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Geoarcheology of Terra Cotta Tobacco Pipes from the Colonial Period Davis Site (44LA46), Lancaster County, Virginia

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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. Plowzone surface collections include a few terra cotta tobacco pipe bowls and stem fragments. This colonial component has been dated to 1650–1718 (mean date: 1684). The site is located 120 m (400 ft) from a clay outcrop of the Late Pleistocene Sedgefield Member of the Tabb Formation. This formation outcrops extensively in the tidewater region of Virginia. The goal of the study was to determine if this formation was a viable clay source for manufacturing terra cotta pipes found at this or other Chesapeake sites. To address this question, two geological analyses were performed on the raw clay, terra cotta pipes, as well as one of the more common white pipes, presumably imported from England. Their mineralogical compositions were compared using X-ray diffraction and their elemental compositions were compared using energy dispersive-scanning electron microscopy. Results indicate the mineralogical composition of the clay is fundamentally different from the pipes due to firing which altered the minerals, and indicates a firing temperature between 550 °C and 950 °C. The elemental composition of the clay is more similar to the terra cotta pipes than the white pipe. Thus, the Sedgefield Member of the Tabb Formation was a viable clay source for terra cotta pipes in the area.

Introduction

Geoarcheology is the application of quantitative geological analytical techniques to test 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). Mineralogical and elemental fingerprinting has been shown to be a useful approach for determining the provenance of artifactual raw materials (Rapp 1985). 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 Perniet 1973), or thermal expansion (e.g., Tite 1969). Because the thermal stability ranges of minerals are known (Küpfer and Maggetti 1978; Mitchell and Hart 1989), ceramic firing temperatures can also be determined by identifying the mineral phases present (Kamilli and Steinberg 1985). This can be done using thin section optical microscopy, differential thermal analysis, or X-ray diffraction (Heimann 1982; Isphording 1974; Maggetti 1982; Tite et al. 1982). In general, X-ray diffraction is preferred over macroscopic techniques such as porosity (Maggetti 1982). When analyzing the mineralogy and chemistry of ancient ceramics, it must be remembered that these properties 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 mineralogy and chemistry of ancient ceramics, by changing the primary mineralogy of the initial clay, to a subsequent mineralogy from firing to the secondary mineralogy from use and/or burial (Maggetti 1982).

This study on the terra cotta tobacco pipes from the Davis Site will use (1) X-ray diffraction to determine the mineral composition of the pipes to constrain the firing temperatures, and (2) chemical fingerprinting to constrain the provenance of the clays used to make the pipes.

Terra Cotta Pipes

Terra cotta tobacco pipes is a term used to refer to the red clay tobacco pipes that differ mainly in color from the more ubiquitous imported European white clay pipes. These red pipes are not found in Europe (Harrington 1951; I. Noël Hume 1963) and have been variously referred to as "aboriginal," "Chesapeake," "Colono," "Colono-Indian," "earthenware," "indigenous," "locally made," and "Virginia-made" pipes. Terra cotta pipes range from dark brown to light orange in color (Emerson 1994; Miller 1991).

Terra cotta pipes have been previously reported in Virginia and Maryland from the following sites: Camden (Heite 1972), Coan (Potter and Waselkov 1994), Davis (Key et al. 2000), Flowerdew Hundred (Deetz 1993; Emerson 1986), Green Spring (Crass 1988), Haddon (Winfree 1967), Jamestown (Harrington 1951), Kingsmill (Kelso 1984), Knowles (Pawson 1969), Martin's Hundred (A. Noël Hume 1979), Millenbeck (Mann 1974), Nominy (Mitchell 1976, 1983; Mitchell and Mitchell 1982), Pasbehay Tenement (Outlaw 1990), Patawomecke (Schmitt 1965), and St. Mary's City (Henry 1979; Miller 1983, 1991).

There are two basic types of terra cotta pipes (i.e., mold-made and handmade) and both were made locally. They are difficult to distinguish, and many presumed handmade pipes probably were mold-made (Deetz 1993). The mold-made pipes were presumably made with molds imported from Europe and using indigenous clays (Deetz 1993; Emerson 1988, 1994; Kelso 1984; Mitchell 1983). These pipes have a distinctive European bowl shape (Henry 1979; Miller 1983) and were probably mold-made due to their relatively consistent dimensions (Emerson 1988). It was originally suggested that the mold-made terra cotta pipes were manufactured by Native Americans or European American colonists (Henry 1979; Miller 1983, 1991; Pogue 1991). Emerson (1988, 1994) argued that pipe making was not a stable livelihood for English colonists in America in the 1600s as only one English pipemaker has been proven to have been practicing in the Chesapeake during the colonial period.

Terra cotta pipes often have distinctive design elements consisting of patterned indentations in the form of a horned, quadrupedal animal. This pattern is often referred to as the Running Deer motif (e.g., Emerson 1994:Figures 3.2c, 3.5a). Once again it was originally attributed to Native Americans or European Americans that were making pipes in the Native American style for trade (Harrington 1951; Henry 1979; Kelso 1984; Miller 1983; Mitchell 1983; Mitchell and Mitchell 1982; Pawson 1969; Pogue 1991; Schmitt 1965; Smolek et al. 1984; Stewart 1954). Native Americans were making clay tobacco pipes before and during English contact (Emerson 1994), but the Running Deer motif has most recently been attributed to African-Americans (Deetz 1993; Emerson 1988, 1994) or a unique Creole culture of interacting Native, European, and African Americans (Mouer 1993).

Based on their decoration style, their overlapping spatial distribution with Africans in Virginia, and their concurrent temporal distribution with Africans in Virginia, terra cotta pipes were most likely made by African Americans (Deetz 1993; Emerson 1988, 1994). Terra cotta pipes, along with Colono ware pottery and iron production, were a cottage industry attempt at colonial self-sufficiency in the 1600s (Deetz 1993).

It has long been suggested that terra cotta pipes were made from more iron-rich, indigenous clays (Calver 1931; Emerson 1988, 1994; I. Noël Hume 1963). Pipe clay was probably collected from lowlands or exposed riverbanks near settlement areas (Emerson 1994), but no physical evidence of sites that were dug for pipe clays has been found (Emerson 1988). This is expected due to the high erosion rates in the Chesapeake region (Rosen 1980). Compared to the white imported pipes, the terra cotta pipes made from indigenous clays are often grittier (Harrington 1951; Pawson 1969) and presumably were fired at lower temperatures (Calver 1931). To determine the source of the clays for these pipes, the composition of the terra cotta pipes and the local clays at the Davis Site were compared. A single sample of a white pipe, probably imported from Bristol, England (Key et al. 2000), was also analyzed for comparison. Most pipes made in Bristol used white ball clay from Devon (Oswald 1961) and should be distinguishable from the terra cotta pipes using geoarcheological techniques. Nobody has successfully been able to correlate Chesapeake terra cotta tobacco pipes from the 1600s to indigenous clay deposits (Emerson 1988). Terra cotta pipes exhibit a variety of colors; thus, attempts to correlate pipe color with clay color in outcrop are futile due to the effects of firing, time, and oxidation on color (Emerson 1988). In this study, it is hoped that the mineral and chemical compositions of the pipes and their source clay can shed light on this problem.

The Davis Site

The Virginia Department of Historic Resources number for the Davis Site is 44LA46. Based on historic documents, clay tobacco pipe stem bore diameters, pipe bowl shapes, and pipe maker's marks, the colonial component of the site was dated to 1650–1718 with a mean date of 1684 (Key et al. 2000). The site was occupied during this time by Thomas Buckley and various other tithables (Key et al. 2000). The site is in the Northern Neck of Virginia (Figure 1) in the Outer Coastal Plain physiographic province (Wentworth 1930). The Northern Neck is a 225 km (140 mi) long, 32 km (20 mi) wide

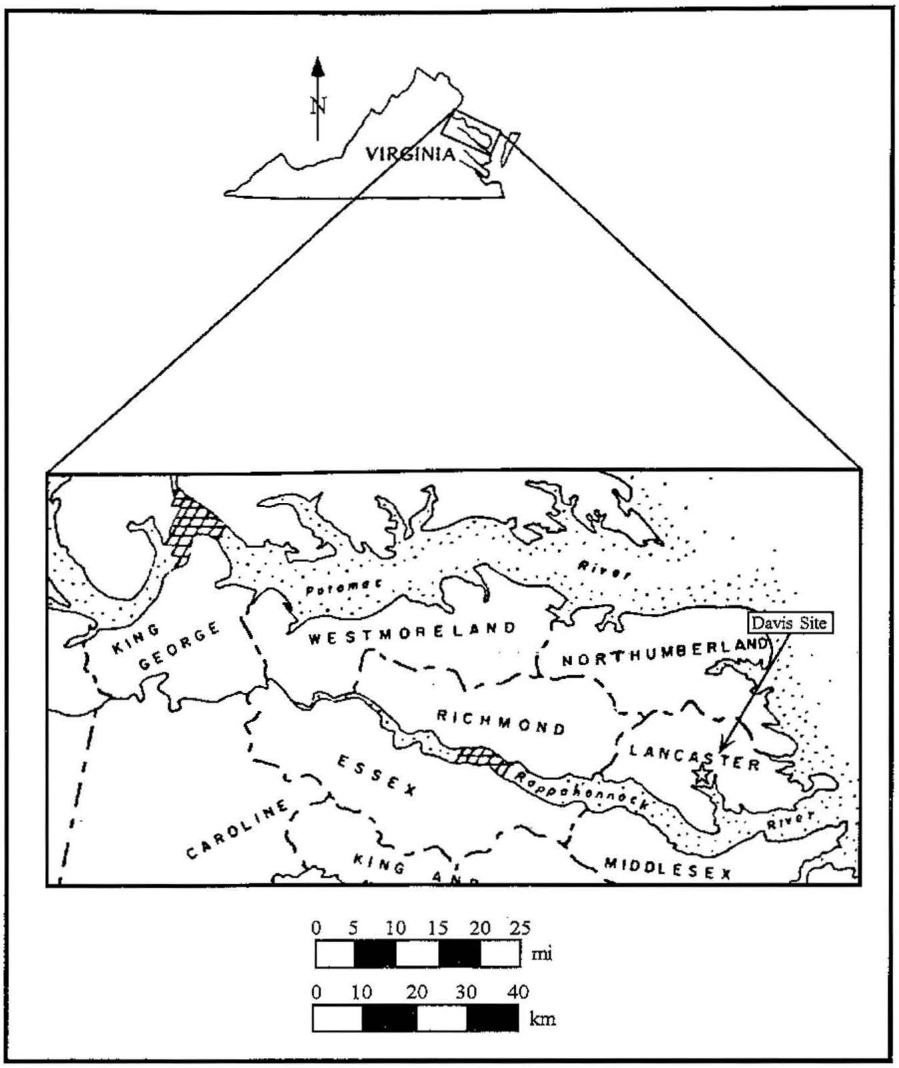

Figure 1. Map of Northern Neck showing the location of Davis Site (44LA46). Cross hatched areas indicate freshwater/saltwater transition zone. (Map modified from Egloff and Potter [1982:Figure 1].)

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 (Beale 1967; Newton and Siudyla 1979). The Northern neck has extensive navigable estuaries which frequently penetrate the peninsula along its length (Beale 1967).

One of these estuaries is the Corrotoman River. The north shore of the Eastern Branch of the Corrotoman River is located 65 m (210 ft) to the southeast of the site. The estuary is still quite navigable at this site (Dickson 1992) and was in the past, as evidenced by the presence of a steam boat landing here in the 1800s. The site is situated between the mouth of Hills Creek and the mouth of Bells Creek. The estuary has a mean tidal range of roughly 0.6 m (2 ft) (Wentworth 1930). The shoreline 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 ups to 1.1 m/y (3.7 ft/y) (Rosen 1980). The distance to navigable water has undoubtedly changed since the site was occupied over 300 years ago. Soil erosion due to agricultural practices causes siltation, whereas waves, tides, storm surges, groundwater flow, and relative sea level rise cause erosion (Rosen 1980). The nearest freshwater is a spring which is the surface reflection of the water table of the Northern Neck's aquifer (Newton and Siudyla 1979). The spring is currently used for domestic water consumption by two adjacent residences and is located 115 m (375 ft) to the west.

The site is located on a relatively level bluff 9 m (30 ft) above the river. 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 (30–45 ft) above sea level in this area (Elder et al. 1963; Wentworth 1930). The soil developed on the site is the Sassafras loamy fine sand soil type. It typically has a 23 cm (9 in) thick A horizon, a 40–60 cm (16–24 in) grayish to yellowish brown surface horizon, and occurs on terraces in this area with a 2–6 % slope (Elder et al. 1963; Markewich et al. 1987). The site is located in actively cultivated farm fields and may be partly covered by an unpaved road. When freshly plowed, the site is immediately identifiable by its markedly darker organic discoloration. Using the spatial distribution of clay pipe fragments to define the extent of the site, the site covers roughly 700 m² (7,500 ft.²). The site has been plowed to a fairly uniform depth of 20 cm (8 in).

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 those in the Coastal Plain which were formed by the transportation and deposition of kaolinite formed elsewhere (Murray 1988; Patterson and Murray 1984). The Sedgefield Member outcrops 120 m (400 ft) to the south-southeast of the site, in a cliff along the Corrotoman River.

The Sedgefield Member has been dated to 71 ky 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 (56 ft) 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 1963; 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 ky B.P., global sea level has been rising (Fairbanks 1989; Tooley 1993). Local sea level curves for the Chesapeake area indicate an average sea level rise of 1.3 mm/y for the last several thousand years, 2.7 mm/y since 1650, and 2.8 mm/y over the last 100 years (Finkelstein and Ferland 1987; Froomer 1980; Kraft 1971; Kraft et al. 1987).

Materials and Methods

All the artifacts in this study are from random, unprovenanced plow zone surface collections. No systematic excavation has been done, as the stratigraphy of the site has been compromised by plowing and erosion. The site has been and is currently plowed two or three times each year depending on the number of crops. A total of 717 clay tobacco pipe fragments were recovered, and 57 (8 %) of these were from terra cotta pipes. These 57 fragments included two relatively complete terra cotta pipe bowls. One was mold-made and one was handmade (Key et al. 2000:Figure 7.1, 7.2). The color, dimensions, and bore diameters of these two pipes are described by Key et al. (2000:Table 3).

The mineral compositions of ten samples were analyzed using an X-ray diffractometer (XRD). The ten samples included three terra cotta pipe stems, three terra cotta bowls, three samples of the local clay from the adjacent outcrop of the Sedgefield Member of the Tabb Formation, and one white pipe stem, probably imported from Bristol, England (Key et al. 2000). Each sample was ground to a fine powder and thoroughly mixed by hand. They were then analyzed with an XRD from 5-45 °2θ following the standard procedures of Moore and Reynolds (1989). XRD has previously been used to determine the source of clays used in ceramic production as well as the firing temperature of ceramics (e.g., Klein 1990; Lightfoot and Jewett 1984; Maggetti 1982; Stimmell et al. 1982; Tankersley and Meinhart 1982; Weymouth 1973), but never for clay tobacco pipes.

The elemental compositions of three samples were analyzed with an energy dispersive X-ray spectrometer attached to a scanning electron microscope (ED-SEM). The three samples included one terra cotta pipe, one white pipe, and one sample of the local clay. Each sample was polished and analyzed at two different locations at various magnifications (i.e., 100, 200, and 500X), and each was run for 500 seconds following the standard procedures of Thomas et al. (1977) and Plotnick and Harris (1989). As the results did not differ significantly within each of the three samples, the results presented for each of the samples is an average of at least four analyses. The amounts of Si, Al, K, Fe, Ca, Ti, Na, Mg, and Cl were measured.

Results and Discussion

The XRD analysis reveals the presence of low (i.e., alpha) quartz, microcline, and kaolinite in the clay samples from the Sedgefield Member of the Tabb Formation. Quartz-bearing, ceramic-quality clays such as 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 has kaolinite.

In contrast, the terra cotta and white clay pipe samples only contained quartz. If the terra cotta pipes were made from the Sedgefield clay, why the mineralogical dissimilarity? It may reflect that the clay used to make the pipes had a different source or more likely the difference is due to the effect of firing on the mineral content of the original clays use to make the pipes. As clay minerals are heated during firing, they dehydrate, become amorphous, and are eventually fused into a ceramic (Heimann 1982; Mitchell and Hart 1989). Thus, XRD can not be used to determine the provenance of the terra cotta pipes, but it is very useful for determining the temperature at which the pipes were fired.

Assuming the Sedgefield clay was the source of the raw clay for the terra cotta pipes, then the differences in the mineral content of the clay and the pipes constrain the firing temperature. The presence of low/alpha quartz in the terra cotta pipes does not greatly constrain the

Element	Raw Clay		Terra Cotta Pipes		White Pipes		Difference between Raw Clay and Terra Cotta Pipes (%)	Difference between Terra Cotta and White Pipes (%)
Si	409,305	(81)	535,274	(66)	649,344	(59)	15	7
Al	32,618	(6)	190,912	(23)	343,856	(31)	17	8
K	24,726	(5)	32,4111	(4)	59,260	(5)	1	1
Fe	25,396	(5)	28,266	(3)	7,613	(1)	2	2
Ca	0	(0)	8,787	(1)	18,385	(2)	1	1
Ti	4,745	(1)	6,572	(1)	15,771	(1)	0	0
Na	0	(0)	5,033	(1)	2,851	(0)	1	1
Mg	0	(0)	7,042	(1)	0	(0)	1	1
Cl	7,853	(2)	0	(0)	0	(0)	2	0
Total	504,642	(100)	814,297	(100)	1,097,080	(100)		

Table 1. Davis Site (44LA46), average elemental compositions from ED-SEM analysis of the raw clay from the Sedgefield Member of the Tabb Formationas as well as terra cotta and white tobacco pipes. All samples from the Davis Site. All values in counts per 500 seconds except those in parentheses which are percentages.

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 absence of microcline in the terra cotta pipes indicates a firing temperature above 480–550 °C as that is the temperature range at which it transforms into orthoclase (Hurlbut and Klein 1977). 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), but extended firing (i.e., over 200 hours) at lower temperatures (i.e., 350 °C) can also transform kaolinite (Grim 1968). In ancient ceramics, kaolonite 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 (Grim 1968; Moore and Reynolds 1989; Rice 1987; Shepard 1956), but others using the powder photography method have discerned 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 terra cotta pipes were made from the Sedgefield clay, the firing temperature can be bracketed between 550 °C and 950 °C.

If the mineral composition does not identify the source of the clay for the terra cotta pipes, perhaps elemental composition can. Whereas some minerals are not conserved during firing, elements are, so elemental composition is unaffected by firing. To a certain extent, the minerals present in a sample control the relative abundance of the elements revealed in ED-SEM analysis. For example, quartz, microcline, and kaolinite all contain Si, thus the most abundant element in all three samples was Si (Table 1 and Figure 2). Two of these three minerals contain Al, and it is the second most common element (see Table 1 and Figure 2). Results indicate that the terra cotta pipe is more similar than the white pipe to the Sedgefield clay in five of the nine elements analyzed (i.e., Si, Al, Fe, Ca, Ti). The white pipe was more similar than the terra cotta pipe to the clay sample in three of the nine elements analyzed (i.e., K, Na, and Mg). The ninth element (i.e., Cl) was not found in the pipes. The total percentage difference between the terra cotta pipe and the clay was 39 % whereas for the white pipe and the clay it was 56 %. This indicates the terra cotta pipe was, as expected, elementally more similar to the Sedgefield Member of the Tabb Formation than the white pipe.

The elemental differences between the white and the terra cotta pipes are undoubtedly due to the former probably being made from clays from Devon, England (Oswald 1961), whereas the latter was probably made

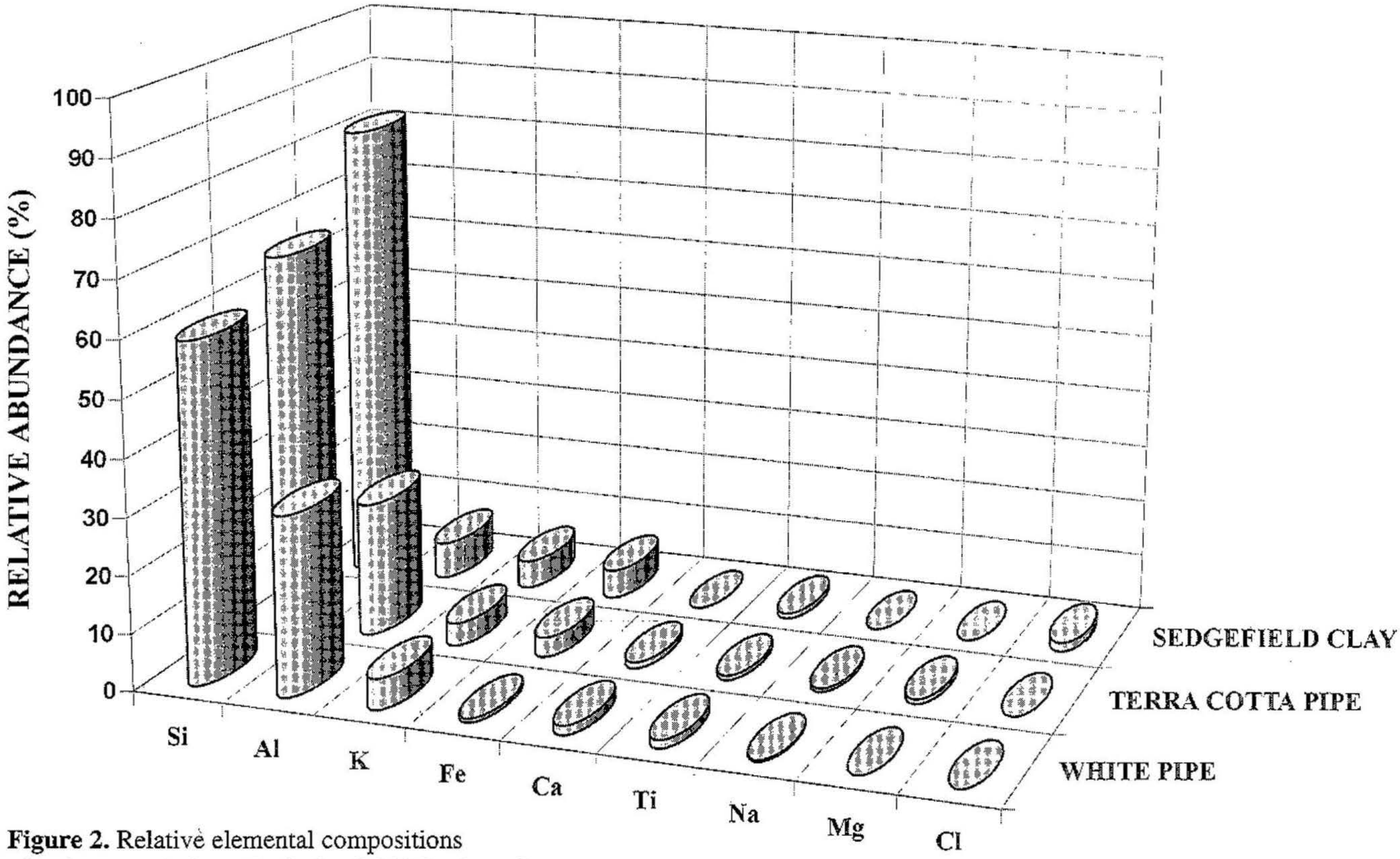

Figure 2. Relative elemental compositions of a clay sample from the Sedgefield Member of the Tabb Formation, a terra cotta pipe, and a white pipe.

from Virginia clays (Emerson 1988). Why the differences between the terra cotta pipe and the Sedgefield clay? If any tempers were added to the clay before firing, this could alter the elemental composition of the clay sample. The source of clay for the terra cotta pipe may have been from a different formation or different outcrop of the same formation that was mineralogically and elementally different.

The percentage of terra cotta pipes at some sites is as high as 70 % with white imported pipes being in the minority (Heite 1972; Henry 1979; Miller 1991). Such sites were probably manufacturing terra cotta pipes. The presence of terra cotta wasters (i.e., unfinished bowls, defective stems, trimming waste, and small clumps of fired clay) at a site is another good indicator of pipe production (Miller 1991; Mitchell and Mitchell 1982). This suggests that sites with few terra cotta pipes and no wasters were probably not manufacturing sites. Terra cotta pipes make up only 8 % of all the pipe fragments and no wasters were found at the Davis Site. These both suggest terra cotta pipes were not being manufactured at the site. This is supported by the fact that the chief occupant of the site, Thomas Buckley, was a tinker who left no evidence of pipe manufacturing in his will or court records (Key et al. 2000). Could the terra cotta pipes have been manufactured elsewhere in colonial Chesapeake using clays from the Sedgefield Member of the Tabb Formation? This 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 terra cotta pipe production. This is likely as clays used in pre-industrial ceramics tend to come from very local sources with 85% coming from within a 7 km (4 mi) radius (Arnold 1980, 1985).

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