Woodland-Era Clay Procurement in the Carolinas:
A Chemical and Mineralogical Study of Clays and Ceramics

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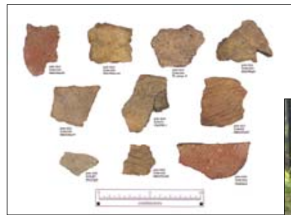
Project Overview

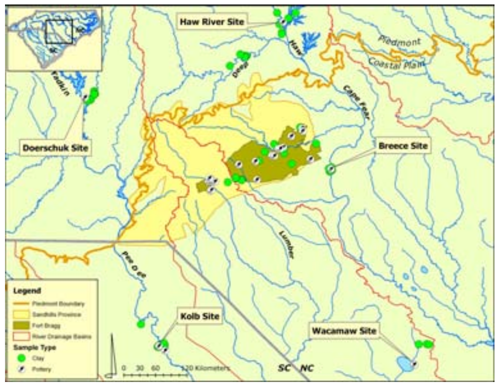


Introduction

This study compares local clay sources with pottery from sites in the Carolina Piedmont, Coastal Plain, and Sandhills to explore patterns of resource acquisition and residential mobility among people living in the Fort Bragg region of the Sandhills during the Woodland era (ca. 1500 B.C.– A.D. 1600). Neutron activation (NAA), x-ray diffraction (XRD), and petrographic analyses were conducted to characterize regional variation in the chemical and mineral constituents of clay resources and to assess the nature of correspondence between clay resources and prehistoric pottery from each region. Performance trials evaluated the usefulness of each clay sample for making pottery.

Research Questions

- Are specific clay source regions recognizable on the basis of chemical and mineralogical composition?
- If so, how do they correlate with pottery from archaeological sites?



Distribution of clay samples and the archaeological sites from which the pottery samples were drawn.

The Sample

A total of 70 classifiable pottery samples was chosen from 21 archaeological sites (Table 1). Ten pottery samples were selected from each of five key sites in the Piedmont and Coastal Plain. The sherds from each of these sites are assumed to typify the pottery and represent the clay sources from the river basins in which they occur. An additional 20 sherds were selected from sites in the Sandhills.

A total of 84 clay samples was collected (Table 1). Based on ethnographic evidence (Arnold 1985), the sampling strategy focused on clay sources adjacent to sites from which pottery samples were selected.

Table 1. Distribution of Samples

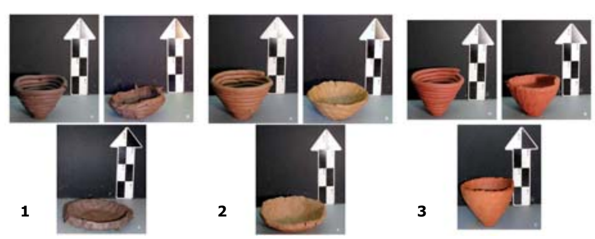
Province: River Basin	Site(s)	Sherds (n)	Clays: Collected (n)	Clays: Analyzed (n)
Piedmont:				
Haw-Cape Fear	Haw River (31Ch29)	10	31	10
Yadkin-Pee Dee	Doerschuk (31Mg22)	10	12	5
Coastal Plain:				
Haw-Cape Fear	Breece (31Cd8)	10	6	5
Lumber	Waccamaw sites	10	5	5
Yadkin-Pee Dee	Kolb (38Da75)	10	9	5
Sandhills:				
Haw-Cape Fear	Fort Bragg sites	12	21	12
Lumber	Camp Mackall sites	8	0	0
Total		**70**	**84**	**42**

The Anthropological Analog

Each clay sample was subjected to performance and replication experiments to assess its suitability for making coiled, paddle-and-anvil-built pots. The plasticity and strength of each clay sample was judged on the basis of coil, ball, and loop tests. Replication tests involved building, drying and firing coil-built vessels.

Samples were assigned to ordinal workability classes designated as lean (a), moderately lean (b), good (c), or fat. Because lean and moderately lean samples would not be appropriate analogs for modeling prehistoric pottery-making technology, only good and fat clay samples were subjected to replication experiments.

Small semi-conical pots were begun by coiling, the coils were annealed by hand, and the pots were paddled. Results reveal that even clays exhibiting good workability and no excessive cracking, warping, or shrinkage may not have the right combination of strength and plasticity for potting (1 and 2). Clays that are suitable for making pots neither slumped nor cracked during annealing and paddling (3).



Overall, Sandhills clay samples performed poorly and Coastal Plain samples from the Lumber and Pee Dee drainages performed the best (Table 2). The very best samples, however, came from the Haw River area of the Piedmont. Only one good clay sample came from the Fort Bragg area, and in fact the majority of Sandhills clays lack the plasticity necessary for building pots.

Table 2. Plasticity of Clay Samples

Province: River Basin	Lean (n)	Mod Lean (n)	Good (n)	Fat (n)
Piedmont:				
Haw-Cape Fear	2	22	6	1
Yadkin-Pee Dee	3	9	0	0
Coastal Plain:				
Haw-Cape Fear	0	3	3	0
Lumber	0	0	5	0
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ODLAND-ERA CLAY PROCUREMENT IN THE CAROLI
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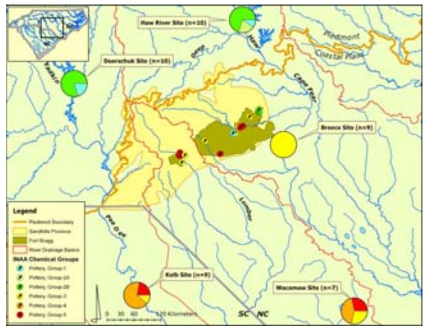
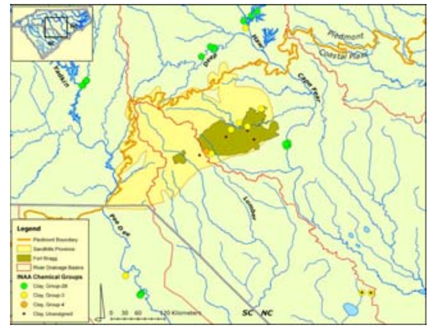
Clay and Ceramic Chemistry through Neutron Activation Analysis

Neutron activation analysis (NAA) was employed to identify chemical differences between ceramic samples and clay resource areas. These data were explored through standard procedures to assess the similarity and dissimilarity among the regions sampled (Bieber et al. 1976; Bishop and Neff 1989; Harbottle 1976; Neff 1992; Sayre 1975; Speakman and Glasscock 2006).

NAA provided elemental concentration values for 30 detectable elements in the ceramic and clay samples. Principal components analysis (PCA) of the dataset indicates that there are six recognizable compositional groups, separation of which is largely based on calcium (Ca), sodium (Na), and, to a lesser extent, manganese (Mn) concentrations. When the number of elements considered is reduced from 30 to 10, these groups are more clearly differentiated. Fifty-five of the 70 pottery specimens and 36 of the 42 clay samples can be assigned to one of these six groups.



Pottery samples assigned to chemical groups based on Mahalanobis distance and posterior classification derived from PC01-PC04 using the abbreviated element list.



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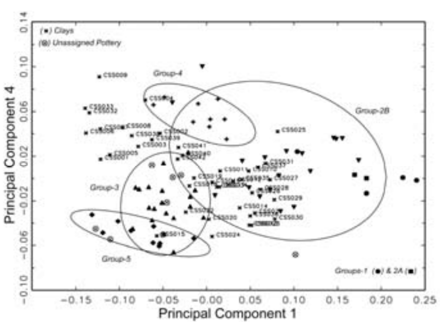

Plot of principal components 1 and 4 derived from PCA of the pottery and clay samples. Ellipses are drawn at the 90% confidence interval. (From Speakman and Glascock 2006.)

Pottery

Samples from the Piedmont fall primarily into Chemical Group 2B, characterized by relatively high Ca and Mn concentrations and low Na concentrations. Mineralogical analyses reveal that the source of the Ca in these samples is igneous rock inclusions, some of which may have been added as tempering material.

Coastal Plain sherds are chemically distinct in comparison to Piedmont sherds. The Breece samples from the middle Cape Fear drainage are homogeneous: all assigned specimens belong to Group 3, which exhibits intermediate concentrations of Ca, Na, and Mn. This homogeneity suggests a specific local clay source in the vicinity of the site. In contrast, samples from the Kolb and Waccamaw sites tend to fall into Groups 4 and 5. Group 4 is characterized by high Ca and intermediate Na and Mn, while Group 5 exhibits low Ca and Mn and intermediate Na concentrations.

Significantly, the Sandhills samples are the most chemically heterogeneous. Fort Bragg sherds fall into Groups 1, 2B, 3, and 5. The presence of four distinct chemical groups in the Sandhills indicates that potters in this region utilized clays from multiple source locations.

Clay

Piedmont clays tend to fall in Group 2B, as do Coastal Plain clays collected along the Pee Dee and Cape Fear Rivers. In contrast, clays collected elsewhere in the Coastal Plain and in the Sandhills belong to Group 3.

With the exceptions of a single Chemical Group 4 clay in the Sandhills and an anomalous Group 3 clay found on the Haw River, these results make sense from a geological standpoint. Group 2B represents Piedmont clay sources and secondary alluvial clays redeposited on Coastal Plain rivers that originated in the Piedmont. Group 3 represents Sandhills and Coastal Plain clays.

Yet these results are somewhat surprising from an archaeological perspective. The chemical similarities between Piedmont sherds and clays indicate local origins for pottery found at the Doerschuk and Haw River sites. Yet whereas the chemical homogeneity of the Breece pottery also suggests a single, local clay source that would be expected to classify as Group 3, clays collected from the middle Cape Fear basin all assign to group 2B. Similarly, the majority of sherds from the Kolb site classify as Group 4, while most clays from the same area belong to Group 2B.

Clay Mineralogy through X-ray Diffraction

To further distinguish clay resource areas, x-ray diffraction (XRD) was employed to identify the relative abundance of ten crystalline minerals in the clay samples. The generated ordinal data were mapped to facilitate identification of geographic patterning.

With only a few exceptions, the distribution of plagioclase and K-feldspar tends to mirror the distribution of Chemical Group 2B clays found in the Piedmont and along Coastal Plain rivers originating in the Piedmont. Amphibole is also restricted to the Piedmont, but occurs primarily in the Yadkin drainage. Occurrences of gibbsite and lepidocrocite are limited to the Sandhills and Coastal Plain, although they appear in both Chemical Group 2B and Chemical Group 3 clays in these areas. If these preliminary patterns are substantiated through additional analyses, these five minerals may prove useful in identifying broad geographic resource-procurement regions.

Quartz and clay minerals (chlorite, illite, kaolin, and smectite) occur almost everywhere and were consequently eliminated from further consideration at this stage in the study. It is anticipated that further study will yield interval-level data for these minerals. At present, it appears that the only clay samples with abundant kaolin are in the western portion of Fort Bragg.

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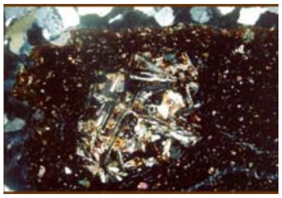
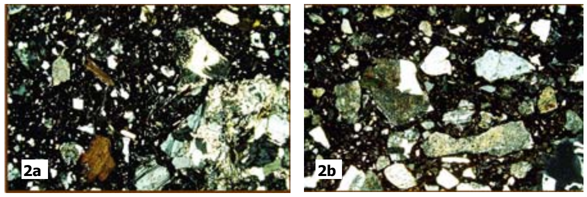
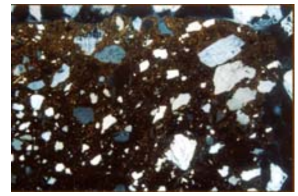
Clay and Ceramic Mineralogy through Petrography



Mineral Group 1 samples include a mineral suite composed primarily of pyroxene and plagioclase derived from mafic igneous rock.



Mineral Group 2 samples incorporate quartz, feldspar, biotite, muscovite, amphibole, opaque minerals, and igneous rock fragments. This group is divided into subgroups (2a and 2b) according to the mafic (amphibole, muscovite, and biotite) and opaque mineral content of the igneous rock fragments.

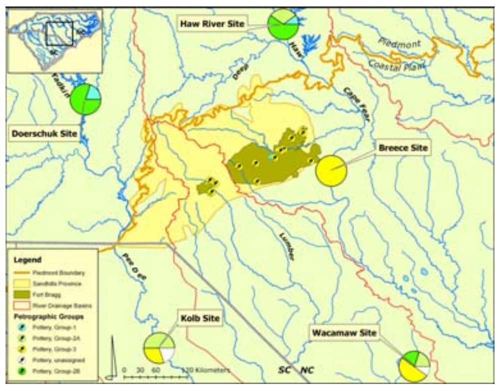


Mineral Group 3 samples contain muscovite, monocrystalline quartz, polygranular quartz rock fragments, and, in about half of the specimens, grog.

Clay

To identify additional diagnostic mineralogical differences between the clay resource regions, fired test tiles made from the 42 clay samples are being analyzed according to standard petrographic procedures.

Disappointingly, final data is not yet available for all of the clay samples. A few distinctive samples have already been identified, however. In particular, clays found near the Kolb site in the Pee Dee basin consist of very fine-grained quartz and muscovite aplastic material that is unique for its small size and limited compositional variation. Kolb clays can be distinguished from other fine-grained aplastic clays from the Deep River basin in the Piedmont as well as from all coarser-grained aplastic clays. As petrographic analyses proceed, more distinctions between clay regions may become apparent.



Distribution of pottery samples by mineral group.

Table 3. Contingency Table of Mineralogical and Chemical Groups

	Chemical Group						
Mineral Group	1 (n)	2a (n)	2b (n)	4 (n)	3 (n)	5 (n)	unx (n)
1	4						
2a		2	1	5	2		
2b			14	1	2		3
3			3	3	14	8	5
unx						2	1

Pottery

Once the mineralogical distinctions between clay regions are fully understood, we will look for correlations between specific clay and pottery samples. Accordingly, thin sections from the 70 pottery samples were also submitted for petrographic analyses. These analyses indicate that the sherds can be classified according to three distinct mineral groups (Smith 2003), the distribution of which resembles the basic patterning suggested by NAA and XRD.

Piedmont sherds cluster in Mineral Groups 1, 2a, and 2b. These groups are characterized by Ca-rich minerals such as clinopyroxene (augite), plagioclase (labradorite), and amphibole and generally correspond to Ca-rich Chemical Groups 1, 2a, 2b, and 4 (Table 3). In contrast, Breece and Sandhills sherds belong to quartz-rich Mineral Group 3, which corresponds to Ca-poor Chemical Groups 3 and 5. The Kolb and Waccamaw sherds show greater mineralogical variation, with some Ca-rich samples resembling Piedmont sherds and other samples resembling Ca-poor Coastal Plain specimens.

Conclusions

Chemical and mineralogical similarities between sherds and clays from the same area presumably reflect exploitation of local clay sources. Based on the convergent results of NAA, XRD, and petrographic analyses, we conclude that potters at the Haw River and Doerschuk sites used locally available Piedmont clays. The chemical and mineralogical homogeneity of the Breece sherds also suggests a local clay source in the vicinity of the site, but the chemical distinction between the sherds and local clays is unexpected, especially given that Breece sherds are grog-tempered. We hope that petrographic analyses of clay test tiles will shed some light on this puzzle.

The presence of several distinct chemical and mineral groups among the Sandhills, Kolb, and Waccamaw sherds suggests that potters in these regions utilized clays from multiple locations. Additional study may help determine whether potters used several different clays from the same general region or exploited clays in more than one region. Our own efforts to find workable clays suggest that good clays are especially difficult to find in the Sandhills, and we therefore consider it likely that at least some of the variability among Sandhills sherds reflects the use of exotic clay sources. The available mineralogical evidence suggests that Coastal Plain clays may be better represented among the Sandhills sherds than Piedmont clays, although the chemical data indicate that pottery may have been imported from both Coastal Plain and Piedmont sources.

Identifying the source locations of clays used to manufacture prehistoric pots and subsequent movement of those pots to other locations provides a means of understanding group mobility and social interaction. Our results indicate that pottery may have circulated over broad regions, suggesting high levels of residential mobility and implying that the acquisition of clay from distant sources was a critical feature of Woodland-era subsistence in the Sandhills.

Acknowledgments

Robert J. Speakman and Michael D. Glascock performed the NAA analyses at the Archaeometry Laboratory of the Missouri University Research Reactor. XRD analyses were carried out by Paul Schroeder and Sheldon Skaggs at the Department of Geology at the University of Georgia. Michael Smith of the Department of Earth Sciences at UNC-Wilmington conducted the petrographic analyses.

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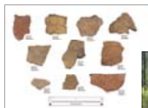

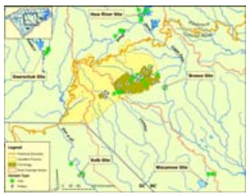

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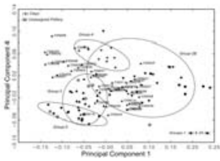
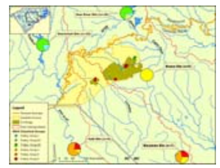


Plot of principal components 1 and 4 derived from PCA of the pottery and clay samples. Ellipses are drawn at the 90% confidence interval. (From Speakman and Glascock 2006.)



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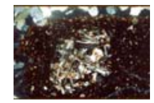
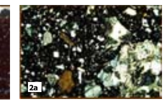
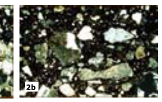
Clay and Ceramic Mineralogy through Petrography

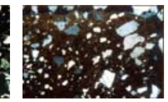


Mineral Group 1 samples include a mineral suite composed primarily of pyroxene and plagioclase derived from mafic igneous rock.





Mineral Group 2 samples incorporate quartz, feldspar, biotite, muscovite, amphibole, opaque minerals, and igneous rock fragments. This group is divided into subgroups (2a and 2b) according to the mafic (amphibole, muscovite, and biotite) and opaque mineral content of the igneous rock fragments.



Mineral Group 3 samples contain muscovite, monocrystalline quartz, polygranular quartz rock fragments, and, in about half of the specimens, grog.

Clay

To identify additional diagnostic mineralogical differences between the clay resource regions, fired test tiles made from the 42 clay samples are being analyzed according to standard petrographic procedures.

Disappointingly, final data is not yet available for all of the clay samples. A few distinctive samples have already been identified, however. In particular, clays found near the Kolb site in the Pee Dee basin consist of very fine-grained quartz and muscovite aplastic material that is unique for its small size and limited compositional variation. Kolb clays can be distinguished from other fine-grained aplastic clays from the Deep River basin in the Piedmont as well as from all coarser-grained aplastic clays. As petrographic analyses proceed, more distinctions between clay regions may become apparent.

Distribution of pottery samples by mineral group.

Table 3. Contingency Table of Mineralogical and Chemical Groups

Mineral Group	Chemical Group 1 (n)	2a (n)	2b (n)	4 (n)	3 (n)	5 (n)	unx (n)
1	4						
2a		2	1	5	2		
2b			14	1	2		3
3			3	3	14	8	5
unx						2	1

Pottery

Once the mineralogical distinctions between clay regions are fully understood, we will look for correlations between specific clay and pottery samples. Accordingly, thin sections from the 70 pottery samples were also submitted for petrographic analyses. These analyses indicate that the sherds can be classified according to three distinct mineral groups (Smith 2003), the distribution of which resembles the basic patterning suggested by NAA and XRD.

Piedmont sherds cluster in Mineral Groups 1, 2a, and 2b. These groups are characterized by Ca-rich minerals such as clinopyroxene (augite), plagioclase (labradorite), and amphibole and generally correspond to Ca-rich Chemical Groups 1, 2a, 2b, and 4 (Table 3). In contrast, Breece and Sandhills sherds belong to quartz-rich Mineral Group 3, which corresponds to Ca-poor Chemical Groups 3 and 5. The Kolb and Waccamaw sherds show greater mineralogical variation, with some Ca-rich samples resembling Piedmont sherds and other samples resembling Ca-poor Coastal Plain specimens.

Conclusions

Chemical and mineralogical similarities between sherds and clays from the same area presumably reflect exploitation of local clay sources. Based on the convergent results of NAA, XRD, and petrographic analyses, we conclude that potters at the Haw River and Doerschuk sites used locally available Piedmont clays. The chemical and mineralogical homogeneity of the Breece sherds also suggests a local clay source in the vicinity of the site, but the chemical distinction between the sherds and local clays is unexpected, especially given that Breece sherds are grog-tempered. We hope that petrographic analyses of clay test tiles will shed some light on this puzzle.

The presence of several distinct chemical and mineral groups among the Sandhills, Kolb, and Waccamaw sherds suggests that potters in these regions utilized clays from multiple locations. Additional study may help determine whether potters used several different clays from the same general region or exploited clays in more than one region. Our own efforts to find workable clays suggest that good clays are especially difficult to find in the Sandhills, and we therefore consider it likely that at least some of the variability among Sandhills sherds reflects the use of exotic clay sources. The available mineralogical evidence suggests that Coastal Plain clays may be better represented among the Sandhills sherds than Piedmont clays, although the chemical data indicate that pottery may have been imported from both Coastal Plain and Piedmont sources.

Identifying the source locations of clays used to manufacture prehistoric pots and subsequent movement of those pots to other locations provides a means of understanding group mobility and social interaction. Our results indicate that pottery may have circulated over broad regions, suggesting high levels of residential mobility and implying that the acquisition of clay from distant sources was a critical feature of Woodland-era subsistence in the Sandhills.

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