a] Total weight loss (%) = [(weight$_{wet}$ - weight$_{fired}$) / weight$_{wet}$] × 100, where weight$_{wet}$ is the weight of the tile prior to any drying and weight$_{fired}$ is the weight after firing.

[b] Nonlocal grog was made by crushing unprovenienced sherds.

[c] Local grog was made by crushing fired test tiles fashioned from the sample clay.

[d] Unprovenienced sand A is a well-sorted, subrounded coarse quartz sand with occasional dark mineral inclusions.

[e] Unprovenienced sand D is a mixture of subrounded and subangular coarse quartz sand, gravels, and pebbles.

[f] This sample contains abundant natural gravels and pebbles that function as temper. No additional tempering materials were added.

Table B.5. Descriptive Information for Clay Samples: Replication.

	Observations		
Sample ID	Conical Base	Addition of Coils	Annealing/ Paddling
FBR011	retains shape	retains shape	slumps
FBR012	retains shape	retains shape	retains shape
FBR014	cracks	retains shape	slumps
FBR017	breaks	-	-
FBR019	cracks	slumps	slumps
FBR020	retains shape	retains shape	slumps and cracks
FBR027	cracks	slumps	slumps
FBR035	retains shape	retains shape	retains shape
FBR040	retains shape	retains shape	retains shape
FBR085	retains shape	retains shape	retains shape

Table B.6. Clay Samples Submitted for NAA and XRD Analyses.

Sample ID	Region	Drainage
FBR002	Sandhills	Lower Little
FBR003	Sandhills	Lower Little
FBR004	Sandhills	Lower Little
FBR005	Sandhills	Lower Little
FBR006	Sandhills	Drowning Creek
FBR007	Sandhills	Lower Little
FBR008	Sandhills	Lower Little
FBR009	Sandhills	Lower Little
FBR010	Sandhills	Lower Little
FBR011	Coastal Plain	Cape Fear
FBR012	Coastal Plain	Cape Fear
FBR013	Coastal Plain	Cape Fear
FBR014	Coastal Plain	Cape Fear
FBR016	Coastal Plain	Cape Fear
FBR017	Sandhills	Lower Little
FBR019	Coastal Plain	Pee Dee
FBR020	Coastal Plain	Pee Dee
FBR021	Coastal Plain	Pee Dee
FBR023	Coastal Plain	Pee Dee
FBR027	Coastal Plain	Pee Dee
FBR029	Piedmont	Haw
FBR030	Piedmont	Haw
FBR035	Piedmont	Haw
FBR040	Piedmont	Haw
FBR041	Piedmont	Haw
FBR048	Piedmont	Yadkin
FBR049	Piedmont	Yadkin
FBR051	Piedmont	Yadkin
FBR054	Piedmont	Yadkin
FBR055	Piedmont	Yadkin
FBR058	Piedmont	Deep
FBR059	Sandhills	Lower Little
FBR067	Sandhills	Lower Little
FBR071	Piedmont	Deep
FBR074	Piedmont	Deep
FBR077	Piedmont	Deep
FBR080	Piedmont	Deep
FBR081	Coastal Plain	Waccamaw
FBR082	Coastal Plain	Waccamaw
FBR083	Coastal Plain	Waccamaw
FBR084	Coastal Plain	Waccamaw
FBR085	Coastal Plain	Waccamaw

Table B.7. Clay Samples Submitted for Petrographic Analysis.

Sample ID: Tile Number	Temper (Weight %)	Region	Drainage
FBR002:			
1	-	Sandhills	Lower Little
FBR003:			
1	-	Sandhills	Lower Little
FBR004:			
1	-	Sandhills	Lower Little
FBR005:			
1	-	Sandhills	Lower Little
FBR006:			
1	-	Sandhills	Drowning Creek
FBR007:			
1	-	Sandhills	Lower Little
FBR008:			
1	-	Sandhills	Lower Little
FBR009:			
1	-	Sandhills	Lower Little
FBR010:			
1	-	Sandhills	Lower Little
FBR011:			
1	-	Coastal Plain	Cape Fear
2	10% nonlocal grog[a]	Coastal Plain	Cape Fear
3	10% local grog[b]	Coastal Plain	Cape Fear
FBR012:			
1	-	Coastal Plain	Cape Fear
2	10% nonlocal grog[a]	Coastal Plain	Cape Fear
3	15% local grog[b]	Coastal Plain	Cape Fear
FBR013:			
1	-	Coastal Plain	Cape Fear
FBR014:			
1	-	Coastal Plain	Cape Fear
FBR016:			
1	-	Coastal Plain	Cape Fear
FBR017:			
1	-	Sandhills	Lower Little
3	10% Lower Little sand (FBR092)	Sandhills	Lower Little
FBR019:			
1	-	Coastal Plain	Pee Dee

Table B.7. Clay Samples Submitted for Petrographic Analysis (continued).

Sample ID: Tile Number	Temper (Weight %)	Region	Drainage
FBR020:			
1	-	Coastal Plain	Pee Dee
FBR021:			
1	-	Coastal Plain	Pee Dee
FBR023:			
1	-	Coastal Plain	Pee Dee
3	10% local grog[b]	Coastal Plain	Pee Dee
4	10% nonlocal grog[a]	Coastal Plain	Pee Dee
FBR027:			
1	-	Coastal Plain	Pee Dee
FBR029:			
1	>30% natural[c]	Piedmont	Haw
FBR030:			
1	>20% natural[c]	Piedmont	Haw
FRB035:			
1	-	Piedmont	Haw
FBR040:			
1	-	Piedmont	Haw
4	10% weathered granitic rock (FBR088)	Piedmont	Haw
5	10% weathered granitic rock (FBR089)	Piedmont	Haw
6	10% weathered metavolcanic rock (FBR090)	Piedmont	Haw
7	10% fresh diabase (FBR091)	Piedmont	Haw
8	10% Deep River quartz (FBR086)	Piedmont	Haw
FBR041:			
1	-	Piedmont	Haw
FBR048:			
1	-	Piedmont	Yadkin
FBR049:			
1	-	Piedmont	Yadkin

Table B.7. Clay Samples Submitted for Petrographic Analysis (continued).

Sample ID: Tile Number	Temper (Weight %)	Region	Drainage
2	10% Richmond County quartz (FBR087)	Piedmont	Yadkin
3	10% weathered granitic rock (FBR089)	Piedmont	Yadkin
4	10% weathered metavolcanic rock (FBR090)	Piedmont	Yadkin
5	10% fresh diabase (FBR091)	Piedmont	Yadkin
FBR051:			
1	-	Piedmont	Yadkin
FBR054:			
1	-	Piedmont	Yadkin
FBR055:			
1	-	Piedmont	Yadkin
FBR058:			
1	-	Piedmont	Deep
FBR059:			
1	-	Sandhills	Lower Little
FBR067:			
1	-	Sandhills	Lower Little
2	10% Lower Little sand (FBR092)	Sandhills	Lower Little
FBR071:			
1	-	Piedmont	Deep
FBR074:			
1	-	Piedmont	Deep
FBR077:			
1	-	Piedmont	Deep
FBR080:			
1	-	Piedmont	Deep
FBR081:			
1	-	Coastal Plain	Waccamaw
FBR082:			
1	-	Coastal Plain	Waccamaw
FBR083:			
1	-	Coastal Plain	Waccamaw

Table B.7. Clay Samples Submitted for Petrographic Analysis (continued).

Sample ID: Tile Number	Temper (Weight %)	Region	Drainage
FBR084:			
1	-	Coastal Plain	Waccamaw
FBR085:			
1	-	Coastal Plain	Waccamaw

[a] Nonlocal grog was made by crushing unprovenienced sherds.

[b] Local grog was made by crushing fired test tiles fashioned from the sample clay.

[c] This sample contains abundant natural gravels and pebbles that function as temper. No additional tempering materials were added.

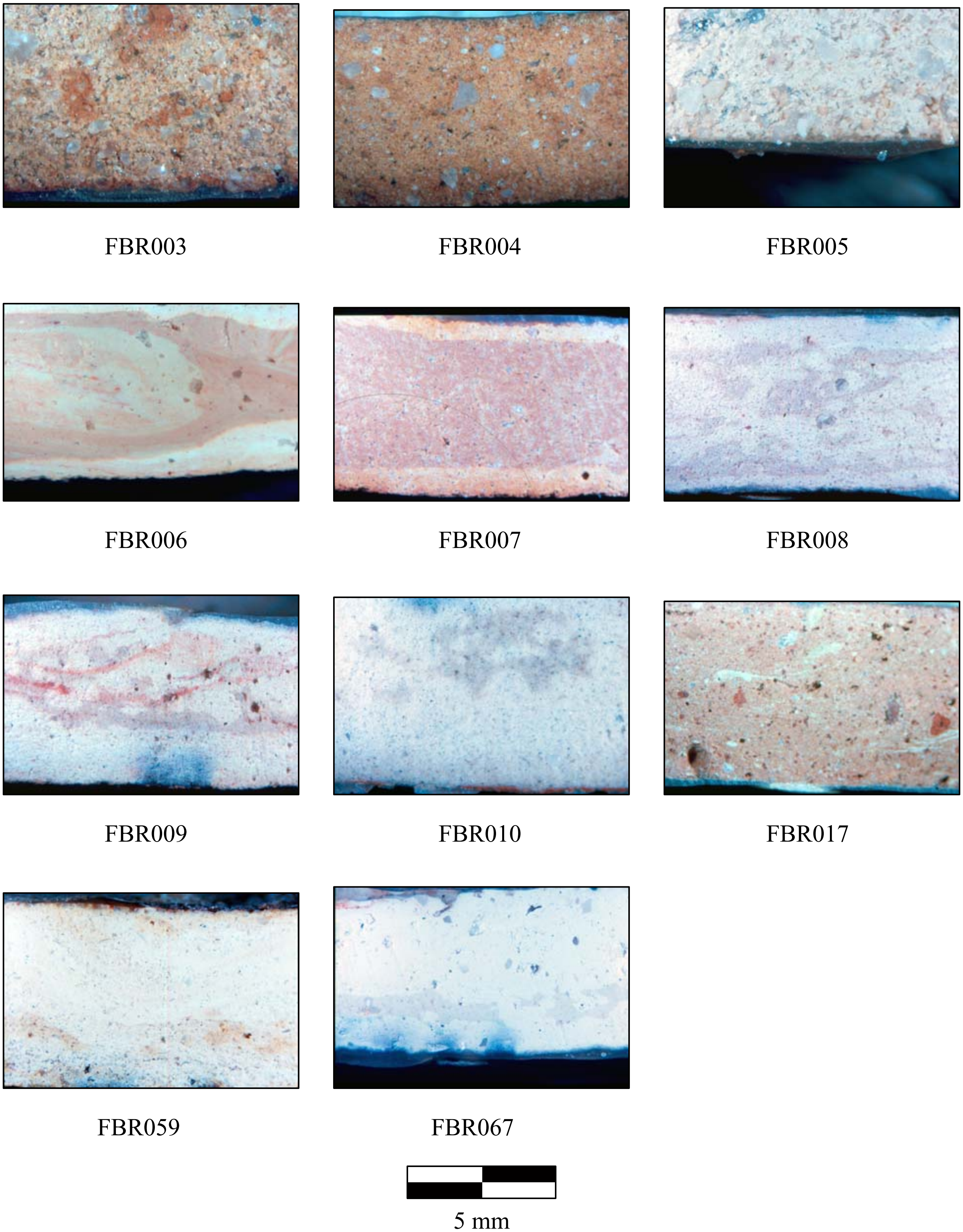


Figure B.1. Cross sections of untempered test tiles made from Sandhills clay samples.

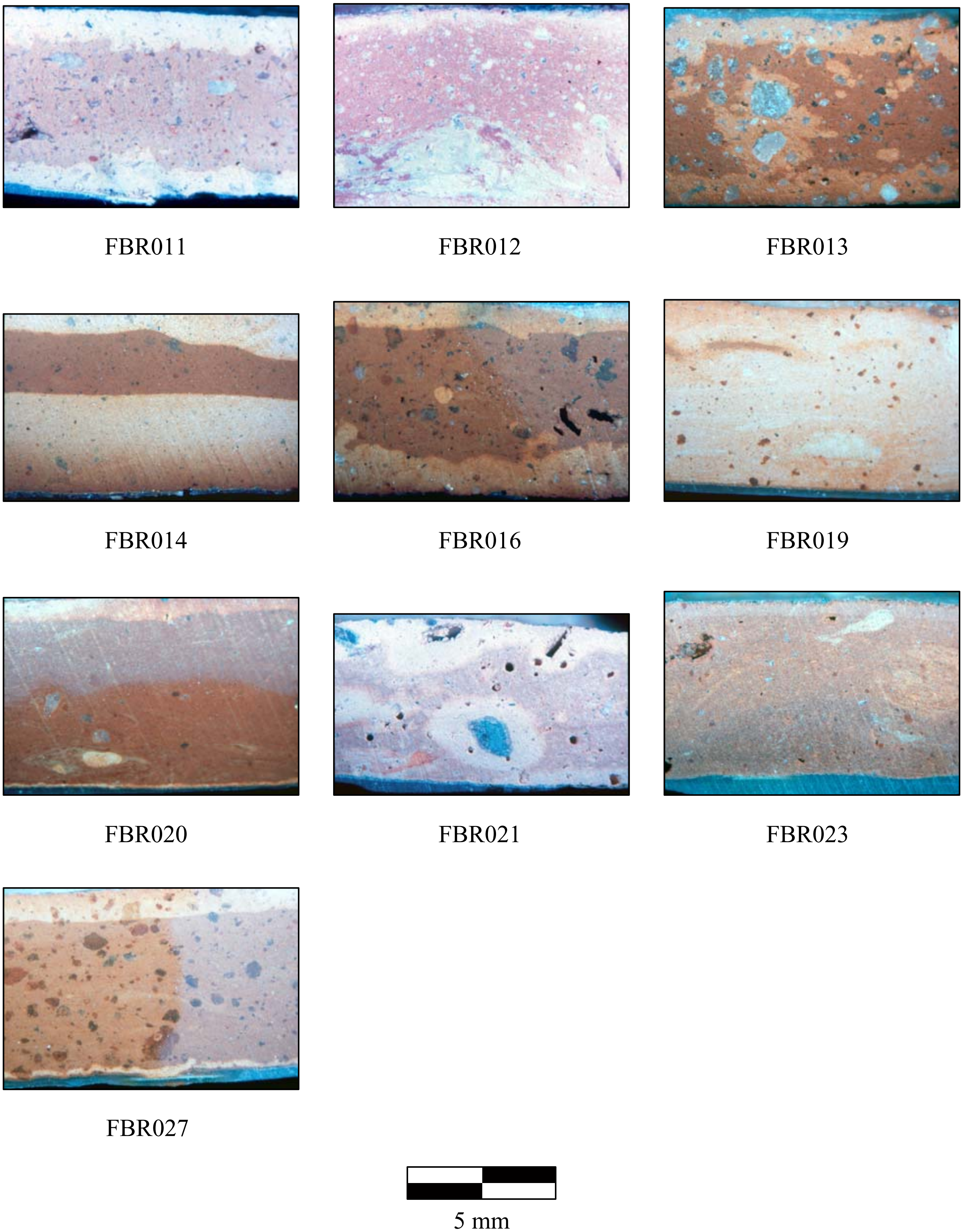


Figure B.2. Cross sections of untempered test tiles made from Coastal Plain clay samples from the Cape Fear (FBR011–FBR014, FBR016) and Pee Dee (FBR019–FBR021, FBR023, FBR027) drainages.

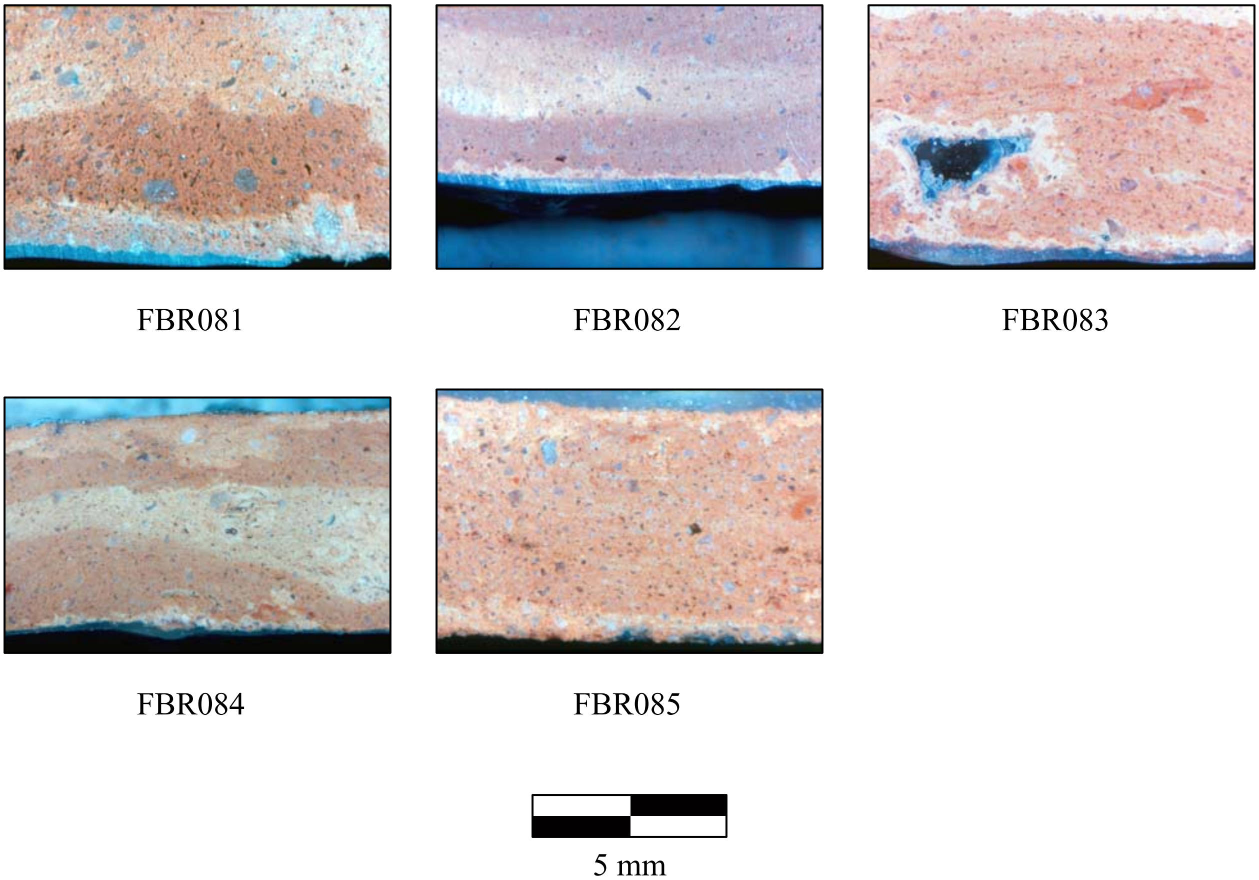


Figure B.3. Cross sections of untempered test tiles made from Coastal Plain clay samples from the Waccamaw drainage.

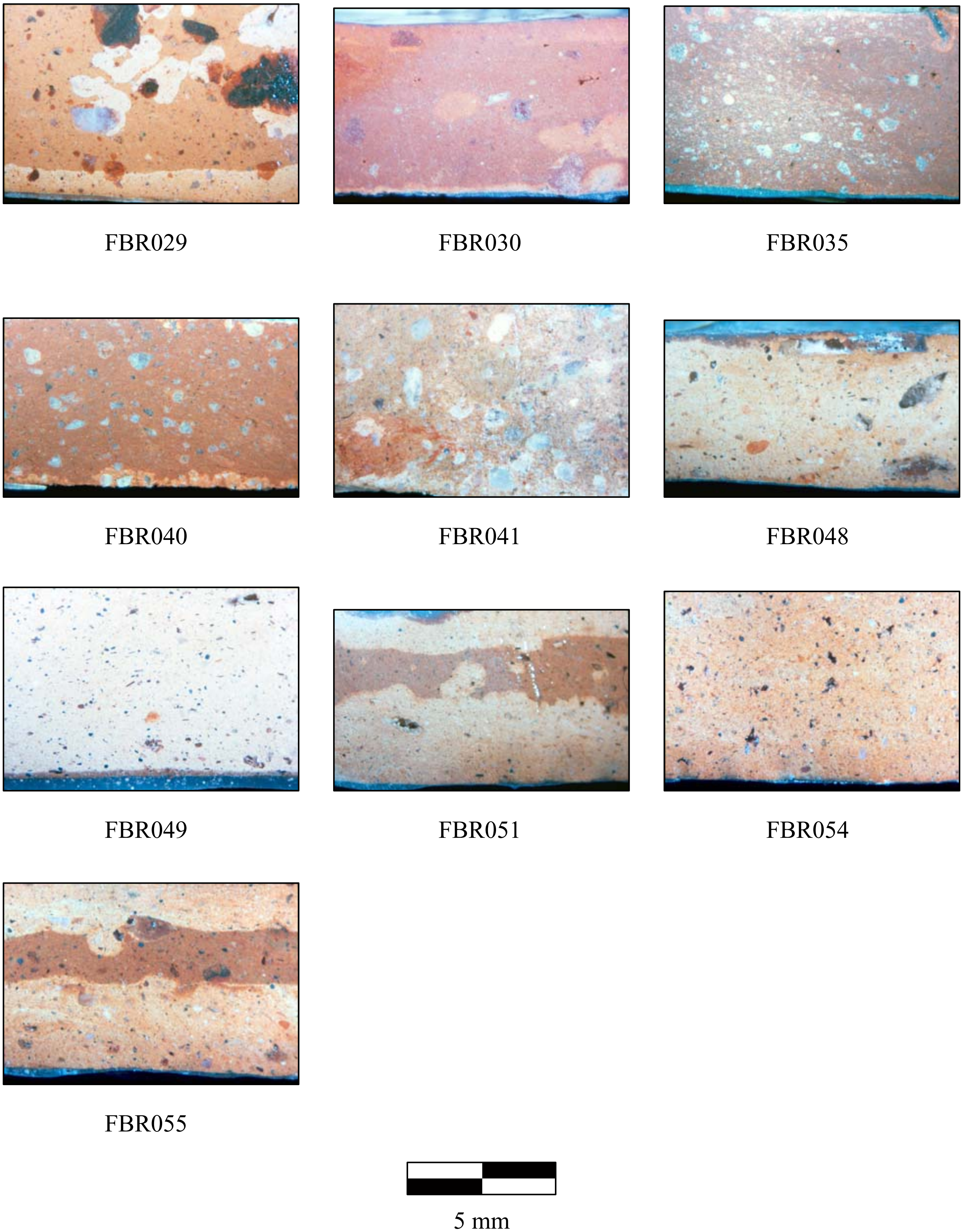
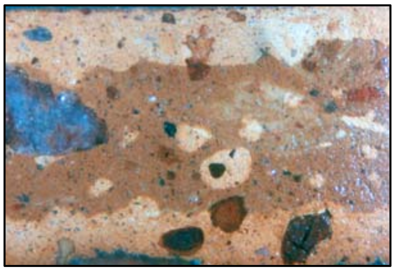
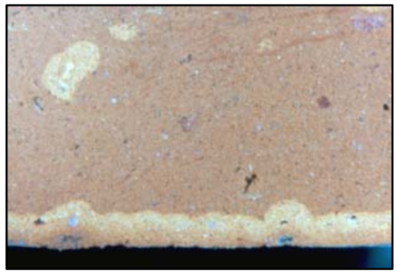


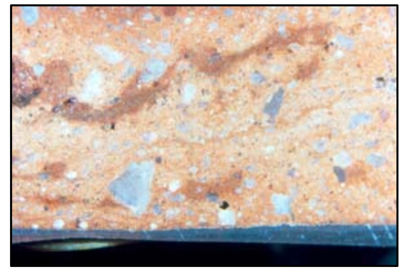
Figure B.4. Cross sections of untempered test tiles made from Piedmont clay samples from the Haw (FBR029, FBR030, FBR035, FBR040, FBR041) and Yadkin (FBR048, FBR049, FBR051, FBR054, FBR055) drainages.



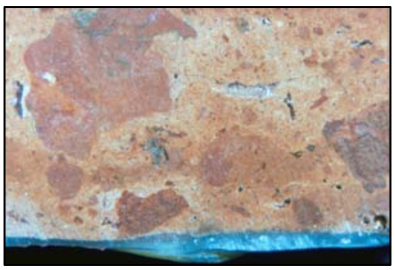
FBR058



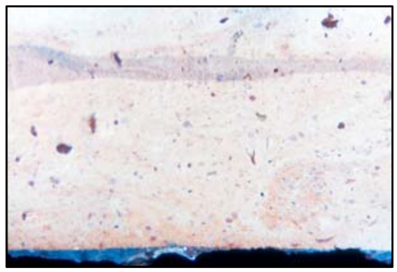
FBR071



FBR074



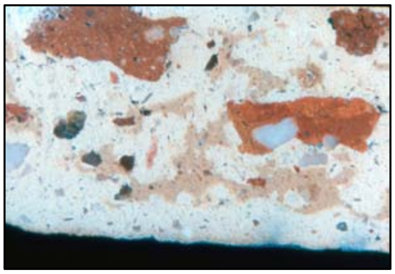
FBR077



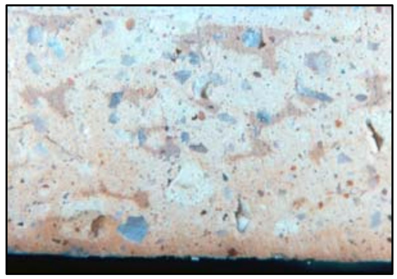
FBR080

5 mm

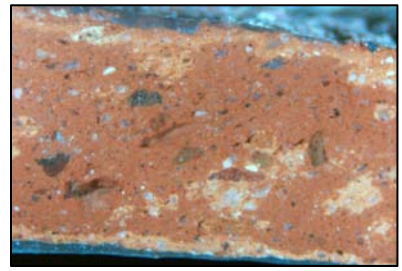
Figure B.5. Cross sections of untempered test tiles made from Piedmont clay samples from the Deep drainage.



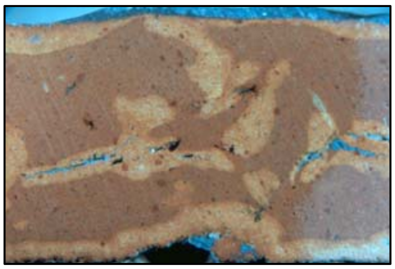
FBR011.2



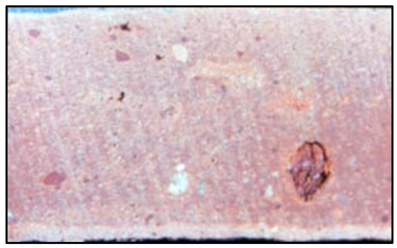
FBR011.3



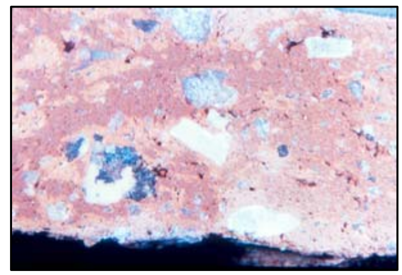
FBR012.2



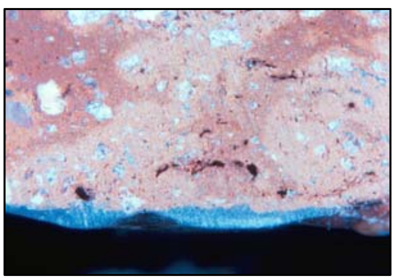
FBR023.3



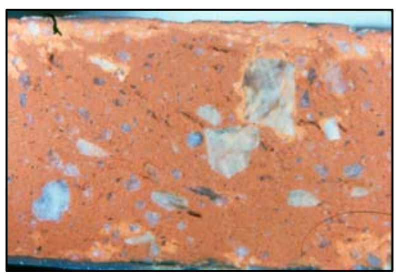
FBR023.4



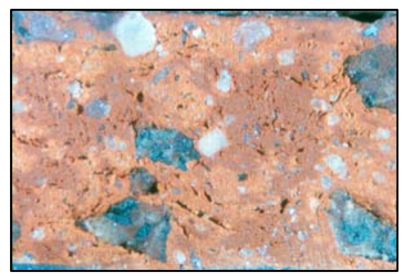
FBR040.4



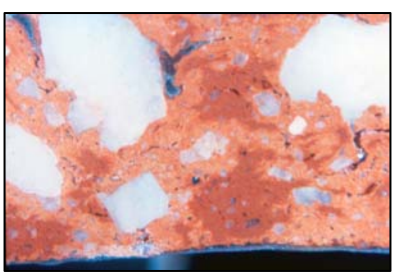
FBR040.5



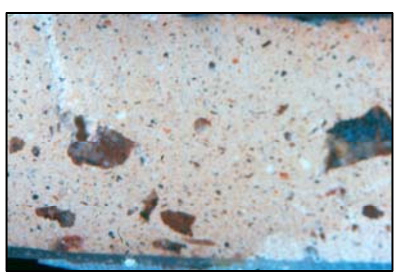
FBR040.6



FBR040.7



FBR040.8



FBR049.5

5 mm

Figure B.6. Cross sections of tempered test tiles made from clay samples collected in the Cape Fear (FBR011.2, FBR011.3, FBR012.2), Pee Dee (FBR023.3, FBR023.4), Haw (FBR040.4–FBR040.8), and Yadkin (FBR049.5) drainages.

Appendix C

Geochemical Data

Robert J. Speakman and Michael D. Glascock

Sherds and clay test tiles were sawed intro three pieces using a water-cooled, diamond-coated slow speed saw blade. One piece from each sample was shipped to MURR.

Once at MURR, fragments of about 1 cm^2 were removed from each sample and abraded using a silicon carbide burr in order to remove adhering soil and exterior surfaces, thereby reducing the risk of measuring contamination. The samples were washed in deionized water and allowed to dry in the laboratory. Once dry, the individual sherds were ground to powder in an agate mortar to homogenize the samples. Archival samples were retained from each sherd (when possible) for future research. Clay, rock, and sand samples were fired in a laboratory furnace to 700˚C for one hour. Each sample was then ground into powder using an agate mortar.

Two analytical samples were prepared from each specimen. Portions of approximately 150 mg of powder were weighed into clean, high-density polyethylene vials used for short irradiations at MURR. At the same time, 200 mg of each sample were weighed into clean, high-purity quartz vials used for long irradiations. Individual sample weights were recorded to the nearest 0.01 mg using an analytical balance. Both vials were sealed prior to irradiation. Along with the unknown samples, reference standards made from SRM-1633a (coal fly ash) and SRM-688 (basalt rock) were similarly prepared, as were quality control samples (i.e., standards treated as unknowns) made from SRM-278 (obsidian rock) and Ohio Red Clay (a standard developed for in-house applications).

Neutron activation analysis of ceramics at MURR, which consists of two irradiations and a total of three gamma counts, constitutes a superset of the procedures used at most other NAA laboratories (Glascock 1992; Neff 1992, 2000). As discussed in detail by Glascock (1992), a short irradiation is carried out through the pneumatic tube irradiation system. Samples in the polyvials are sequentially irradiated, two at a time, for five seconds at a neutron flux of 8×10^{13} $n/cm^2/s$. The 720-second count yields gamma spectra containing peaks for nine short-lived elements: aluminum (Al), barium (Ba), calcium (Ca), dysprosium (Dy), potassium (K), manganese (Mn), sodium (Na), titanium (Ti), and vanadium (V). The samples encapsulated in quartz vials are subjected to a 24-hour irradiation at a neutron flux of 5×10^{13} $n/cm^2/s$. This long irradiation is analogous to the single irradiation utilized at most other laboratories. After the long irradiation, samples decay for seven days and then are counted for 1,800 seconds (the "middle count") on a high-resolution germanium detector coupled to an automatic sample changer. The middle count yields data for seven medium half-life elements, namely arsenic (As), lanthanum (La), lutetium (Lu), neodymium (Nd), samarium (Sm), uranium (U), and ytterbium (Yb). After an additional three- or four-week decay, a final count of 8,500 seconds is carried out on each sample. The latter measurement yields data for 17 long half-life elements: cerium (Ce), cobalt

(Co), chromium (Cr), cesium (Cs), europium (Eu), iron (Fe), hafnium (Hf), nickel (Ni), rubidium (Rb), antimony (Sb), scandium (Sc), strontium (Sr), tantalum (Ta), terbium (Tb), thorium (Th), zinc (Zn), and zirconium (Zr).

The analyses at MURR produced elemental concentration values for 32 or 33 elements in most of the analyzed samples. Tables C.1–C.3 present the data in parts per million of the element, with missing values (i.e., not detected) indicated by the presence of zeroes (i.e., 0.000).

Table C.1. Element Concentrations as Measured by Neutron Activation Analysis (As–Fe).

Sample Number[a]	As (ppm)	La (ppm)	Lu (ppm)	Nd (ppm)	Sm (ppm)	U (ppm)	Yb (ppm)	Ce (ppm)	Co (ppm)	Cr (ppm)	Cs (ppm)	Eu (ppm)	Fe (ppm)
FBR002	23.594	71.736	0.420	67.269	13.992	6.952	2.281	140.222	4.561	215.075	4.446	2.700	82236.800
FBR003	6.249	22.819	0.294	10.854	2.270	2.079	1.827	41.785	1.632	37.250	1.069	0.304	16592.800
FBR004	0.851	52.504	0.511	39.277	8.016	4.006	3.450	104.917	10.886	38.725	1.767	1.120	23043.100
FBR005	1.362	31.565	0.301	19.891	4.423	2.698	1.967	62.906	2.552	40.955	2.592	0.778	8148.100
FBR006	4.525	96.267	0.400	48.206	8.163	3.713	2.663	166.942	7.794	122.760	2.651	1.514	22807.100
FBR007	11.396	74.926	0.533	68.076	14.162	5.988	3.504	158.713	4.832	82.224	1.386	2.948	25343.900
FBR008	1.002	44.772	0.613	33.581	7.390	6.680	3.769	87.764	5.337	81.490	1.315	1.179	15062.800
FBR009	0.000	54.662	0.506	33.114	7.068	5.597	3.047	87.843	3.818	91.100	1.665	1.354	16063.600
FBR010	0.912	50.542	0.659	37.432	7.900	5.879	4.088	100.759	1.776	43.165	1.375	0.595	6375.200
FBR011	1.291	20.858	0.276	17.074	3.588	2.205	1.842	42.672	10.720	41.899	3.206	0.695	14794.900
FBR012	3.913	24.053	0.355	21.455	4.541	3.064	2.342	50.314	8.376	51.760	3.214	0.916	32838.800
FBR013	2.830	17.722	0.334	12.790	2.704	2.648	2.059	32.395	7.107	52.294	3.511	0.530	29444.700
FBR014	6.213	27.111	0.509	25.832	5.552	3.087	3.360	66.924	22.703	58.120	3.881	1.331	45434.700
FBR016	4.409	38.184	0.461	31.768	6.782	2.623	3.135	84.459	20.256	64.476	3.286	1.378	39500.800
FBR017	1.216	35.030	0.735	26.108	5.997	2.204	5.831	65.064	27.713	42.627	0.941	1.530	53318.300
FBR019	3.622	44.676	0.494	33.825	6.839	4.478	3.325	76.891	14.694	98.689	6.009	1.496	38797.300
FBR020	3.515	52.366	0.497	44.621	8.938	3.124	3.580	99.657	19.533	94.105	6.198	1.967	45473.000
FBR021	2.711	54.719	0.487	41.386	8.321	4.739	3.297	102.590	17.211	94.805	7.084	1.795	25718.700
FBR023	4.042	29.298	0.400	24.401	4.901	3.858	2.514	58.068	7.680	100.562	5.928	0.957	39377.400
FBR027	6.801	59.789	0.592	50.426	10.518	3.555	4.239	131.058	29.595	96.909	7.140	2.386	61514.300
FBR029	4.970	18.652	0.403	17.715	3.908	1.886	2.840	31.870	12.689	75.509	2.714	1.002	31593.900
FBR030	8.029	24.976	0.518	18.921	3.794	2.825	3.596	44.620	5.007	84.033	9.618	0.856	55224.300
FBR035	9.382	13.983	0.263	9.400	2.207	3.423	1.481	26.701	10.561	58.103	7.048	0.406	61965.900
FBR040	3.280	17.177	0.202	10.737	2.157	3.154	1.202	30.629	5.377	40.824	6.276	0.410	35678.000
FBR041	1.219	10.933	0.223	6.588	1.850	3.934	0.925	20.757	3.293	30.838	3.483	0.365	20710.000
FBR048	7.082	22.521	0.441	23.578	4.904	2.193	3.079	54.374	12.652	79.468	5.489	1.135	35703.500
FBR049	2.146	27.362	0.422	24.136	5.729	1.964	3.130	54.062	11.895	65.476	4.371	1.406	34194.200
FBR051	5.083	25.360	0.444	23.630	5.282	1.771	3.058	57.127	15.538	72.295	4.928	1.278	35968.800
FBR054	8.208	20.983	0.416	19.613	4.367	1.773	2.836	48.048	16.841	80.662	3.860	1.033	33488.300
FBR055	10.374	21.871	0.426	20.015	4.563	1.564	2.938	52.217	22.063	68.511	4.451	1.100	45839.100
FBR058	2.893	25.886	0.372	22.483	5.076	1.861	2.820	48.974	7.551	47.610	3.036	1.236	27666.600
FBR059	2.806	55.201	0.571	53.042	11.455	6.268	3.818	115.106	2.802	58.844	1.074	2.058	9241.500

Table C.1. Element Concentrations as Measured by Neutron Activation Analysis (As–Fe) (continued).

Sample Number[a]	As (ppm)	La (ppm)	Lu (ppm)	Nd (ppm)	Sm (ppm)	U (ppm)	Yb (ppm)	Ce (ppm)	Co (ppm)	Cr (ppm)	Cs (ppm)	Eu (ppm)	Fe (ppm)
FBR067	3.429	92.295	0.704	93.478	21.288	7.878	5.040	201.202	6.475	119.736	3.685	4.836	10472.200
FBR071	7.492	25.993	0.468	25.509	5.544	4.049	3.182	59.652	14.418	55.006	4.415	1.185	38110.500
FBR074	7.107	27.203	0.382	22.928	4.871	4.026	2.549	55.396	9.617	46.936	3.796	0.953	28953.900
FBR077	6.837	38.099	0.492	34.124	7.407	2.308	3.710	78.268	22.730	82.131	7.945	1.660	56235.300
FBR080	4.623	24.220	0.452	21.094	4.970	1.661	3.263	55.374	13.602	46.309	4.216	1.232	24842.500
FBR081	3.311	22.764	0.338	17.517	3.614	2.682	2.254	45.117	1.456	42.210	1.414	0.454	18143.300
FBR082	2.174	34.572	0.406	26.119	5.137	4.795	2.530	64.042	3.284	89.585	6.100	0.955	20431.400
FBR083	3.670	15.975	0.369	13.531	2.929	1.272	2.613	32.432	2.082	2.096	3.363	0.581	13408.500
FBR084	4.668	24.443	0.291	16.619	3.134	2.876	1.939	42.370	3.451	81.047	5.134	0.537	23204.900
FBR085	1.712	22.356	0.256	14.581	2.861	1.959	2.026	37.620	3.462	65.097	5.561	0.485	25990.900
FBR086	0.560	0.096	0.000	0.000	0.017	0.000	0.008	0.138	0.151	0.343	0.108	0.006	393.400
FBR087	0.000	1.101	0.010	0.632	0.118	0.000	0.083	1.880	0.056	0.391	0.060	0.029	101.500
FBR088	2.671	17.618	0.211	22.043	4.830	0.681	1.448	40.814	27.843	55.417	1.741	1.270	64908.500
FBR089	0.000	31.960	0.441	24.894	5.064	2.775	3.278	85.735	3.209	2.706	1.496	1.250	15275.600
FBR090	5.001	30.786	0.400	23.821	4.951	3.387	2.726	60.756	2.437	55.190	3.719	0.811	18140.100
FBR091	0.000	8.035	0.473	8.759	3.017	0.000	3.581	18.261	59.677	87.632	0.479	1.084	92692.000
FBR092	0.514	7.649	0.076	6.215	1.239	0.919	0.447	15.288	0.298	4.798	0.133	0.092	1239.500
JMH001	0.000	99.573	0.597	88.442	16.525	4.707	5.056	201.871	13.332	96.040	14.652	3.702	56657.600
JMH002	2.905	49.728	0.466	48.391	9.153	2.394	3.424	113.475	18.575	70.817	2.078	2.104	34714.000
JMH003	3.459	19.271	0.284	17.785	3.367	1.990	2.207	40.828	8.247	79.967	3.101	0.711	43108.000
JMH004	0.000	30.408	0.415	27.681	5.047	3.006	2.729	63.644	12.798	92.270	3.436	0.960	39329.400
JMH005	5.247	33.117	0.467	32.021	5.847	2.361	3.151	74.602	10.259	111.235	3.608	1.105	44259.100
JMH006	6.488	14.073	0.314	18.459	3.569	0.000	2.352	25.840	34.253	116.213	1.546	1.129	78398.100
JMH007	5.988	96.570	0.740	115.844	20.561	2.901	5.180	242.706	9.314	66.070	1.606	4.727	57486.700
JMH008	0.000	23.345	0.362	22.413	4.160	3.244	2.245	50.033	6.713	63.240	3.812	0.922	27035.200
JMH009	0.000	56.936	0.424	47.532	8.398	3.473	2.921	118.273	12.288	69.377	5.232	1.920	38941.600
JMH010	0.000	15.828	0.299	12.333	2.377	2.244	2.055	31.624	8.121	60.641	2.020	0.333	26525.400
JMH011	8.360	19.163	0.305	12.624	2.962	3.420	1.998	37.882	3.802	86.411	3.246	0.445	71261.300
JMH012	0.000	94.441	0.480	103.917	16.966	4.465	4.139	244.006	9.250	74.443	3.371	3.496	32402.100
JMH013	0.000	61.274	0.511	67.970	11.409	2.668	4.038	133.113	4.819	126.901	5.171	2.508	25383.700
JMH014	4.715	22.037	0.450	20.829	5.013	0.922	3.061	71.276	67.643	474.600	2.844	1.201	87132.700
JMH015	0.000	55.782	0.538	39.592	7.783	3.947	3.868	114.630	4.372	34.050	2.695	1.245	28877.200

Table C.1. Element Concentrations as Measured by Neutron Activation Analysis (As–Fe) (continued).

Sample Number[a]	As (ppm)	La (ppm)	Lu (ppm)	Nd (ppm)	Sm (ppm)	U (ppm)	Yb (ppm)	Ce (ppm)	Co (ppm)	Cr (ppm)	Cs (ppm)	Eu (ppm)	Fe (ppm)
JMH016	2.016	36.615	0.347	29.595	6.067	3.476	2.393	68.522	10.240	85.039	5.567	1.148	38107.800
JMH017	7.811	52.746	0.576	53.838	10.647	4.704	4.111	112.068	12.653	143.882	2.904	2.231	29814.900
JMH018	3.377	40.046	0.522	43.235	7.856	7.514	3.508	88.014	6.944	90.420	2.774	1.543	21778.900
JMH019	12.366	44.969	0.477	44.061	8.603	4.745	3.282	109.287	8.886	79.011	3.273	1.540	30943.300
JMH020	10.078	77.515	0.449	71.281	13.067	4.269	3.267	163.849	16.298	84.747	3.949	2.902	87631.100
JMH021	9.806	53.686	0.430	40.444	7.952	4.962	2.572	119.003	10.358	90.667	4.903	1.557	56558.900
JMH022	0.000	38.554	0.365	37.422	7.058	3.191	2.483	87.955	7.926	69.065	4.353	1.638	18654.200
JMH023	0.000	28.384	0.394	18.198	4.434	4.246	2.226	59.583	6.259	88.280	3.784	0.775	37904.800
JMH024	0.000	42.246	0.547	38.289	7.604	4.250	3.727	97.137	10.429	82.155	2.247	1.401	47858.300
JMH025	8.630	48.626	0.518	41.729	7.452	5.052	3.754	92.921	15.614	69.897	3.307	1.469	80846.200
JMH026	0.000	55.737	0.469	45.921	10.203	3.472	3.063	123.486	14.153	99.842	15.946	2.043	62416.600
JMH027	0.000	32.739	0.403	28.616	5.471	3.601	2.640	70.133	8.694	69.044	1.898	0.897	40833.800
JMH028	2.109	68.977	0.548	65.450	12.622	4.855	4.629	152.880	19.697	84.613	3.134	2.746	37861.900
JMH029	0.000	24.593	0.507	21.214	4.966	3.355	3.882	61.501	8.516	86.277	2.127	0.953	31953.600
JMH030	3.076	23.765	0.478	23.100	4.968	3.619	3.788	60.650	8.810	87.351	1.939	0.971	32413.600
JMH031	3.522	17.866	0.297	16.288	3.459	2.455	2.179	39.587	22.506	376.716	1.594	0.800	45417.800
JMH032	9.648	11.850	0.172	10.752	2.606	0.000	1.817	23.827	30.098	425.733	1.427	0.682	60026.100
JMH033	71.267	38.655	0.540	35.062	8.294	5.091	4.055	83.758	21.952	93.851	5.201	1.757	46638.900
JMH034	11.308	17.692	0.261	13.446	2.804	0.000	2.035	29.684	34.820	296.490	1.375	0.858	61965.100
JMH035	0.000	22.712	0.330	13.378	4.249	1.148	1.979	57.453	13.275	159.235	1.159	1.118	36362.200
JMH036	3.663	10.713	0.161	9.714	2.680	1.333	1.227	24.652	12.651	71.202	0.773	0.817	42734.100
JMH037	4.925	24.181	0.637	28.847	5.819	0.000	4.589	61.979	17.528	173.651	7.522	1.410	37654.000
JMH038	0.000	104.457	0.616	77.848	12.623	5.870	4.799	184.168	11.974	57.802	2.818	2.214	44114.600
JMH039	0.000	13.420	0.214	11.394	1.961	1.497	1.262	17.122	14.507	60.640	0.707	0.536	37293.500
JMH040	8.203	26.245	0.193	38.895	5.731	2.355	1.369	55.823	14.544	84.140	2.371	1.315	59591.200
JMH041	0.000	15.182	0.228	11.437	2.531	1.993	1.182	28.145	6.209	51.287	2.467	0.565	21430.800
JMH042	0.000	13.241	0.208	14.561	2.120	1.172	1.204	23.774	6.111	54.559	2.702	0.500	22842.300
JMH043	0.000	20.328	0.329	11.931	3.506	0.000	1.982	36.652	21.692	64.131	1.372	0.906	72439.600
JMH044	0.000	37.379	0.465	29.664	6.610	22.413	1.950	73.472	3.527	30.390	4.013	0.982	15407.400
JMH045	3.585	20.398	0.202	27.389	4.432	0.000	1.427	40.047	15.050	57.936	2.432	1.384	50409.600
JMH046	0.000	5.526	0.139	0.000	1.492	0.000	1.108	8.395	30.566	138.697	0.372	0.510	47952.900
JMH047	0.000	6.972	0.173	10.393	1.984	0.000	1.429	12.052	33.187	298.070	0.702	0.713	72005.400

Table C.1. Element Concentrations as Measured by Neutron Activation Analysis (As–Fe) (continued).

Sample Number[a]	As (ppm)	La (ppm)	Lu (ppm)	Nd (ppm)	Sm (ppm)	U (ppm)	Yb (ppm)	Ce (ppm)	Co (ppm)	Cr (ppm)	Cs (ppm)	Eu (ppm)	Fe (ppm)
JMH048	4.596	19.565	0.194	22.909	4.427	1.790	1.590	43.702	15.037	62.355	2.731	1.391	52688.600
JMH049	0.000	8.019	0.139	7.242	1.905	0.600	0.962	16.914	15.691	52.241	0.490	0.700	22481.700
JMH050	0.000	14.467	0.205	14.377	2.233	1.348	1.111	26.106	5.549	46.036	2.512	0.503	19133.900
JMH051	12.799	23.667	0.368	24.828	5.098	3.230	2.413	52.271	3.977	89.475	4.152	0.955	34277.100
JMH052	12.175	19.330	0.309	16.576	3.157	2.686	2.232	39.559	3.092	89.987	4.732	0.574	38555.000
JMH053	5.633	23.451	0.387	27.997	4.810	2.804	2.673	52.921	5.375	66.668	4.111	0.979	33289.400
JMH054	11.909	40.415	0.311	45.440	7.637	1.807	2.458	84.501	9.681	108.272	5.392	1.516	45620.400
JMH055	6.184	39.022	0.375	32.224	5.658	3.522	2.880	67.745	7.837	97.387	5.487	0.994	44300.900
JMH056	1.970	25.096	0.290	20.273	3.677	2.839	2.053	43.737	5.268	91.102	2.255	0.602	28377.000
JMH057	4.642	42.257	0.335	32.799	5.541	3.445	2.364	71.518	7.735	86.884	4.652	0.966	43877.600
JMH058	1.643	34.170	0.397	26.632	5.165	2.763	2.723	61.353	10.439	99.772	3.304	0.695	33480.800
JMH059	3.882	95.499	0.658	108.373	19.165	4.030	5.688	198.214	12.630	109.999	3.480	3.731	37887.600
JMH060	2.470	33.802	0.339	30.140	5.059	2.628	2.457	61.174	7.244	82.534	2.528	0.821	30927.800
JMH061	2.223	36.875	0.355	36.969	6.472	2.988	2.544	72.409	8.896	72.397	4.422	1.284	26360.600
JMH062	2.273	46.005	0.447	44.427	7.872	2.975	3.253	89.746	14.916	79.266	4.809	1.624	26793.500
JMH063	4.850	57.959	0.526	53.851	10.578	3.992	3.644	115.110	7.238	101.190	4.461	1.812	41413.200
JMH064	2.488	26.141	0.265	22.939	4.698	2.479	2.072	55.889	5.424	61.519	3.532	0.918	23579.000
JMH065	4.683	41.187	0.485	39.429	7.212	5.013	3.428	84.886	10.195	121.414	6.879	1.358	34830.500
JMH066	2.471	21.473	0.279	20.090	3.968	2.311	1.885	44.944	4.275	48.812	2.924	0.780	15434.400
JMH067	4.807	27.419	0.303	18.557	4.081	3.620	1.965	51.562	15.258	172.373	3.711	0.680	27304.300
JMH068	7.494	78.180	0.583	85.356	13.755	5.018	4.360	134.826	15.031	97.803	5.029	2.673	48819.400
JMH069	1.910	13.312	0.271	13.441	2.366	1.687	1.533	28.464	5.606	56.505	2.712	0.429	24172.100
JMH070	2.740	14.273	0.259	12.558	2.978	4.864	1.393	32.599	3.896	68.439	2.691	0.443	19281.300

[a] Clay samples have FBR prefix; pottery samples have JMH prefix.

Table C.2. Element Concentrations as Measured by Neutron Activation Analysis (Hf–Al).

Sample Number[a]	Hf (ppm)	Ni (ppm)	Rb (ppm)	Sb (ppm)	Sc (ppm)	Sr (ppm)	Ta (ppm)	Tb (ppm)	Th (ppm)	Zn (ppm)	Zr (ppm)	Al (ppm)
FBR002	7.481	0.000	35.160	1.603	18.704	94.250	1.069	1.922	19.635	41.140	219.930	100288.800
FBR003	7.291	0.000	9.050	0.292	7.040	0.000	0.646	0.347	11.039	14.640	160.280	52783.600
FBR004	13.429	19.830	54.930	0.178	8.177	60.520	1.069	0.980	13.638	35.620	319.480	69284.700
FBR005	7.219	31.490	27.910	0.161	7.982	33.840	0.995	0.679	8.878	15.470	182.220	67776.500
FBR006	6.255	0.000	26.980	0.323	21.112	66.610	2.015	0.747	22.477	36.100	205.400	191590.700
FBR007	10.972	0.000	22.770	0.395	15.133	85.510	1.290	1.710	17.707	24.660	330.810	107983.000
FBR008	19.124	0.000	13.730	0.114	15.399	0.000	1.579	1.062	16.447	26.360	470.530	86690.700
FBR009	12.053	0.000	31.060	0.152	23.704	0.000	1.735	0.804	13.374	28.060	311.720	130531.600
FBR010	27.605	26.240	28.040	0.235	6.574	28.560	1.868	0.866	22.171	13.030	670.170	44090.300
FBR011	7.026	0.000	50.590	0.392	9.692	121.740	0.786	0.474	7.498	34.310	165.180	61603.900
FBR012	9.156	0.000	44.910	0.494	13.093	88.710	0.905	0.560	9.182	35.680	230.420	75691.200
FBR013	8.662	0.000	51.550	0.469	10.416	65.940	1.085	0.387	8.435	39.160	187.210	78578.600
FBR014	8.819	0.000	60.560	0.816	17.478	0.000	1.085	1.011	7.068	131.920	218.070	88048.400
FBR016	8.973	0.000	53.990	0.791	15.816	101.240	1.030	0.851	10.470	90.240	213.030	82081.000
FBR017	9.031	0.000	6.940	0.237	18.008	0.000	0.471	1.189	3.740	60.310	245.210	78631.200
FBR019	10.224	60.770	110.650	0.374	19.838	119.290	1.562	1.154	12.714	105.450	239.110	103365.600
FBR020	8.622	0.000	99.440	0.455	20.769	93.200	1.394	1.165	12.280	119.720	194.580	107782.200
FBR021	8.767	67.760	91.060	0.381	21.694	95.020	1.372	1.132	13.013	106.080	240.680	121681.100
FBR023	13.098	0.000	60.010	0.510	19.705	0.000	1.426	0.561	13.513	51.940	308.600	107249.800
FBR027	7.527	82.720	122.220	0.601	23.739	58.910	1.649	1.240	14.334	128.640	183.120	123849.900
FBR029	6.940	0.000	16.350	0.613	14.160	58.110	0.775	0.632	4.629	34.750	177.890	45887.600
FBR030	7.615	0.000	151.360	1.971	22.424	71.270	1.127	0.759	12.844	56.920	197.480	111678.000
FBR035	6.440	36.290	138.240	0.622	14.600	0.000	1.116	0.256	14.002	51.770	161.180	112171.000
FBR040	6.388	0.000	104.430	0.476	10.717	0.000	1.050	0.214	10.870	38.360	169.520	86818.400
FBR041	5.268	0.000	114.080	0.292	8.738	93.810	0.907	0.200	12.609	29.260	130.640	75822.000
FBR048	6.871	0.000	68.560	0.548	21.693	70.040	1.097	0.780	6.568	84.580	180.650	79331.000
FBR049	5.816	34.850	51.200	0.407	20.508	73.640	1.558	0.795	5.359	67.370	132.090	65541.700
FBR051	6.362	0.000	62.610	0.637	24.253	48.950	0.898	1.025	6.260	83.070	138.310	86266.200
FBR054	6.808	0.000	53.180	0.487	16.134	56.390	1.004	0.800	5.216	57.420	189.250	57081.300
FBR055	6.463	0.000	59.400	0.496	19.047	0.000	1.119	0.683	5.753	63.870	145.370	67817.000
FBR058	6.732	0.000	37.890	1.184	14.580	72.360	0.708	0.770	5.234	62.610	167.350	72123.300
FBR059	12.471	34.000	19.270	0.314	13.026	0.000	1.183	1.507	16.312	19.140	337.910	69191.800

Table C.2. Element Concentrations as Measured by Neutron Activation Analysis (Hf–Al) (continued).

Sample Number[a]	Hf (ppm)	Ni (ppm)	Rb (ppm)	Sb (ppm)	Sc (ppm)	Sr (ppm)	Ta (ppm)	Tb (ppm)	Th (ppm)	Zn (ppm)	Zr (ppm)	Al (ppm)
FBR067	8.735	72.330	37.410	0.695	25.071	100.310	1.699	2.717	20.227	39.190	290.800	176702.300
FBR071	7.699	0.000	74.770	1.073	12.394	41.470	0.894	0.768	8.967	48.970	204.110	64720.800
FBR074	7.580	0.000	64.370	0.834	10.637	63.070	0.853	0.666	8.608	41.440	193.860	66633.200
FBR077	6.764	0.000	125.600	1.836	23.640	99.580	0.973	1.071	10.903	99.970	174.270	94165.100
FBR080	7.000	35.100	59.520	0.933	14.458	79.670	0.874	0.794	6.104	55.570	175.910	72965.800
FBR081	15.134	0.000	4.270	0.442	4.806	0.000	1.443	0.489	8.228	14.710	364.830	36485.400
FBR082	11.253	0.000	58.230	0.353	13.018	66.170	1.103	0.581	9.369	31.840	294.440	74334.700
FBR083	4.258	0.000	35.720	0.237	5.831	126.820	0.305	0.491	4.716	32.290	104.130	56857.700
FBR084	9.753	0.000	39.940	0.394	12.968	42.440	1.199	0.386	9.893	24.470	251.800	80228.800
FBR085	9.314	0.000	25.770	0.283	10.559	70.900	1.032	0.440	8.267	22.430	221.240	65213.600
FBR086	0.000	0.000	0.610	0.180	0.045	0.000	0.000	0.003	0.014	1.050	0.000	1424.300
FBR087	0.093	0.000	0.460	0.044	0.079	0.000	0.010	0.015	0.045	0.860	1.800	1870.100
FBR088	3.091	34.260	53.270	0.207	20.831	652.860	0.244	0.488	4.655	115.420	82.980	83898.900
FBR089	7.991	0.000	79.770	0.047	3.930	219.560	0.948	0.686	10.954	61.210	204.880	79362.400
FBR090	16.742	34.330	14.880	0.453	8.137	0.000	1.449	0.662	9.541	15.180	383.300	64835.900
FBR091	2.721	101.840	10.920	0.000	43.829	147.780	0.206	0.706	0.803	105.780	0.000	78527.400
FBR092	3.662	0.000	3.330	0.080	0.718	0.000	0.226	0.146	2.829	8.630	91.260	3857.900
JMH001	10.433	0.000	115.550	0.177	20.138	0.000	1.418	1.620	17.364	71.930	295.520	107775.900
JMH002	8.965	0.000	36.240	0.249	16.821	0.000	1.003	0.927	8.181	79.670	211.190	100492.400
JMH003	7.393	0.000	37.050	0.525	16.593	0.000	0.800	0.466	8.645	43.590	149.560	98163.200
JMH004	8.812	0.000	58.010	0.234	19.794	0.000	0.986	0.698	9.882	46.280	167.510	102272.900
JMH005	12.843	0.000	41.130	0.391	12.943	0.000	1.100	0.795	11.951	41.820	298.750	70116.900
JMH006	2.855	71.690	20.210	0.748	27.881	242.920	0.352	0.517	2.146	73.420	25.980	75884.700
JMH007	8.134	105.180	19.860	0.288	16.693	0.000	0.825	1.728	10.229	45.790	196.710	93285.700
JMH008	7.976	0.000	58.810	0.428	15.140	0.000	0.857	0.499	9.384	58.090	151.900	94327.500
JMH009	6.652	0.000	71.220	0.146	15.245	0.000	1.151	0.994	11.349	55.640	180.970	100753.700
JMH010	9.099	0.000	68.290	0.296	16.066	0.000	0.741	0.243	10.886	40.880	184.870	77444.300
JMH011	10.545	0.000	34.670	0.368	14.136	0.000	1.178	0.323	12.302	0.000	210.570	85121.500
JMH012	9.938	0.000	51.910	0.185	14.384	0.000	1.053	1.495	14.002	53.230	238.340	102703.100
JMH013	8.186	0.000	57.960	0.418	19.750	0.000	1.180	1.440	11.837	54.670	160.230	118903.600
JMH014	5.447	168.910	47.110	0.626	30.058	0.000	0.764	0.531	5.571	0.000	113.950	85389.500
JMH015	16.864	0.000	83.310	0.272	10.322	60.080	1.717	0.954	18.559	29.340	408.780	72424.200

Table C.2. Element Concentrations as Measured by Neutron Activation Analysis (Hf–Al) (continued).

Sample Number[a]	Hf (ppm)	Ni (ppm)	Rb (ppm)	Sb (ppm)	Sc (ppm)	Sr (ppm)	Ta (ppm)	Tb (ppm)	Th (ppm)	Zn (ppm)	Zr (ppm)	Al (ppm)
JMH016	6.168	0.000	90.600	0.394	18.839	0.000	0.967	0.564	12.717	83.310	134.390	99991.600
JMH017	12.203	0.000	32.090	0.536	15.532	0.000	0.923	1.178	11.904	52.350	311.850	82920.300
JMH018	8.906	0.000	22.650	0.600	16.563	0.000	1.418	0.904	12.432	64.810	230.320	102517.500
JMH019	12.582	0.000	39.840	0.209	15.700	0.000	1.406	0.900	13.967	57.020	280.230	95614.800
JMH020	6.392	0.000	54.900	0.197	19.525	0.000	1.091	1.246	12.253	81.590	160.500	113968.800
JMH021	8.660	58.800	63.090	0.225	19.680	0.000	1.448	0.789	13.020	66.780	203.360	110402.200
JMH022	4.882	0.000	32.260	0.326	15.281	0.000	0.918	0.910	8.752	45.370	110.720	95015.900
JMH023	9.091	0.000	44.160	0.171	20.567	0.000	1.776	0.535	13.296	82.750	193.480	114752.100
JMH024	13.429	0.000	31.080	0.139	17.381	0.000	1.678	1.080	18.642	49.380	331.750	101000.800
JMH025	7.616	0.000	55.670	0.104	16.822	0.000	1.093	0.919	12.121	61.250	167.590	95631.000
JMH026	9.120	0.000	110.180	0.163	21.372	0.000	1.458	0.917	15.946	76.780	203.990	106153.800
JMH027	8.568	0.000	36.620	0.157	14.562	0.000	1.457	0.508	13.820	38.820	167.600	95475.600
JMH028	11.510	0.000	40.990	0.168	15.796	0.000	1.575	1.465	16.180	49.080	267.400	89498.100
JMH029	12.137	0.000	36.420	0.148	18.551	0.000	1.808	0.557	14.860	73.110	296.740	112708.800
JMH030	12.547	0.000	29.500	0.151	18.677	0.000	1.797	0.495	14.453	45.720	289.880	114508.500
JMH031	7.141	81.260	20.110	0.244	17.429	0.000	0.628	0.448	3.809	45.010	158.900	58933.300
JMH032	1.708	93.150	18.810	1.149	30.319	0.000	0.445	0.701	2.066	63.130	0.000	80937.600
JMH033	3.485	51.530	67.370	3.042	19.015	415.580	0.905	1.213	11.797	123.400	115.700	98574.900
JMH034	1.492	159.490	12.040	0.553	28.052	0.000	0.253	0.412	1.632	72.070	30.920	68782.300
JMH035	9.411	0.000	30.290	0.162	21.290	215.770	0.681	0.470	4.977	44.340	235.350	87530.900
JMH036	4.181	0.000	17.860	0.088	19.309	346.630	0.253	0.306	2.573	45.110	115.560	111179.400
JMH037	5.472	0.000	87.550	0.490	21.819	0.000	0.575	0.926	5.370	79.530	101.030	83730.700
JMH038	21.614	0.000	106.810	0.156	12.456	100.930	2.210	1.271	21.214	63.120	461.550	92941.600
JMH039	12.070	0.000	33.770	0.114	17.780	216.070	1.129	0.156	6.005	62.330	256.720	91433.000
JMH040	8.707	0.000	36.860	0.544	19.665	294.470	0.402	0.438	7.263	131.710	198.530	109640.000
JMH041	7.345	0.000	39.060	0.345	17.116	74.880	0.762	0.203	6.481	0.000	153.170	94047.500
JMH042	8.839	0.000	45.550	0.396	17.820	0.000	0.855	0.167	7.228	72.210	181.860	99853.300
JMH043	7.645	0.000	67.660	0.182	19.821	0.000	1.232	0.366	4.216	68.180	145.290	77553.600
JMH044	10.964	0.000	158.250	0.121	7.068	196.800	1.970	0.562	18.540	40.430	301.950	105961.600
JMH045	4.681	0.000	45.640	0.909	17.124	392.320	0.278	0.354	5.811	112.830	120.760	97900.400
JMH046	0.797	0.000	0.000	0.546	33.130	0.000	0.095	0.000	0.636	85.930	0.000	78527.500
JMH047	1.146	0.000	24.810	0.348	40.890	103.540	0.124	0.293	1.383	109.990	0.000	104690.100

Table C.2. Element Concentrations as Measured by Neutron Activation Analysis (Hf–Al) (continued).

Sample Number[a]	Hf (ppm)	Ni (ppm)	Rb (ppm)	Sb (ppm)	Sc (ppm)	Sr (ppm)	Ta (ppm)	Tb (ppm)	Th (ppm)	Zn (ppm)	Zr (ppm)	Al (ppm)
JMH048	3.728	48.820	45.970	0.975	17.910	493.690	0.397	0.409	6.660	114.550	115.250	100257.000
JMH049	3.662	0.000	18.430	0.061	8.135	187.780	0.169	0.239	1.598	37.160	82.340	102177.400
JMH050	9.137	0.000	38.760	0.308	14.370	0.000	0.771	0.219	6.368	43.710	180.450	83408.900
JMH051	13.348	43.820	38.390	0.410	12.597	20.100	1.165	0.632	10.638	35.430	312.540	62884.800
JMH052	10.537	0.000	43.930	0.418	11.829	0.000	1.185	0.401	10.846	32.020	276.500	59342.600
JMH053	7.921	0.000	30.980	0.397	12.144	0.000	1.125	0.782	10.339	44.660	199.400	71317.700
JMH054	5.487	27.830	50.420	0.344	14.316	0.000	0.792	0.922	11.355	65.320	150.920	76059.600
JMH055	6.061	27.960	92.090	0.488	13.543	102.190	1.138	0.721	11.515	49.360	158.740	80261.400
JMH056	9.045	0.000	52.240	0.278	12.486	294.430	1.156	0.505	9.051	40.090	224.330	69392.500
JMH057	7.676	0.000	117.390	0.339	12.898	208.490	1.028	0.755	11.324	46.540	206.780	77642.700
JMH058	12.097	0.000	64.270	0.302	15.499	127.870	1.041	0.642	14.243	52.990	292.970	79901.100
JMH059	9.260	51.810	88.840	0.313	16.309	171.070	1.043	2.275	12.469	62.780	315.570	96704.200
JMH060	10.845	0.000	124.160	0.261	14.397	254.010	0.937	0.724	11.811	47.700	273.310	69257.800
JMH061	5.942	0.000	96.450	0.353	17.472	172.570	1.000	0.722	11.285	65.830	162.950	102850.100
JMH062	7.113	0.000	118.310	0.342	18.516	260.140	1.113	1.027	11.907	84.620	154.450	97892.700
JMH063	8.119	32.880	104.750	0.466	14.334	200.060	1.787	1.458	15.019	55.480	249.900	80984.400
JMH064	7.478	0.000	57.920	0.343	13.288	81.550	0.887	0.502	9.754	44.590	232.470	80367.600
JMH065	10.946	0.000	53.160	0.467	17.927	0.000	1.304	1.010	12.839	72.460	353.890	94010.600
JMH066	6.838	0.000	25.590	0.251	9.621	0.000	0.822	0.486	7.332	27.650	191.620	58089.900
JMH067	12.304	111.490	22.530	0.653	12.536	0.000	0.935	0.473	11.103	46.640	326.860	74437.200
JMH068	8.350	60.780	56.150	0.421	14.141	0.000	0.977	1.705	10.847	61.110	256.720	88450.600
JMH069	6.952	0.000	20.120	0.375	9.550	0.000	0.889	0.312	6.474	27.660	170.500	57996.100
JMH070	7.773	0.000	11.830	0.309	10.159	0.000	1.028	0.304	9.666	28.550	227.310	65253.900

[a] Clay samples have FBR prefix; pottery samples have JMH prefix.

Table C.3. Element Concentrations as Measured by Neutron Activation Analysis (Ba–V).

Sample Number[a]	Ba (ppm)	Ca (ppm)	Dy (ppm)	K (ppm)	Mn (ppm)	Na (ppm)	Ti (ppm)	V (ppm)
FBR002	174.100	0.000	7.402	2456.400	38.150	207.000	3404.200	189.020
FBR003	53.500	0.000	1.562	840.400	27.990	192.100	2768.900	62.550
FBR004	385.400	0.000	4.346	16304.700	87.440	720.600	4555.100	69.080
FBR005	160.900	0.000	3.682	6111.600	32.010	396.000	3732.700	55.590
FBR006	186.800	0.000	4.609	5026.700	31.810	391.200	8681.900	199.770
FBR007	233.000	0.000	9.143	4379.100	41.240	343.000	5793.600	121.680
FBR008	129.100	0.000	5.867	3527.300	42.840	305.300	7094.000	97.340
FBR009	162.300	0.000	5.366	7029.900	54.440	489.900	6741.200	102.950
FBR010	195.100	0.000	5.838	8499.300	76.170	470.600	6647.000	53.200
FBR011	392.900	3095.900	2.920	9013.200	340.150	4672.400	4876.800	74.080
FBR012	343.700	2486.000	3.128	8099.000	141.530	5153.500	5262.300	102.090
FBR013	352.000	2400.400	3.060	11578.500	156.490	3488.500	5703.300	122.470
FBR014	412.000	2929.100	4.853	14449.500	1430.970	4084.700	7798.300	148.890
FBR016	352.300	0.000	5.061	8976.100	1271.740	4070.500	6832.500	124.560
FBR017	134.600	1176.000	7.619	2363.600	108.140	282.800	4683.200	81.480
FBR019	667.900	3482.500	5.486	18410.300	492.690	4251.600	7330.000	151.800
FBR020	662.600	4005.300	6.751	16677.900	599.420	4586.500	7126.400	145.940
FBR021	608.600	2446.000	6.792	15869.000	304.070	3318.400	7480.800	154.840
FBR023	316.300	0.000	3.640	11455.000	179.980	1756.100	7732.300	161.740
FBR027	660.200	3206.100	7.384	16921.100	1299.900	2494.100	8576.600	178.870
FBR029	156.900	5209.500	4.351	0.000	1111.570	1504.500	8992.400	129.420
FBR030	563.300	1289.800	4.788	23913.900	119.020	1278.700	5310.000	143.540
FBR035	405.500	1510.700	1.774	15308.100	240.980	3479.600	3793.300	131.530
FBR040	327.700	567.300	1.747	12854.300	153.150	1567.400	3813.300	87.970
FBR041	492.100	4774.400	1.444	21524.100	181.550	7687.200	2762.600	68.950
FBR048	305.500	6546.800	4.871	10805.200	835.390	3040.500	8317.100	152.560
FBR049	231.300	11583.400	4.645	5597.700	1568.160	4682.400	12838.700	113.190
FBR051	363.300	7465.000	4.952	9724.000	841.770	3512.000	7358.900	160.780
FBR054	212.100	7308.500	3.951	9700.500	1736.520	3693.000	6452.900	108.680
FBR055	280.000	6144.300	4.075	9683.900	2175.060	2911.900	8291.100	130.370
FBR058	233.400	7759.200	4.472	5406.800	535.560	7227.600	5262.800	91.870
FBR059	196.500	0.000	7.412	4547.000	47.070	337.300	4708.900	78.760

Table C.3. Element Concentrations as Measured by Neutron Activation Analysis (Ba–V) (continued).

Sample Number[a]	Ba (ppm)	Ca (ppm)	Dy (ppm)	K (ppm)	Mn (ppm)	Na (ppm)	Ti (ppm)	V (ppm)
FBR067	306.200	0.000	13.859	7008.700	44.710	505.800	7104.600	186.560
FBR071	285.900	2343.700	5.088	9461.600	188.560	5904.700	5010.200	88.090
FBR074	253.200	2745.900	4.026	10190.500	411.720	9250.000	3669.100	88.800
FBR077	720.200	2955.000	5.732	22553.500	972.460	7663.000	5435.700	154.360
FBR080	411.800	6439.500	4.493	8884.900	449.830	6107.700	6056.100	108.830
FBR081	51.200	0.000	3.032	0.000	41.140	205.500	6432.600	50.500
FBR082	240.000	4073.900	3.952	9776.900	65.440	558.600	5424.600	108.360
FBR083	109.500	3069.000	3.780	1731.000	63.170	347.400	6821.900	80.580
FBR084	213.800	4290.200	2.858	5749.700	52.850	700.900	5242.500	105.690
FBR085	97.800	4366.900	2.412	4235.700	52.180	488.500	4722.700	83.990
FBR086	0.000	0.000	0.000	0.000	17.930	136.000	0.000	0.000
FBR087	0.000	0.000	0.099	0.000	3.780	127.900	0.000	0.000
FBR088	370.400	45658.000	2.483	14776.500	1498.380	22877.700	6771.100	215.520
FBR089	625.100	7654.300	3.769	30643.100	754.310	31082.800	1705.700	19.270
FBR090	767.000	7947.000	3.117	15027.800	320.120	32426.200	1215.500	15.270
FBR091	171.300	70385.900	4.405	5357.000	1885.570	19979.600	3892.200	282.680
FBR092	22.300	0.000	0.588	626.200	23.160	398.700	662.500	5.200
JMH001	504.100	667.700	8.561	13633.000	451.630	627.500	6283.000	133.620
JMH002	380.400	1530.600	6.306	7381.100	175.380	786.400	5113.500	78.260
JMH003	239.600	3309.800	2.607	7986.900	200.420	5098.300	5406.300	118.090
JMH004	316.600	1603.700	4.387	10200.500	182.800	1380.100	5878.500	110.800
JMH005	308.200	2234.900	4.619	8137.000	290.430	1799.200	6139.500	104.660
JMH006	85.200	30003.200	2.536	2752.400	1160.840	10900.500	3886.700	207.150
JMH007	238.200	754.400	9.032	2066.000	222.060	248.800	6133.800	139.640
JMH008	472.900	4178.700	3.345	9436.200	263.180	6177.600	5499.900	94.950
JMH009	471.400	434.300	6.131	15678.200	124.360	740.100	4582.300	109.550
JMH010	117.400	1439.800	2.301	8762.200	129.420	603.800	5254.600	97.670
JMH011	216.700	554.200	2.683	4108.200	79.400	373.800	5719.600	101.430
JMH012	320.500	464.600	7.840	10601.200	141.600	573.600	5164.600	88.000
JMH013	303.600	346.900	9.370	10529.500	91.890	592.700	6377.500	133.870
JMH014	199.100	6218.600	3.094	3567.500	1460.520	3342.900	4140.800	137.310

Table C.3. Element Concentrations as Measured by Neutron Activation Analysis (Ba–V) (continued).

Sample Number[a]	Ba (ppm)	Ca (ppm)	Dy (ppm)	K (ppm)	Mn (ppm)	Na (ppm)	Ti (ppm)	V (ppm)
JMH015	809.300	923.000	4.888	26057.400	261.000	3341.300	5688.300	68.270
JMH016	475.100	2061.100	3.902	14400.600	245.030	3672.900	5248.700	119.800
JMH017	196.000	826.400	7.731	2659.900	213.420	719.600	4890.400	99.610
JMH018	370.400	2518.400	5.969	4501.300	113.440	1865.700	6909.800	136.630
JMH019	259.100	547.000	5.577	7029.200	99.670	647.500	7073.100	112.860
JMH020	400.600	2233.300	7.415	9209.300	181.440	1687.600	5543.500	142.400
JMH021	628.400	1526.600	4.651	10100.700	272.760	535.200	5984.600	131.960
JMH022	500.800	4265.900	5.364	5695.100	144.360	1262.100	5002.100	117.820
JMH023	620.800	895.800	3.303	4484.700	285.900	371.500	7037.200	106.030
JMH024	364.100	2235.100	5.380	5170.900	194.700	370.000	6701.100	124.220
JMH025	591.300	1454.600	5.198	10860.800	322.270	715.300	5137.600	128.690
JMH026	901.900	3401.300	5.237	14042.600	648.370	470.200	5455.100	135.890
JMH027	488.900	1065.600	3.882	5331.500	370.420	666.100	5261.600	96.470
JMH028	366.900	2242.900	7.101	5580.900	321.420	765.000	6590.100	124.530
JMH029	692.100	1175.100	3.901	4040.500	126.060	366.700	7446.300	117.790
JMH030	636.900	976.100	4.094	4200.400	225.180	347.300	7523.700	120.380
JMH031	451.400	19629.400	3.244	3610.300	433.720	4172.700	4416.900	122.050
JMH032	222.300	31258.300	2.585	4192.600	560.660	4868.400	3620.400	167.380
JMH033	829.400	11253.100	5.154	16671.300	628.030	8460.300	5216.200	123.430
JMH034	229.500	35367.400	2.999	3231.300	853.430	5206.600	3175.800	177.000
JMH035	566.000	12488.100	3.506	4863.200	520.710	6225.500	7620.400	201.500
JMH036	366.500	18038.800	2.291	2010.900	288.490	13339.400	4464.300	150.700
JMH037	648.300	5309.000	6.682	7653.400	652.360	4867.800	4307.400	115.860
JMH038	881.500	6945.800	7.795	26299.600	300.210	7972.200	6001.500	63.160
JMH039	635.300	7336.400	1.353	11918.300	670.100	5458.800	11324.400	133.840
JMH040	494.900	15490.700	2.581	8722.200	736.550	11113.600	5579.300	180.510
JMH041	1165.700	3568.700	1.710	9461.200	357.560	3940.900	6440.600	117.410
JMH042	811.200	2029.500	1.571	10618.600	569.970	3881.400	6485.800	136.260
JMH043	858.800	5408.600	3.265	11608.400	1072.190	3463.800	15585.600	166.240
JMH044	861.600	6841.200	3.570	32733.100	190.200	13873.400	3355.100	53.120
JMH045	926.900	20579.300	2.688	13740.300	634.590	16191.800	4826.800	170.940

Table C.3. Element Concentrations as Measured by Neutron Activation Analysis (Ba–V) (continued).

Sample Number[a]	Ba (ppm)	Ca (ppm)	Dy (ppm)	K (ppm)	Mn (ppm)	Na (ppm)	Ti (ppm)	V (ppm)
JMH046	448.200	29425.000	1.890	0.000	691.880	3399.900	2087.800	162.800
JMH047	1145.500	35208.600	2.309	6353.300	1130.730	3343.100	3284.000	213.250
JMH048	855.700	21406.700	2.266	16008.300	601.470	16712.100	5449.100	169.130
JMH049	601.100	7081.100	1.693	4349.800	379.820	10951.900	2833.600	80.960
JMH050	507.700	2372.700	1.535	11130.900	360.690	4203.800	6325.200	118.150
JMH051	231.300	601.600	3.829	5413.300	127.770	913.100	5911.800	125.040
JMH052	183.600	406.700	3.389	5453.000	79.450	652.300	5676.700	115.970
JMH053	231.700	442.100	4.074	5385.700	97.580	1659.100	5467.100	115.110
JMH054	282.700	2962.900	4.910	7653.200	205.690	1590.500	4607.400	117.660
JMH055	1028.900	11805.100	4.410	8655.000	110.210	654.900	4921.100	114.160
JMH056	2041.000	12633.800	2.939	7297.000	108.070	968.100	5646.300	80.040
JMH057	1322.300	16292.200	4.416	10988.900	136.050	677.200	4578.400	101.470
JMH058	1386.200	8408.900	3.608	7935.600	150.260	1640.500	5333.600	104.390
JMH059	1028.200	10770.100	12.711	10763.400	175.560	1492.200	5853.600	117.230
JMH060	1707.900	9360.400	3.676	13988.800	268.210	977.000	4988.900	88.500
JMH061	925.900	7329.500	4.619	14768.100	345.070	3005.400	5140.100	110.880
JMH062	1160.800	11776.500	5.178	13210.000	239.540	4106.800	5424.600	120.310
JMH063	1502.100	14321.800	7.436	11709.000	134.510	731.600	4988.300	111.850
JMH064	457.800	2489.200	3.736	10798.800	605.480	2916.800	4658.100	99.810
JMH065	258.400	2453.700	5.235	7966.400	106.330	726.200	6462.800	155.020
JMH066	220.000	1070.100	2.886	5184.700	40.960	1285.800	4031.200	82.480
JMH067	133.200	821.400	2.771	3030.900	177.290	569.600	5624.500	117.610
JMH068	289.700	5562.100	8.101	9334.600	852.810	1573.900	5475.300	122.540
JMH069	141.700	668.200	2.427	3315.300	95.950	680.000	5093.500	103.130
JMH070	89.300	460.600	2.298	1334.700	82.390	462.900	5149.700	85.320

[a] Clay samples have FBR prefix; pottery samples have JMH prefix.

Appendix D

Petrographic Data

Michael S. Smith

Prior to petrographic analysis, each sherd was photographed and described (see Chapter 3 and Appendix A). Sherds and clay test tiles were then sawed into three pieces using a water-cooled, diamond-coated slow speed saw blade. One piece was submitted to a commercial firm for thin-sectioning, and the other two pieces were retained for additional analyses and reference purposes. Standard size (27 × 46 mm) petrographic thin sections (30 µm) were prepared such that both the inner and outer vessel surfaces could be examined. Because of the friable nature of some samples, epoxy impregnation (both surface treatment and vacuum impregnation) was used for binding.

Thin sections were examined using an Olympus BH-2 research grade petrographic microscope utilizing transmitted light. The overall matrix color of the sherd and other textural and structural features were examined and described under plane-polarized light. Cross-polarized light was used to define the identity of the aplastic components and to distinguish mineral grains and rock fragments. Examination under cross-polarized light also allowed the evaluation of the paste's isotropic behavior, variation in firing atmospheres (oxidized versus reduced), and void spaces. During thin-sectioning, mineral or rock fragment grains are sometimes accidentally "plucked" out of the matrix by the saw, producing voids that mimic natural matrix voids. Often the difference between artificial and natural voids can be detected under cross-polarized light.

Grain sizes of sherd components (minerals, rock fragments, grog, etc.) were measured using a calibrated micrometer at 25× magnification and evaluated according to the Wentworth scale (very fine, 0.0625–0.125 mm; fine, 0.125–0.25 mm; medium, 0.25–0.49 mm; coarse, 0.50–1.0 mm; and very coarse, greater than 1.0 mm). A quick strip-grid count was implemented to evaluate whether the grain size distribution was uniform, bimodal, or trimodal.

Proportions of components and physical parameters such as grain shape and form were estimated by visual examination under plane-polarized light. A more quantitative determination of the proportions of components was accomplished using point counting techniques modified from Stoltman (1989) and Stoltman et al. (1992). Due to the variability in grain size distribution among samples, point counts with an n value greater than 300 were taken to provide the smallest possible error (Chayes 1956; van der Plas and Tobi 1965).

Table D.1 summarizes the diagnostic petrographic characteristics of the 70 pottery samples. Table D.2 provides point count data (%) for the pottery samples.

Table D.1. Selected Petrographic Characteristics of Pottery Samples.

Sample ID	Diagnostic Minerals[a]				Diagnostic Rock Fragments					Other Diagnostic Inclusions	Comments
	Mafic	Feldspar	Mica	Other	Diabase	Quartz + Feldspar + Mafic	Quartz + Feldspar	Quartz	Sedimentary/ Metasedimentary		
JMH001	Am	Pl; Kfs	Ms	Op; Zrn	-	-	-	x	-	grog; ACF	coarse muscovite lathes; rutile needles in quartz; petrified wood fragment
JMH002	Am	Pl; Kfs	Bt; Ms	Op; Zrn	-	-	-	x	-	grog; ACF	-
JMH003	Am	Pl	Bt; Ms	Op; Zrn	-	-	-	x	-	grog; ACF	fluid inclusions in quartz
JMH004	Am	-	Ms	Op; Zrn	-	-	-	x	-	grog; ACF	-
JMH005	Am	Pl; Kfs	Ms	Op	-	-	-	x	-	grog; ACF	-
JMH006	Px	Pl	-	-	x	-	-	x	-	grog	no quartz mineral grains; fresh diabase rock fragments
JMH007	-	-	Ms	Op	-	-	-	x	-	grog; ACF	-
JMH008	Am	Pl; Kfs	Ms	Op	-	-	-	-	x	ACF	-
JMH009	-	Kfs	Ms	-	-	-	x	x	-	grog; ACF	-
JMH010	-	Kfs	Ms	Op; Tur; Zrn	-	-	-	x	-	grog; ACF	-
JMH011	Am	Kfs	Ms	-	-	-	-	x	-	grog; ACF	-
JMH012	-	Kfs	Ms	Op; Tur	-	-	-	x	-	grog; ACF	rutile needles in quartz
JMH013	Am	Kfs	Ms	Op	-	-	-	-	-	ACF	-
JMH014	Am	-	Ms	Op	-	x	-	x	-	grog	-
JMH015	-	Kfs	Ms	-	-	-	-	x	-	-	-
JMH016	-	Kfs	Ms	-	-	-	-	x	-	ACF	-
JMH017	Am	Kfs	Ms	Op	-	-	-	x	-	grog; ACF	-
JMH018	Am	Pl; Kfs	Ms	-	-	-	-	x	-	-	-
JMH019	Am	-	Ms	Op	-	-	-	x	-	ACF	-
JMH020	-	Pl; Kfs	Ms	-	-	x	x	x	-	grog; ACF	-
JMH021	-	Kfs	Ms	Op	-	x	x	x	-	grog; ACF	-
JMH022	-	Kfs	Ms	-	-	-	-	x	-	-	rutile/fluid inclusions
JMH023	-	-	Bt; Ms	Zrn	-	-	-	x	-	ACF	rutile/fluid inclusions

Table D.1. Selected Petrographic Characteristics of Pottery Samples (continued).

Sample ID	Diagnostic Minerals[a] Mafic	Feldspar	Mica	Other	Diagnostic Rock Fragments Diabase	Quartz + Feldspar + Mafic	Quartz + Feldspar	Quartz	Sedimentary/ Metasedimentary	Other Diagnostic Inclusions	Comments
JMH024	Am	-	Bt; Ms	Op; Tur; Zrn	-	-	-	x	x	grog; ACF	-
JMH025	-	Pl; Kfs	Ms	Tur	-	x	-	x	x	grog; ACF	-
JMH026	Am	-	Ms	Op; Tur	-	x	-	x	-	grog; ACF	-
JMH027	-	-	Ms	Op; Tur	-	x	-	x	x	grog; ACF	-
JMH028	-	Pl; Kfs	Ms	Zrn	-	-	-	x	-	grog; ACF	-
JMH029	-	-	Bt; Ms	Tur	-	-	-	x	x	grog; ACF	-
JMH030	-	Pl	Ms	Op; Tur; Zrn	-	-	-	x	x	grog; ACF	petrified wood fragments
JMH031	Px	Pl; Kfs	Ms	-	x	-	-	x	x	grog	-
JMH032	Am	Pl; Kfs	Ms	-	-	-	x	x	-	-	-
JMH033	Am	Pl; Kfs	Bt; Ms	Tur	-	x	x	x	-	-	sericite-altered rock fragments
JMH034	Am	Pl	Bt; Ms	-	-	x	x	x	x	-	altered feldspar
JMH035	Am	Pl; Kfs	Bt; Ms	Op; Tur	-	-	x	x	-	ACF	-
JMH036	Am	Pl; Kfs	Ms	Op; Zrn	-	-	x	x	-	ACF	-
JMH037	Am	-	Ms	Op	-	x	x	x	-	grog	altered quartz + k-feldspar
JMH038	Am	Pl; Kfs	Ms	Zrn	-	-	x	x	-	grog; ACF	altered quartz + feldspar; heavily altered k-feldspar
JMH039	Am	Pl; Kfs	Ms	Op; Tur; Zrn	-	-	-	x	-	-	altered k-feldspar
JMH040	Am	Pl; Kfs	Bt	Op	-	x	x	x	-	ACF	petrified wood
JMH041	Am	Pl	Ms	Op; Zrn	-	-	x	x	-	ACF	heavily altered feldspar
JMH042	-	Pl; Kfs	Bt	Op	-	-	x	x	-	ACF	heavily altered feldspar
JMH043	Am	Pl	Ms	Op; Tur	-	-		x	-	ACF	-
JMH044	-	Pl; Kfs	Bt; Ms	Op	-	-	x	x	-	-	heavily altered feldspar; exsolution textures
JMH045	Am	Pl; Kfs	-	Op	-	x	x	x	-	-	heavily altered feldspar; exsolution textures
JMH046	Px	-	Ms	Zrn	x	-	-	x	-	-	-
JMH047	Px	Pl	Bt; Ms	Op	x	-	-	x	-	ACF	some carbonate infill in voids

Table D.1. Selected Petrographic Characteristics of Pottery Samples (continued).

	Diagnostic Minerals[a]				Diagnostic Rock Fragments						
Sample ID	Mafic	Feldspar	Mica	Other	Diabase	Quartz + Feldspar + Mafic	Quartz + Feldspar	Quartz	Sedimentary/ Metasedimentary	Other Diagnostic Inclusions	Comments
JMH048	Px	Pl; Kfs	Bt; Ms	Tur; Zrn	-	x	x	x	-	-	heavily altered feldspar; exsolution textures
JMH049	-	Pl	Bt	Zrn	-	x	x	x	-	ACF	heavily altered feldspar; exsolution textures
JMH050	Am	Pl; Kfs	-	Op; Tur	-	x	x	x	-	ACF	heavily altered k-feldspar
JMH051											cut too thin
JMH052											cut too thin, but resembles JMH068
JMH053	Am	Pl	Ms	Op	-	-	-	x	-	ACF	-
JMH054	Am	-	Ms	Op; Tur	-	-	-	x	-	ACF	-
JMH055	Am	Kfs	Ms	Zrn	-	x	-	x	-	-	-
JMH056	-	Pl; Kfs	Ms	-	-	-	-	x	-	ACF	resembles JMH034
JMH057	Am	Pl; Kfs	Ms	Tur; Zrn	-	-	x	x	-	grog; ACF	-
JMH058	Am	Kfs	Ms	Zrn	-	x	-	x	x	ACF	resembles JMH034
JMH059	-	Kfs	Ms	-	-	-	-	-	-	ACF	-
JMH060	-	-	Ms	Op; Tur	-	-	-	x	-	ACF	resembles JMH018
JMH061	-	Pl; Kfs	Ms	Tur	-	-	-	x	-	ACF	-
JMH062	-	Kfs	Ms	Tur	-	-	-	x	-	ACF	-
JMH063	-	-	Ms	Tur	-	-	-	x	-	grog; ACF	-
JMH064	Am	Pl	Ms	Zrn	-	-	-	x	x	grog	-
JMH065	-	-	Ms	Op; Tur	-	-	-	-	-	grog; ACF	-
JMH066	Am	Kfs	Ms	Tur	-	x	-	x	-	-	resembles JMH070
JMH067	Am	Kfs	Ms	-	-	-	-	-	-	grog; ACF	-
JMH068	-	-	Ms	Tur	-	-	-	x	-	grog; ACF	resembles JMH052
JMH069	-	-	Ms	-	-	x	-	x	-	-	quartz + zircon fragments
JMH070	-	Pl	Ms	Op; Tur; Zrn	-	x	-	x	-	-	reduced

[a] Key: Am, amphibole; Bt, biotite; Kfs, K-feldspar; Ms, muscovite; Op, opaque; Pl, plagioclase; Px, pyroxene; Tur, tourmaline; Zrn, zircon.

Table D.2. Point Count Data for Pottery Samples.

		Minerals[a]											Rock Fragments[b]													
			Feldspar			Mica		Mafic																		
Sample ID	Total Points	Qtz (%)	Pl (%)	Kfs (%)	Unid (%)	Bt (%)	Ms (%)	Px (%)	Am (%)	Op (%)	Tur (%)	Other (%)	Qtz (%)	Qtz + Fsp (%)	Qtz + Pl (%)	Qtz + Kfs (%)	Qtz + 2 Fsp (%)	Qtz + Fsp + Mafic (%)	Siltstone/ Metasilt-stone (%)	Diabase (%)	Other (%)	Grog (%)	ACF[c] (%)	Void (%)	Paste (%)
JMH001	529	15.3	0.2	0.4	2.8	0.0	7.0	0.0	0.2	1.7	0.0	0.2	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	12.3	5.1	50.3
JMH002	752	31.0	0.8	0.3	1.6	0.1	7.0	0.0	0.3	1.5	0.0	1.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	3.1	51.6
JMH003	324	29.6	0.3	0.0	0.9	0.3	3.4	0.0	0.3	0.6	0.0	2.2	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	3.1	53.7
JMH004	478	25.5	0.0	0.0	2.1	0.0	4.4	0.0	0.8	1.3	0.0	0.4	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.7	18.4	3.1	41.2
JMH005	488	30.7	0.8	1.2	2.7	0.0	7.8	0.0	0.6	1.0	0.0	0.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4	1.8	2.5	43.0
JMH006	421	0.0	4.0	0.0	7.8	0.0	0.0	10.5	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	28.0	1.9	1.0	0.0	5.7	39.9
JMH007	566	22.6	0.0	0.0	0.9	0.0	1.2	0.0	0.0	0.7	0.0	0.2	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.8	21.0	1.6	43.5
JMH008	461	34.1	0.4	0.9	0.7	0.0	8.5	0.0	0.4	0.2	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.4	0.0	11.9	2.6	36.7
JMH009	420	30.7	0.0	6.0	1.7	0.0	15.2	0.0	0.0	0.0	0.0	0.2	5.2	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.2	37.6
JMH010	419	35.3	0.0	0.5	1.7	0.0	2.6	0.0	0.0	2.6	1.0	0.5	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	5.5	4.3	39.4
JMH011	391	27.9	0.0	1.0	0.5	0.0	5.1	0.0	0.5	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	14.1	1.3	48.3
JMH012	440	25.7	0.0	4.1	2.0	0.0	4.5	0.0	0.0	0.2	0.5	0.9	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	2.3	2.7	53.4
JMH013	361	26.3	0.0	1.4	0.3	0.0	6.4	0.0	0.3	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	61.8
JMH014	372	6.2	0.0	0.0	4.6	0.0	0.3	0.0	5.4	0.3	0.0	0.0	2.4	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	21.5	0.0	4.3	53.2
JMH015	433	33.0	0.0	2.3	8.1	0.0	3.9	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	45.5
JMH016	391	14.8	0.0	0.3	0.8	0.0	14.8	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.4	0.0	7.7	3.6	47.3
JMH017	406	29.6	0.0	3.2	0.7	0.0	1.5	0.0	1.0	0.2	0.0	0.7	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.0	2.5	55.7
JMH018	320	22.8	1.6	7.5	0.0	0.0	6.3	0.0	1.3	0.0	0.0	0.9	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	58.1
JMH019	387	27.6	0.0	0.0	2.1	0.0	4.7	0.0	1.8	0.5	0.0	1.3	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	56.1
JMH020	364	17.0	1.1	4.1	0.0	0.0	13.5	0.0	0.0	0.0	0.0	0.0	5.2	0.0	0.0	0.0	1.6	1.9	0.0	0.0	0.0	3.0	0.0	2.5	50.0
JMH021	456	22.1	0.0	1.3	2.2	0.0	12.1	0.0	0.0	1.3	0.0	0.0	3.5	0.2	0.0	0.0	0.0	0.4	0.0	0.0	0.0	5.9	5.7	3.1	42.1
JMH022	513	29.8	0.0	2.3	2.1	0.0	2.3	0.0	0.0	0.0	0.0	0.0	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	52.6
JMH023	671	19.4	0.0	0.0	1.2	1.6	4.6	0.0	0.0	0.0	0.0	0.3	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	4.6	65.3
JMH024	656	26.7	0.0	0.0	1.4	0.6	12.5	0.0	0.6	0.5	0.9	0.5	2.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	6.1	3.8	3.0	40.4
JMH025	717	21.6	1.3	2.0	1.5	0.0	18.5	0.0	0.0	0.0	0.1	0.0	3.3	0.0	0.0	0.0	0.0	0.4	5.4	0.0	0.0	2.5	1.3	2.1	39.9
JMH026	455	19.3	0.0	0.0	2.2	0.0	13.8	0.0	0.7	0.2	1.5	0.0	1.8	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	1.8	11.4	1.5	44.6
JMH027	639	25.2	0.0	0.0	0.5	0.0	14.7	0.0	0.0	0.2	3.3	0.0	7.7	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	3.9	8.1	0.5	35.7
JMH028	501	27.9	1.0	1.2	1.0	0.0	6.6	0.0	0.0	0.0	0.0	0.6	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	2.4	47.1
JMH029	473	26.8	0.0	0.0	0.4	0.4	10.1	0.0	0.0	0.0	0.2	0.0	1.7	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	3.2	8.9	1.5	45.7
JMH030	526	24.7	0.2	0.0	2.1	0.0	9.1	0.0	0.0	0.8	1.1	1.0	4.4	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	2.7	5.3	2.7	44.5
JMH031	451	26.8	2.2	0.2	2.9	0.0	0.7	1.1	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0	3.8	15.1	0.0	0.7	0.0	4.2	39.5
JMH032	431	11.8	0.9	2.3	3.7	0.0	4.4	0.0	14.6	0.0	0.0	0.0	7.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	49.4
JMH033	536	10.3	0.7	0.4	2.6	7.1	21.8	0.0	0.9	0.0	2.4	0.0	3.9	1.7	0.4	0.0	0.0	12.7	0.0	0.0	0.0	0.0	0.0	1.9	33.2
JMH034	463	5.6	2.4	0.0	4.1	6.5	1.5	0.0	17.3	0.0	0.0	0.0	7.6	0.9	0.0	0.0	0.0	1.5	1.3	0.0	0.0	0.0	0.0	1.9	49.5
JMH035	502	27.9	2.6	2.6	2.8	1.0	1.2	0.0	4.0	2.2	4.2	0.8	3.6	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	44.4
JMH036	434	18.9	2.3	0.5	2.5	0.0	2.8	0.0	3.9	0.9	0.0	0.7	7.8	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	54.1

Table D.2. Point Count Data for Pottery Samples (continued).

		Minerals[a]											Rock Fragments[b]												
			Feldspar			Mica		Mafic																	
Sample ID	Total Points	Qtz (%)	Pl (%)	Kfs (%)	Unid (%)	Bt (%)	Ms (%)	Px (%)	Am (%)	Op (%)	Tur (%)	Other (%)	Qtz (%)	Qtz + Fsp (%)	Qtz + Pl (%)	Qtz + Kfs (%)	Qtz + 2 Fsp (%)	Qtz + Fsp + Mafic (%)	Siltstone/ Metasilt-stone (%)	Diabase (%)	Other (%)	Grog (%)	ACF[c] (%)	Void (%)	Paste (%)
JMH037	488	27.5	0.0	0.0	2.7	0.0	2.7	0.0	0.8	0.4	0.0	0.0	8.4	0.4	0.0	0.0	0.0	2.9	0.0	0.0	0.0	2.7	0.0	4.3	47.3
JMH038	576	22.9	1.2	5.7	6.4	0.0	1.9	0.0	0.3	0.0	0.0	1.2	2.8	1.6	0.0	1.2	0.0	0.0	0.0	0.0	0.0	3.3	0.0	3.6	47.7
JMH039	474	34.6	1.7	1.9	2.3	0.0	0.8	0.0	1.9	5.3	0.4	1.1	5.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	43.9
JMH040	494	10.9	2.2	3.0	6.5	4.0	0.0	0.0	3.2	2.0	0.0	3.6	0.4	3.0	0.0	0.0	0.0	11.9	0.0	0.0	0.0	0.0	0.0	1.8	47.2
JMH041	394	19.8	0.5	0.0	4.1	0.0	0.8	0.0	0.8	1.5	0.0	1.5	7.1	0.3	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	58.6
JMH042	394	26.6	0.3	2.5	3.6	1.5	0.0	0.0	0.0	1.0	0.0	3.3	6.3	2.5	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	3.3	47.5
JMH043	437	21.5	1.1	0.0	3.7	0.0	2.1	0.0	0.9	3.9	0.5	8.5	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	47.6
JMH044	568	31.0	2.3	3.3	3.7	1.1	16.0	0.0	0.0	1.1	0.0	0.2	3.7	1.9	0.0	1.4	1.2	0.0	0.0	0.0	1.1	0.0	0.0	0.5	31.5
JMH045	464	9.3	1.3	1.3	9.5	0.0	0.0	0.0	3.0	0.4	0.0	0.2	1.5	8.0	0.9	0.9	6.5	11.4	0.0	0.0	0.0	0.0	0.0	2.2	43.8
JMH046	411	14.4	0.0	0.0	4.9	0.0	2.7	14.4	0.0	0.0	0.0	0.5	7.1	0.0	0.0	0.0	0.0	0.0	0.0	5.8	0.0	0.0	0.0	1.0	49.4
JMH047	471	7.9	0.2	0.0	5.5	0.8	0.6	5.7	0.0	0.6	0.0	3.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	11.0	0.0	0.0	2.1	3.0	58.8
JMH048	439	9.3	3.9	1.8	13.7	0.7	0.2	1.6	0.0	0.0	0.2	0.7	0.2	6.6	0.0	0.9	6.4	5.0	0.0	0.0	0.0	0.0	0.0	1.8	46.9
JMH049	400	15.3	1.5	0.0	3.8	3.0	0.0	0.0	0.0	0.0	0.0	0.8	14.8	2.0	2.3	0.0	0.5	9.8	0.0	0.0	0.0	0.0	0.0	3.3	43.3
JMH050	455	24.2	1.8	1.5	2.9	0.0	0.0	0.0	0.9	0.4	0.4	0.4	7.7	2.6	0.7	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	3.3	50.8
JMH053	447	28.6	0.4	0.0	0.7	0.0	2.7	0.0	0.2	0.4	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.0	3.8	2.5	53.5
JMH054	481	18.9	0.0	0.0	0.0	0.0	13.9	0.0	0.2	0.6	0.2	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	5.6	2.3	53.2
JMH055	355	13.8	0.0	3.1	0.6	0.0	13.5	0.0	0.6	0.0	0.0	0.6	0.6	0.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	1.7	58.6
JMH056	430	26.5	0.2	0.5	0.5	0.0	2.3	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	65.8
JMH057	426	25.8	1.2	0.9	2.6	0.0	9.2	0.0	0.5	0.0	0.2	0.7	7.3	0.7	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.5	0.0	3.1	46.0
JMH058	416	27.2	0.0	0.5	1.4	0.0	2.2	0.0	0.2	0.0	0.0	0.2	1.7	0.0	0.0	0.0	0.0	0.5	7.7	0.0	0.0	0.0	0.0	2.6	55.8
JMH059	320	29.4	0.0	1.3	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	62.8
JMH060	458	25.3	0.0	0.0	2.6	0.0	5.9	0.0	0.0	0.7	0.9	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	4.1	0.9	55.7
JMH061	452	20.4	1.1	0.7	0.9	0.0	1.8	0.0	0.0	0.0	0.2	0.0	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	2.0	3.3	63.1
JMH062	433	25.4	0.0	0.7	1.2	0.0	0.7	0.0	0.0	0.0	0.5	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	3.7	64.2
JMH063	561	33.5	0.0	0.0	0.4	0.0	1.6	0.0	0.0	0.0	0.2	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.4	8.0	4.1	49.2
JMH064	347	28.2	0.3	0.0	0.9	0.0	0.9	0.0	0.3	0.0	0.0	0.3	3.5	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.6	0.0	12.1	52.4
JMH065	290	20.3	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.3	1.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.5	0.0	1.4	58.6
JMH066	401	22.9	0.0	1.5	1.2	0.0	1.0	0.0	0.2	0.0	0.2	0.5	6.7	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	7.5	57.9
JMH067	353	30.9	0.0	1.4	1.4	0.0	1.4	0.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	5.9	49.3
JMH068	386	22.8	0.0	0.0	1.3	0.0	2.6	0.0	0.0	0.0	0.8	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	3.1	7.3	58.3
JMH069	375	28.5	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.5	6.1	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	4.8	58.9
JMH070	427	33.3	0.2	0.0	0.9	0.0	3.7	0.0	0.0	0.7	0.2	0.2	8.9	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	2.6	48.9

[a] Key: Am, amphibole; Bt, biotite; Kfs, K-feldspar; Ms, muscovite; Op, opaque; Pl, plagioclase; Px, pyroxene; Qtz, quartz; Tur, tourmaline; Unid, unidentified.
[b] Key: Fsp, feldspar; Kfs, K-feldspar; Pl, plagioclase; Qtz, quartz.
[c] Point-count data for some samples do not accurately reflect the abundance of argillaceous clay clots, which blend into the surrounding paste under cross-polarized light.

Bibliography

Abbott, L. E.

1994 *Spring Lake Bypass, NCDOT TIP No. R-2629 Archaeological, Historical, and Architectural Historical Consulting Services/Cultural Resources Survey: NCDOT Project R-2629: Spring Lake Bypass, Cumberland County, North Carolina*. New South Associates, Stone Mountain. Submitted to Maguire Associates Incorporated, Raleigh, NCDOT TIP No. R-2629.

Arnold, D. E.

1985 *Ceramic Theory and Culture Process*. Cambridge University Press, Cambridge.

1992 Comments on Section II. In *Chemical Characterization of Ceramic Pastes in Archaeology*, edited by H. Neff, pp. 159–166. Monographs in World Archaeology No. 7. Prehistory Press, Madison, Wisconsin.

Barna, G. L.

1967 Plasticity of Clay Minerals. *American Ceramic Society Bulletin* 46:1091–1093.

Bartlett, M. L., H. Neff, and P. A. McAnany

2000 Differentiation of Clay Resources on a Limestone Plain: The Analysis of Clay Utilization During the Maya Formative at K'axob Belize. *Geoarchaeology* 15(2):95–133.

Baxter, M. J.

1992 Archaeological Uses of the Biplot — A Neglected Technique? In *Computer Applications and Quantitative Methods in Archaeology,* edited by G. Lock and J. Moffett, pp. 141–148. BAR International Series S577. Tempus Reparatum, Archaeological and Historical Associates, Oxford.

1994 Stepwise Discriminant Analysis in Archaeometry: A Critique. *Journal of Archaeological Science* 21:659–666.

Baxter, M. J., and C. E. Buck

2000 Data Handling and Statistical Analysis. In *Modern Analytical Methods in Art and Archaeology*, edited by E. Ciliberto and G. Spoto, pp. 681–746. John Wiley & Sons, New York.

Benson, R. W.
2000 *Archeological Testing of 50 Sites, Overhills Tract, Fort Bragg, Harnett and Cumberland Counties, North Carolina*. Gulf South Research Corporation and Southeastern Archaeological Services, Inc. Submitted to the U.S. Army Corps of Engineers, Savannah, Georgia, Contract No. DACW21-89-D-0016.

Benson, R. W., and C. O. Braley
1998 *Living on the Edge: Cultural Resources Survey of the Overhills Tract, 10,546 Acres in Harnett and Cumberland Counties, North Carolina*. Gulf Engineers & Consultants, Inc., Baton Rouge, and Southeastern Archaeological Services, Inc., Athens. Submitted to the U.S. Army Corps of Engineers, Savannah, Georgia, Contract No. DACW21-89-D-0016.

Beutel, E. K., S. Nomade, A. K. Fronabarger, and P. R. Renne
2005 Pangea's Complex Breakup: A New Rapidly Changing Stress Field Model. *Earth and Planetary Science Letters* 236:471–485.

Bieber, A. M., Jr., D. W. Brooks, G. Harbottle, and E. V. Sayre
1976 Application of Multivariate Techniques to Analytical Data on Aegean Ceramics. *Archaeometry* 18:59–74.

Binford, L. R.
1979 Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research* 35:255–273.

Binns, C. F.
1947 *The Potter's Craft*. 3rd ed. D. Van Nostrand, New York.

Bishop, R. L., and H. Neff
1989 Compositional Data Analysis in Archaeology. In *Archaeological Chemistry IV*, edited by R. O. Allen, pp. 576–586. Advances in Chemistry Series 220. American Chemical Society, Washington, D.C.

Bishop, R. L., R. L. Rands, and G. R. Holley
1982 Ceramic Compositional Analysis in Archaeological Perspective. In *Advances in Archaeological Method and Theory*, Vol. 5, edited by M. B. Schiffer, pp. 275–330. Academic Press, New York.

Bjørn, A.
1969 *Exploring Fire and Clay: Man, Fire, and Clay Through the Ages*. Van Nostrand Reinhold, New York.

Braley, C. O.
1989a *Cultural Resources Survey of the Master Plan Lands, Fort Bragg, North Carolina*. Gulf Engineers & Consultants, Inc., Baton Rouge, and Southeastern Archaeological Services, Inc., Athens. Submitted to the U.S. Army Corps of Engineers, Savannah, Georgia, Contract No. DACA21-87-D-0539.

1989b *A Cultural Resources Survey of Fort Bragg's Northern Training Area, Harnett, Moore, and Cumberland Counties, North Carolina*. Gulf Engineers & Consultants, Inc., Baton Rouge, and Southeastern Archaeological Services, Inc., Athens. Submitted to the U.S. Army Corps of Engineers, Savannah, Georgia, Contract No. DACA21-87-D-0539.

1992 *An Intensive Cultural Resources Survey and Site Testing on Fort Bragg's Sicily Drop Zone, Hoke County, North Carolina: Management Summary*. Gulf Engineers & Consultants, Inc., Baton Rouge, and Southeastern Archaeological Services, Inc., Athens. Submitted to the U.S. Army Corps of Engineers, Savannah, Georgia.

Braley, C. and J. Schuldenrein
1993 *An Intensive Cultural Resources Survey and Site Testing on Fort Bragg's Sicily Drop Zone, Hoke County, North Carolina*. Gulf Engineers & Consultants, Inc., Baton Rouge, and Southeastern Archaeological Services, Inc., Athens. Submitted to the U.S. Army Corps of Engineers, Savannah, Georgia, Contract No. DACW21-89-D-0016.

Buol, S. W.
2003 Formation of Soils in North Carolina. In *Papers Commemorating a Century of Soil Science*, pp. 31–56. Soil Science Society of North Carolina. Electronic document, http://agronomy.agr.state.nc.us/sssnc/papers.htm, accessed January 22, 2007.

Butler, J. R.
1991 Metamorphism. In *The Geology of the Carolinas*, edited by J. W. Horton and V. A. Zullo, pp. 127–141. University of Tennessee Press, Knoxville.

Butler, J. R., and D. T. Secor, Jr.
1991 The Central Piedmont. In *The Geology of the Carolinas*, edited by J. W. Horton and V. A. Zullo, pp. 59–78. University of Tennessee Press, Knoxville.

Cable, J. S., and C. E. Cantley
2005 *Phase II Archaeological Testing and Evaluations of Thirteen Sites, Fort Bragg, NC*. Palmetto Research Institute. Submitted to the National Park Service and Fort Bragg, North Carolina.

Chayes, F.
1956 *Petrographic Modal Analysis*. John Wiley & Sons, New York.

Claggett, S. R., and J. S. Cable, assemblers
1982 *The Haw River Sites: Archeological Investigations at Two Stratified Sites in the North Carolina Piedmont*. Commonwealth Associates, Inc. Submitted to the U. S. Army Corps of Engineers, Wilmington, North Carolina, Contract No. DACW54-79-C-0052.

Clement, C. O., S. D. Smith, R. M. Grunden, and J. S. Quattlebaum
1997 *Archaeological Survey of 4,000 Acres on the Lower Little River, Cumberland, Hoke, and Moore Counties, Fort Bragg, North Carolina*. South Carolina Institute of Archaeology

and Anthropology, Columbia. Submitted to the National Park Service, Tallahassee, Florida, Cooperative Agreement No. CA-500-3-9010 and Subagreement No. CA-500-4-9003-4.

Coe, J. L.
1964 *The Formative Cultures of the Carolina Piedmont*. Transactions of the American Philosophical Society, Vol. 54, Pt. 5. The American Philosophical Society, Philadelphia.

Culpepper, W., C. L. Heath, J. D. Irwin, and J. M. Herbert
2000 *From Drowning Creek to Sicily: Archaeological Investigations at Fort Bragg, North Carolina*. Research Report Series No. 2. Fort Bragg Cultural Resources Program. Submitted to the North Carolina State Historic Preservation Office, Raleigh.

Cuomo di Caprio, N., and S. Vaughan
1993 An Experimental Study in Distinguishing Grog (Chamotte) from Argillaceous Inclusions in Ceramic Thin Sections. *Archeomaterials* 7:21–40.

Feiss, P. G., A. H. Maybin, III, S. R. Riggs, and A. E. Grosz
1991 Mineral Resources of the Carolinas. In *The Geology of the Carolinas*, edited by J. W. Horton and V. A. Zullo, pp. 319–345. University of Tennessee Press, Knoxville.

Fitzpatrick, S. M., H. Takamiya, H. Neff, and W. R. Dickinson
2006 Compositional Analysis of Yayoi-Heian Period Ceramics From Okinawa: Examining the Potential for Provenance Study. *Geoarchaeology* 21:803–822.

Flohr, M. J. K.
1997 X-Ray Powder Diffraction. USGS Information Handout. Electronic document, http://pubs.usgs.gov/info/diffraction/html/index.html, accessed June 28, 2007.

Fowles, S. M., L. Minc, S. Duwe, and D. V. Hill
2007 Clay, Conflict, and Village Aggregation: Compositional Analyses of Pre-Classic Pottery from Taos, New Mexico. *American Antiquity* 72:125-152.

Glascock, M. D.
1992 Characterization of Archaeological Ceramics at MURR by Neutron Activation Analysis and Multivariate Statistics. In *Chemical Characterization of Ceramic Pastes in Archaeology*, edited by H. Neff, pp. 11–26. Prehistory Press, Madison, Wisconsin.

Goffer, Z.
1980 *Archaeological Chemistry: A Sourcebook on the Applications of Chemistry to Archaeology*. Chemical Analysis: A Series of Monographs on Analytical Chemistry and its Applications 55. John Wiley & Sons, New York.

Gray, J. and C. H. McNutt, Jr.
2004 *Phase I Intensive Archaeological Survey of 1457.5 Hectares (3600 Acres) NTA 2, NTA 3, RR, and NCA Study Areas, Fort Bragg Military Reservation, Cumberland and Harnett Counties, North Carolina*. Panamerican Consultants, Inc., Memphis. Submitted to the U.S.

Army Corps of Engineers ERDC/CERL, Champaign, Illinois, Contract No. DACA42-00-D-0009.

2005 *Phase I Intensive Archaeological Survey of 1527.7 Hectares (3775 Acres), L1, N2, M1, Q2, P2, and II2 Study Areas, Fort Bragg Military Reservation, Cumberland and Hoke Counties, North Carolina*. Panamerican Consultants, Inc., Memphis. Submitted to the U.S. Army Corps of Engineers ERDC/CERL, Champaign, Illinois, Contract No. DACA42-02-D-0011.

Grunden, R. and D. Ruggiero
2007 *Phase I Archaeological Reconnaissance of 4882 Acres (1976 Hectares) at Fort Bragg and Camp Mackall, Cumberland, Hoke, and Richmond Counties, North Carolina*. TRC Garrow Associates, Inc., Chapel Hill. Submitted to National Park Service, Atlanta Federal Center, Contract No. C500031248.

Harbottle, G.
1976 Activation Analysis in Archaeology. *Radiochemistry* 3:33–72.

Herbert, J. M.
2003 Woodland Ceramics and Social Boundaries of Coastal North Carolina. Unpublished Ph.D. dissertation, Department of Anthropology, University of North Carolina, Chapel Hill.

2001 Ceramic Taphonomy, Prehistoric Technology and Site Formation Processes in the Carolina Sandhills. *South Carolina Antiquities* 33(1–2):39–57.

Herbert, J. M., J. K. Feathers, and A. S. Cordell
2002 Building Ceramic Chronologies with Thermoluminescence Dating: A Case Study from the Carolina Sandhills. *Southeastern Archaeology* 21:92–108.

Heron, S. D., Jr.
1960 Clay Minerals of the Outcropping Basal Cretaceous Beds Between the Cape Fear River, North Carolina, and Lynches River, South Carolina. In *Clays and Clay Minerals: Proceedings of the Seventh National Conference on Clays and Clay Minerals*, pp. 148–161. Committee on Clay Minerals of the National Academy of Sciences—National Research Council and the Rice Institute. Pergamon Press, New York.

Hurst, V. J., P. A. Schroeder, and R. W. Styron
1997 Accurate Quantification of Quartz and Other Phases by Powder X-ray Diffractometry. *Analytica Chimica Acta* 337:233–252.

Idol, B. S.
1999 *Revised Draft Report, Fort Bragg Delivery Order One: Phase I Archaeological Survey of 2,774 Acres (1,123 Hectares), Fort Bragg, Cumberland and Hoke Counties, North Carolina*. TRC Garrow Associates, Inc., Chapel Hill. Submitted to National Park Service, Atlanta Federal Center, Contract No. 144CX509097025.

Idol, B. S., and M. S. Becker
2001 *Final Report: Phase I Archeological Reconnaissance of 2,945 Acres (1,193 Hectares) in the Flat Creek Drainage, Fort Bragg, Hoke County, North Carolina*. TRC Garrow Associates, Inc., Durham. Submitted to the U.S. Army Construction Engineering Research Laboratory, Champaign, Illinois, Contract No. DACA88-97-D-0020.

Irwin, J. D., W. C. J. Boyko, J. M. Herbert, and C. Braley
1999 Woodland Burial Mounds in the North Carolina Sandhills and Southern Coastal Plain. *North Carolina Archaeology* 48:59-86.

Kahle, M., M. Kleber, and R. Jahn
2002 Review of XRD-based Quantitative Analyses of Clay Minerals in Soils: The Suitability of Mineral Intensity Factors. *Geoderma* 109:191–205.

Kelly, R. L.
1995 *The Foraging Spectrum: Diversity in Hunter-Gatherer Lifeways*. Smithsonian Institution Press, Washington, D.C.

King, A.
1992a *Cultural Resources Survey of a Land Exchange Tract, Fort Bragg, North Carolina*. Gulf Engineers & Consultants, Inc., Baton Rouge, and Southeastern Archaeological Services, Inc., Athens. Submitted to the U.S. Army Corps of Engineers, Savannah, Georgia, Contract No. DACE21-89-D-0016.

1992b *Cultural Resources Survey of the Whitehurst Tract Moore County, North Carolina: Management Summary*. Gulf Engineers & Consultants, Inc., Baton Rouge, and Southeastern Archaeological Services, Inc., Athens. Submitted to the U.S. Army Corps of Engineers, Savannah, Georgia, Contract No. DACW21-89-D-0016.

Klein, C., and Hurlbut, C. S., Jr.
1993 *Manual of Mineralogy*. 21st ed. John Wiley & Sons, New York.

Klein, M., F. Jesse, H. U. Kasper, and A. Gölden
2004 Chemical Characterization of Ancient Pottery from Sudan by X-ray Fluorescence Spectrometry (XRF), Electron Microprobe Analyses (EMPA) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS). *Archaeometry* 46:339–356.

Lane, E.
1999 Chemical and Mineralogical Characterization of Middle Woodland Ceramics from the Jenkins Neck Site in Gloucester County, Virginia. *Quarterly Bulletin of the Archaeological Society of Virginia* 54(1):65–80.

Leese, M. N., and P. L. Main
1994 The Efficient Computation of Unbiased Mahalanobis Distances and their Interpretation in Archaeometry. *Archaeometry* 36:307–316.

Loftfield, T. C.
1979 *Cultural Resource Reconnaissance of Fort Bragg, Camp Mackall, and Simmons Army Airfield, North Carolina.* Coastal Zone Resources Division Ocean Data Systems, Inc., Wilmington. Submitted to the U.S. Army Corps of Engineers, Savannah, Georgia, Contract No. DACA21-77-0139.

MacCord, H. A., Jr.
1966 The McLean Mound, Cumberland County, North Carolina. *Southern Indian Studies* 18:3–45.

McCormick, O. F.
1970 Archaeological Resources of the New Hope Reservoir Area, North Carolina. Unpublished Master's thesis, Department of Anthropology, University of North Carolina, Chapel Hill.

Matson, F. R. (editor)
1965 *Ceramics and Man*. Aldine Publishing Company, Chicago.

Neff, H.
1992 Introduction. In *Chemical Characterization of Ceramic Pastes in Archaeology*, edited by H. Neff, pp. 1–10. Prehistory Press, Madison, Wisconsin.

1994 RQ-Mode Principal Components Analysis of Ceramic Compositional Data. *Archaeometry* 36:115–130.

2000 Neutron Activation Analysis for Provenance Determination in Archaeology. In *Modern Analytical Methods in Art and Archaeology*, edited by E. Ciliberto and G. Spoto, pp. 81–134. John Wiley & Sons, New York.

2001 Quantitative Techniques for Analyzing Ceramic Compositional Data. In *Ceramic Production and Circulation in the Greater Southwest: Source Determination by INAA and Complementary Mineralogical Investigations*, edited by D. M. Glowacki and H. Neff, pp. 15–36. Monograph 44. Cotsen Institute of Archaeology, Los Angeles.

Neiheisel, J., and C. E. Weaver
1967 Transport and Deposition of Clay Minerals, Southeastern United States. *Journal of Sedimentary Petrology* 37:1084–1116.

North Carolina Geological Survey
1985 *Geologic Map of North Carolina*. Thematic map, 1:500,000. Department of Natural Resources and Community Development, Division of Land Resources, Raleigh.

1998a Geology - NC. Electronic thematic map, 1:250,000. Department of Environment, Health, and Natural Resources, Division of Land Resources, North Carolina Geological Survey, Raleigh.

1998b Geology, Dikes - NC. Electronic thematic map, 1:250,000. Department of Environment, Health, and Natural Resources, Division of Land Resources, North Carolina Geological Survey, Raleigh.

Noss, R. F.
1989 Longleaf Pine and Wiregrass: Keystone Components of an Endangered Ecosystem. *Natural Areas Journal* 9(4): 211-213.

Olive, W. W., A. F. Chleborad, C. W. Frahme, J. Shlocker, R. R. Schneider, and R. L. Schuster
1989 Swelling Clays Map of the Coterminous United States. Thematic map, 1:7,500,000. Miscellaneous Investigations Series Map I-1940. U. S. Geological Survey, Reston, Virginia.

Olsen, P. E., A. J. Froelich, D. L. Daniels, J. P. Smoot, and P. J. W. Gore
1991 Rift Basins of Early Mesozoic Age. In *The Geology of the Carolinas*, edited by J. W. Horton and V. A. Zullo, pp. 142–170. University of Tennessee Press, Knoxville.

Phillips, S. C., and M. Morgenstein
2002 A Plains Ceramic Clay Source Characterization by Comparative Geochemical and Petrographic Analyses: Results from the Calhan Paint Mines, Colorado, U.S.A. *Geoarchaeology* 17:579–599.

Porat, N., J. Yellin, and L. Heller-Kallai
1991 Correlation Between Petrography, NAA, and ICP Analyses: Application to Early Bronze Egyptian Pottery from Canaan. *Geoarchaeology* 6:133–149.

Prowell, D. C., R. A. Christopher, K. E. Waters, and S. K. Nix
2003 The Chrono- and Lithostratigraphic Significance of the Type Section of the Middendorf Formation, Chesterfield County, South Carolina. *Southeastern Geology* 42:47–66.

Ragland, P. C.
1991 Mesozoic Igneous Rocks. In *The Geology of the Carolinas*, edited by J. W. Horton and V. A. Zullo, pp. 171–190. University of Tennessee Press, Knoxville.

Reves, W. D.
1956 The Clay Minerals of the North Carolina Coastal Plain. Unpublished Master's thesis, Department of Geology and Geography, University of North Carolina, Chapel Hill.

Rice, P. M.
1987 *Pottery Analysis: A Sourcebook*. University of Chicago Press, Chicago.

Ries, H.
1897 *Clay Deposits and Clay Industry in North Carolina*. Bulletin No. 13, North Carolina Geological Survey, Raleigh.

1927 *Clays: Their Occurrence, Properties, and Uses, with Especial Reference to Those of the*

United States and Canada. John Wiley & Sons, New York.

Rieth, C. B.
2002 Trace Element Analysis and Its Role in Analyzing Ceramics in the Eastern Woodlands. In *Archaeological Chemistry: Materials, Methods, and Meaning*, edited by K. A. Jakes, pp. 199–213. ACS Symposium Series. American Chemical Society, Washington, D.C.

Rogers, J. J. W.
1999 History and Environment of North Carolina's Piedmont: Evolution of a Value-Added Society. Electronic document, www.geosci.unc.edu/faculty/rogers/piedmont_hist_env.pdf, accessed January 22, 2007.

2006 The Carolina Slate Belt. In *Stone Quarries and Sourcing in the Carolina Slate Belt*, edited by V. P. Steponaitis, J. D. Irwin, T. E. McReynolds, and C. R. Moore, pp. 10–15. Research Report 25. Research Laboratories of Archaeology, University of North Carolina, Chapel Hill.

Ruggiero, D.
2003 *Phase I Archaeological Reconnaissance of 4109 Acres (1659 Hectares) at Fort Bragg and Camp Mackall, Cumberland, Hoke, and Richmond Counties, North Carolina*. TRC Garrow Associates, Inc., Chapel Hill. Submitted to the U.S. Army Construction Engineering Research Laboratory, Champaign, Illinois, Contract No. DACA42-00-D-0010, Delivery Order 0001.

2004 *Phase I Archaeological Reconnaissance of 3248 Acres (1314 Hectares) in the James Creek and Lower Little River Drainages, Fort Bragg, Hoke County, North Carolina*. TRC Garrow Associates, Inc., Chapel Hill. Submitted to the U.S. Army Construction Engineering Research Laboratory, Champaign, Illinois, Contract No. DACA42-00-D-0010, Delivery Order 0003.

Ruggiero, D., and R. Grunden
2004 *Phase I Archaeological Reconnaissance of 8542 Acres (3456 Hectares) at Fort Bragg, Hoke County, North Carolina*. TRC Garrow Associates, Inc., Chapel Hill. Submitted to the National Park Service, Atlanta, Contract No. 1443CX509097025.

Russo, M. J., B. A. Sorrie, B. van Eerden, and T. E. Hippensteel
1993 *Rare and Endangered Plant Survey and Natural Area Inventory for Fort Bragg and Camp Mackall Military Reservations, North Carolina*. The Nature Conservancy, North Carolina Chapter, Carrboro, and the Natural Resources Heritage Program, Division of Parks and Recreation, Department of Environment, Health, and Natural Resources, Raleigh. Submitted to the Directorate of Public Works, Endangered Species Program, Fort Bragg, Contract No. M61004-91-D-0010.

Rye, O. S.
1981 *Pottery Technology: Principles and Reconstruction*. Taraxacum, Washington, D.C.

Sayre, E. V.
1975 *Brookhaven Procedures for Statistical Analyses of Multivariate Archaeometric Data*. Brookhaven National Laboratory Report BNL-23128. Upton, New York.

Schafale, M. P., and A. S. Weakley
1990 *Classification of the Natural Communities of North Carolina, Third Approximation*. North Carolina Natural Heritage Program, Division of Parks and Recreation, Department of Environment, Health, and Natural Resources, Raleigh. Submitted to the Directorate of Public Works, Endangered Species Program, Fort Bragg.

Schroeder, P. A., J. G. Kim, and N. D. Melear
1997 Mineralogical and Textural Criteria for Recognizing Remnant Cenozoic Deposits on the Piedmont: Evidence from Sparta and Greene County, Georgia, U.S.A. *Sedimentary Geology* 108:195–206.

Schroeder, P. A., and L. West
2005 Weathering Profiles Developed on Granitic and Mafic Terrains in the Area of Elberton, Georgia. In *Geologic Investigations of Elberton Granite and Surrounding Rocks*, edited by M. F. Roden, P. A. Schroeder, and S. E. Swanson, pp. 55–80. Georgia Geological Society Guidebook, Vol. 25. The Georgia Geological Society, Atlanta.

Shepard, A. O.
1974 *Ceramics for the Archaeologist*. Publication 609. Carnegie Institution of Washington, Washington, D.C.

Siple, G. E.
1999 [1957] *Carolina Geological Society Guidebook for the South Carolina Coastal Plain Field Trip, November 16–17, 1957*. U.S. Geological Survey Open-File Report. Electronic document, http://carolinageologicalsociety.org/gb%201957.pdf, accessed August 6, 2008.

Smith, G. P.
1965 An Archaeological Survey of the New Hope Valley. Unpublished Master's thesis, Department of Anthropology, University of North Carolina, Chapel Hill.

Sohl, M. F., and J. P. Owens
1991 Cretaceous Stratigraphy of the Carolina Coastal Plain. In *The Geology of the Carolinas*, edited by J. W. Horton and V. A. Zullo, pp. 191–220. University of Tennessee Press, Knoxville.

Sorrie, B. A., J. B. Gray, and P. J. Crutchfield
2006 The Vascular Flora of the Longleaf Pine Ecosystem of Fort Bragg and Weymouth Woods, North Carolina. *Castanea* 71(2): 127–159.

South Carolina Geological Survey
2005 General Geologic Map Data. Electronic thematic map. South Carolina Department of

Natural Resources, Columbia. Electronic document, \\scdnradmin\data\gisdata\scdata\geology\ggms_poly.shp, accessed January 23, 2007.

Stanjek, H., and W. Häusler
2004 Basics of X-ray Diffraction. *Hyperfine Interactions* 154:107–119.

Steen, Carl
2008 Archaeology on the Great Pee Dee River: The Johannes Kolb Site. Manuscript on file, Diachronic Research Foundation, Columbia, SC. Electronic document, http://38da75.com/professional.htm, accessed July 7, 2008.

Steponaitis, V., M. J. Blackman, and H. Neff
1996 Large-Scale Compositional Patterns in the Chemical Composition of Mississippian Pottery. *American Antiquity* 61:555–572.

Steponaitis, V. P., J. D. Irwin, T. E. McReynolds, and C. R. Moore (editors)
2006 *Stone Quarries and Sourcing in the Carolina Slate Belt*. Research Report 25. Research Laboratories of Archaeology, University of North Carolina, Chapel Hill.

Stoddard, E. F.
2006 Petrography. In *Stone Quarries and Sourcing in the Carolina Slate Belt*, edited by V. P. Steponaitis, J. D. Irwin, T. E. McReynolds, and C. R. Moore, pp. 42–75. Research Report 25. Research Laboratories of Archaeology, University of North Carolina, Chapel Hill.

Stoltman, J. B.
1989 A Quantitative Approach to the Petrographic Analysis of Ceramic Thin Sections. *American Antiquity* 54:147–160.

Stoltman, J. B., J. H. Burton, and J. Haas
1992 Chemical and Petrographic Characterizations of Ceramic Pastes: Two Perspectives on a Single Data Set. In *Chemical Characterization of Ceramic Pastes in Archaeology*, edited by H. Neff, pp. 85–92. Monographs in World Archaeology No. 7. Prehistory Press, Madison, Wisconsin.

Stoltman, J. B., and R. C. Mainfort
2002 Minerals and Elements: Using Petrography to Reconsider the Findings of Neutron Activation in the Compositional Analysis of Ceramics from Pinson Mounds, Tennessee. *Midcontinental Journal of Archaeology* 27(1):1–33.

Stuiver, M., and T. F. Braziunas
1993 Modeling atmospheric ^{14}C Influences and ^{14}C Ages of Marine Samples to 10,000 BC. *Radiocarbon* 35:137–189.

Stuiver, M., and P. J. Reimer
1993 Extended ^{14}C Database and Revised CALIB Radiocarbon Calibration Program. *Radiocarbon* 35:215–230.

Trinkley, M., N. Adams, and D. Hacker
1996 *An Archaeological Survey of the 557.5 Ha Sicily Drop Zone Fort Bragg, Hoke County, North Carolina*. Chicora Research Foundation, Inc., Columbia, South Carolina. Chicora Research Contribution 182. Submitted to the National Park Service, Atlanta, Contract No. 1443CX500095043.

Trinkley, M., W. B. Barr, and D. Hacker
1996a *An Archaeological Survey of the 230 Ha Camp Mackall Drop Zone 70 Ha Manchester Road Tract Fort Bragg, Scotland and Cumberland Counties, North Carolina*. Chicora Research Foundation, Inc., Columbia, South Carolina. Chicora Research Contribution 187. Submitted to the National Park Service, Atlanta, Contract No. 1443CX500095043.

1996b *Fort Bragg 3: An Archaeological Survey of the 29.57 Ha Camp Mackall Special Forces Training Area and 776.55 Ha, Richmond, Cumberland, and Harnett Counties, North Carolina.* Chicora Research Foundation, Inc., Columbia, South Carolina. Chicora Research Contribution 193. Submitted to the National Park Service, Atlanta, Contract No. 1443CX500095043.

1997 *Fort Bragg 4: An Archaeological Survey of the 625.73 Ha Holland Drop Zone and 243.81 Ha on Fort Bragg, Cumberland and Hoke Counties, North Carolina*. Chicora Research Foundation, Inc., Columbia, South Carolina. Chicora Research Contribution 204. Report submitted to the National Park Service, Atlanta, Contract No. 1443CX500095043.

1998 *Fort Bragg 5: An Archaeological Survey of the 942.63 Ha Northern Training Area IV on Fort Bragg, Harnett County, North Carolina.* Chicora Research Foundation, Inc., Columbia, South Carolina. Chicora Research Contribution 240. Submitted to the National Park Service, Atlanta, Contract No. 1443CX500095043.

United States Department of Agriculture
1998 Hydrologic Units – North Carolina River Basins. Electronic thematic map. U.S. Department of Agriculture, Natural Resources Conservation Service, Raleigh.

United States Geological Survey
2002 U.S. Rivers and Streams. Electronic thematic map. U.S. Geological Survey in cooperation with U.S. Environmental Protection Agency, ESRI.

2004 The National Geochemical Survey — Database and Documentation. U.S. Geological Survey Open-File Report 2004-1001. U.S. Geological Survey, Reston, Virginia. Electronic document, http://tin.er.usgs.gov/geochem/, accessed January 28, 2008.

van der Plas, L., and A. C. Tobi
1965 A Chart for Judging the Reliability of Point Counting Results. *American Journal of Science* 263:87–90.

Velde, B., and I. C. Druc
2000 *Archaeological Ceramic Materials: Origin and Utilization*. Springer, Berlin.

Vitelli, K. D.
1984 Greek Neolithic Pottery by Experiment. In *Pots and Potters: Current Approaches in Ceramic Archaeology*, edited by P. M. Rice, pp. 113–131. Institute of Archaeology, University of California, Los Angeles.

Weigand, P. C., G. Harbottle, and E. V. Sayre
1977 Turquoise Sources and Source Analysis: Mesoamerica and the Southwestern U.S.A. In *Exchange Systems in Prehistory*, edited by T. K. Earle and J. E. Ericson, pp. 15–34. Academic Press, New York.

Whitbread, I. K.
1986 Characterization of Argillaceous Inclusions in Ceramic Thin Sections. *Archaeometry* 28:79–88.

1987 A Proposal for the Systematic Description of Thin Sections Towards the Study of Ancient Ceramic Technology. In *Archaeometry: Proceedings of the 25th International Symposium,* edited by Y. Maniatis, pp. 127–138. Elsevier, Amsterdam.

Wilson J. H., Jr.
1976 *Excavations within the New Hope Reservoir*. The Research Laboratories of Archaeology, University of North Carolina, Chapel Hill. Submitted to the National Park Service, Contract No. CX5000-3-1663. (Electronic copies available at: http://rla.unc.edu/Publications/Misc_reports.html).

Windom, H. L., W. J. Neal, and K. C. Beck
1971 Mineralogy of Sediments in Three Georgia Estuaries. *Journal of Sedimentary Petrology* 41:497–504.

Zug, C. G., III
1986 *Turners and Burners: The Folk Potters of North Carolina*. The University of North Carolina Press, Chapel Hill.