Preliminary mineralogical and chemical study of Pre-Madisonville and Madisonville horizon Fort Ancient ceramics

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Abstract

Fort Ancient ceramics can be divided into two distinct groups referred to as Pre-Madisonville (A.D. 1000-1400) and Madisonville (A.D. 1400-1750), based on stylistic features. Ceramics from these two periods were analyzed to test the hypothesis that Pre-Madisonville peoples utilized a large number of local clay sources and that Madisonville peoples utilized a limited number of clay sources. X-ray diffraction and x-ray fluorescence analyses were conducted on 15 ceramic sherds from the Thompson, Fox Farm, and Petersburg sites. Each site is a multi-component Fort Ancient site located in the Middle Ohio River Valley.

The mineralogy of the ceramics from all three sites are indistinguishable both temporally and spatially and contain quartz, micas, and trace amounts of feldspars. Compositional variation for the ceramics was documented between the sites using multivariate statistics and bivariate plots. Ceramics from the Petersburg site appeared to be distinguishable temporally, but not spatially. Ceramics from the Thompson and Fox Farm sites are distinguishable spatially, but not temporally. Thus, it appeared that the changes in the style of ceramics between the Pre-Madisonville and Madisonville correspond to a change in clay sources at the Petersburg site, but not at the Thompson and Fox Farm sites.

Introduction

Archaeologists consider the introduction of ceramics a profound technological leap. Ceramic styles evolved following the introduction of ceramic technology. This evolution of ceramic technologies and styles gives ceramic artifacts high diagnostic value. Ceramic sherds and vessels can be easily associated with specific prehistoric cultures and/or time periods, and in some cases, with specific activities. Thus, ceramics are some of the most analytically useful artifact classes found on prehistoric sites.

Archaeologists have traditionally categorized ceramic types based on qualitative observations of temper, surface treatment, and morphology. Although the value of this kind of analysis has been recognized, identification of the mineralogy of ceramic paste has been less often used (Carr and Komorowski 1995; Isphording 1974; Kamilli and Steinberg 1985; Lizée et al 1995; Lynott et al 2000; and Steponaitis et al 1996). However, these types of studies have been conducted in areas with a limited number of clay sources. Mineralogical analyses of clays and ceramic pastes could help establish the source of clays used in the ceramic industries of certain cultures, temporal periods, or specific sites. This might shed some light on prehistoric trade, travel routes, and procurement strategies.

The manufacture of ceramics began in the Middle Ohio River Valley (MORV) (Figure 1) approximately 3000 years ago. Several different prehistoric cultures made pottery in this region, such as the Adena, Hopewell, Newtown, and Fort Ancient cultures. The most recent MORV ceramic producers were the Ft. Ancient peoples (A.D. 1000-1750). The high number of possible clay sources in the MORV (Birkeland 1999) may have contributed to the lack of sourcing studies in this region.
The Ft. Ancient culture was not static throughout its 750-year history (Henderson 1998; Pollack and Henderson 1992, 2001). Archaeologists have documented many important changes in Ft. Ancient culture after A.D. 1400. Archaeologists refer to the period of Ft. Ancient culture from A.D. 1400 to approximately 1750 as the Madisonville Horizon. The Ft. Ancient period circa A.D. 1000-1400 will be referred to as the Pre-Madisonville Period for the purposes of this study. The shift from the Pre-Madisonville period to the Madisonville horizon is marked by:

1) Changes in physical layout of villages from those that were circular with a central plaza to villages composed up of scattered house clusters;

2) An increase in village size with a corresponding decrease in the number of villages, which may reflect an aggregation of small villages;

3) Changes in burial practices from placement of bodies in low earthen mounds, around village central plazas, or the dead being buried in areas adjacent to house clusters;

4) An increase in exchange of exotic goods with other cultures outside of the MORV, as evidenced by marine shell ornaments possibly from Mississippian chiefdom societies in eastern Tennessee; and

5) A marked change in ceramics both stylistically and in vessel form diversity.

Several Pre-Madisonville sub-regional ceramic styles, such as Anderson, Fox Farm, Baum, and Jessamine, give way to the pan-regional Madisonville style (Sharp 1990; and Turnbow and Henderson 1992). Jars, which predominated during the Pre-Madisonville period, are joined by bowls, pans, and colanders during the Madisonville Horizon. Archaeologists postulate that greater interaction among and between Ft. Ancient villages (i.e., potters sharing information) may account for the pan-regional ceramic homogeneity in ceramic style and vessel form that developed after A.D. 1400.

The most obvious change in Madisonville Horizon ceramics is a thinning of the vessel walls and an appearance more refined to the modern eye. This may reflect an improvement in firing techniques. It is also possible that whereas the Pre-Madisonville people utilized local, low quality clay sources, the Madisonville people utilized a limited number of high quality clay sources. Because archaeologists have not incorporated

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Figure 1. Modified map of the Middle Ohio River Valley from Henderson, 1992. Site locations are indicated by filled triangles.
the identification of the mineralogy and chemistry of ceramic pastes and clay sources in their analyses of Ft. Ancient ceramics, they do not know whether available clays at Ft. Ancient can be distinguished from each other on a sub-regional basis or, most importantly, whether the changes identified in Ft. Ancient ceramics also extend to the kinds of clays Ft. Ancient potters used.

Did all Ft. Ancient potters after A.D. 1400 use clay from a few particular sources (which might be reflected in ceramics with uniform pastes), or did Ft. Ancient potters continue to use the same sources of clay they had used previously? The purpose of this study is to determine whether changes in the use of clay sources mirror the changes documented in Ft. Ancient ceramic technology, vessel form, and style after A.D. 1400.

Methods

Site Descriptions

The northern Kentucky three, multi-component sites chosen for this study, were Thompson (15Gp27), Fox Farm (15Ms1), and Petersburg (15Be6, Figure 1). Potsherds were chosen from these sites because they are within or adjacent to the Middle Ohio River Valley and contain vertically and/or horizontally stratified, chronometrically dated Pre-Madisonville and Madisonville components.

Thompson. Thompson is located in northwestern Greenup County, Kentucky. It lies in the floodplain on the south bank of the Ohio River. The site is situated near the western edge of the Cumberland Plateau where it borders the Knobs (Henderson, 1992). The bedrock of the Cumberland Plateau consists of Pennsylvanian and Mississippian sandstones, conglomerates, and shales alternating with high grade coal beds (Bailey and Winsor 1964).

Fox Farm. Fox Farm is located in southern Mason County, Kentucky. It lies in an upland setting approximately 2.5 km south of the North Fork of the Licking River (Turnbow 1992). It is located in the Outer Bluegrass physiographic region, which is underlain by Upper Ordovician limestones (McFarlan 1961). This site sits on a broad, gently rolling ridge top that exhibits mild karst topography (Turnbow 1992).

Petersburg. Petersburg is located in northwestern Boone County, Kentucky. It lies in the floodplain immediately adjacent to the south bank of the Ohio River in the Hills of the Bluegrass region (Henderson 1993). Boone County is underlain by Upper Ordovician limestones, shaly limestones, and shales. Streams in this area contain glacial gravels, sands, and silts (Webb and Funkhouser 1932). In addition, Petersburg is underlain by Pleistocene and Holocene alluviums (Swadley 1972).

Sample Selection and Preparation

Sample Selection. Five body sherds were obtained from each Pre-Madisonville Period and Madisonville Horizon component at each site (Table 1). All of the sherds were shell tempered and ranged in size from 4 to 6 cm² (Figure 2). Recognizing the diversity of vessel types in the Madisonville Horizon, care was taken to select sherds exhibiting definite morphological characteristics of a jar.

Potsherd Preparation. A portion of each potsherd was ground to a particle size of 5 to 10 microns using a tungsten-carbide ball mill. A portion of the powder from each potsherd was pressed into a pellet using a Spex 3624 B X-Press for x-ray fluorescence analysis. Each pellet was held at 20 tons for one minute.

Analytical Conditions

X-Ray Diffraction Analysis. The powders were then analyzed using a Seimens D-500 x-ray diffraction system with a copper x-ray tube in the Geology Department at the University of Cincinnati. The 2θ range from 2θ to 50θ with a step of 0.05θ. A count time of 1 second was used at each step. The 2θ range of 2θ to 50θ was chosen because it covered a wide range of clay and other silicate mineral compositions.

X-Ray Fluorescence. A Rigaku 3070 x-ray fluorescence spectrometer, located in the Geology Department at the University of Cincinnati, was used to analyze all of the potsherds. The samples were analyzed for SiO₂, TiO₂, Al₂O₃, Fe₂O₃ (total iron), MnO, MgO, CaO, Na₂O, K₂O, P₂O₅, Nb, Zr, Sr, Rb, th, Pb, Zn, Cu, Ni, Cr, and V. Intensity data were converted to weight percent, or parts per million (ppm), using multiple regressions applied to USGS and NIST soil and...
sedimentary rock standards and loss of ignition (LOI) data. A small portion of each ground sherd was heated to 1000 °C for one hour to determine the LOI values.

Table 2 lists the results of the XRF analysis and LOI values for each sherd.

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Results

XRD Results and Interpretation

The mineralogy of the Pre-Madisonville and Madisonville sherds from the Thompson, Fox Farm, and Petersburg sites are presented in Figures 3 through 5, respectively. These figures were used to assess the temporal variability of the mineralogy of the sherds. Each figure contains a representative XRD trace for the Pre-Madisonville and Madisonville sherds for a given site. The vertical axis represents the intensity of the x-ray signal and the horizontal axis represents the 20 range in each figure. All traces contain a strong calcite peak, because of the fresh water shell temper present in all of the sherds. There may be calcite in the sherds, which is inherent to the source clays, but I was not able to distinguish it from the shell temper. The predominant mineralogy for both the Pre-Madisonville and Madisonville sherds for all three sites is quartz, mica (probably chlorite), and trace amounts of feldspars. Thus there appear to be no temporal changes in the mineralogy of the sherds within each site.

Figure 2. Examples of fresh water shell tempered sherds from each site.
Figures 6 and 7 depict representative traces from each site. Figure 6 is an analysis of the Pre-Madisonville sherds, and Figure 7 is an analysis of the Madisonville sherds. These figures were used to assess the regional variability of the mineralogy of the sherds. The mineralogy for both the Pre-Madisonville and the Madisonville sherds from all the sites is predominantly quartz, micas (probably chlorite), and trace amounts of feldspar. Thus, it is clear that there is little to no regional variability in the mineralogy of the sherds.

Also, based on the mineralogy of the sherds, I determined an approximate temperature range for their firing. Clays, which were used to make the sherds, are typically referred to as hydrous silicates (DHZ 1992). When heated above 500 °C the hydroxyl component is driven off. This results in a collapse of the clay structure, which results in mica-like structures. If the clays are heated to approximately 900 °C or higher, the clays become vitreous and form porcelain. When the sherds in this study were analyzed there were no peaks for clays or glasses. Thus the sherds in this study were probably fired above 500 °C but below 900 °C.

**XRF Results and Interpretation**

Major, minor, and trace element data are presented in Table 2. PCA analysis was applied to assess if the temporal and regional relationships of the sherds were reflected in their chemistry. Based on their chemistry, divergence in the samples was assessed by applying a variance-covariance matrix to the data set. Fresh water shells and clays incorporate calcium (Ca) and strontium (Sr) into their structures. Concentrations of these elements can be as high or higher in shell material than in clays (Lizee et al 1995), therefore, they were excluded from this analysis. Phosphorous was also excluded because of atypically high concentrations for...
MORV clays, which suggests that it might also be a temper component rather than a clay component.

The population of sherds were best separated by chromium (Cr) and lead (Pb). First, the temporal variations for each site were evaluated. Figure 8 is the Thompson site (see Figure 1). The Pre-Madisonville and Madisonville clusters overlapped between 33 to 66%. The Pre-Madisonville cluster displayed the greatest range in both Cr (11.2 to 65.3 ppm) and Pb (14.9 to 53.5 ppm) concentrations compared to the Madisonville cluster (Cr 36.7 to 56.9 ppm and Pb 21.2 to 46.6 ppm). Figure 9 is the Fox Farm site (see Figure 1). The Pre-Madisonville and Madisonville clusters overlap strongly. The Pre-Madisonville sherds had Cr concentrations that range from 52.4 to 100.1 ppm compared to the Madisonville sherds that range from Cr 66.5 to 126.2 ppm. The Pb concentrations displayed greater variations between the two clusters. The Pre-Madisonville cluster had a limited range from 15.4 to 20.8 ppm while the Madisonville sherds displayed a larger range from 9 to 22.9 ppm. Figure 10 is the Petersburg site (see Figure 1). The Pre-Madisonville sherds had high Cr (39.1 to 73.0 ppm) and Pb (13 to 16.6 ppm) concentrations compared to the Madisonville sherds (Cr 12.4 to 48.8 ppm and Pb 10.1 to 11.9 ppm). The Pre-Madisonville and Madisonville clusters have the best separation at the Petersburg site and the greatest degree of overlap at the Thompson site.

Next, the spatial variability was evaluated (Figure 11). I observed that the Fox Farm and Petersburg sites overlapped between 40 to 60%. The Petersburg site appeared to share a common boundary with the Thompson site. I observed that the Fox Farm and Thompson sites did not overlap. Based on the small data set, I distinguished sherds from the Fox Farm and Thompson sites based on their Cr and Pb concentrations. However, I could not distinguish sherds from Fox Farm and Petersburg and probably would not be very successful in trying to distinguish Petersburg and Thompson site sherds based on their Cr and Pb concentrations.

Conclusions

We reached the following conclusions:

1) The mineralogy of the Pre-Madisonville and Madisonville ceramic pastes are indistinguishable both temporally and spatially.

2) The ceramic pastes in this study were probably fired to about 700 °C. This is based on the comparison of the XRD traces.

3) The chemical composition of the of the Pre-Madisonville and Madisonville ceramic pastes are not temporally unique for Thompson and Fox Farm but are spatially unique from each other. I could not identify them temporally on the basis of chemical composition alone.

4) The chemical composition of the Pre-Madisonville and Madisonville ceramic pastes are unique temporally for Petersburg but are not unique spatially from the Fox Farm or Thompson site. Thus one could not identify them spatially on the bases of chemical composition alone.

5) At the Fox Farm and Thompson sites the Pre-Madisonville and Madisonville Ft. Ancient peoples
appeared to have used the same clay source(s). However, at the Petersburg site it appeared that the Madisonville peoples used different clay sources than the Pre-Madisonville peoples.

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References


Figure 8. Test of temporal variability: Thompson. The filled diamonds represent Pre-Madisonville and the filled squares represent Madisonville sherds.
Figure 9. Test of temporal variability: Fox Farm. The filled diamonds represent Pre-Madisonville and the filled squares represent Madisonville sherds.

Figure 10. Test of temporal variability: Petersburg. The filled diamonds represent Pre-Madisonville and the filled squares represent Madisonville sherds.


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