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Geoarcheology of Native American Pottery from the Prehistoric Davis Site (44LA46) in Lancaster County, Virginia

Marcus M. Key, Jr., and Emily S. Gaskin

Abstract

The Davis Site (44LA46) is a multicomponent (colonial and prehistoric) site located on the Eastern Branch of the Corrotoman River in Lancaster County, Virginia. The Native American occupation has been dated with archeological evidence from the Early Archaic to historic periods. Plow zone surface collections included numerous Native American pottery sherds. The pottery wares present included Mockley, Townsend, and Potomac Creek, with Mockley ware being the most common. The goals of the study were: (1) to determine the firing temperatures of the Native American pottery; and (2) to determine if local clay was viable for manufacturing Native American pottery found at this or other Chesapeake sites. To address these questions, the raw clay was fired at various temperatures. The mineralogical composition of the raw clay, the various fired clays, and the three types of pottery were compared using X-ray diffraction. The Sedgefield Member of the Tabb Formation was a viable clay source for Native American pottery in the area. The mineral composition of the pottery indicates a firing temperature around 550 °C. This is supported by X-ray diffraction and color analysis of the fired clays.

Introduction

Geoarcheology is the application of quantitative geological analytical techniques in testing archeological hypotheses. This integration of geology and archeology typically focuses on archeometry, the field of archeology concerned with the measurement of the composition of artifacts for such purposes as determining provenance and ceramic firing temperature (Braun 1983). When analyzing the composition of ancient ceramics, it must be remembered that it can change from the time the clay is extracted to the time the ceramic is analyzed. The addition of temper, firing, use, age, burial conditions, and weathering can all affect the composition of ancient ceramics (Maggetti 1982).

Provenance studies such as this aim to determine the source of the raw materials, and not necessarily where the artifacts were manufactured. It is often difficult to assign artifactual materials to specific geographical source deposits as the potential source deposits may not all be known or may be geographically widespread. The latter is especially difficult with common minerals (e.g., quartz, feldspar, and clays). Despite these potential problems, mineralogical and elemental fingerprinting has been shown to be a useful approach for determining the provenance of artifactual raw materials (Rapp 1985). It must be remembered that comparing fired raw clay with pottery can provide circumstantial evidence but not direct proof of source (Shepard 1956). Instances where it can be proven what the very clay was that was used to make a prehistoric pottery are rare (Shepard 1956).

Ceramic firing temperatures can be retrospectively estimated from the extent of vitrification by examining macroscopic properties such as porosity (e.g., Sanders 1973), hardness (e.g., Fabre and Perinet 1973), or thermal expansion (e.g., Tite 1969). Because the thermal stability ranges of minerals are known, ceramic firing temperatures can also be determined by identifying the mineral phases present (Küpfer and Maggetti 1978; Mitchell and Hart 1989). This can be done using thin section optical microscopy, controlled refiring of the sherds themselves, and/or X-ray diffraction (XRD) (Heimann 1982; Isphording 1974; Maggetti 1982; Tite et al. 1982). In general XRD is preferred over macroscopic techniques such as porosity analysis (Maggetti 1982). XRD has long been used to determine the source of clays used in ceramic production as well as the firing temperature of ceramics (e.g., Bareis and Porter 1965; Lightfoot and Jewett 1984; Maggetti 1982; Mitchell and Hart 1989; Shepard 1971; Stimmell et al. 1982; Tankersley and Meinhart 1982; Weymouth 1973; Young and Whitmore 1957), including those from Virginia (e.g., Klein 1990; Mouer 1985).

The goals of this study on the native American pottery from the Davis Site are to (1) constrain the firing temperatures used in making the pottery; and (2) determine the provenance of the clays used to make the pottery.

The Study Site

The Virginia Department of Historic Resources site number for the Davis Site is 44LA46. The site is in the Northern Neck of Virginia in the Outer Coastal Plain physiographic province (Wentworth 1930). The Northern Neck is a 225-km-long, 32-km-wide peninsula in northern Virginia bounded by the Potomac River to the north, the Chesapeake Bay to the east, and the Rappahannock River to the south (Newton and Siudyla 1979). The Northern Neck is deeply dissected by extensive navigable estuaries that frequently penetrate the peninsula along its length. One of these estuaries is the Corrotoman River. The north shore of the Eastern Branch of the Corrotoman River is located 65 m southeast of the Davis Site.

The site is located on a relatively level bluff 9 m above the estuary. This bluff has been interpreted as being a low, flat Coastal Plain marine terrace that formed when sea level was higher than today (Mixon 1985). The elevation of the site places it on the Chowan Terrace, which is 9–14 m above sea level in this area (Elder et al. 1963; Wentworth 1930). The soil developed on the site is the Sassafras loamy fine sand (Elder et al. 1963; Markewich et al. 1987).

The most recent geologic map of the area indicates the site is on the Late Pleistocene Sedgefield Member of the Tabb Formation (Mixon et al. 1989), which is equivalent to the offshore Upper Allomember of the Hudson Canyon Alloformation (Poag and Ward 1993). These sediments consist of estuarine to marine, pebbly to bouldery, clayey sand and fine to medium, shelly sand grading upward to sandy and clayey silt (Mixon et al. 1989). This clay is kaolinite-rich (Markewich et al. 1987) and is typical of sedimentary kaolinite deposits in the Coastal Plain that were formed by the transportation and deposition of kaolinite formed elsewhere (Murray 1988; Patterson and Murray 1984).

The Sedgefield Member has been dated to 71,000 B.P. (Mixon et al. 1982) and was deposited when sea-level was higher than today. During this time, estuarine and marine sediments were deposited in the areas adjacent to the ancestral Rappahannock River in the Northern Neck (Farrell 1979). Most of the sediments of the Coastal Plain less than 17 m in elevation represent similar Late Pleistocene high stand sea level deposits (Mixon et al. 1982). After this the climate cooled, polar ice volumes increased, and global sea level dropped (Tooley 1993) to the point that the estuaries of the Chesapeake Bay became small rivers and streams flowing into the Susquehanna River (Carter 1964; Kraft 1971). The Corrotoman River is one such estuary, which is simply a drowned tributary of the Rappahannock, which is a drowned tributary of the Susquehanna (Newton and Siudyla 1979). Since 15,000 B.P., global sea level has been rising (Fairbanks 1989; Hallam 1992; Tooley 1993). Local sea-level curves for the Chesapeake area indicate an average sea level rise of 1.3 mm/year for the last several thousand years, 2.7 mm/year since 1650, and 2.8 mm/year over the last 100 years (Braatz and Aubrey 1987; Finkelstein and Ferland 1987; Froomer 1980; Kraft 1971; Kraft et al. 1987).

The Sedgefield Member outcrops 120 m south-southeast of the site in a cliff along the Corrotoman River. The shoreline near the Davis Site consists of a veneer of sand overlying impermeable, pre-Holocene, clay-rich sediments (Rosen 1980). This type of shoreline has the highest erosion rates in the Chesapeake Bay region with rates up to 1.1 m/year (Rosen 1980). Thus, the distance to the clay outcrop has undoubtedly decreased since the site was occupied by native Americans.

The Davis Site experienced two periods of occupation, first by Native Americans and then by English colonists. Previous work at the site focused on dating these two occupations (Key and Gaskin 2000; Key et al. 2000). Based on projectile point and pottery typologies, the Native American occupation had a maximum range of the Early Archaic period through the historic period with a weighted mean age of Late Archaic. Historical evidence suggests the Native Americans had abandoned the site before settlement by the English colonists. Based on historical records and clay tobacco pipe artifacts, the colonial occupation of the site had a maximum range of 1650–1718 with a mean date of 1684 and a most likely range of 1669–1703. Thus, the site was probably intermittently occupied by Native Americans from the Early Archaic period to the Protohistoric period.

Materials and Methods

All the artifacts in this study are from random, unprovenanced plow zone surface collections. A total of 337 pottery sherds were recovered with 41% being Mockley ware, 24% Townsend ware, and 35% Potomac Creek ware. The ages, dimensions, rim, wall, and base thicknesses, temper, and surface treatment are described by Key and Gaskin (2000:Table 1). Each of the three pottery types was represented by three replicates for a total of nine pottery sherds. Each sherd contained both paste and temper. The raw clay from the local outcrop of the Late Pleistocene Sedgefield Member of the Tabb Formation was represented by four replicates. Five additional samples of the raw clay were used in a firing experiment for a total of 18 samples.

Five raw clay samples were fired in an electric kiln to either 100, 400, 600, 800, or 1000 °C following the methodology of Mitchell and Hart (1989). Once the sample reached that temperature, it was kept there for one hour and then air-quenched. The mineralogy of all 18 samples was determined using XRD. All samples were first air-dried. The samples were ground to a fine powder using a mortar and pestle and thoroughly mixed by hand. Each was then analyzed with XRD from 5-45 °2θ following the standard procedures of Moore and Reynolds (1989). Finally, the exterior surface colors of all samples were determined using the Munsell (1994) color notation.

Results and Discussion

The XRD analysis revealed the presence of kaolinite, low (i.e., alpha) quartz, and microcline in the raw clay samples from the Sedgefield Member of the Tabb Formation. Quartz-bearing ceramic-quality clays such as those in the Sedgefield are common in the Virginia Coastal Plain (Sweet 1982). In fact, Markewich et al. (1987:Figure 16), using XRD, also showed that the clay in the Sedgefield contains kaolinite. These same clays were also analyzed in a study on the provenance of clays used in colonial terra cotta pipes (Key and Jones 2000).

Pottery

Based on the XRD analysis, all three pottery types contained low (i.e., alpha) quartz, and the Mockley and Townsend wares also contained calcite and microcline. The presence of quartz is expected as most ceramic-quality clays typically contain some quartz, which is a very stable mineral (Sweet 1982). The presence of quartz in all three wares is also expected as their tempers often contain quartz. Potomac Creek ware is dominated by quartz temper, and the Mockley and Townsend wares often contain minor amounts of quartz sand (Egloff and Potter 1982; Griffith 1980; Potter 1982; Stephenson et al. 1963). The presence of calcite in the Mockley and Townsend wares is expected as they both are characterized by shell temper (Egloff and Potter 1982; Potter 1982; Stephenson et al. 1963). The presence of microcline in two of the wares may reflect the Sedgefield clay, which contains microcline, being the common source.

Assuming the Sedgefield clay was the source of the raw clay for the pottery, then the differences in the mineral composition of the raw clay and the pottery can be used to constrain the pottery's firing temperature. The presence of low/alpha quartz in the pottery does not greatly constrain the maximum temperature of firing. Low/alpha quartz converts to high/beta quartz at 573 °C and tridymite at 867 °C. These two higher temperature forms of SiO_2 are metastable at atmospheric pressure and readily convert to low/alpha quartz upon cooling (Heaney 1994). Cristobalite (the highest temperature form of SiO_2) is stable at atmospheric pressure, but it does not form until 1470 °C (Heaney 1994; Navrotsky 1994). Thus, all that can be concluded from the presence of low/alpha quartz is that the firing temperature never reached 1470 °C.

The presence of calcite in the Mockley and Townsend wares indicates a firing temperature below 650–900 °C as that is the temperature range at which calcite decomposes (Klein 1990; Klemptner and Johnson 1984, 1985; Maggetti 1982; Mitchell and Hart 1989; Shepard 1956; Stimmell et al. 1982; Rice 1987). The absence of microcline in the Potomac Creek ware indicates a firing temperature above 480–550 °C as that is the temperature range at which it transforms into orthoclase (Hurlbut and Klein 1977). Conversely, the presence of microcline in the Mockley and Townsend wares indicates a firing temperature below 480–550 °C.

The absence of kaolinite indicates a firing temperature generally above 400–800 °C as that is the temperature range at which it transforms by dehydration into metakaolinite (Grim 1968; Nutting 1943; Rice 1987; Ross and Kerr 1931). In ancient ceramics, kaolinite is generally lost around 550 °C (Maggetti 1982; Mitchell and Hart 1989). Metakaolinite is often not detected in XRD patterns as its crystalline lattice structure typically collapses during dehydration (Giese 1988; Grim 1968; Moore and Reynolds 1989; Rice 1987; Shepard 1956), but others using the powder photography method have been able to discern metakaolinite (e.g., Klein 1990). The absence of the higher temperature forms of kaolinite (i.e., mullite which forms at 950 °C and cristobalite at 1075 °C [Maggetti 1982]) indicates a firing temperature below 950 °C.

Thus assuming the pottery was made from the Sedgefield clay, the pottery's firing temperatures can be bracketed by the mineral composition of the pottery. The Potomac Creek ware was definitely fired to between 480 °C and 900 °C (Figure 1), and most likely it was between 550 °C and 650 °C. The Mockley and Townsend wares were definitely fired to between 400 °C and 550 °C (Figure 2), and most likely it was closer to 550 °C.

Fired Clay

The XRD analyses revealed that as the raw Sedgefield clay was fired at higher temperatures (100, 400, 600, 800, and 1000 °C) the mineralogy changed. There was no calcite in any of the samples as it would have been

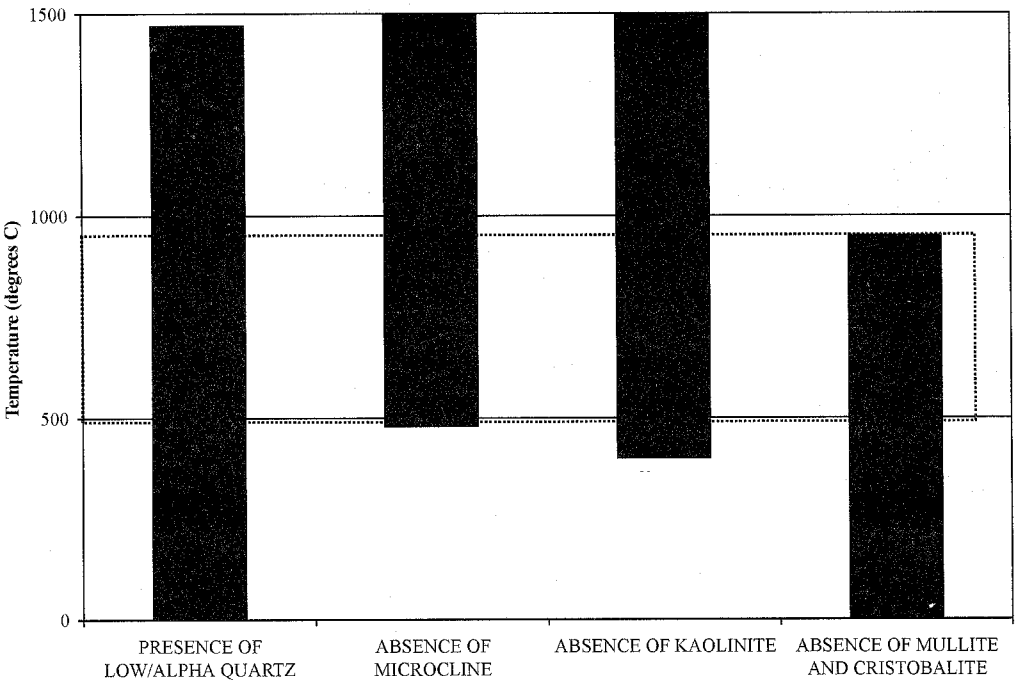

Figure 1. Davis Site (44LA46), bracketed firing temperatures for native American Potomac Creek Ware pottery. Vertical bars show the range of possible firing temperatures based on the presence and absence of various minerals.

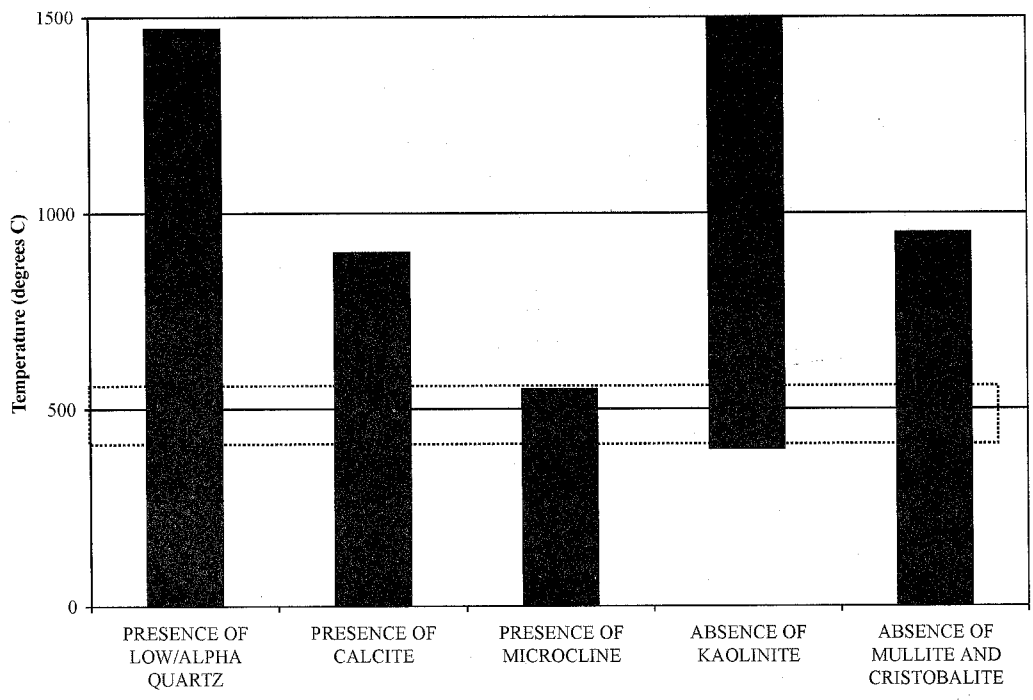

Figure 2. Davis Site (44LA46), bracketed firing temperatures for native American Mockley and Townsend Ware pottery. Vertical bars show the range of possible firing temperatures based on the presence and absence of various minerals.

added to the clay as temper in the pottery making process. Low (i.e., alpha) quartz remained in all the samples as expected as it would not be lost until 1470 °C, as discussed above. Microcline was present up to 400 °C in keeping with its conversion to orthoclase at 480–550 °C, as discussed above. Kaolinite was present up to 800 °C, but the XRD peaks became fewer, smaller, and more spread out after 400 °C, indicating progressive breakdown of the lattice structure as the clays dehydrated and became amorphous (Heimann 1982; Mitchell and Hart 1989). Mullite first appeared at 1000 °C in response to the conversion of kaolinite to mullite at 950 °C as discussed above. This is similar to the results from Klein (1990) who found mullite when he heated his samples to 1100 °C for one hour.

Thus, assuming the pottery was made from the raw Sedgefield clay, the pottery's firing temperature can be bracketed by the mineralogy of the fired clay to between 400 °C and 1000 °C (see Figure 1). To obtain more precise temperature ranges would have required more closely spaced firing temperatures (e.g., every 50 °C as opposed to every 200 °C).

Color Analysis

Another approach to constraining firing temperatures involves color analysis. This less quantitative method is based on the general observation that pottery color changes with firing. Color can be relatively objectively determined using the Munsell (1994) color notation. But due to varying composition of the raw material, especially the amount of organic inclusions, varying temperatures during firing, and post-manufacturing and post-depositional alterations to the pottery, pottery color can often not be directly related to firing temperature (Rice 1987). Despite these problems, there is a general change in color from yellow to red (Y to R in the Munsell color notation) with increasing firing temperature (Rice 1987).

The colors of the pottery as well as the raw and fired clay are presented in Table 1. The colors presented in Table 1 indicate the maximum range of colors seen. The pottery was generally brown with tints of yellow and red. The unfired raw clay was pale yellow, and the fired clay became more red with increasing temperature. These results are similar to those obtained by Klein (1990), which showed that in general as the firing temperature increases, the color of pottery generally changes from brown to red. According the Rice (1987) the change from yellow to red occurs around 850 °C (Rice 1987).

Thus, assuming the pottery was made from the raw Sedgefield clay, the pottery's firing temperature can be bracketed by the color of the fired clay to greater than 400 °C and less than 1000 °C. More precise temperature ranges cannot be obtained from this method.

Conclusions

Based on the XRD and color analysis of the fired raw Sedgefield clay, the firing temperature of the Native American pottery was probably between 400 °C and 1000 °C. Based on the differences between the mineralogy of the raw Sedgefield clay and the Native American pottery, the firing temperature of the pottery was probably around 550 °C. The Mockley and Townsend wares may have been fired at a slightly lower temperature and the Potomac Creek ware at a somewhat higher temperature. These estimates are similar to those reported by ethnographers that most low-fired, unglazed, unvitrified, high-porosity, coarse, non-kiln-fired, prehistoric, terra cotta pottery was fired at 450–1000 °C (Klein

Sample	Exterior Surface Color
Mockley ware	Brown (7.5YR5/4) to yellowish red (5YR5/6)
Townsend ware	Pale brown (10YR6/3) to reddish brown (2.5YR4/4)
Potomac Creek ware	Pale brown (10YR6/3) to yellowish red (5YR5/6)
Raw clay	Pale yellow (5Y8/2) to yellow (2.5Y7/6)
100 °C clay	White (5Y8/1) to yellow (2.5Y7/6)
400 °C clay	Light gray (5Y7/1) to light reddish brown (2.5YR6/4)
600 °C clay	Very pale brown (10YR8/3) to red (2.5YR4/6)
800 °C clay	Very pale brown (10YR8/3) to light red (2.5YR7/8)
1000 °C clay	Yellow (10YR8/6) to red (2.5YR5/6)

Table 1. Davis Site (44LA46), Munsell color notations for the pottery as well as raw and fired clay samples.

1990; Rice 1987). These estimates are based on the assumption that the raw Sedgefield clay was the source of clay for making the Native American pottery at the Davis Site. Is this a valid assumption?

Determining the provenance of clays used in ceramic archeological material is difficult for numerous reasons discussed in the Introduction. The mineralogy of the pottery was changed from that of the raw Sedgefield clay for two main reasons. First was the addition of both quartz (sand) and calcite (shell) temper. Both sand and shell are readily available at the site. Second was the firing at elevated temperatures that altered the mineral composition. Thus, the mineral analysis does not preclude the Sedgefield clay from being the source of the pottery, but it does not absolutely prove it. It most likely was the source for the clay used in making the pottery as clays used in pre-industrial ceramics tend to come from very local sources with 85% coming from within a 7-km radius (Arnold 1980, 1985). McLearen and Mouer (1989) suggested that many of the clays used to make Mockley ware found in the coastal section of the James River came from one source, whereas the clays used to make the contemporaneous, non-shell-tempered ceramics were obtained near the sites where the pottery was found. This may be the case with the Davis Site pottery as well. The Sedgefield Member of the Tabb Formation has a geographically extensive outcrop distribution along most of the downstream portions of the Tidewater rivers (Mixon et al. 1989), so its clay could have been used at multiple sites for pottery production.

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