COLONIAL CERAMIC WARES: COMPARISON BASED ON MINERALOGICAL, PETROLOGICAL AND COMPOSITIONAL DATA

by

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(Under the Direction of Samuel Swanson)

Abstract

Merida (Spanish), orange micaceous (Spanish) and Morgan Jones wares (Colonial Virginia/Maryland) are ceramic wares recovered at sixteenth century North American sites that are similar in appearance and inclusions. Merida and Morgan Jones wares are found at St. Mary's City, Maryland. Orange micaceous ware is found at St. Augustine, Florida. Petrographic, x-ray diffraction and electron microprobe data helped defined each ware. Spanish ceramics contain ilmenite with Ti/Ti+Fe = 0.6 to 0.65. Ilmenite in Morgan Jones is lower Ti (Ti/Ti+Fe = 0.3 to 0.5). Plagioclase in the Merida ware is mostly albite (An 0 to 9) with some oligoclase/andesine (An 26 to 30). Morgan Jones ware contains albite (An 1 to 2) and oligoclase/andesine (An 30 to 41). Orange micaceous ware only contains albite (An 0 to 2). Merida and orange micaceous wares contain similar materials thus likely have similar sources. Morgan Jones ware has different materials and thus a different source.

INDEX WORDS: Colonial ceramics, Electron Microprobe, X-ray Diffraction, Ceramic Petrography, Geoarchaeology

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Introduction

Merida, Morgan Jones and orange micaceous wares are ceramic types that are very similar and found at colonial sites in North America (Council, 1975; Miller, 1986, 1989; Deagan, 1987; South, 1988). Typological descriptions show any similarities between paste colors and temper constituents in these three wares. However, there are different areas of manufacture (Deagan, 1987; Miller, 1989). Periods of manufacture also overlap for all three types. A problem in distinguishing between these ceramics can arise when these wares are found at the same archaeological site. Merida wares are found alongside Morgan Jones wares at St. Mary's City, Maryland (Miller, 1986; 1989). Orange micaceous wares are abundant at Spanish colonial sites in Florida and the Caribbean (Council, 1975; Deagan, 1987). Morgan Jones ware is manufactured in the Chesapeake Bay area of southern Maryland and northern Virginia. Merida and orange micaceous wares were both manufactured on the Iberian Peninsula and were traded into the New World by the Spanish. The purpose of this study is to provide a way of distinguishing between of Merida, Morgan Jones, and orange micaceous ceramics using petrographic methods. Archaeologists (Miller, 1986; 1987; Deagan, 1987; South, 1988) note the high degree of similarity between Merida and orange micaceous wares. Distinctions between the two wares are not provided, however they are treated as separate wares by archaeologists (Miller, 1986; 1989; Deagan, 1987).

Clay has been used by humans to produce a wide variety of objects needed for everyday (pottery) uses and as ritual objects (figurines) (Rice, 1987). Pottery is one of the most common types of items produced from clay. Pottery is defined as a class of artifacts in which clay is formed into containers, often decorated and fired (Sharer and Ashmore, 2003). Containers are produced from clay to serve as cooking and storage vessels (Sharer and Ashmore, 2003). Pottery has been produced for over 12,000 years in one form or another and by many different cultures the world over (Rice, 1987; Sharer and Ashmore, 2003). Most archaeological studies dedicate a lot of attention to pottery analyses due to the common occurrence of pottery at archaeological sites (Shepard, 1956; Rice, 1987; Sharer and Ashmore, 2003). Pottery is abundant at archaeological sites due to its resistance to weathering, which leads to preservation (Rice, 1987). Pottery is often regarded as a rock or as stony archaeological material and in fact can be described as artificial or man-made stone (Rice, 1987; Garrison, 2003). Because of its anhydrous, stony nature, pottery is resistant to chemical erosion. Pots may be broken, but their sherds will remain and are common in the archaeological record (Rice, 1987; Sharer and Ashmore, 2003). Also, because of the stony nature, ceramics can be treated as rocks and many geological and mineralogical techniques can be used to define and study ceramics (Shepard 1956; Rice 1987).

Ceramics are considered to be everyday items and are often studied for information about the everyday citizen of a culture (Sharer and Ashmore, 2003). Vessel form can tell an archaeologist about what types of materials a vessel could have held and coupled with studies of residues can also elude to the diet of a culture (Sharer and Ashmore, 2003). Other residues such as resins, pollen and unfired clay could tell an archaeologist about other activities conducted by members of a culture (Sharer and Ashmore, 2003).

Information about a culture’s technology can be gained by studying ceramics (Rice, 1987). Pottery production requires many steps and each must be followed to ensure a useful vessel is produced. By analyzing the pottery from archaeological sites, manufacturing and firing technology can be determined (Sharer and Ashmore, 2003). The earliest pots were most likely formed by hand and then were left to air or sun dry. As time progressed and technologies improved wheel thrown pots that were kiln fired emerged. The type of manufacturing technique used by a potter would be apparent in the sherd (Rice, 1987; Sharer and Ashmore, 2003).

Chronological history for a culture or archaeological site is often established based on the ceramics found at a site (Rice, 1987; Sharer and Ashmore, 2003). Just as cultures change through time so do the ceramics produced by that culture. Broad classes of vessel forms are established for a culture and most often include bowls, jars and platters. The same vessel forms may appear with slight differences through time. For example, the mouths of jars may change in size or shape.

Iconographic and stylistic depictions on ceramic vessels can also tell an archaeologists about a culture (Sharer and Ashmore, 2003). Iconographic depictions can allude to the type of belief system a culture followed. Also, iconographic depictions can elucidate the function that a vessel had in a culture. Stylistic depictions have been the most analyzed feature of ceramics (Sharer and Ashmore, 2003). Styles that appear on vessels are guided by choices made by a culture and are not functions of technology. Stylistic attributes can be studied to see changes in choices made by a culture (Sharer and Ashmore, 2003). Most often, stylistic attributes coupled with stratigraphic data are used to determine a relative chronology for a site (Sharer and Ashmore, 2003).

Since ceramics are common products made by cultures they are also used frequently in trade and exchange systems (Rice, 1987). Ceramics, even those used for everyday uses, are traded, exchanged and given as gifts for different occasions. Potters were specialized members of society. Their wares must be traded for goods and services to provide for their families.

Ceramics are also offered as gifts at special times deemed by a society, such as marriage or thebirth of a child (Sharer and Ashmore, 2003). Sharing of goods between neighbors and cooperative groups are also common in many societies (Sharer and Ashmore, 2003). Presence of foreign or exotic ceramic styles and forms can help to clear up trade networks between past cultures (Rice, 1987; Sharer and Ashmore, 2003).

Terminology used in ceramic studies comes from geology, archaeology and anthropology (Rice, 1987). Many terms are defined in all three subfields, but are often defined differently. Terms used in this study will combine those commonly encountered in archaeology and geology (Table 1).

Table 1. Ceramic terminology.

Term	**Definition**
Paste	Clay matrix of a ceramic type that has been fired
Fabric	Paste materials and inclusions
Inclusion	Aplastic materials, especially minerals, occurring in a clay or fabric prior to manufacture of the vessel; could be intentionally or unintentionally added during manufacture
Temper	Aplastic materials not naturally occurring in the clay and added intentionally by the potter during the manufacture of the vessel; added to improve the working, drying and firing properties; composed of clay and silicate framework minerals
Clay	Plastic material used by potters to produce ceramic artifacts
Grog	Pieces of already fired ceramic materials crushed and included as temper by the potter
Slip	A fluid suspension of clay and/or other materials in water that is applied before firing to form a thin coat; applied previous to other surface treatments
Glaze	A coating of glass melted in place and thus fused with the surface of a vessel; make a surface impermeable
Typology	Classification of artifacts, especially ceramics based on shared attributes
Earthenware	Porous wares that are fired at a variety of temperatures; clays are typically red color; most are coarse grained
Stoneware	Vitrified to partially vitrified ceramic ware fired to high temperatures; gray to light brown and low in iron; medium coarse grained
Majolica	Earthenware covered with an opaque tin-lead glaze; a technological class of ceramics; includes faience
Pottery	A class of ceramic artifacts in which clay is formed into containers, often decorated and fired
Ceramics	Artifacts of fired clay, belonging to pottery, figurine or other ceramic industries
Ware	A ceramic vessel definition based on hand sample analysis by archaeologists

Archaeologists rely on typological or stylistic characteristics to determine the identity of ceramics (eg. Miller, 1986; 1989; Deagan, 1987). Ceramic wares are based on hand sample observations (Sharer and Ashmore, 2003) such as paste color and hardness. Often, paste color is based on the observation of the archaeologist which is skewed by human perception (Rice, 1987). In the past paste color was not defined using a standard reference and were most often not replicated between two different archaeologists. In scientific studies today, Munsell Color Charts are most often used to characterize paste color. Other standardized color charts can also be used (Rice, 1987). Typological assignment allows archaeologists to describe large numbers of artifacts; while, for the moment ignoring attributes that are different (Sharer and Ashmore, 2003). Archaeologists will name the ceramic ware and use that name in subsequent descriptions. Other archaeologists may or may not use the same name for the same ware.

Archaeologists may also use visual inclusions or vessel form to define ceramic ware (Rice, 1987; Garrison, 2003). Inclusions are materials not naturally occurring in the source clay, but were some how incorporated during manufacture. Temper is material added intentionally by the potter to enhance the strength of the ceramic vessel during firing (Shepard, 1956; Rice, 1987). Differences between most inclusions and temper cannot be determined. Grog is one material that is classified as temper. Grog cannot naturally occur because it is man made.

Finally, ceramic wares defined by archaeologists most often do not take into account any geological, mineralogical or geochemical data. Only inclusions that are visible in hand sample and most often identified by archaeologists with little geological training (Rice, 1987). For instance, red ocher is mentioned in the typological definition of many ceramic wares, but this could be any number of oxide inclusions including hematite, ilmenite or/and rutile (Miller, 1989).

Petrographic analyses are most often used to identify inclusions in ceramic vessels because of the stony nature of ceramics (Garrison, 2003; Sharer and Ashmore, 2003). Petrographic analyses can be used to help define or redefine ceramic typologies. Also, by conducting petrographic analyses definition of resource areas exploited by a culture can be determined (Rice, 1987; Sharer and Ashmore, 2003).

Merida wares in the New World

Relatively little is known about Merida wares in North America and their relationships to European Merida ware samples and other earthenware types. Historical records do not reveal how a Spanish ceramic ware appeared at an English colony, especially given the hostilities between the English and Spanish during the colonial era. Hostilities between European powers began almost immediately after Columbus sailed into the West Indies to discover the "New World". England, France, Spain, Sweden, Netherlands and Russia all raced to establish colonies in these new lands in an effort to monopolize the resources. England and Spain both had strongholds along the east coast of North America. Competition between these two powers led to raiding of settlements and skirmishes between English and Spanish forces in the New World (Deagan, 1983; 1987). Unfortunately, Spain tried to attack the England with the unsuccessful Spanish Armada of 1588. Even after the Spanish Armada raiding of settlements continued and was compounded by the pirates from both sides (Figure 1).

JG Hurst first described Merida ware ceramics from samples found at medieval sites in England (Hurst, 1976). This ware is described as a micaceous ceramic with a hard orange-red paste. Manufacture of this ceramic type started in the thirteenth century and continues today

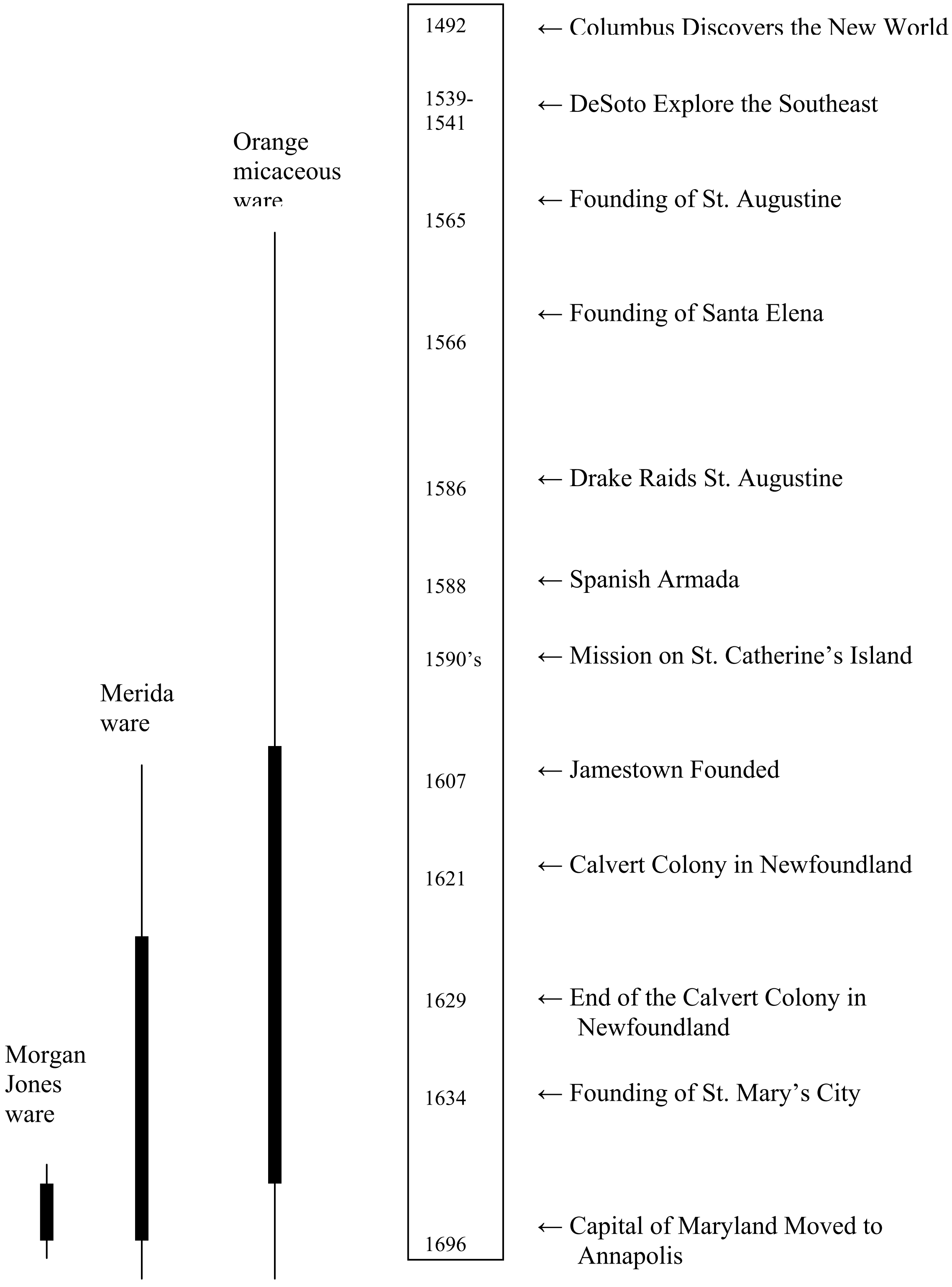


Figure 1: Timeline and Chronological Seriation. This timeline shows major events occurring in the Colonial Period along with the chronological seriation of the three ceramic wares. Line thickness corresponds with abundance.

along the border between Spain and Portugal. The name of the ceramic type comes from the city Merida in western Spain where the ceramics were first thought to be manufactured. The city of Merida lies in the Extremadura region of Spain (Figure 2). Later studies concluded that the ceramic was produced not only in Merida, Spain but also in areas across the border into the Alentjo region of Portugal (Paravaux, 1968). There are many different vessel forms for Merida wares including bowls, jars, wide necked jars, globular costrels (standing and barrel) and olive jars (Hurst, 1976; 1986). Decoration and surface treatments are also variable; some samples are painted; some are green glazed, while others just exhibit an incised line along the rim of the vessel. A few samples are plain and exhibit none of the afore mentioned surface treatments.

Figure 2: Map of the Iberian Peninsula (National Geographic Society 1998).

Merida wares samples in Europe are mainly found at medieval sites and are older than the samples found in Maryland (Hurst, 1976; 1986). Merida ware ceramics are also found in excavations of the Spanish Armada fleet off the coast of England (Martin, 1994; Brown and Curnow, 2004). Other North American sites where Merida ware is found include the Patxuent Point site in southern Maryland (King and Ubelaker, 1996) and a colonial site in Newfoundland (Gilbert, 1997). The Newfoundland site was the first attempt by the Calvert family to colonize the New World.

The majority of research about Merida ware ceramics comes from samples found at medieval sites in Europe, especially England. Williams (1984) examined Merida ware samples from Exeter England using petrographic thin sections and the petrographic microscope. Williams was able to identify at least two distinct fabrics based upon mineral constituents. Williams failed in an attempt to correlate a clay source for these ceramics. No other attempt has been made to locate an area of manufacture.

Today there are many potters working in Extremadura region of Spain. Many of the same forms of pottery are produced today are similar to those of Merida wares (Artigas and Corredor-Matheos, 1970). Potters of both Spanish and Portuguese descent still make similar ceramics to Merida and use similar clays. However, no historical documents reveal the exact clay sources used in the manufacture of Merida wares.

Morgan Jones wares

Morgan Jones wares resemble Merida-type wares based on typological descriptions (Kelso and Chappell, 1974; Miller 1989). Morgan Jones pottery varies in color from buff (pinkish white) to orange and the paste is medium to coarse grained and contains varying quantities of red ocher nodules (possible oxide inclusions), mica flakes, quartz pebbles and other impurities (Kelso and Chappell, 1974; Miller, 1986; 1989). A poorly applied lead glaze varies in color from brown to orange to green. Morgan Jones and his associates manufactured Morgan Jones pottery in the Chesapeake Bay area from circa 1660 until circa 1680 (Kelso and Chappell, 1974; Miller, 1986; 1989).

Morgan Jones wares have been found at other English colonial sites in North America (Kelso and Chappell, 1974; Straube, 1995). One important site is in Glebe Harbor near Glebe Point, Westmoreland County, Virginia (Figure 3) (Kelso and Chappell, 1974). Archaeologists believe that this is a kiln site for Morgan Jones wares. They assigned the kiln wasters as Morgan Jones ware due to similarity in appearance to the typological description. Typological assignment has been confirmed using petrographic analysis. This confirmation is based on mineralogy and basic physical hand descriptions (Kelso and Chappell, 1974; Straube, 1995).

Orange micaceous wares

Orange micaceous wares bear a remarkable resemblance to Merida wares. Bruce Council (1975) first defined this ceramic ware while excavating at Convento de San Francisco in Santo Domingo, Dominican Republic. Researchers at the Museum of Natural History in Florida state “Orange micaceous wares of the Spanish colonies may originate from that tradition [Merida]” (Deagan, 1987). Merida and orange micaceous wares are very similar in appearance and temper inclusions. Orange micaceous ware ceramics are believed (Council, 1975; Deagan, 1987) to be a mass produced ware type that was made and traded after 1550. Deagan (1987) describes orange micaceous as a having a compact clear orange paste without noticeable sand temper inclusions, although there are numerous visible flakes of mica. Deagan goes on to further describe the vessel surfaces of orange micaceous ware samples as smooth and normally unglazed, though remnants of a thin orange or red slip may be detected. Striations on the outer surface may be visible

(South, 1988). Decorations include incised lines, pinched or finger molded areas and linear series of rouletting. Vessel forms of orange micaceous ware include taza (a small drinking cup), pocillo

Figure 3: St. Mary's City. St. Mary's City lies across the Potomac River from the Morgan Jones Kiln site in Westmoreland County, Virginia (Papenfuse and Coale III 2003).

(a small, handless cup form with a height greater than its width) and plato (a flat plate or shallow saucer like ceramic vessel) forms (Deagan, 1987). No clay sources or manufacturing areas were identified in the research on orange micaceous ceramics (Deagan, 1987). Also, there are no known samples of orange micaceous wares from Europe.

Orange micaceous wares are found at other colonial sites in the New World including Santa Elena in South Carolina (Deagan, 1987). This ware is most abundantly found at the Spanish colonial sites in Florida and the Caribbean (Deagan, 1987; South, 1988). Orange micaceous wares are found at the Convento de San Francisco in Santo Domingo, Dominican Republic, and at other Caribbean sites such as El Morro, Puerto Rico and Havana (Deagan, 1987; South, 1988). Excavations at several colonial sites in Florida have also yielded orange micaceous ceramics (Deagan, 1987). These include St. Augustine, San Juan del Puerto, Fig Springs and Baptizing Springs (King, 1981; Deagan 1987). Outside of Florida and the Caribbean orange micaceous ware samples have been identified at Santa Elena, South Carolina and Nueva Cadiz, Venezuela (Deagan, 1987).

Deagan (1987) and South (1988) raise the possibility of Merida and orange micaceous wares being the same ceramic style based on hand sample description of both ceramic wares. Petrographic examination in this study has allowed for the determination of the relationship between these two wares.

Comparison of Morgan Jones ware to Merida ware and orange micaceous ware is needed to determine the relationship between these three wares. Confirmation of the typological assignment of samples to Morgan Jones has also been conducted using petrography and modal analysis. Confirmation was needed to ensure kiln waste samples from a kiln in Glebe Harbor, Virginia were truly Morgan Jones ware samples.

Geology of Ceramic Source Areas

Iberian Peninsula

In order to determine provenance of the Merida ceramics, a basic understanding of the geology of the proposed source area on the Iberian Peninsula is needed. Many different rock types are present in the proposed area of manufacture (Figure 4). The Badajoz-Còrdoba shear belt runs diagonally across the regions of Alentejo, Portugal and Extremadura, Spain. Gibbons and Moreno (2002) describes the shear belt continuing along the same strike into Portugal. The shear belt contains high-grade metamorphic rocks including schist, gneiss and amphibolites (Gibbons and Moreno, 2002). These rocks are potential sources of mica, both biotite and muscovite. The metamorphic rocks were intruded during the Paleozoic by granite (calc-alkaline varieties), diorite, gabbro and tonalite (Gibbons and Moreno, 2002). A Tertiary sedimentary basin overlies the crystalline rocks. Merida, Spain is near one of the sedimentary basins. Sandstone, mudstone, siltstone, limestone and gypsum are all found in this basin (Gibbons and Moreno, 2002).

Quartz, feldspar and micaceous minerals are present in many of these rock types present in this area. The modern climate of the Iberian Peninsula is warm and dry and physical weathering is dominant. Feldspars and quartz would remain largely unweathered in this environment. Micaceous minerals would also be expected in sediments in this area.

Maryland and North Virginia

St. Mary's City is located on the coastal plain of southern Maryland along the Chesapeake Bay. The city lies in the region known as the Western Shore Uplands, an area of the

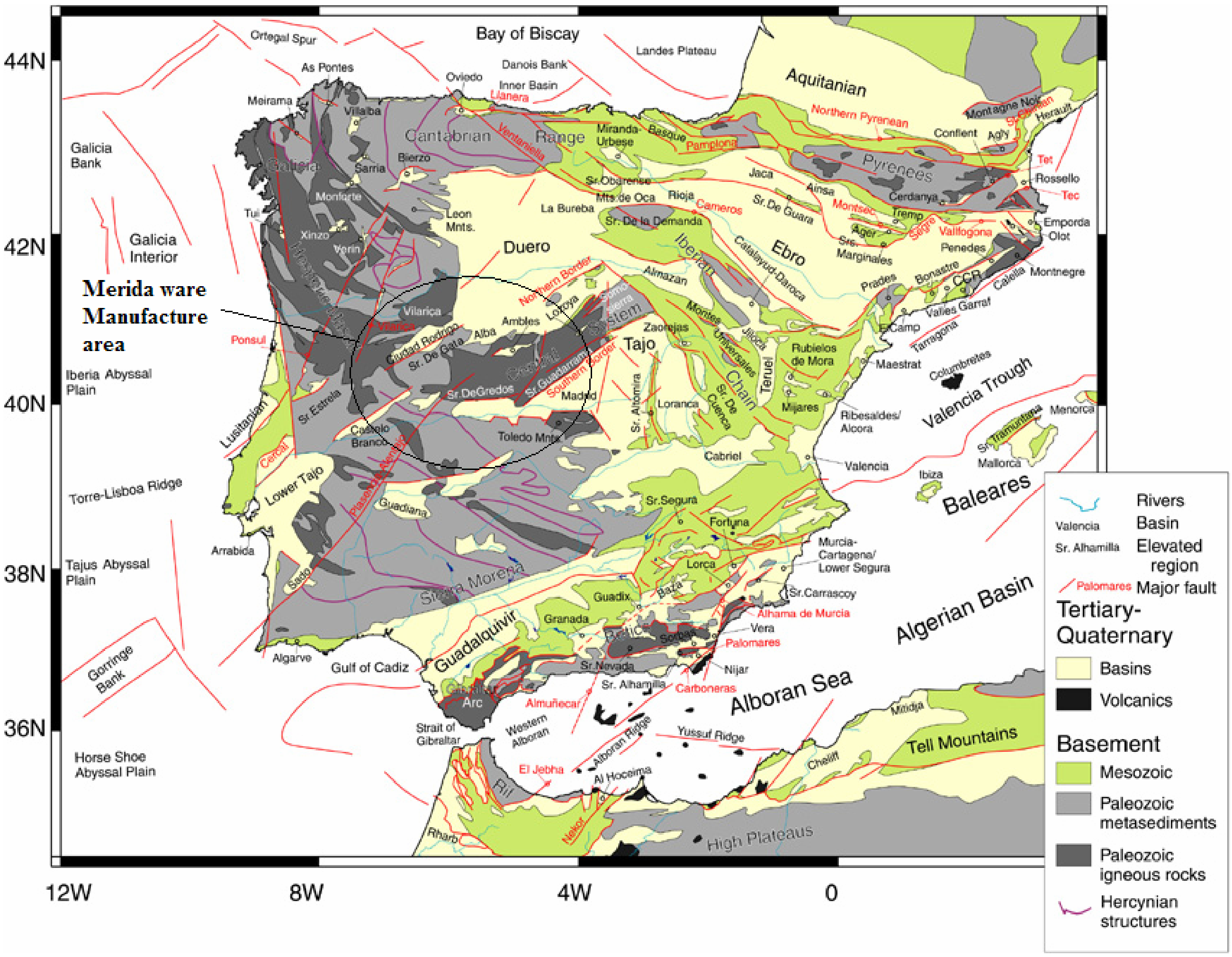


Figure 4: Generalized geologic map of the Iberian Peninsula (Andeweg, 2002).

coastal plain that is higher in elevation. The geology of Maryland and Northern Virginia is very similar (Figure 5). The coastal plain of Maryland and Northern Virginia is composed of unconsolidated gravel, sand, silt and clay size sediments that range in age from Triassic through the Quaternary. The sediments unconformably overlay the crystalline rocks of the Piedmont and Coastal Plain. Rocks of the Piedmont are crystalline igneous and metamorphic rocks. Metamorphic rocks in the area include schist, gneiss and metavolcanic rocks.

Paleozoic crystalline rocks underneath the sediments in the coastal plain are rich in quartz, feldspars and micaceous minerals. However, the climate in this are would affect what products remain after. In this area, the climate is mild and wet thus promoting extreme chemical weathering along with physical weathering. The feldspar minerals are mostly weathered to clay minerals and are not expected in sources for clay and tempering agents. Quartz generally resists physical and chemical weathering. Micaceous minerals on the other had, would be dramatically weathered and oxidized in the environment of northern Virginia and Southern Maryland.

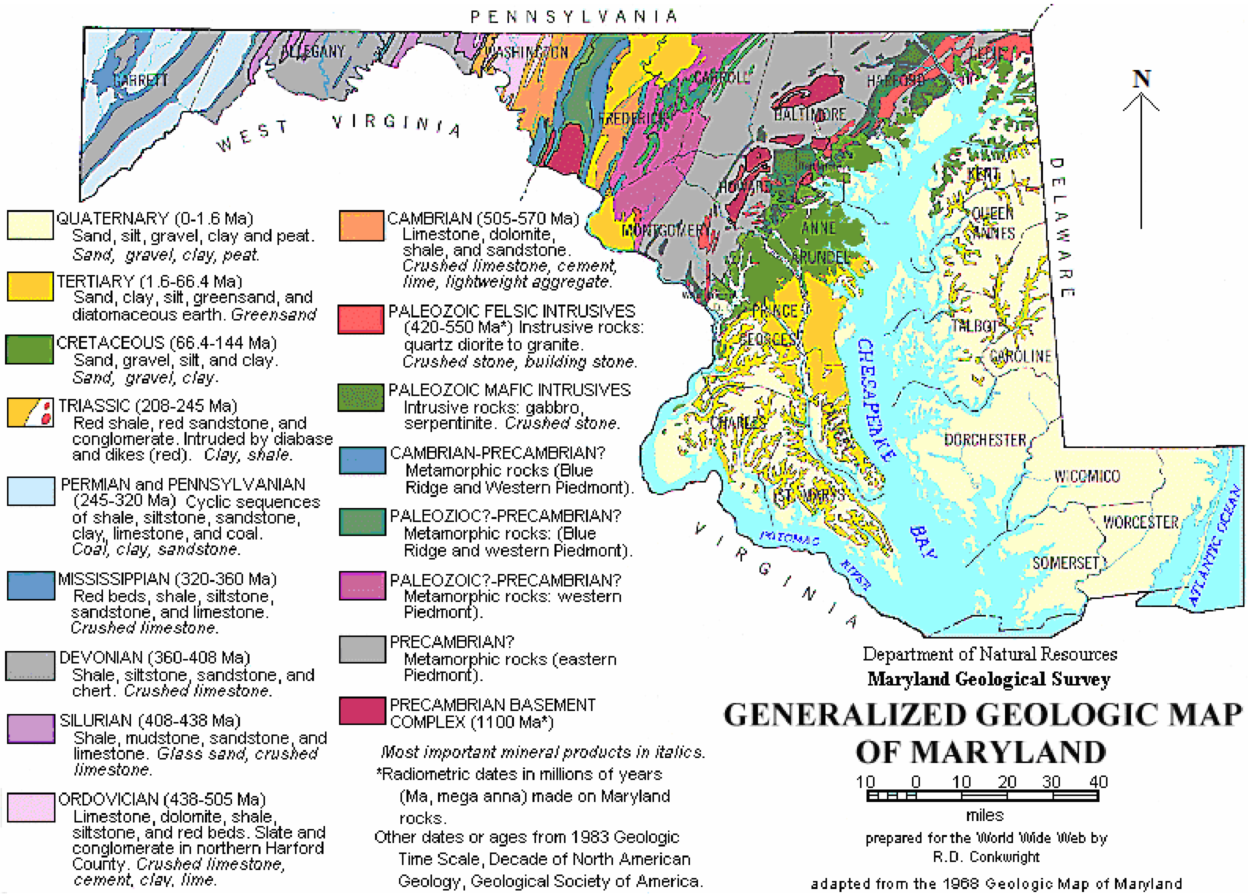


Figure 5: Generalized map of the geology of Maryland. The yellow and white areas are sediments present in the coastal plain. The green areas demark the beginning of the Piedmont province. (Maryland Geological Survey 2002).

History of the Archaeological Sites and Ceramic Wares

St. Mary's City Historic St. Mary's City, the first capital of colonial Maryland, was settled in 1634 under a charter granted by King Charles I of England (Hall, 1959). The charter granted the colonists land above the Potomac River which to be settled as a religious haven (Figure 3). Colonists sailed from England in November of 1633 aboard *The Ark* and *The Dove* (Miller, 1989). An exploratory expedition found a Yaocomaco village approximately six miles from the confluence of the Potomac and St. George's River (today called St. Mary's River) (Stone, 1987). The Yaocomaco, an Algonquin tribe, were early agriculturalists that lived off the abundant plant and animal life in the area, supplementing these natural resources with the crops. Leonard Calvert, the expedition's leader and later the colony's first governor, negotiated with the Yaocomaco and purchased the Yaocomaco village for the colony.

Soon after the settlers moved into the Native American village, they promptly began building a fort to ward off any attacks from the local native groups. The attacks never came and the fort fell into decay until the colonists dismantled the remains (Miller, 1989). A peaceful relationship was established between the colonists and the Yaocomaco. The Yaocomaco taught the settlers how to prepare the land to grow crops and introduced the settlers to tobacco, which would become the nucleus of the economy of colonial Maryland (Stone, 1987). Large manors were built in town while tobacco plantations were built outside the town limits along the rivers and creeks that cut across the land. The settlement soon expanded to approximately two square miles (Miller, 1989).

St. Mary’s City became the governmental, economic and judicial center for the colony of Maryland, but only had a population of less than one hundred people. These governmental and related activities were the basis for the founding of St. Mary‘s City, and soon many inns (and probably taverns) were constructed for the outlying farmers to stay when they came to town to conduct business. During the English Civil Wars (1642-1660), the economy of St. Mary’s City suffered (Stone, 1987). With the restoration of King Charles II in 1660, the city felt a resurgence of growth. Nevertheless, in 1694, the Maryland Assembly decided to move the capital and governmental offices to Annapolis primarily due to political reasons. Many of the city’s residents and businesses moved to the new capital (Miller, 1989). The town was abandoned and its buildings crumbled. Some residents did remain behind to continue growing their crops.

In the eighteenth century, several tobacco and wheat plantations occupied the area of St. Mary’s City. By 1840 a very successful tobacco plantation, Brome Plantation, was built. The plantation covered most of the area where the city had once been (Miller, 1989). This contributed to limited disturbance of the area. To celebrate the two-hundredth anniversary of the founding of Maryland, the St. Mary’s Female Seminary was built. Today the college functions as St. Mary’s College of Southern Maryland and a living history museum has been built where the city once stood.

St. Mary’s Ceramics

Six broad categories of ceramic wares have been described from excavations at St. Mary’s City (Miller, 1986; 1989; Hurry and Miller, 1989). They include porcelains, stonewares, tin glazed earthenwares, lead glazed earthenwares, slip decorated wares and unglazed earthenwares (Miller, 1986). Lead glazed earthenwares are by far the most common and diverse category of ceramics found in the collections from this site. Ten different ceramic types of lead glazed earthenwares were described from the 1981 excavations alone (Miller, 1986). Lead glazed earthenwares include Morgan Jones ware and other Colonial wares. Slip decorated wares are the second most abundant ceramic ware category at St. Mary’s City. North Devon Sgraffito Ware is the most common slip decorated ware seen in the 1981 excavations. Stonewares are also abundant and include Rhenish Brown, Rhenish Blue and Gray and English Brown wares. Tin glazed earthenwares present at St. Mary’s city are not very common or diverse. Unglazed earthenwares are also not very abundant, but do include Merida Micaceous Redware (Merida ware). Porcelain is very rare and only presents one sample from excavations in 1981 (Miller, 1986).

At St. Mary’s City, Merida wares are found in areas of the city that date between circa 1650-1700. These identifications were based on the typology established by JG Hurst (1976). Confirmation of this assignment was conducted during a visit by Hurst (Hurry personal communications, 2004). All of sherds found thus far do not exhibit any apparent glazes. Merida ware samples from St. Mary’s City are either plain or decorated with an incised line below the rim. This ceramic ware is abundant at the St. John’s site within St. Mary’s City (Miller, 1989).

Researchers at St. Mary’s City also cite the similarity in the Merida ware samples found at their site to the Spanish Florida orange micaceous wares (Hurry and Miller, 1989). Merida ware at St. Mary’s City was identified based on specific forms or rim profiles that are essential identifying traits to these wares (Hurry and Miller, 1989).

Morgan Jones pottery is the most common ware found at all of the sites in St. Mary’s City (Miller, 1989). Typology of this ceramic ware was established by archaeologists working at St. Mary’s City and in northern Virginia. Descriptions of this Morgan Jones are based on excavations and historical documents describing this ware (Kelso and Chappell, 1974; Miller, 1986; 1989). This ceramic ware is found at numerous sites within the city. Merida and Morgan Jones are found alongside one another at the site of St. John's within the city (Miller, 1989).

Researchers from St. Mary's City maintain that Morgan Jones wares are very different from the Merida wares that they find at the site (Miller, 1989). The major difference is that Morgan Jones wares found at St. Mary's City have a poorly applied glaze on the inner and outer ceramic surfaces and could, potentially, be confused with Merida wares that are glazed.

St. Augustine

St. Augustine was founded in 1565 as a joint venture between Pedro Menèndez de Aviles and the King of Spain as a way to stop the French encroachment in the New World (Figure 6) (Deagan, 1987). Figure Ultimately, Menèndez wished to raid the riches of gold in Florida. No gold was found and the native inhabitants were not easily tamed and ruled using a tribute system known as encomienda. Soon the Spanish also had to contend with the English as well as the French and the city was well fortified. St. Augustine was on of the dominant ports in the colony of Florida, which included parts of modern day Alabama and Mississippi.

During the seventeenth century the many Franciscan missions converting the native Indians, held the colony together. Garrisoned soldiers were housed near all missions to maintain peace and ensure that the friars taught the native allegiance to the Catholic Church and the Spanish Crown (Tebeau, 1971). However during this century Florida saw many changes. Trade between Spain and Florida was often unpredictable and colonists turned to the indigenous peoples for food and other supplies. Ceramic items were also acquired from indigenous peoples and began to replace the Spanish made products (Deagan, 1983). However, Spanish ceramics such as tin glazed earthenware, orange micaceous and other coarse earthenwares are still present in late seventeenth century sites.

Figure 6: St. Augustine. The city of St. Augustine is on the coast of northeast Florida (Mintz, 2003).

Beginning in 1763 under concessions in the First Treatise of Paris, Florida was seceded to the British, thus ending the First Spanish Period. However, British rule was short lived and the Second Spanish Period began in 1784. This period would continue until 1821 when Florida became part of the United States as a territory.

De Leon is an archaeological site located in the city of St. Augustine (King, 1981). No documentary or cartographic information has been located for the sixteenth and seventeenth century (Deagan, 1987). However, archaeological excavations in the late 1970 have revealed materials dating to these time periods (Deagan, 1987; King, 1981). From these excavations dates of occupation were defined as circa 1575 through the nineteenth century. Of the many archaeological finds from this site several pieces of orange micaceous wares were found (King, 1981). After the end of the First Spanish Period, there are many historical records mentioning the site and its owners (King, 1981). Today the site is home to a private residence. The St. Francis Barracks has more complete written history than the De Leon site (Hoffman, 1993). This site began as a Franciscan monastery in 1588 where friars were trained before leaving for their mission stations (Hoffman, 1993). A fire in 1599 destroyed the convento and chapel. The chapel was rebuilt in 1603 and in the convento was also rebuilt in 1610. The convento served as the headquarters for the Santa Elena province beginning in 1674 and was staffed by a preacher, a guardian and a lay brother (Hoffman, 1993). In 1702, fire once again destroyed the church and convento due to the attack by Colonel Moore, an English military leader. The monastery was not rebuilt until the 1750's. This time the Spaniards built the structure out of coquina. In 1764, the monastery first appeared on a map of St. Augustine. During the British period between the two Spanish periods, the site was home to British soldiers and two structures were built on the site (Hoffman, 1993). During the second Spanish period, the monastery was home to Spanish soldiers. After Florida became part of the United States in 1821 the site was home to a jail and then a military reservation. At this time the site was named "St. Francis Barracks (Hoffman, 1993)." The military reservation was abandoned in 1900. Between 1901 and 1907 the site was vacant. In 1907 the site became home to its current resident the State Military Headquarters.

Archaeological excavations were conducted in 1988 to mitigate the impact of proposed sub-surface construction activities on archaeological resources and to locate the Franciscan monastery (Hoffman, 1993). Orange micaceous wares were found during these excavations (Hoffman, 1993).

St. Augustine Ceramics

St. Augustine is the oldest continuous occupied city in the New World. With this long and rich history there are a number of ceramic types found at sites throughout the city of St. Augustine (Deagan, 1987). Origins of these ceramic types are also varied due to the various occupations by different powers. Native Americans dominated the area prior to European contact. Post-contact many of these same cultures traded with the Spanish after the settlement of St. Augustine. Several of the ceramic types that are present in the historical collections from St. Augustine are Native American origin (Deagan, 1987). One hundred thirty-three different ceramic types dating to the historical period are found in St. Augustine (Deagan, 1987). Spanish ceramic types are the most abundant and most variable. These ceramic wares include unglazed coarse grained earthenwares, majolica, lead glazed coarse earthenwares, porcelain and stoneware. Majolica and unglazed earthenwares are both very abundant and diverse (Deagan, 1987). Unglazed earthenwares include orange micaceous ware. Majolica wares include those produced in Iberian Peninsula and in Mexico (Deagan, 1987). Several different styles of Chinese Porcelain have been recovered in excavations, but are rare. Stonewares are present, but are not as common as the Spanish produced earthenwares. Spanish produced wares are more common than any other ceramic ware excavated at St. Augustine (Deagan, 1987).

Orange micaceous ware is found at a number of sites within the city of St. Augustine. These sherds of ceramic are abundant in the archaeological assemblage dating to the late sixteenth century through the early to middle seventeenth century. Many vessels were mended together to provide the common vessel forms. Within St. Augustine, orange micaceous ware vessels were most commonly cups and plates (platos).

Orange micaceous ware sherds from St. Augustine follow the typology described in Deagan (1987). Decoration of this ware is limited incised lines below the rim of some vessels. Glazed vessels are not present in the assemblages. Orange micaceous sherds are found a numerous archaeological sites throughout St. Augustine including the sites of De Leon and St. Francis Barracks.

Previous Research

Merida

John G. Hurst (1976) first identified Merida-type wares by examining pottery found at Medieval and Post-Medieval sites in England. Six fabrics have been defined by Hurst (1976). Captions below illustrations of select vessels from Hurst 1976 provide descriptions of six fabrics. Distinctions between these six fabrics are based on the observed paste color (Table 2) coupled with some textural descriptions. Paste color varies from orange-buff to brown. All six fabrics are noted for their micaceous nature. Two of the wares are described as sandy. Hurst is most likely referring to the coarse grained nature of inclusions/temper.

Table 2: Fabrics of Merida ware described by Hurst.

Fabric	Paste Color	Vessel Form
1	Micaceous red to buff with grey core	Standing costrel, barrel costrels
2	Brown micaceous	Standing costrel
3	Brown micaceous with buff red surface	Standing costrel
4	Orange-buff micaceous sandy fabric	Standing costrel
5	Very micaceous pink-brown sandy fabric	Standing costrel
6	Red micaceous	Standing costrel, bottles

Thin section examination of some Merida-type ware ceramics found at a site in Exeter England was conducted by Williams in 1984. Williams (1984) distinguished two distinct fabrics based upon mineral constituents (Table 3).

Fabric one is described as having a fine to coarse texture. Samples of this fabric are micaceous (both muscovite and biotite) and common feldspar inclusions (Williams, 1984). Samples of fabric one date to the sixteenth through the eighteenth century (Williams, 1984).

Fabric two samples are described as being fine textured with small amounts of muscovite and biotite. Large quartz grains are present in samples of this fabric (Williams, 1984). Feldspar is present as plagioclase, microcline and orthoclase (Williams, 1984). Quartzite, sandstone and siltstone rock fragments are also present.

Table 3: Comparison of Williams' and Cranfill Merida ware fabrics.

	Exeter England (Williams 1984) *	Historic St. Mary's City (Cranfill 2004)
Fabric One	Fairly micaceous with muscovite and biotite. Frequent feldspars. Dates from sixteenth century to 1700.	Micaceous with both muscovite and biotite. Muscovite more abundant than biotite. Rutilated quartz present along with monocrystalline and polycrystalline quartz. Light to medium orange-red paste. Some rock fragments present
Fabric Two	Fine textured with lesser amounts of biotite and muscovite. Larger quartz grains and some plagioclase, microcline and orthoclase. Some quartzite, sandstone and siltstone also present.	Micaceous with both muscovite and biotite. Muscovite more abundant than biotite. Monocrystalline and polycrystalline quartz present. Dark orange-red paste. Some rock fragments present.

Attempts were made to correlate fabric compositions to clay and kiln sources based on the mineralogy of the fabric (Williams, 1984). Williams' attempts were inconclusive because of the wide geographic area of manufacture and thus a wide variety of clay resources (Hurst 1986; Williams 1984). Additionally, the mineral phases (feldspar, quartz, biotite and muscovite) identified by Williams occur in a wide variety of rocks world wide.

Brown (2002) compiled nine different fabrics of Merida ware based on samples from Medieval archaeological collections from various sites in England (Table 2). These different fabrics are based on visual estimates of the quantity of inclusions and paste color. Brown's work did not include any systematic petrographic or geologic analyses.

Fabrics described by Brown are very similar to one another. Fabric three (Brown Fabric 1371) is stated as the most common fabric present in the Medieval archaeological assemblage (Brown, 2002). Though there are nine fabrics, the paste color descriptions are very similar. The majority of the fabrics have a paste color described as red or some slight variation on red. Seven fabrics mention red as descriptor in the paste color. Only one other fabric has the paste color described and it is rich dark brown. It is not clear whether these colors were identified using a Munsell color chart or whether these descriptions are based on observations by archaeologists.

Surface features also do not provide a clear distinction between the nine fabrics. Two fabrics exhibit a clear lead glaze. One fabric exhibits a green glaze and a final fabric is burnished and smoothed. Surface treatments are not listed for five of the nine fabrics (Table 4).

Vessel form also, does not provide a clear distinction between the fabrics. The most common vessel form is a flask accounting for five of the nine fabrics. The other vessel forms are bowls, jars, jugs and cooking pots (Brown, 2002).

Some differences in inclusions are apparent when comparing these fabrics. White mica is the most abundant inclusion class and was present in seven fabrics. Quartz is also a common inclusion and is identified as clear and/or gray inclusions. One inclusion class is an unidentified powdery white inclusion and found in two fabrics. Some fabrics have a greater variety of inclusions when compared to the others (fabrics 1355, 1371, 1470, 1476 and 1536). These five fabrics have more than one inclusion class defined with the most common combination of inclusions being quartz and white mica. Some fabrics have as many as three inclusions described.

It is difficult to compare the fabrics described by Hurst (1976), Brown (2002) and Williams (1984). All three researchers have used different criteria for the definition of unique fabrics. Hurst (1976) used paste color combined with limited textural data. Brown (2002) used visible inclusions to define unique fabrics. Williams (1984) defined fabrics based on inclusions identified in petrographic analysis. Additionally, all three studies show the number of different ways ceramics can be described. Hurst (1976) described fabrics based solely on the paste color visible in hand sample. Brown (2002) used several hand sample descriptions to define fabrics. He used paste color, surface treatments, vessel from and inclusions that are visible in hand sample. Williams (1984) defined his two fabrics based on inclusions identified in

Table 4: Nine Merida ware fabrics identified by Brown (2002).

Brown Fabric	Paste Color	Surface Treatment	Vessel Form	Inclusions
Fabric 1305	Pink-red	not given	Flask	Quartz
Fabric 1355	Warm red-orange	burnished and smoothed	small bowl	white mica, red iron
Fabric 1371	red to dark brown	not given	flasks, bowls, jugs, oil jars	clear and gray quartz, white mica
Fabric 1470	Pale red	not given	Flask	white mica, powdery white inclusions
Fabric 1471	red	not given	Flask	clear quartz
Fabric 1476	red	greenish glazed	Flask	quartz, white mica, metamorphic rocks
Fabric 1536	rich dark brown	clear lead glaze	small jug or jar	quartz, white mica, powdery white inclusions
Fabric 1543	not given	not giver	Mercury jar	sparse mica inclusions
Fabric 1776	Red	clear lead glaze	jar, cooking pot	white mica

petrographic analysis. Paste colors were defined by Hurst and Brown. Neither author stated if a Munsell Color Chart was used to define the paste color or if the colors are based on their perception.

Comparisons between the Williams and Hurst studies yielded basic relationships. All six fabrics described by Hurst mention the micaceous nature of each fabric. Due to this micaceous nature all six could correlate with Williams fabric one. However, micaceous minerals are also mentioned in fabric two. Abundances of the micaceous minerals are not mentioned in the Hurst descriptions. Hurst only describes the paste color and vessel form of his six wares. Williams only describes the mineralogy of his two wares. In order to compare Hurst and Williams you would need paste color and/or vessel form for the fabrics defined by Williams or mineralogy of the six Hurst fabrics.

Comparison of fabrics identified by Hurst (1976) and Brown (2002) is easier because both studies describe vessel form and paste color. Six different paste colors are described by Hurst. Brown (2002) provides the paste color for eight of the nine fabrics he describes. Hurst describes one fabric paste as brown and this fabric correlates with one of Brown's fabrics (fabric 1536). Another Hurst fabric is described as brown with a red surface. Brown's fabric 1371 is described as red to dark brown and cold correlate with Hurst's fabric with a brown paste with a red surface. An orange to buff (cream to beige) paste is described by Hurst (1976) and could correlate to Brown's fabric with a warm red-orange paste color (fabric 1355). Brown (2002) and Hurst (1976) both describe a pink paste (Hurst fabric 5 and Brown fabric 1305). Red micaceous paste is described by Hurst and is very common in Brown's descriptions, accounting for four fabrics (fabrics 1470, 1471, 1476 and 1776). Hurst describes three vessel forms including standing costrels, barrel costrels and bottles. Costrels are drinking vessels that can be attached to the belt. All six Hurst fabrics are present in costrel vessel from. Brown describes flasks for the vessel form of five of his nine fabrics. Flasks are very similar to costrels described by Hurst.

When comparing the work conducted by Brown (2002) and that conducted by Williams (1984) differences in technique and ways of describing different fabrics are apparent. Williams used petrographic techniques to describe his fabrics, whereas Brown described what was visible in hand sample. Both Brown and Williams describe similar inclusions and similar paste colors. A possible relationship between the fabrics of these two studies is apparent when comparing the inclusions identified in the fabrics of each study. Williams (1984) fabric one is described as being highly micaceous containing both biotite and muscovite. Brown (2002) describes seven fabrics that contain white mica inclusions (fabrics 1355, 1371, 1470, 1476, 1536, 1543, 1776) and could correspond to Williams' fabric one. Williams describes fabric two as contains smaller amounts of micaceous minerals along with other mineral inclusions such as microcline, orthoclase, plagioclase and large quartz inclusions. Brown describes two fabrics that do not have white mica inclusions, but do contain quartz inclusions (fabrics 1305 and 1471) and could correlate to Williams' fabric two.

Mineralogical analysis of the Merida wares from Maryland was conducted by the author as part of a senior thesis at University of North Carolina at Wilmington (Cranfill, 2004). Petrographic studies revealed two distinct fabrics that are different from the fabrics identified by Williams (1984) (Table 3). Major minerals found in the paste and as temper inclusions are muscovite, quartz, biotite, and the feldspars. Quartz was the most abundant mineral included as temper followed by muscovite. Biotite was an accessory mineral that was not very abundant. One mineral inclusion was found in only a few samples is rutilated quartz. Grog was also included as temper. This research concluded that the ceramics were probably produced in Spain and transported or traded to Maryland. A need for comparison between similar ceramic types (orange micaceous and Morgan Jones wares) and a need to narrow the area in which a clay source is located for Merida wares was also apparent after the study (Cranfill, 2004).

When comparing my previous study (Cranfill, 2004) to Hurst (1976) both fabrics from 2004 could correspond to Hurst's fabric with orange-buff micaceous sandy fabric (Fabric 4). Both fabric one and fabric two from the 2004 study have an orange-red paste. The diverse mineral inclusions present in both fabrics one and two from the 2004 study could correlate to Williams' fabric two. Both fabrics from Cranfill (2004) could also correspond with fabric 1355 identified by Brown based on the orange paste color.

Morgan Jones

Morgan Jones wares have not been extensively studied. Most studies of Morgan Jones wares have focused on identifying and locating the kiln where the pottery was manufactured (Miller, 1989; Kelso Chappell, 1974). Morgan Jones worked alongside several associates and founded a kiln in Virginia across the Potomac from St. Mary's City (Figure 3). Kelso and Chappell (1974) identified the kiln used in the year 1677 during archaeological excavations in Westmoreland County.

Comparison of Morgan Jones wares to other colonial pottery being produced in the Tidewater of Virginia was conducted by Straube (1995). This study focused on historical records as a basis of comparison. Kiln type and basic hand sample descriptions were produced during this study. No petrographic analysis was conducted during any of these studies.

Orange micaceous

Council (1975) first identified orange micaceous wares during excavations in the Dominican Republic. Other archaeologists (Deagan, 1987) working in the Spanish North

America identified these same ceramics from sites in the Caribbean and at other colonial sites in the present day United States. South (1988) also identified orange micaceous ceramics in deposits from Santa Elena, South Carolina. Relatively little comparison has been conducted between the orange micaceous wares found at these sites.

Petrographic analysis has not been conducted on any orange micaceous ware samples. Comparisons between Merida and orange micaceous wares have been based on descriptions provided by archaeologists such as Hurst (1986) and Council (1975). These descriptions and comparison have been based on paste color; temper identified in hand sample, vessel form, paste characteristic (texture) and decoration. No systematic studies to compare these two wares have been conducted previous to the present study.

Present Study

Samples

Six Merida ware samples were obtained from the collections at Historic St. Mary's City. These samples were chosen by the archaeologists at this site and they stated their assignment as Merida ware samples (Hurry personal communications, 2004). All six were beach finds from the Chancellor's Point area along the St. Mary's River south of the city. Other samples of Merida wares were identified at the site of St. John's and other sites within the city (Miller, 1989).

Four Morgan Jones samples were chosen from collections at St. Mary's City. Two of these samples were recovered in excavations at St. Mary's City (Hurry personal communications, 2004). The other two samples were recovered in excavations at a kiln site at Glebe Harbor, Westmoreland County, Virginia. These samples were chosen based on an overlap of time period between these samples and the Merida samples. Within St. Mary's City, Morgan Jones wares are found at the St. John's site alongside Merida wares (Miller, 1989).

Four orange micaceous samples were obtained from the historic collections at the Florida Museum of Natural History, University of Florida, Gainesville, Florida (Woods personal communication, 2004). Archaeologists at the museum assigned these samples as orange micaceous based on hand sample characteristics. One sample (89-1345) was recovered in excavations at St. Francis Barracks site in St. Augustine, Florida (Woods personal communication, 2004). The three other samples were recovered in excavations at the De Leon site in St. Augustine, Florida (Woods personal communication, 2004). These samples were also chosen because of an overlap of time period with the Merida ware samples.

Archaeologists from both the Historical St. Mary's City Commission and the Florida Museum of Natural History were consulted for the selection of samples for this study (Hurry, 2004/2005 personal communications; Wood 2004, personal communication). Few collections contain these ceramic types and thus there is a limited availability for destructive studies. The small sample size used in this study is thought to be representative of Merida ware, Morgan Jones ware and orange micaceous wares from colonial sites in North America.

Sample Preparation

Samples were sent to a lab that specializes in the manufacture of thin sections. Thin sections were manufactured and polished for use in an electron microprobe. The manufacturing process requires very small samples be adhered to a glass slide using a special epoxy (Nesse, 2000). Several grinding steps are required to grind samples down to 0.03 millimeters thickness. This thickness is important when identifying minerals petrographically and most researchers chose to send samples to commercial thin section labs for preparation for this reason. After the necessary thickness is achieved these thin sections were polished for use in an electron microprobe.

Analytical Methods

Petrographic analysis using a petrographic microscope with transmitted and reflected light was conducted to determine tempering agents in three ceramic wares. Ceramics are considered stony archaeological materials because it is essentially man made stone and many of the same techniques used on rocks are used in ceramic analyses. Identification of temper inclusions aids in determining a clay or temper source (Rice, 1987; Garrison, 2003). During firing clay minerals lose their crystalline structure at temperatures around 500-600° C (Rice, 1987) and most types of pottery are fired to temperatures between 650-900°C. Ceramics fired to high temperatures thus do not have any identifiable clay minerals and the resulting paste is vitrified material. Only paste color is visible under the petrographic microscope all other properties were lost during the firing process. Tempering materials are most often minerals and can be differentiated from the paste by visible mineral properties. Inclusions are materials not naturally occurring in the clay and can be minerals, rock fragments, organic fragments or man made objects (Shepard, 1956; Rice, 1987). Inclusions serve a similar function as tempering agents; however, it is not known whether they were intentionally added to the clay or not. Grog is a common man made object included as temper in clay during pottery manufacture. Under the petrographic microscope, grog is opaque. The presence of visible inclusions of minerals in the grains of rounded grog coupled with the fact that grog does not reflect light distinguishes it from opaque minerals.

Polycrystalline quartz and quartzite rock fragments are difficult to distinguish from one another especially in the sand-sized inclusions found in ceramics. Polycrystalline quartz often has smaller crystals than the quartzite inclusions. Also, quartzite rock fragments are more angular than the subrounded polycrystalline quartz inclusions.

Plagioclase (Ca, Na) and alkali (K, Na) feldspar are the two basic types of feldspar. Solid solution occurs between the albite (Na) to anorthite (Ca) end members of plagioclase and the albite (Na) to potassium feldspar (K) end members of alkali feldspar producing intermediate compositions. Twinning in feldspar grains is used to differentiate between plagioclase and alkali feldspar. Plagioclase has albite (polysynthetic, parallel twin planes) and Carlsbad (single, penetration twin plane) twinning (Nesse, 2000). Alkali feldspars also have Carlsbad twinning. However, alkali feldspars sometimes have a grid-iron style of twinning that is produced by a combination of albite and perilcine twin planes (Nesse, 2000). This allows plagioclase and potassium feldspar to be differentiated using the petrographic microscope. Feldspars are difficult to differentiate in ceramics when grains are untwinned.

Opaque minerals are abundant in all three ceramic types studied. These minerals reflect light and can be differentiated from the grog inclusions. All opaque minerals were combined during modal analysis. However, each inclusion was checked with reflected light microscopy to ensure that it was truly an opaque mineral and not a small piece of grog.

Modal Analysis

Point count analysis (PCA) was conducted to determine the percentage of particular components within each sample (Garrison, 2003). Each type of temper or inclusion identified during petrographic analysis was counted along with paste. Spacing between points that was greater than the average grain size of the temper. Stoltman (1989) suggests that there be at least one hundred points per sample to improve counting statistics. Stoltman (1989) also states that if samples are large enough more points should be counted. Points counted represent the temper and inclusions present in the ceramic sample. Some samples included in this study were large enough for more points to be counted and up to 300 points were counted in these samples; but many of the samples analyzed in this study are small and did not allow for large number of points counted. With these smaller sized samples a total of 150 points were counted. Using the numbers from these counts percentages of the major, minor and accessory temper and inclusions were calculated.

Electron Microprobe Analysis

Electron microprobe analysis (EMPA) was conducted in the Electron Microprobe Lab, Department of Geology, University of Georgia to determine compositions of the temper minerals. Temper minerals analyzed include the feldspars (plagioclase and potassium feldspar), micaceous minerals (muscovite and biotite) and oxide minerals (rutile, ilmenite and hematite). Details of microprobe analyses are repeated in Appendix 3. Due to the high degree of similarity in the inclusions and temper between samples of a ceramic type, representative samples of each ceramic ware were chosen for analysis in the electron microprobe. Samples with twinned feldspar grains and larger inclusions of biotite and muscovite were chosen for analysis. When necessary, additional samples were chosen to gather more data. Multiple samples of Merida ware were chosen because two fabrics were identified in a previous study and there was a need to determine if inclusions differed compositionally.

Aside from determining compositions of certain mineral phases EMPA was also used to determine relative abundances of the feldspar inclusions. Energy dispersive analysis (EDS) determined the identity of feldspar inclusions. Relative abundances were then determined based on proportions of identified plagioclase and potassium feldspar inclusions.

The small grain size of temper materials (0.04-0.10 millimeters), presented a challenge for the electron microprobe analyses. Some grains are too small to even attempt analyses due to interference from other phases or the clay mixture itself. Micaceous phases were the smallest and most difficult grains to analyze. With these inclusions, it was necessary to widen the electron beam to prevent excitement of the surrounding paste. Void spaces near large mica inclusions were associated with oxidation of the micas and these areas were avoided during analysis.

X-ray Diffraction

X-ray diffraction (XRD) was conducted on two samples of Merida ware and two samples of Morgan Jones ware to confirm the temper mineralogy and determine if clay minerals were present. XRD is an analytical technique that is commonly used for the investigation of clay minerals (Moore and Reynolds, 1997). Clay materials used in pottery manufacture are commonly analyzed to determine the source area for the pottery type. However, when most clay minerals are fired to temperatures between 500-600° C they lose their crystalline structure and thus lose any properties that would all for identification (Rice, 1987). Temper materials were also determined using XRD.

Results

Morgan Jones Ware

At total of four samples of Morgan Jones ware were examined in this study (Table 5). Samples represent broken sherds of pottery found at St. John's archaeological site at St. Mary's City and the Glebe Harbor Kiln site in Westmoreland County, Virginia. The basic mineralogy of these samples includes quartz, feldspars, muscovite, biotite, opaque minerals and accessory minerals (Figure 7; Table 6). Quartz occurs as polycrystalline and monocrystalline subrounded to subangular grains without the presence of rutile needles. Micaceous minerals are rare inclusions in Morgan Jones samples. Micaceous mineral inclusions include biotite, muscovite and chlorite occurring as elongate and Rectangular grains. Subrounded to rounded opaque minerals include hematite, ilmenite and rutile along with some pyrite. Grog is present in fabric one identified in this study. Grog temper occurs as rounded to subrounded inclusions in samples of Morgan Jones ware.

All Morgan Jones ware samples appear similar in both hand sample and in thin section. Minute differences in paste color that are visible in hand sample are due to firing techniques. Two samples are grayish orange (10YR7/4) to dark yellowish orange (10YR6/6) and the other two samples are very pale orange (10YR8/2). Tempering agents were the same in all samples, though relative abundances may vary. Grog was not present in two the samples (ST1-23-47/AP and R-VA). Following the tradition of archaeologists examining colonial ceramics two fabrics were distinguished based on paste color.

Fabric one consists of the two samples with paste colors grayish orange and dark yellowish orange (Table 5). Both samples are lead glazed and lack any other decoration. Grog is not included as a tempering agent in these samples. Fabric two consists of two samples with paste colors that are grayish orange and dark yellowish orange. Both sample exhibit a lead glaze on the outer edge. Grog is included as tempering agent in these samples. Both fabrics are otherwise very similar in mineralogy with quartz, feldspar and opaque mineral inclusions being dominant (Figure 7). Size ranges of all inclusions overlap for all four samples (Table 6).

Two samples (R-VA and ST1-23-47/AP) were chosen for XRD analysis to determine minerals and if clay constituents were present in Morgan Jones wares. Minerals identified using this method include quartz and feldspar (albite or orthoclase) and this would be expected based on the abundances of these phases (Figures 8, 9). Clay minerals were not identified in either sample.

Table 5: Samples of Morgan Jones ware used in this study.

Sample Number	Fabric	Site	Color	Vessel Form	Inclusions
ST1-23-47/AP	One	St. John's, St. Mary’s City, MD	Pale Orange (10YR8/2)	Pitcher	quartz, feldspar, opaque minerals, biotite, muscovite, zircon, tourmaline and rock fragments
R VA	One	Glebe Harbor, VA	Very Pale Orange (10YR8/2)	Kiln Waste	quartz, feldspar, opaque minerals, biotite, muscovite, zircon, tourmaline and rock fragments
ST1-23-27/EJ	Two	St. John's, St. Mary’s City, MD	Grayish Orange (10YR7/4)	Pot	quartz, feldspar, biotite, opaque minerals, muscovite, zircon and grog
12 VA	Two	Glebe Harbor, VA	Dark Yellowish Orange (10YR6/6)	Kiln Waste	quartz, feldspar, opaque minerals, biotite and chlorite and grog

Table 6: Size ranges and abunaces of inclusions in Morgan Jones wares.

Sample Number	Quartz	Feldspar	Grog	Biotite	Muscovite	Opaque Minerals	Accessory Minerals	Rock Fragments
ST1-23-47/AP	43.5% (0.15-0.85 mm)	30.4% (0.10-0.60 mm)	0%	Minor {2.4%} (0.10-0.20 mm)	Minor {2.9%} (0.10-0.20 mm)	Ilmenite, Rutile Hematite 15.5% (0.02-0.14 mm)	Tourmaline Zircon 3.5%	1.8% (0.80-1.5 mm)
R VA	34.8% (0.05-0.80 mm)	20.6% (0.10-0.70 mm)	0%	Accessory {0.5%} (0.15-0.65 mm)	0%	Ilmenite, Rutile Hematite 39.2% (0.02-0.10 mm)	Chlorite Zircon 4.9%	0%
ST1-23-27/EJ	34.3% (0.10-0.85 mm)	29.4% (0.15-0.81 mm)	5.9% (0.20-1.5 mm)	Minor {2%} (0.20-0.70 mm)	Minor {5.5%} (0.90 mm)	Ilmenite, Rutile Hematite 21.9% (0.02-0.10 mm)	Zircon 1.0%	0%
12 VA	18.4% (0.10 - 0.85 mm)	34.6% (0.10-0.25 mm)	8.1% (0.20-0.90 mm)	Minor {1.8%} (0.30-0.70 mm)	0%	Ilmenite, Rutile Hematite 34.5% (0.02-0.10 mm)	Tourmaline Zircon 1.3%	1.3% (2.00 mm)

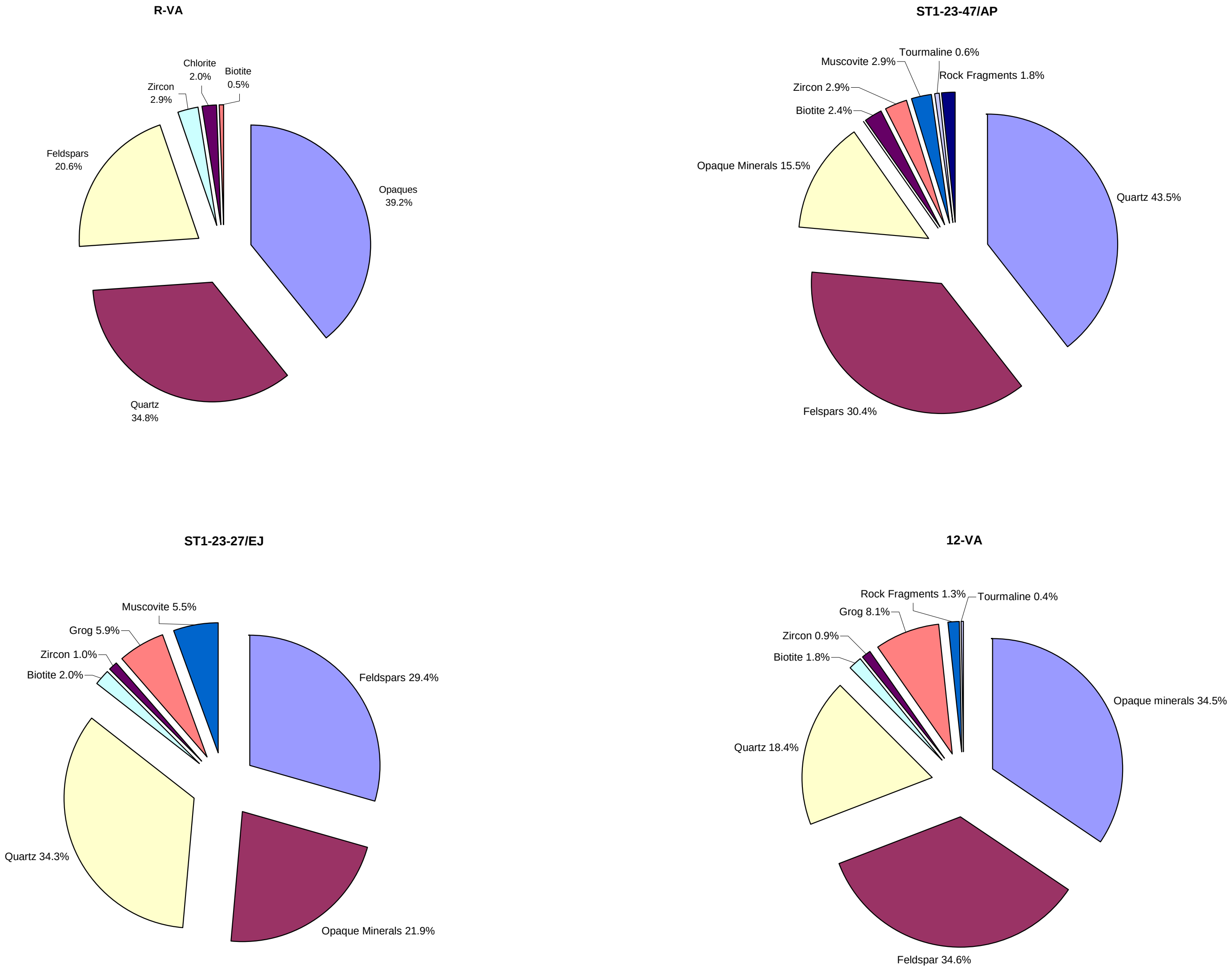


Figure 7: Modal Analyses of temper phases in Morgan Jones ware samples.

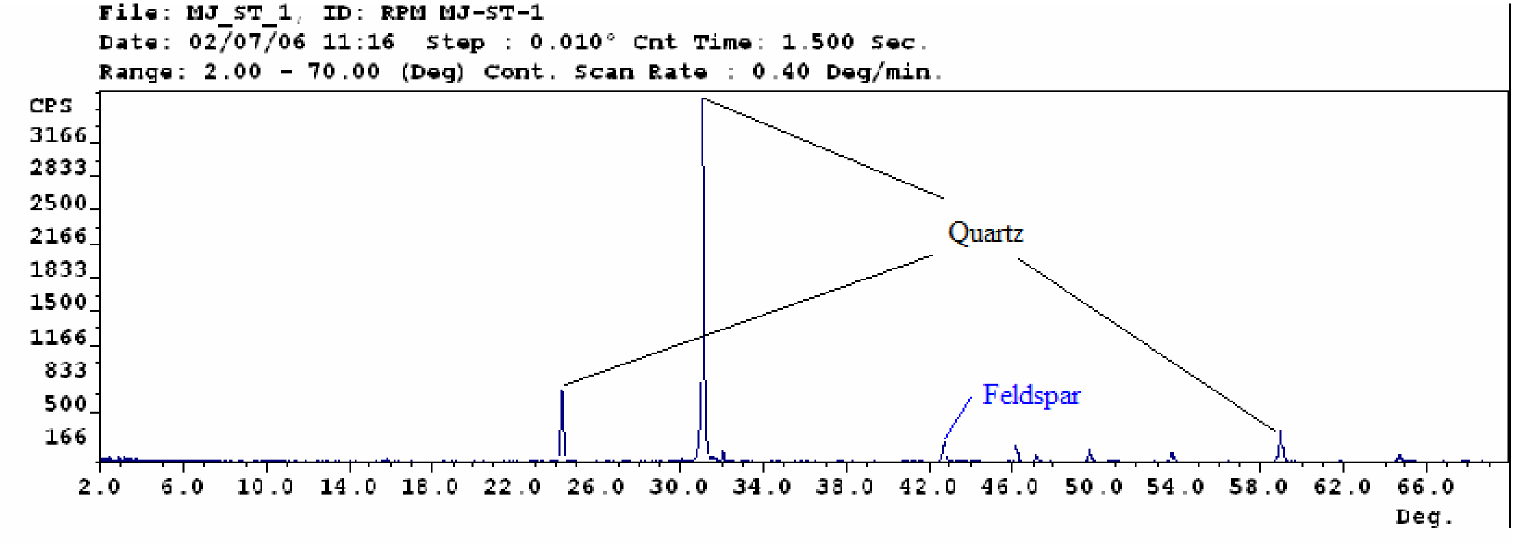


Figure 8: X-ray diffraction analysis of Morgan Jones sample ST1-23-47/AP.

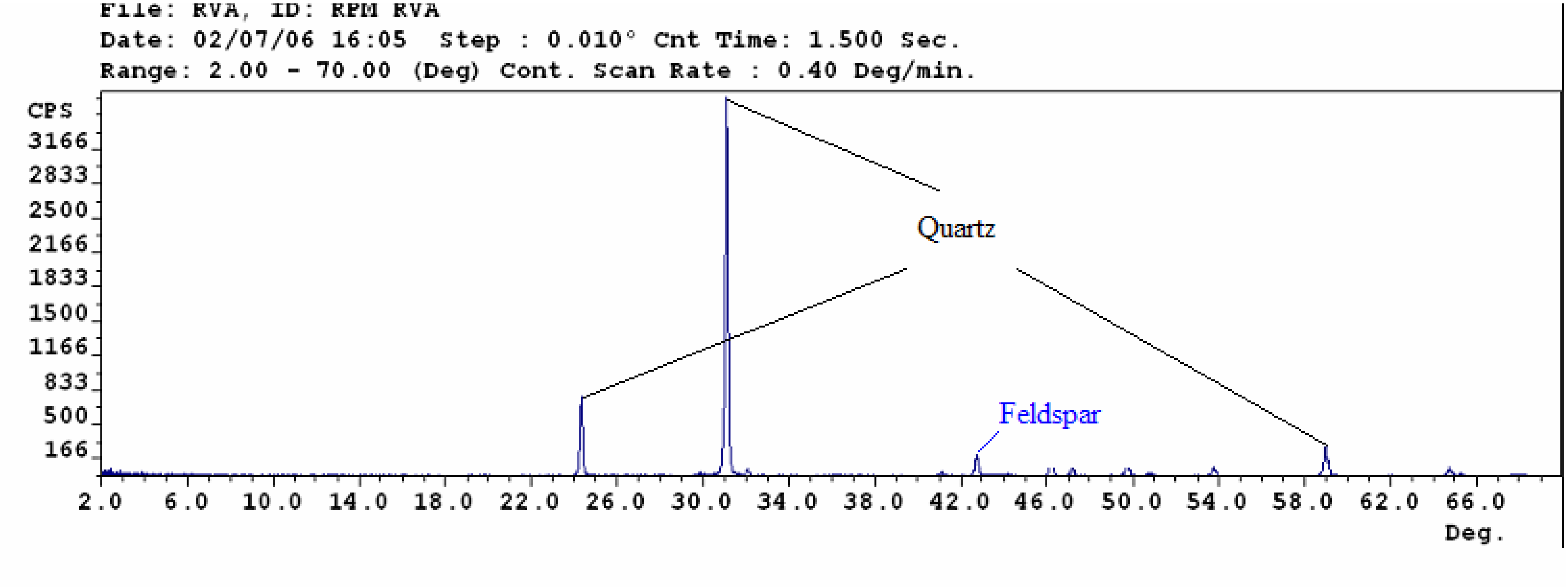


Figure 9: X-ray diffraction analysis of Morgan Jones sample R-VA.

Merida

A total of six Merida ware samples were examined in this study (Table 7). Samples of Merida ware represent broken vessel fragments that were collected along the shore of the St. Mary's River at a site known as Chancellor's Point. Excavations were not conducted and these samples were salvaged and used for destructive analysis because they have lost any contextual data.

The basic mineralogy of Merida wares includes quartz, feldspar, muscovite, biotite, rock fragments, grog, opaque minerals and accessory minerals (Figure 10; Table 8). Quartz occurs as subrounded to subangular polycrystalline and monocrystalline grains. Rutile needles are present in some of the monocrystalline quartz inclusions and these needles are visible petrographically. Feldspar inclusions are subrounded to subangular grains of plagioclase and alkali feldspar. Twinning is rare, but does occur occasionally in some grains of both plagioclase and potassium feldspar. Opaque minerals occur as subrounded to rounded inclusions. The majority of the opaque inclusions are oxide minerals and include rutile and ilmenite. Pyrite also occurs in Merida ware samples, but only as an accessory inclusion and is much less abundant than rutile and ilmenite. Grog occurs as rounded to subrounded inclusions and is present in all six samples. Most grog fragments have visible inclusions of quartz. Micaceous minerals present in samples of Merida ware include muscovite, biotite and chlorite. Muscovite occurs as elongate to Rectangular grains. Biotite occurs as Rectangular grains and is generally less abundant than muscovite. Chlorite is an accessory mineral occurring in only a few samples as Rectangular grains. Subangular rock fragments of metamorphic (phyllite) and sedimentary (sandstone) rocks. Zircon is an accessory mineral that occurs as subangular grains. Tourmaline is also an accessory minerals occurring as subrounded inclusions.

Table 7: Samples of Merida ware used in this study.

Sample Number	Fabric	Site	Color	Vessel Form	Inclusions
ST1-62-1/CZ Probed	One	Chancellor's Point	Moderate Reddish Orange (10R6/6)	Unknown	quartz, feldspar, opaque minerals, biotite, muscovite, rock fragments and grog
ST1-62Δ/JB	One	Chancellor's Point	Moderate Reddish Orange (10R6/6)	Unknown	quartz, feldspar, opaque minerals, biotite, muscovite, zircon, chlorite, rock fragments and grog
ST1-62Δ/PM	One	Chancellor's Point	Dark Yellowish Orange (10YR6/6)	Unknown	quartz, feldspar, opaque minerals, biotite, muscovite and grog
ST1-62Δ/PN	One	Chancellor's Point	Dark Yellowish Orange (10YR6/6)	Unknown	quartz, feldspar, opaque minerals, biotite, muscovite and grog
ST1-62Δ/PP Probed	Two	Chancellor's Point	Moderate Reddish Brown (10R4/6)	Unknown	quartz, feldspar, opaque minerals, biotite, muscovite, chlorite, rock fragments, tourmaline and grog
ST1-62Δ/PO Probed	Two	Chancellor's Point	Moderate Reddish Brown (10R4/6)	Unknown	quartz, feldspar, opaque minerals, biotite, muscovite and grog

Table 8: Size ranges and abundances of inclusions in Merida wares.

Sample Number	Quartz	Feldspar	Grog	Biotite	Muscovite	Opaque Minerals	Accessory Minerals	Rock Fragments
ST1-62Δ/PP	41.8% (0.04-0.61 mm)	33.6% (0.04-0.27 mm)	3.9% (0.25-0.82 mm)	Minor {2.5%} (0.03-0.13 mm)	Major {12.5%} (0.04-0.58 mm)	Ilmenite Rutile Pyrite 3.6% (0.02-0.10 mm)	Tourmaline, Chlorite 0.7%	1.4% (0.20-0.90 mm)
ST1-62Δ/PO	31.5% (0.06-0.80 mm)	45% (0.05-0.50 mm)	3.5% (0.15-0.85 mm)	Minor {3%} (0.03-0.17 mm)	Major {10%} (0.04-0.58 mm)	Illmenite, Rutile, Pyrite 7% (0.03-0.05 mm)	None	0%
ST1-62-1/CZ	27% (0.05-0.70 mm)	32.7% (0.04-0.45 mm)	3.7% (0.10-0.90 mm)	Major {7.3%} (0.03-0.23 mm)	Major {14.7%} (0.04-0.65 mm)	Ilmenite, Rutile, Pyrite 12.3% (0.02-0.10 mm)	None	2.3% (0.20-0.65 mm)
ST1-62Δ/JB	30.6% (0.05-0.83 mm)	18.3% (0.04-0.13 mm)	3.9% (0.10-0.60 mm)	Major {7.0%} (0.11-0.25 mm)	Major {21.4%} (0.05-0.55 mm)	Ilmenite, Rutile, Pyrite 9.6% (0.01-0.03 mm)	Chlorite, zircon 2.6%	6.6% (0.25-0.65 mm)
ST1-62Δ/PM	37.7 % (0.04-0.82 mm)	30.9% (0.03-0.13 mm)	0.5% (0.08-0.64 mm)	Major {5.5%} (0.08-0.14 mm)	Major {15%} (0.03-0.60 mm)	Ilmenite, Rutile, Pyrite 9.5% (0.02-0.07 mm)	None	0.9% (0.20-0.82 mm)
ST1-62Δ/PN	39.6% (0.08-0.81 mm)	27.7% (0.07-0.51 mm)	13% (0.13-0.88 mm)	Minor {4.5%} (0.03-0.18 mm)	Major {12.4%} (0.03-0.40 mm)	Ilmenite, Rutile, Pyrite 2.9% (0.02-0.10 mm)	None	0%

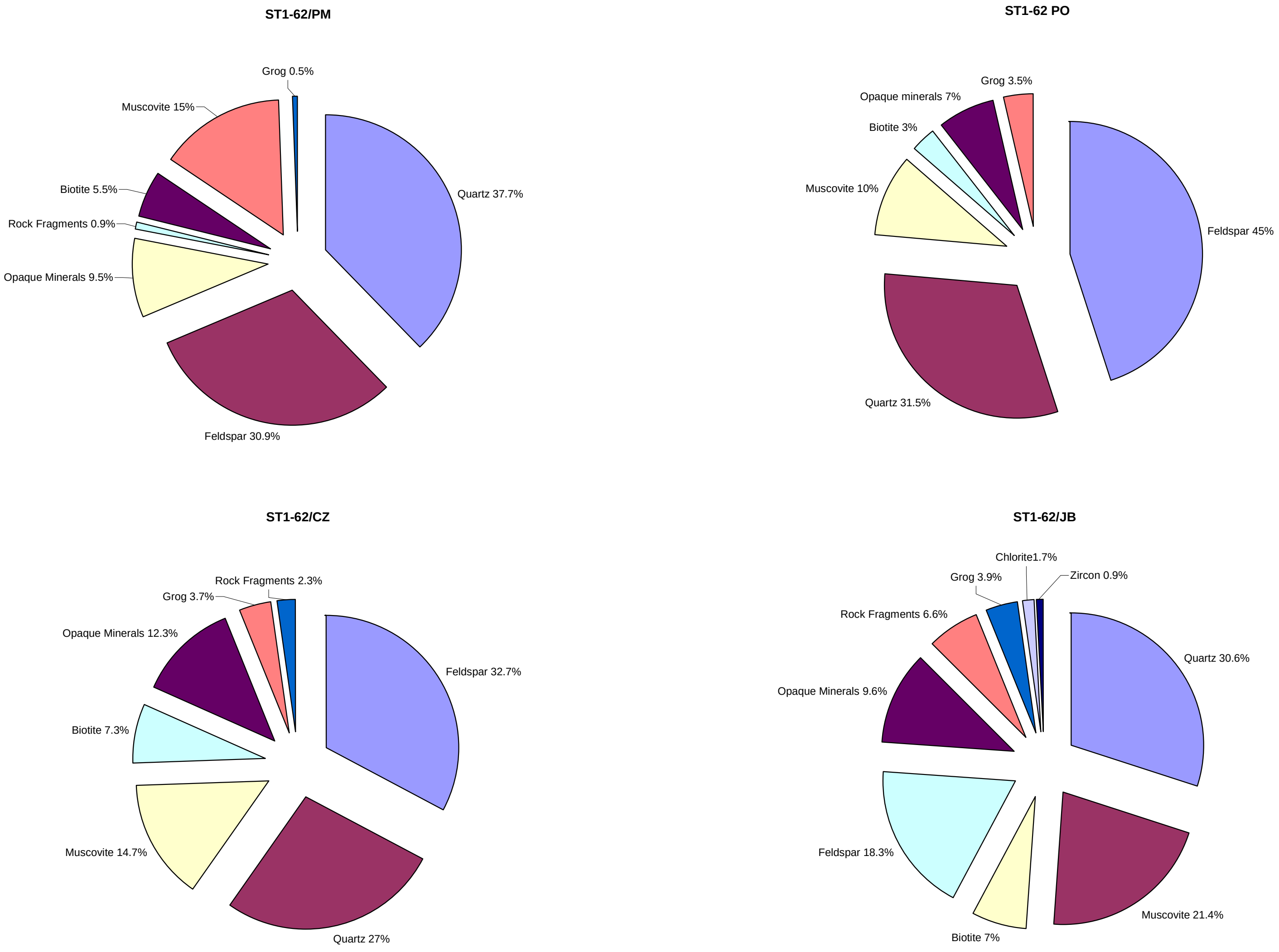
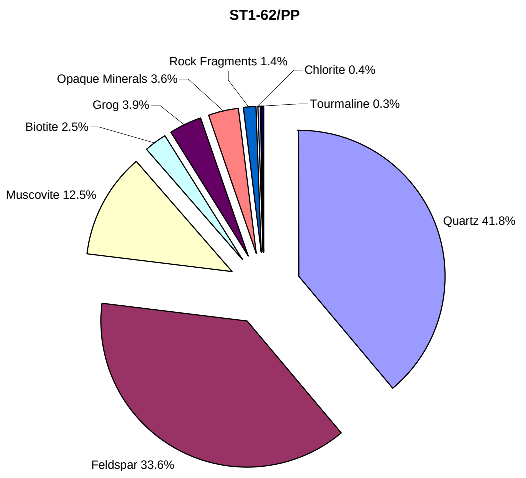


Figure 10: Percentages of temper phases in Merida ware samples.



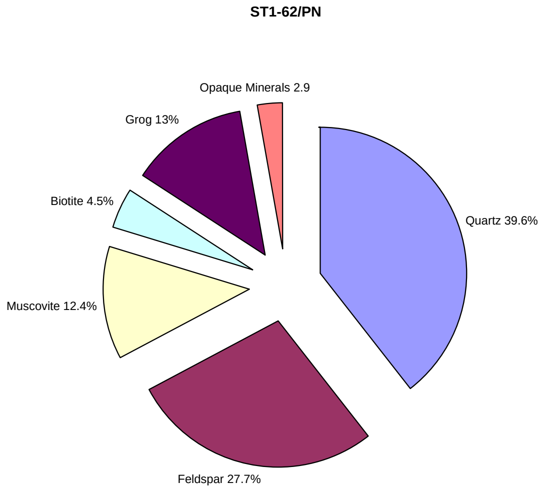


Figure 10 Continued: Percentages of temper phases in Merida ware samples continued.

Merida ware samples are similar in hand sample with slight differences in paste color. Following on past studies conducted by archaeologists on ceramic wares, two fabrics can be differentiated based on this slight difference in paste color along with the presence or absence of rutilated quartz following on my earlier study (Cranfill 2004) (Table 3).

Fabric one has a moderate reddish orange (10R6/6) to dark yellowish orange (10YR6/6) and inclusions of rutilated quartz. Mineralogically, these samples follow the description outline above for all Merida ware samples.

Fabric two has a moderate reddish brown (10R6/6) paste and no rutilated quartz. Mineralogically, these samples are also the same as the description of Merida wares outlined above.

Two samples of Merida ware were chosen for XRD analysis to determine and confirm the inclusions and temper materials added to these samples (samples ST1-62Δ/PP and ST1-62-1/CZ) (Figures 11, 12). Clay minerals were not identified in either sample. Minerals present in both samples are quartz, feldspar (albite or orthoclase) and muscovite mica. Quartz was identified as one of the most dominant phase present in petrographic analysis in both samples. Due to its dominance one would expect to identify it in the x-ray analysis. Feldspar is also a dominant phases in these two samples and appears in the x-ray data. Muscovite was identified in the x-ray analysis. XRD analysis correlates with the petrographic and modal analysis data presented earlier.

Orange micaceous

Four samples of orange micaceous ware samples were examined in this study (Table 9). The basic mineralogy of orange micaceous wares includes quartz, feldspar, biotite, muscovite,

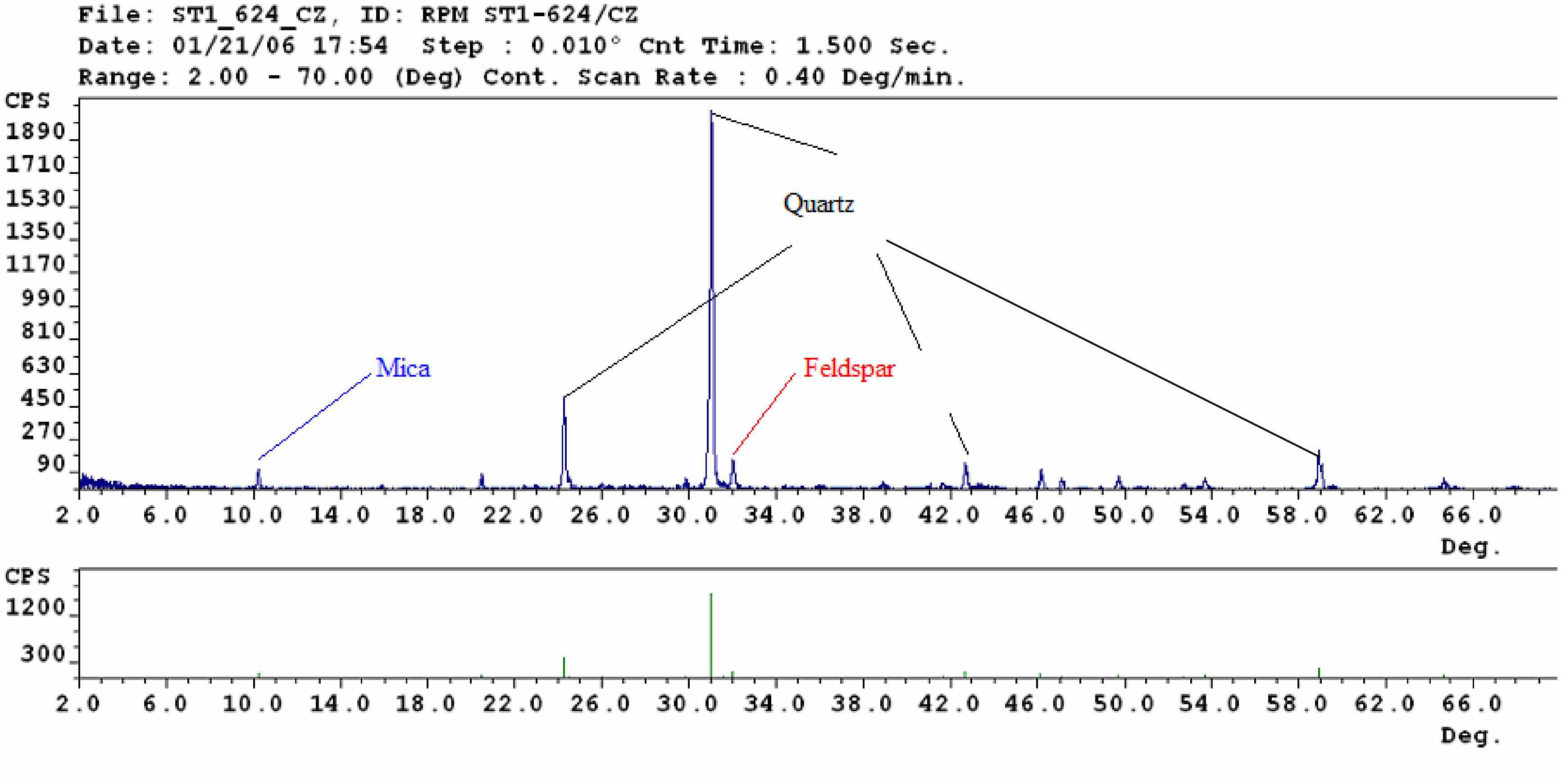


Figure 11: X-ray diffraction data for Merida sample ST1-62-1/CZ.

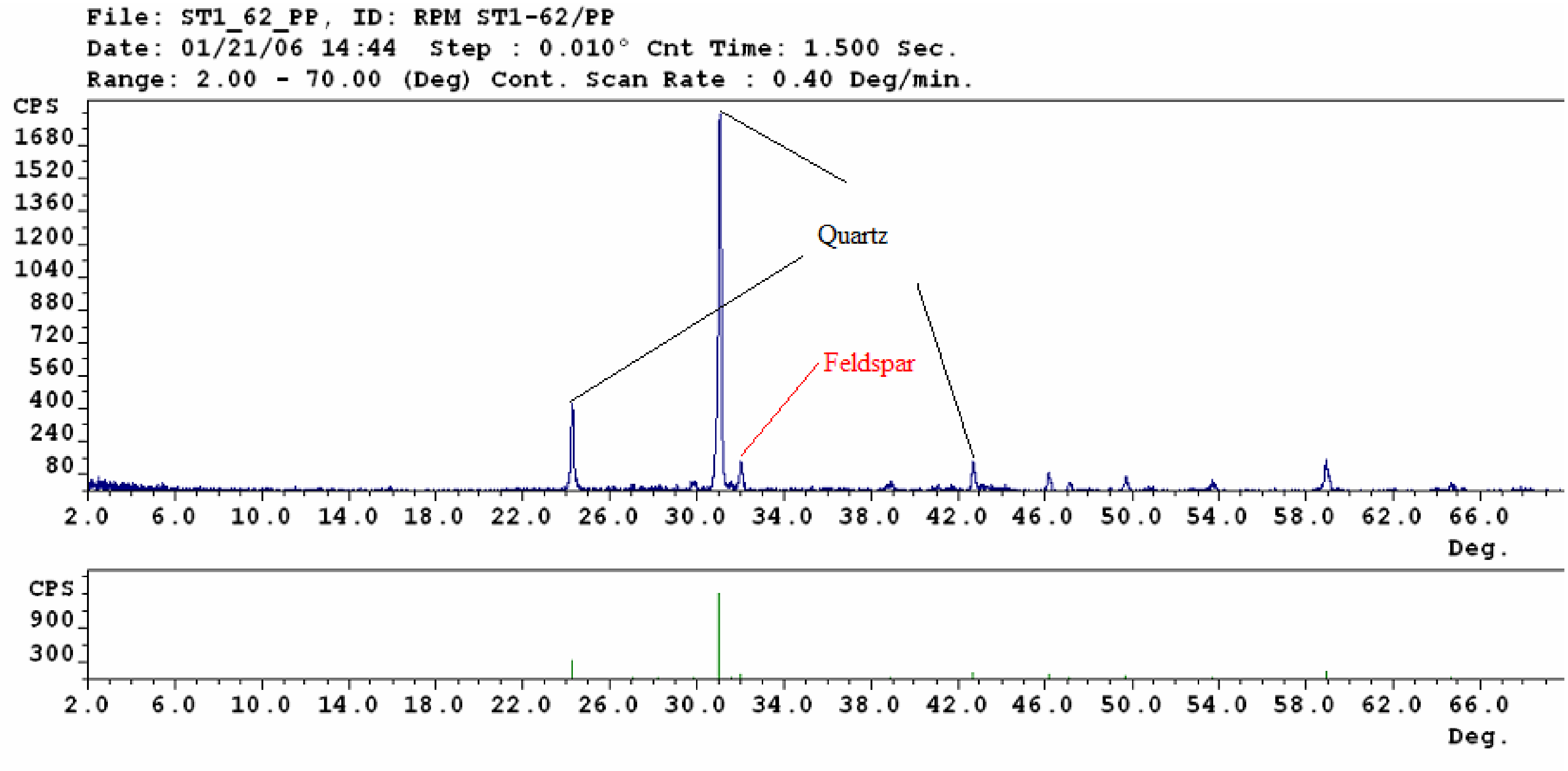


Figure 12: X-ray diffraction data from Merida ware sample ST1-62Δ/PP.

Table 9: Samples of orange micaceous wares used in this study.

Sample Number	Site Within St. Augustine	Color	Vessel Form	Inclusions
90-21-398	St. Francis Barracks	Light Brown (5YR5/6)	Unknown	biotite, feldspar, quartz, opaque minerals, grog, muscovite, rock fragments, chlorite and zircon
90-21-411	De Leon	Moderate Reddish Orange (10R6/6)	Unknown	feldspar, quartz, biotite, muscovite, grog and opaque minerals
90-21-402	De Leon	Light Brown (5YR5/6)	Unknown	feldspar, quartz, biotite, muscovite, chlorite, grog, opaque minerals, rock fragments and zircon
89-1-345	De Leon	Moderate Reddish Brown (10R6/6)	Unknown	feldspar, quartz, biotite, muscovite, grog, rock fragments, zircon and opaque minerals

rock fragments, grog, opaque minerals and accessory minerals (Figure 9; Table 10). Quartz occurs as polycrystalline and monocrystalline inclusions that are subrounded to subangular. Feldspar inclusions occur as subangular to subrounded grains of both plagioclase and potassium feldspar. Subrounded to rounded rutile inclusions are the most common opaque phase followed by ilmenite. Micaceous minerals include muscovite, biotite and accessory chlorite. Muscovite occurs as elongate to Rectangular grains. Biotite occurs mainly as Rectangular grains, though some may be elongated. Chlorite occurs as subrounded Rectangular grains. Grog occurs as rounded to subrounded inclusions. Rock fragments are subangular and are metamorphic or sedimentary in origin. Metamorphic rock fragments show some slight foliations and could possibly be a phyllite. Zircon is another accessory mineral that occurs as subangular grains.

Average grain sizes of inclusions in all four samples are relatively the same. Inclusions in sample 89-1-345 tend to be larger than those in the other three samples (Table 10). However, the average grain size of the inclusions in sample 89-1-345 falls within the range of grain sizes present in the other three samples. Grain size coupled with mineralogy shows that there is little to no variation present in these samples. Fabrics cannot be defined.

Mineralogy of Temper Phases

Quartz

Polycrystalline and monocyrstalline quartz grains are abundant in samples of all three ceramic wares (Figures 7, 10, 13). Inclusions of quartz are subrounded to subangular. Some inclusions exhibit iron staining. Rutile inclusions are only petrographically visible in samples of Merida ware. Other quartz inclusions are rock fragments, most likely quartzite.

Merida ware Merida ware samples have a variety of different quartz inclusions. Monocrystalline and polycrystalline grains are present as subrounded to subangular inclusions in

Table 10: Size range of inclusions in orange micaceous wares. Size ranges of inclusions present in each samples of orange micaceous wares along with the percentages of the major and minor inclusions present in each sample.

Sample Number	Quartz	Feldspar	Grog	Biotite	Muscovite	Opaque Minerals	Accessory Minerals	Rock Fragments
90-21-398	20.8% (0.14-0.82 mm)	28.2% (0.12-0.65 mm)	4% (0.15-0.67 mm)	Major {7.4%} (0.07-0.27 mm)	Major {4%} (0.06-0.75 mm)	Rutile Ilmenite 24.8% (0.03-0.08mm)	Zircon, Chlorite 2.1%	Sedimentary Metamorphic 8.7% (0.33-0.80 mm)
90-21-411	36% (0.11-0.86 mm)	36.5% (0.08-0.62 mm)	5% (0.20-0.67 mm)	Minor {2%} (0.04-0.36 mm)	Major {9.5%} (0.08-0.40 mm)	Rutile Ilmenite 11.0% (0.03-0.08 mm)		
89-1-345	40.5% (0.10-0.77 mm)	26.5% (0.10-0.58 mm)	3% (0.22-0.70 mm)	Minor {3%} (0.04-0.33 mm)	Minor {4.5%} (0.08-0.43 mm)	Rutile Ilmenite 20.5% (0.03-0.08 mm)	Zircon, Chlorite 1.5%	Sedimentary Metamorphic 0.5% (0.27-0.87 mm)
90-21-402	32% (0.20-0.98 mm)	20.5% (0.15-0.76 mm)	5.5% (0.15-0.80 mm)	Major {6%} (0.08-0.45 mm)	Major {8.5%} (0.08-0.65 mm)	Rutile Ilmenite 24.5% (0.03-0.08 mm)	Zircon, Chlorite 1.5%	Sedimentary Metamorphic 1.5% (0.25-0.85 mm)

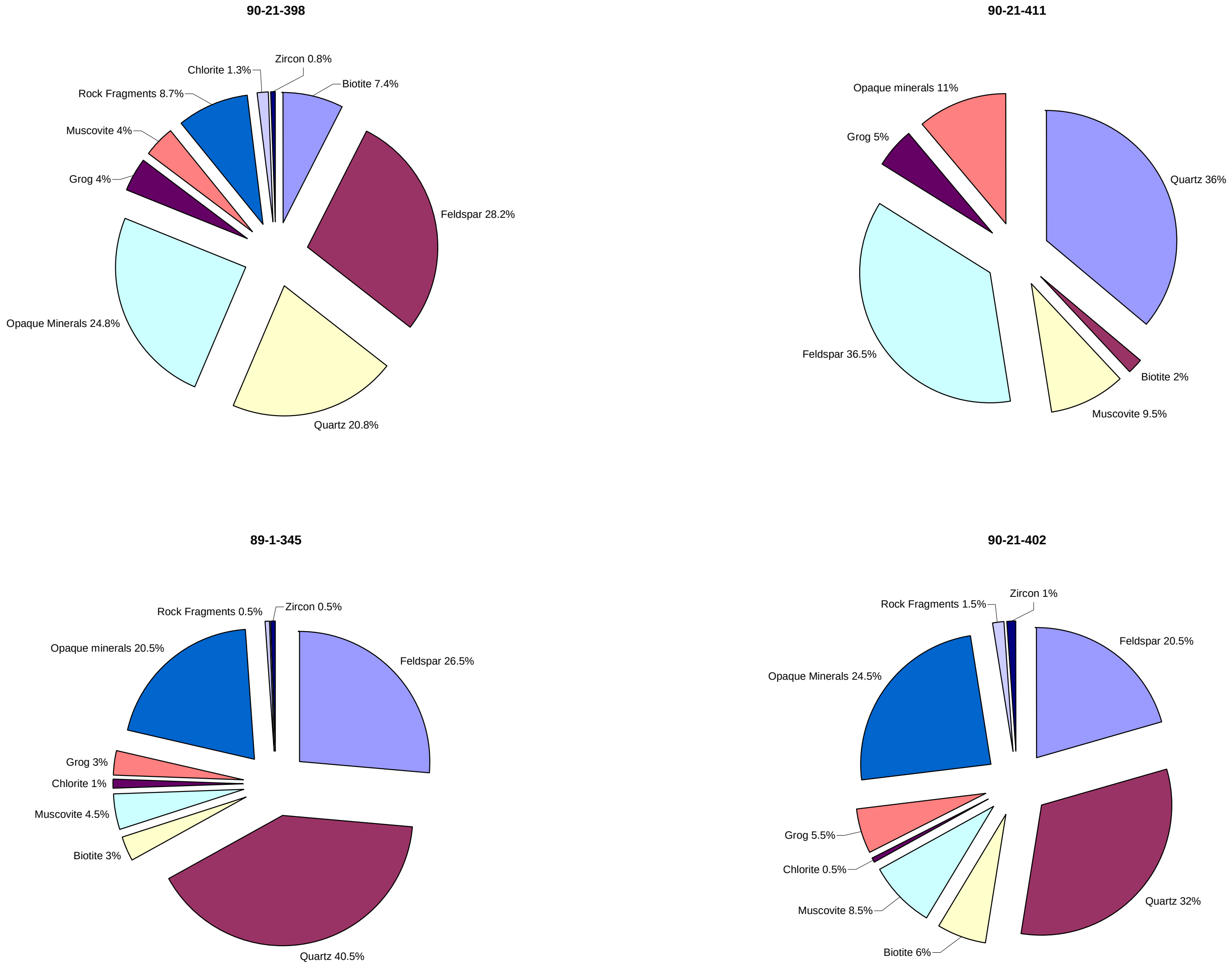


Figure 13: Modal Analyses of temper phases in orange micaceous ware samples.

both fabrics. Four samples of Merida with fabric one have rutilated quartz petrographically visible. Two samples from fabric two do not exhibit any petrographically rutilated quartz inclusions. Rutilated quartz inclusions are rare, but allow for differentiating between the two fabrics (Cranfill 2004). Quartzite rock fragments also occur in samples of Merida ware.

Orange micaceous wares Orange micaceous ware samples contain abundant inclusions of monocrystalline and polycrystalline quartz (Figure 9). Quartz grains are subrounded to subangular with the majority being more subangular. Quartz inclusions in orange micaceous ware samples exhibit some iron staining. No inclusions of petrographically visible rutilated quartz were identified in samples of orange micaceous ware.

Morgan Jones wares Morgan Jones ware samples contain abundant grains of quartz temper (Figure 7). Quartz occurs as both monocrystalline and polycrystalline grains that are subrounded to subangular with the majority of grains being subrounded. Staining is evident on some of the quartz inclusions. Some quartzite rock fragments are also present.

Feldspars

Feldspar inclusions are one of the most abundant temper types following quartz inclusions (Figures 7, 10, 13) in all three ceramic types. Plagioclase grains could be identified based on albite twinning. Potassium feldspar grains could be identified based on grid-iron twinning. Any twinned inclusions that were evident during petrographic analyses were noted. Twinned plagioclase and alkali feldspar grains are rare in all samples of all three ceramic wares. During PCA, all feldspar grains were lumped for this reason. Electron microprobe analyses of feldspars distinguished different compositions within the ceramics. However, the small grain size of the feldspars made analysis difficult as reflected in the nonstoichiometry of the Na-K-Ca in many of the feldspar analyses. The use of feldspar molecules Ab, Or, An involves a normalizing of Na-K-Ca and this makes it possible to compare different analyses in terms of the relative feldspar components.

Merida ware Feldspar grains are the second most abundant inclusion found in the Merida samples (Figure 8). These inclusions are mainly subangular, though some subrounded grains also occur. Grid-iron twinned potassium feldspar grains are smaller than plagioclase feldspar. Feldspars in Merida ware vary from single inclusions of plagioclase or potassium feldspar to composite grains of plagioclase and potassium feldspar occurring in the same inclusions. Composite grains represent perthitic potassium feldspar.

Eighteen total plagioclase and potassium feldspar inclusions from three samples (ST1-62Δ/PP, ST1-62Δ/PO and ST1-62-1/CZ) were analyzed using EMPA (Table 11). Eight inclusions of plagioclase feldspar were analyzed with five being single plagioclase grains and three occurring in larger potassium feldspar grains. Single grains inclusions occurred more abundant in sample ST1-62Δ/PP than the other two samples and all the plagioclase analyses of these grains only come from this sample. Four of the single grains are oligoclase (Ab 90-70%). The other single plagioclase grain is an albite (Ab > 90%). All three plagioclase grains occurring in the larger potassium feldspar grains are albite (Ab > 90%) as would be expected in perthitic potassium feldspar. Ten potassium feldspar grains were analyzed and represent all three samples. Nine are end member orthoclase grains (Or > 91%). The other perthitic alkali feldspar grain (Or 81%) shows exsolution of the plagioclase within the alkali feldspar host grains.

Orange micaceous ware Feldspar grains are second only to quartz in terms of abundance in samples of orange micaceous samples. Twinning is rare in these inclusions. For PCA analyses all feldspar grains were lumped together to gain an accurate representation of feldspar inclusions.

Table 11: Electron microprobe analyses of feldspar inclusions from Merida ware samples.

Sample Number	ST1-62Δ/PP	ST1-62Δ/PP	ST1-62Δ/PP	ST1-62Δ/PP	ST1-62Δ/PP	ST1-62Δ/PP	ST1-62Δ/PP	ST1-62Δ/PP	ST1-62Δ/PP	ST1-62Δ/PP
Mineral Name	Albite	K-spar	Albite	K-spar	Albite	Oligoclase	Andesine	Alkali Feldspar	K-Spar	Albite
SiO_2	66.36	63.70	68.54	64.84	67.32	64.33	63.43	68.44	64.97	70.55
Al_2O_3	20.10	18.42	19.64	18.45	19.91	22.74	22.54	19.92	18.75	20.53
FeO	0.04	0.09	0.08	0.05	0.20	0.05	0.50	0.05	0.13	0.09
CaO	1.07	0.68	0.06	0.08	0.58	3.42	4.06	0.21	0.22	0.06
K_2O	0.84	12.38	0.30	14.50	0.11	0.28	0.23	2.03	14.61	0.19
Na_2O	10.05	1.94	11.33	0.86	11.25	9.34	8.33	10.03	0.79	10.95
BaO	0.07	0.00	0.12	0.12	0.00	0.09	0.03	0.09	0.05	0.03
Total	98.54	97.19	100.50	98.90	99.36	100.25	99.13	100.76	99.53	102.39
Based on 8 O										
Si	2.952	2.988	2.993	3.006	2.965	2.829	2.815	2.983	2.994	2.997
Al	1.054	1.018	1.011	1.008	1.034	1.179	1.179	1.023	1.019	1.028
Mg	0.003	0.001	0.000	0.000	0.000	0.000	0.016	0.002	0.001	0.002
Fe	0.002	0.003	0.003	0.002	0.008	0.002	0.019	0.002	0.005	0.003
Ca	0.051	0.034	0.003	0.004	0.027	0.161	0.193	0.010	0.011	0.003
K	0.048	0.741	0.017	0.857	0.006	0.016	0.013	0.113	0.859	0.010
Na	0.867	0.176	0.959	0.077	0.961	0.796	0.717	0.848	0.070	0.902
Ba	0.001	0.000	0.002	0.002	0.000	0.002	0.001	0.002	0.001	0.001
Ab	84	12	97	6	94	72	66	82	5	98
Or	7	83	3	94	1	2	2	17	94	2
An	9	5	0	0	5	26	32	1	1	0

Table 11 Continued: Electron microprobe analyses of feldspar inclusions from Merida ware samples.

Sample Number	ST1-62Δ/PP	ST1-62Δ/PP	ST1-62Δ/PO	ST1-62Δ/PO	ST1-62-1/CZ	ST1-62-1/CZ	ST1-62-1/CZ	ST1-62-1/CZ
Mineral Name	Oligoclase/ Andesine	Albite	K-spar	K-spar	K-spar	K-spar	K-spar	K-spar
SiO_2	64.41	68.81	63.32	64.06	64.88	64.16	63.17	64.86
Al_2O_3	22.73	20.03	18.77	19.09	18.45	19.23	18.94	19.14
FeO	0.06	0.23	0.57	0.20	0.13	0.17	0.08	0.37
CaO	3.92	0.09	0.12	0.06	0.02	0.02	0.00	0.05
K_2O	0.04	0.91	13.92	14.01	15.12	14.63	14.36	14.07
Na_2O	9.21	11.00	0.58	0.85	0.76	0.79	0.78	0.76
BaO	0.00	0.00	0.24	0.93	0.29	0.00	0.21	0.05
Total	100.38	101.07	97.51	99.20	99.65	99.01	97.54	99.30
Based on 8 O								
Si	2.828	2.981	2.978	2.975	3.000	2.974	2.974	2.987
Al	1.176	1.023	1.040	1.045	1.005	1.051	1.051	1.039
Fe	0.002	0.008	0.022	0.008	0.005	0.007	0.003	0.014
Ca	0.185	0.004	0.006	0.003	0.001	0.001	0.000	0.002
K	0.002	0.051	0.835	0.830	0.892	0.865	0.863	0.827
Na	0.784	0.924	0.053	0.076	0.069	0.071	0.071	0.068
Ba	0.000	0.000	0.004	0.017	0.005	0.000	0.004	0.001
Ab	70	92	4	6	5	5	5	5
Or	0	8	95	94	95	95	95	95
An	30	0	1	0	0	0	0	0

Twinned plagioclase and potassium feldspar grains were noted. Potassium feldspar grains are smaller than plagioclase grains. Individual inclusions of plagioclase were relatively rare.

Five grains of plagioclase and composite grains of plagioclase and potassium feldspar from one sample (90-21-411) were analyzed from orange micaceous wares using the electron microprobe (Table 12). The composite feldspar grains are perthitic potassium feldspar with albite (Ab 100-96%) exsolution. One single plagioclase grain (Ab 99%) was analyzed and probably represents an albite fragment from perthitic potassium feldspar.

Morgan Jones Morgan Jones ware samples were also abundant in feldspar inclusions, but were less numerous than quartz and opaque minerals. Twinning is relatively rare in all four samples, though when twinning did occur the identity was noted. For a more accurate representation of feldspar inclusions, all feldspar grains were lumped together for PCA. The presences of twinned plagioclase or potassium feldspar grains were noted. Twinned plagioclase grains were larger than potassium feldspar grains.

Morgan Jones ware had the most monocrystalline plagioclase inclusions compared to the other two ceramic wares. Eight total feldspar inclusions were analyzed for their compositions in sample ST1-23-47/AP (Table 13). Four of the inclusions were end member albite grains (Ab > 96%). The remaining four inclusions were oligoclase inclusions (Ab 70-90%).

Opaque Minerals

Opaque minerals are present in all the samples and are the most abundant mineral phase in several of the samples analyzed in this study (Figures 7, 10, 13). Opaque mineral inclusions were mainly oxide minerals, though a few sulfide and phosphate minerals were identified. Grains

Table 12: Electron microprobe analyses of feldspar inclusions from orange micaceous ware sample 90-21-411.

Mineral Name	Albite	Orthoclase	Albite	Alkali Feldspar	Albite
SiO_2	69.89	66.75	69.98	66.38	69.59
Al_2O_3	19.49	19.27	20.42	18.45	19.75
FeO	0.00	0.13	0.07	0.21	0.15
CaO	0.22	0.17	0.02	0.01	0.05
K_2O	0.20	14.18	0.24	12.67	0.13
Na_2O	11.15	0.71	11.45	2.20	11.43
BaO	0.06	0.02	0.00	0.08	0.06
Total	101.02	101.23	102.17	100.00	101.17
Based on 8 O					
Si	3.014	3.004	2.985	3.019	2.999
Al	0.990	1.022	1.026	0.989	1.003
Fe	0.000	0.005	0.003	0.008	0.005
Ca	0.010	0.008	0.001	0.000	0.002
K	0.011	0.814	0.013	0.735	0.007
Na	0.933	0.062	0.947	0.194	0.955
Ba	0.001	0.000	0.000	0.001	0.001
Ab	96	5	98	15	98
Or	2	94	2	85	1
An	2	1	0	0	1

Table 13: Electron microprobe analyses for feldspar inclusions from sample ST1-23-47/AP of Morgan Jones ware samples.

Mineral Name	Albite	Albite	Albite	Andesine	Andesine	Andesine	Albite	Oligoclase/ Andesine
SiO_2	67.75	63.61	67.92	63.22	61.95	62.81	68.66	63.63
Al_2O_3	19.52	17.97	19.28	23.62	24.05	23.46	19.27	22.21
FeO	0.15	0.13	0.09	0.17	0.00	0.09	0.07	0.04
CaO	0.14	0.20	0.27	4.86	5.76	5.10	0.20	4.02
K_2O	0.33	0.74	0.49	0.06	0.07	0.10	0.24	0.15
Na_2O	11.63	10.64	10.80	8.33	8.28	8.51	11.20	9.08
BaO	0.04	0.08	0.08	0.00	0.04	0.00	0.00	0.05
Total	99.55	93.37	98.92	100.27	100.15	100.07	99.64	99.20
Based on 8 O								
Si	2.980	2.990	3.000	2.783	2.742	2.777	3.002	2.829
Al	1.012	0.996	1.004	1.226	1.254	1.222	0.993	1.164
Fe	0.006	0.005	0.003	0.006	0.000	0.003	0.003	0.002
Ca	0.007	0.010	0.013	0.229	0.273	0.242	0.010	0.192
K	0.019	0.044	0.027	0.004	0.004	0.005	0.013	0.009
Na	0.992	0.970	0.925	0.711	0.711	0.730	0.950	0.783
Ba	0.001	0.001	0.001	0.000	0.001	0.000	0.000	0.001
Ab	96	92	93	62	59	62	96	69
Or	3	6	4	1	0	1	2	1
An	1	2	3	37	41	37	2	30

sizes of opaque minerals in all three wares were similar ranging from 0.02 millimeters to 0.11 millimeters (Figures 6, 8, 10). The fine grained nature of the oxide mineral inclusions in all three ceramic wares made electron microprobe analysis difficult. The presence of silica and aluminum in these analyses or nonstoichiometry of the structural formulas is due to excitement of the surrounding paste material by the electron beam.

Merida ware Merida ware ceramics contain small grains of rutile, ilmenite and pyrite. Ilmenite is the most abundant and pyrite is the least abundant. The fine grained size (0.01-0.10 millimeters) suggests these mineral inclusions could be naturally occurring in the clay. Rutilated quartz identified during the petrographic study and was confirmed during EMPA. Slight variation is present in the ilmenite grains (Table 14). Three ilmenite grains have a ratio of Ti to Ti+Fe that ranges from 0.61 to 0.65. Rutile showed little to no variation in composition and thus most of the analyzed rutile inclusions in Merida samples are end member rutile. However, due to paste excitement during analysis one grain appears to have a ratio of Ti to Ti+Fe of only 0.94.

Orange micaceous Orange micaceous ware samples contain rutile, ilmenite, pyrite and monazite. Rutile and ilmenite are more abundant that pyrite and monazite. Rutile was much more abundant that ilmenite. Rutile inclusions occur as end member rutile (Table 15). However, due to paste excitement by the electron beam some analyses have lower Ti to Ti+Fe ratios. Ilmenite has a Ti to Ti+Fe ratio of 0.63.

Morgan Jones Morgan Jones ware contains hematite, rutile, ilmenite, pyrite and monazite. Red ocher nodules are mentioned in the definition of this ceramic type (Kelso and Chappell 1974; Miller 1989) and could present oxide mineral inclusions or oxidized chunks of clay or grog. Rutile was the most abundant opaque mineral phase followed by ilmenite. Rutile occurs as end member rutile and shows little compositional variation. Ilmenite shows little variation (Ti/Ti+Fe = 0.53-0.67). Hematite was rare in samples of Morgan Jones, but is unique to this ceramic ware.

Micaceous minerals

Micaceous minerals are mentioned in the definition (Kelso and Chappell 1974, Council 1975 and Hurst 1986) of each ceramic ware compared in this study. Muscovite and biotite inclusions are present in all of the ceramic types. Small amounts of chlorite were included in a few of the samples of each ceramic ware. All three micaceous minerals show differences in size

Table 14: Electron microprobe analyses of oxide mineral inclusions in sample ST1-62Δ/PP of Merida ware.

	Rutile	Rutile	Rutile	Ilmenite	Ilmenite	Rutile	Ilmenite	Rutile
SiO2	1.71	0.90	1.70	0.29	4.59	0.38	1.61	0.33
TiO2	89.11	94.74	81.52	58.41	57.14	96.20	54.33	99.32
Al2O3	1.78	1.07	1.80	0.98	1.11	0.35	0.87	0.32
MgO	1.05	0.17	0.23	0.20	0.62	0.01	0.13	0.00
FeO	6.09	0.30	8.65	32.36	30.69	1.22	35.17	0.37
MnO	0.01	0.03	0.00	0.92	0.72	0.07	1.11	0.05
Total	99.75	97.19	93.89	93.16	94.87	98.24	93.22	100.40
Based on 2 or 3 O								
Si	0.023	0.012	0.025	0.007	0.111	0.005	0.041	0.004
Ti	0.909	0.969	0.895	1.113	1.037	0.982	1.046	0.989
Al	0.028	0.017	0.031	0.029	0.031	0.006	0.026	0.005
Mg	0.021	0.003	0.005	0.008	0.022	0.000	0.005	0.000
Fe	0.069	0.003	0.106	0.686	0.619	0.014	0.753	0.004
Mn	0.000	0.000	0.000	0.020	0.015	0.001	0.024	0.001
O	2.000	2.000	2.000	3.000	3.000	2.000	3.000	2.000
Ti/Ti+Fe	0.93	1.000	0.89	0.62	0.63	0.99	0.58	1.000
Fe/Ti+Fe	0.07	0	0.21	0.38	0.37	0.01	0.42	0

Table 15: Electron microprobe analyses of oxide mineral inclusions in orange micaceous ware sample 90-21-411.

	Rutile	Rutile	Rutile	Rutile	Rutile	Rutile	Rutile	Rutile	Ilmenite
SiO2	0.13	0.93	1.17	0.34	0.60	0.31	0.19	0.25	2.13
TiO2	97.05	96.35	87.07	97.64	78.71	97.10	97.92	97.15	53.44
Al2O3	0.29	0.60	1.62	0.32	1.40	0.33	0.23	0.25	1.87
MgO	0.00	0.06	0.19	0.01	0.24	0.00	0.00	0.03	0.23
FeO	1.14	0.74	5.72	0.36	13.89	0.32	0.55	0.92	31.61
MnO	0.12	0.04	0.06	0.04	0.42	0.00	0.02	0.04	4.15
Total	98.92	98.83	96.36	98.85	95.42	98.18	99.16	98.78	93.44
Based on 2 or 3 O									
Si	0.002	0.013	0.017	0.005	0.009	0.004	0.003	0.003	0.054
Ti	0.986	0.975	0.923	0.988	0.880	0.989	0.990	0.987	1.020
Al	0.005	0.010	0.027	0.005	0.025	0.005	0.004	0.004	0.056
Mg	0.000	0.001	0.004	0.000	0.005	0.000	0.000	0.001	0.009
Fe	0.013	0.008	0.067	0.004	0.173	0.004	0.006	0.010	0.671
Mn	0.001	0.001	0.001	0.001	0.005	0.000	0.000	0.001	0.890
O	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	3.000
Ti/Ti+Fe	0.987	0.992	0.932	0.996	0.836	0.996	0.994	0.990	0.603
Fe/Ti+Fe	0.013	0.008	0.068	0.004	0.164	0.004	0.006	0.010	0.397

Table 16: Electron microprobe analyses of oxide minerals in sample ST1-23-47/AP of Morgan Jones ware.

	Rutile	Rutile	Ilmenite	Ilmenite	Ilmenite	Ilmenite	Rutile	Rutile	Rutile
	1	2	3	4	5	6	7	8	9
SiO2	0.88	0.21	0.01	0.03	1.12	0.28	1.44	0.16	1.58
TiO2	95.86	98.70	48.68	52.25	62.12	54.06	94.64	96.89	96.38
Al2O3	0.91	0.16	0.10	0.27	1.11	1.31	0.88	0.16	0.99
MgO	0.03	0.00	0.80	0.46	0.21	0.25	0.03	0.00	0.00
FeO	1.01	0.60	43.63	40.32	30.93	34.11	1.10	0.58	0.55
MnO	0.00	0.00	0.54	0.82	0.10	1.40	0.04	0.00	0.05
Total	98.68	99.68	93.77	94.14	95.60	91.42	98.14	97.80	96.93
Based on 2 or 3 O									
Si	0.012	0.003	0.000	0.001	0.027	0.007	0.020	0.002	0.021
Ti	0.968	0.992	0.983	1.031	1.129	1.067	0.962	0.992	0.963
Al	0.014	0.003	0.003	0.008	0.032	0.041	0.014	0.003	0.016
Mg	0.001	0.000	0.032	0.018	0.008	0.010	0.001	0.000	0.000
Fe	0.011	0.007	0.980	0.885	0.625	0.749	0.013	0.007	0.006
Mn	0.000	0.000	0.012	0.018	0.002	0.031	0.001	0.000	0.001
O	2.000	2.000	3.000	3.000	3.000	3.000	2.000	2.000	2.000
Ti/Ti+Fe	0.989	0.993	0.501	0.538	0.644	0.588	0.987	0.993	0.994
Fe/Ti+Fe	0.011	0.007	0.499	0.462	0.356	0.412	0.013	0.007	0.006

in each of the three ceramic types (Tables 6, 8, 10). Many of these inclusions are also quite small and it was difficult to obtain good quality analyses. Biotite grains present in Merida ware and orange micaceous ware showed lower amounts of potassium than expected in fresh biotite grains. Biotite loses potassium during weathering/alteration and the low potassium contents probably reflect the weathered character of the biotite used in the ceramic. Alternatively, the biotite may have lost potassium during firing, but muscovite fired in the same ceramic sample does not have low potassium thus favoring the weathering loss of potassium.

Merida Ware Micaceous minerals are very abundant inclusions in Merida type wares (Figure 10). Muscovite is the most common followed by biotite. Chlorite is a rare inclusion and only occurs in a few of the samples (Table 8). Compositions of micaceous mineral inclusions were obtained from two samples (ST1-62Δ/PO, and ST1-62-1/CZ) (Table 16).

More muscovite grains were analyzed than biotite and no chlorite grains were analyzed. Muscovite inclusions in Merida ware are low in Na (Na/Na+K= 0.03 to 0.06) (Table 17). Titanium weight percentages ranged from 0.00 to 0.72 weight percent TiO_2.

Biotite appears as smaller, less abundant inclusions making analysis difficult. Biotite from sample ST1-62-1/CZ is lower in magnesium (Mg/Fe+Mg = 0.18 to 0.20) (Table 17) than biotite from sample ST1-62Δ/PO (Mg/Fe+Mg = 0.30 to 0.47; Table 17). Titanium in biotite varies from 1.57 to 3.71 weight percent TiO_2.

Orange micaceous Orange micaceous ware samples are contain visible mica inclusions; hence why the name orange micaceous. Muscovite and biotite occur in approximately equal amounts. Chlorite grains were accessory minerals and are found in three of the four samples.

Muscovite inclusion present in orange micaceous ware had sodium to potassium ratios slightly higher than those found in Merida and Morgan Jones wares (Na/Na+K= 0.30 to 0.47) (Table 18). Titanium ranged from 0.04 to 1.64 weight percent TiO_2.

Biotite grains were smaller and less abundant in samples of orange micaceous ware than in Merida ware samples. The small size of the biotite grains made it impossible to obtain meaningful analyses of the biotite in the orange micaceous ware. The analyses listed in Table 18 as biotite show high Si contents and low K, Fe, and Mg; relative to biotite stoichiometry. These analyses are probably a mixture of biotite and some of the paste and thus should not be considered when comparing different samples.

Morgan Jones Micaceous minerals are not common in the four Morgan Jones (Figure 7). Biotite is the most abundant followed by muscovite. Chlorite is an accessory mineral and was only identified in one sample (Table 6).

Table 17: Electron microprobe analyses of micaceous minerals from samples of Merida ware.

	ST1-62-1/CZ	ST1-62-1/CZ	ST1-62-1/CZ	ST1-62-1/CZ	ST1-62-1/CZ	ST1-62-1/CZ	ST1-62-1/CZ
	Muscovite	Muscovite	Muscovite	Muscovite	Muscovite	Biotite	Biotite
SiO_2	45.73	47.84	47.08	46.47	45.27	38.74	37.93
TiO_2	0.67	0.13	0.47	0.50	0.41	1.75	1.89
Al_2O_3	35.47	35.41	38.57	36.43	36.91	24.11	24.33
MgO	0.85	0.76	0.36	0.78	0.42	2.49	2.48
FeO	1.30	2.31	0.66	1.18	0.64	17.97	20.17
MnO	0.03	0.00	0.04	0.00	0.08	0.46	0.33
K_20	9.80	9.19	8.55	9.03	8.91	4.54	4.80
Na_2O	0.32	0.28	0.26	0.23	0.27	0.26	0.36
Cl	0.00	0.01	0.00	0.02	0.04	0.00	0.00
F	0.00	0.00	0.00	0.11	0.18	0.40	0.17
Total	94.16	95.94	95.98	94.70	93.05	90.57	92.39
Based on 11 O							
Si	3.065	3.137	3.047	3.070	3.036	2.921	2.850
Ti	0.034	0.006	0.023	0.025	0.021	0.099	0.107
Al	2.802	2.737	2.943	2.837	2.917	2.143	2.154
Mg	0.085	0.074	0.034	0.077	0.042	0.280	0.278
Fe	0.073	0.127	0.036	0.065	0.036	1.133	1.267
Mn	0.002	0.000	0.002	0.000	0.005	0.030	0.021
K	0.838	0.769	0.706	0.761	0.762	0.436	0.460
Na	0.042	0.036	0.032	0.030	0.035	0.039	0.052
Cl	0.000	0.001	0.000	0.002	0.004	0.000	0.000
F	0.000	0.000	0.000	0.023	0.039	0.095	0.042
Na/Na+K	0.048	0.045	0.043	0.038	0.044	-	-
Mg/Fe+Mg	-	-	-	-	-	0.198	0.180

Table 17 continued: Electron microprobe analyses of micaceous minerals from samples ST1-62-1/CZ and ST1-62Δ/PO of Merida ware.

	ST1-62-1/CZ	ST1-62-1/CZ	ST1-62-1/CZ	ST1-62-1/CZ	ST1-62Δ/PO	ST1-62Δ/PO	ST1-62Δ/PO	ST1-62Δ/PO	ST1-62-1/CZ
	Muscovite	Muscovite	Muscovite	Muscovite	Biotite	Biotite	Muscovite	Biotite	Biotite
SiO_2	48.19	47.02	46.81	47.86	42.41	39.38	47.34	44.94	34.89
TiO_2	0.16	0.53	0.00	0.72	3.07	3.71	0.40	1.57	2.82
Al_2O_3	37.31	36.79	38.34	37.62	24.38	22.75	35.04	20.59	19.13
MgO	0.72	0.83	0.33	0.66	7.51	6.21	0.69	6.60	5.42
FeO	1.50	1.13	0.88	0.93	15.36	20.54	2.59	16.29	22.69
MnO	0.06	0.00	0.00	0.10	0.04	0.12	0.00	0.00	0.24
K_2O	9.23	10.11	9.62	9.28	3.32	2.05	9.19	2.59	7.91
Na_2O	0.23	0.38	0.29	0.20	0.23	0.22	0.22	0.28	0.17
Cl	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.03
F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.86
Total	97.41	96.82	96.27	97.37	96.33	94.99	95.46	92.08	93.79
Based on 11 O									
Si	3.098	3.062	3.046	3.073	2.931	2.836	3.125	3.205	2.709
Ti	0.008	0.026	0.000	0.035	0.160	0.201	0.020	0.084	0.165
Al	2.828	2.823	2.940	2.847	1.986	1.931	2.726	1.730	1.750
Mg	0.069	0.081	0.032	0.064	0.774	0.666	0.068	0.702	0.627
Fe	0.081	0.062	0.048	0.050	0.888	1.237	0.143	0.971	1.473
Mn	0.003	0.000	0.000	0.005	0.002	0.007	0.000	0.000	0.016
K	0.757	0.840	0.799	0.760	0.293	0.189	0.774	0.235	0.783
Na	0.028	0.049	0.036	0.025	0.031	0.031	0.028	0.039	0.026
Cl	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.004
F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.211
Na/Na+K	0.036	0.055	0.043	0.032	-	-	0.035	-	-
Fe/Fe+Mg	-	-	-	-	0.466	0.350	-	0.420	0.299

Table 18: Electron microprobe analyses of micaceous inclusions from orange micaceous ware sample 90-21-411.

	Biotite	Biotite	Muscovite	Biotite	Muscovite	Muscovite	Muscovite
SiO_2	53.31	50.95	45.81	51.43	46.98	45.34	46.76
TiO_2	0.40	0.48	1.39	0.04	1.64	0.02	1.60
Al_2O_3	27.28	30.18	34.60	35.41	36.02	35.34	37.85
MgO	2.79	2.01	0.96	1.09	0.86	0.54	0.55
FeO	5.50	5.43	1.47	2.84	1.08	2.63	0.78
MnO	0.04	0.01	0.04	0.00	0.00	0.08	0.00
K_2O	4.87	5.81	9.14	6.90	7.85	9.50	9.77
Na_2O	0.63	0.47	0.32	0.27	0.30	0.33	0.32
Cl	0.02	0.01	0.04	0.00	0.01	0.01	0.00
F	0.05	0.06	0.25	0.00	0.12	0.00	0.02
Total	94.86	95.38	93.91	97.98	94.81	93.80	97.64
Based on 11 O							
Si	3.482	3.335	3.070	3.246	3.079	3.066	3.010
Ti	0.020	0.024	0.070	0.002	0.081	0.001	0.078
Al	2.100	2.329	2.733	2.633	2.782	2.816	2.872
Mg	0.272	0.196	0.096	0.102	0.084	0.054	0.053
Fe	0.301	0.297	0.082	0.150	0.059	0.149	0.042
Mn	0.002	0.001	0.002	0.000	0.000	0.005	0.000
K	0.406	0.485	0.781	0.555	0.656	0.819	0.803
Na	0.079	0.060	0.042	0.033	0.038	0.044	0.040
Cl	0.002	0.001	0.004	0.000	0.002	0.001	0.000
F	0.011	0.012	0.052	0.000	0.026	0.000	0.004
Na/Na+K			0.051		0.055	0.051	0.047
Mg/Fe+Mg	0.475	0.398		0.405			

Muscovite inclusions were the only inclusions large enough for electron microprobe analysis (Table 19). The muscovite in Morgan Jones ceramics was higher in Na (Na/Na+K= 0.08 to 0.12) than the two Spanish ceramics. Titanium contents ranged between 0.16 and 0.68 weight percent TiO_2.

Table 19: Electron microprobe analyses of micaceous minerals in sample ST1-23-47/AP of Morgan Jones ware.

	Muscovite	Muscovite	Muscovite	Muscovite	Muscovite	Muscovite	Muscovite	Muscovite
SiO_2	47.92	48.33	47.71	49.26	47.35	48.62	47.00	47.12
TiO_2	0.53	0.54	0.49	0.16	0.40	0.68	0.38	0.42
Al_2O_3	33.66	32.33	34.89	32.51	34.44	30.32	35.01	35.27
MgO	0.93	1.66	1.09	1.77	0.99	2.23	0.86	0.96
FeO	3.13	5.00	3.46	4.68	3.54	4.83	3.38	3.04
MnO	0.00	0.03	0.01	0.06	0.04	0.14	0.01	0.11
K_2O	8.41	8.82	7.77	7.42	8.20	8.13	9.51	9.02
Na_2O	0.57	0.47	0.57	0.56	0.62	0.70	0.71	0.51
Cl	0.00	0.02	0.00	0.04	0.01	0.03	0.01	0.00
F	0.10	0.08	0.32	0.48	0.38	0.89	0.00	0.01
Total	95.30	97.38	96.27	96.87	95.86	96.51	96.90	96.47
Based on 11 O								
Si	3.169	3.171	3.115	3.205	3.116	3.203	3.089	3.093
Ti	0.027	0.027	0.024	0.008	0.020	0.034	0.019	0.021
Al	2.624	2.500	2.685	2.493	2.671	2.354	2.711	2.729
Mg	0.092	0.162	0.106	0.172	0.097	0.219	0.085	0.094
Fe	0.173	0.275	0.189	0.255	0.195	0.266	0.186	0.167
Mn	0.000	0.002	0.001	0.003	0.002	0.008	0.001	0.006
K	0.709	0.738	0.647	0.616	0.688	0.683	0.797	0.755
Na	0.073	0.060	0.072	0.070	0.079	0.090	0.090	0.064
Cl	0.000	0.002	0.000	0.004	0.002	0.003	0.001	0.000
F	0.021	0.016	0.067	0.099	0.080	0.185	0.000	0.003
Na/Na+K	0.093	0.075	0.100	0.102	0.103	0.116	0.101	0.078

Grog

Grog is often used as temper in pottery (Shepard 1956; Rice 1987). Grog occurs in all three ceramic types analyzed in this study. Grog is differentiated from opaque minerals by the occurrence of visible inclusions inside the grog inclusion. Sometimes those inclusions are large enough for identification. Grog inclusions in these samples are much larger than the opaque minerals. In reflected light microscopy, grog inclusions reflect light from the as silicate grains.

Merida ware All six samples of Merida ware analyzed in this study contain grog temper. Grog occurs as reddish black opaque tempering agents that have visible inclusions within the larger inclusion. Although, some grog inclusions do not have visible inclusions, they do not reflect light in reflected light microscopy. Grog inclusions are rounded to subrounded and range in size from 0.08 millimeters to 0.88 millimeters. Inclusions visible in the pieces of grog are most often quartz inclusions.

Orange micaceous All four samples of orange micaceous ware analyzed in this study contain grog as a tempering agent. Grog occurs as black to reddish black tempering agents that have visible inclusions within the larger inclusion. Some grog inclusions may not have visible inclusions, but they do not reflect light in reflected light microscopy. Grog inclusions are rounded to subrounded and range in size from 0.15 millimeters to 0.67 millimeters. The most common visible inclusion in the grog pieces is quartz.

Morgan Jones ware Only two of the four Morgan Jones ware samples analyzed in this study contain grog as temper. Grog occurs as either large subrounded to rounded inclusions with visible inclusions or as slightly smaller inclusions without visible inclusions. Both types of grog do not reflect light in reflected light microscopy. Grog ranges in size from 0.20 millimeters to 1.5 millimeters. Visible inclusions in the grog temper are usually quartz grains. In fact grog was used to differentiate between the two fabrics identified in this study.

Rock Fragments

Rock fragments are included as temper in all three ceramic types. Rock fragment inclusions are not very abundant, but are important because of the information they provide about source areas for ceramic raw materials. All rock fragments are subangular and are about the same size as other tempering agents.

Merida ware Four samples of Merida ware have rock fragments included as temper (Table 8). The rock inclusions contain quartz, muscovite, biotite and feldspar grains and represent crystalline and sedimentary rocks. Formation environment of these fragments also vary from sedimentary environments to metamorphic environments. Metamorphic characteristics include slight alignment of small micaceous minerals in a foliation. The rock fragment inclusions are most likely phyllite. Quartzite fragments were also present in samples of Merida ware. Quartzite appears as polygranular of quartz grains. Multi-grain quartzite rock fragments are only visible during crossed polarized light from the petrographic microscope. Sedimentary characteristics include a clastic texture and these rocks most likely represent sandstone rock fragments.

Orange micaceous Three samples of orange micaceous ware contain rock fragments as temper. These inclusions contain quartz, muscovite, biotite and feldspar grains. Sedimentary characteristics are visible in some fragments while others exhibit metamorphic characteristics. Sedimentary rock fragments are composed of quartz and micaceous minerals and show rounded to subrounded smaller grains of quartz. They appear to be sandstone. Metamorphic fragments have slight alignment of small micaceous minerals (foliation) and these rock fragments are most likely phyllite Quartzite inclusions in these samples are polygranular inclusions of quartz.

Morgan Jones ware Two of the four Morgan Jones ware samples contain rock fragments as temper. These inclusions contain rounded to subrounded grains of both the micaceous minerals and quartz grains and probably represent sandstones. Quartzite is present in these samples and appears as polygranular of quartz inclusions. The multi-grain nature of these fragments is only visible in crossed polarized light from the petrographic microscope.

Accessory Minerals

Accessory minerals present in all three ceramic wares are very similar. These minerals account for less than two percent of the total temper. Accessory minerals are not present in all samples and vary between samples. Zircon, tourmaline, chlorite, monazite and pyrite are accessory minerals identified in this study. Chlorite grains were described in the micaceous mineral section, but are considered accessory minerals in many of the samples analyzed in this study.

Zircons are small subangular grains that range in size from 0.03 millimeters to 0.11 millimeters. These inclusions were identified in one of six Merida ware samples, three of four orange micaceous ware samples and in all four samples of Morgan Jones wares. These inclusions were most likely residual grains present in the deposits were temper and clay sources were collected.

Tourmaline inclusions are less abundant that zircon inclusions. Small yellow-green grains of tourmaline are subrounded and range in size form 0.05 millimeters to 0.13 millimeters. They are only present in one of six Merida ware samples and two of the four Morgan Jones ware samples. How these grains were added to these ceramic is not clear, but the smaller grains could be residual in the clay or temper sources.

Trace amounts of pyrite and monazite was identified in samples of Merida ware, orange micaceous ware and Morgan Jones ware. Grain sizes for pyrite inclusions are very small (0.02-0.10 millimeters). Small monazite grains (0.02-0.10 millimeters) were found in some samples of Merida ware.

Discussion

Fabrics

Morgan Jones ware

Mineralogically, Morgan Jones ware examined in this study differs from the description provided in Kelso and Chappell (1974). There authors describe this ware as having a buff (creamy white) to pink paste with a pale orange, yellow or olive green lead glaze poorly applied to the surface. Red ochre nodules are also described as a tempering agent (Kelso and Chappell, 1974). Archaeologists at St. Mary's City describe Morgan Jones ware as also having inclusions of mica of varying quantities and quartz pebbles along with other (unspecified) inclusions (Miller, 1989). During the petrographic investigation I found very few mica inclusions. The opaque minerals, rutile, ilmenite, hematite and pyrite, are the most common inclusions found in all the Morgan Jones samples. Quartz and feldspar inclusions are also abundant. Temper phases identified by the XRD are quartz and feldspar (albite or orthoclase). This description is supports the description defined by Kelso and Chappell (1974) with a few exceptions. First, micaceous minerals are not very abundant. Grog is used as a tempering agent, but is not described by in the typology established by Kelso and Chappell (1974) or that supplemented by Miller (1986, 1989).

Two fabrics can be distinguished from the four samples of Morgan Jones wares analyzed in this study based on paste color and the presence of grog. Distinction of these two fabrics follows previous studies that have also based fabrics on differences in paste color (Rice, 1987).

Fabric one has a dark orange brown paste with a greenish glaze on the outer surface. Tempering materials include quartz, plagioclase and potassium feldspar, opaque minerals and biotite (Figure 13, 14). Grog temper is absent in these samples.

Fabric two has a light brown paste. Quartz, plagioclase and potassium feldspar and opaque minerals dominate the temper inclusions (Table 6). One noticeable difference between fabric two and fabric one is the lack of grog in fabric two. Samples of fabric two follow the typology established by Kelso and Chappell with only a few differences (Figure 14). These samples are a little overfired and thus do not represent the creamy to orange paste found in most Morgan Jones ware samples. Micaceous minerals are rare in this fabric as well.

Paste color has been used for a number of years to differentiate between fabrics of several ceramic wares (Rice, 1987). Often the only descriptive data in ceramic studies are the colors of the paste (Shepard, 1956). Differences between the paste colors of the two Morgan Jones fabrics are due to differences in firing techniques as can be seen by the two fabrics identified in this study. Morgan Jones worked with other potters in the Tidewater region of Maryland and Virginia (Straube, 1995). Morgan Jones and his cohorts had a basic formula for producing Morgan Jones earthenwares. Each individual potter would take the basic formula and add additional materials, glazes. In the seventeenth century there was no way to ensure even and consistent firing conditions. Due to the kiln conditions in the seventeenth century and the differences in manufacturing and firing techniques each potter could bring to the association, we can see visible differences between the ceramic samples of Morgan Jones ware. To compare and differentiate fabrics based on paste color would require samples from the same kiln firing event (Shepard, 1956; Rice, 1987). Thus, paste color is not useful in differentiating between Morgan Jones

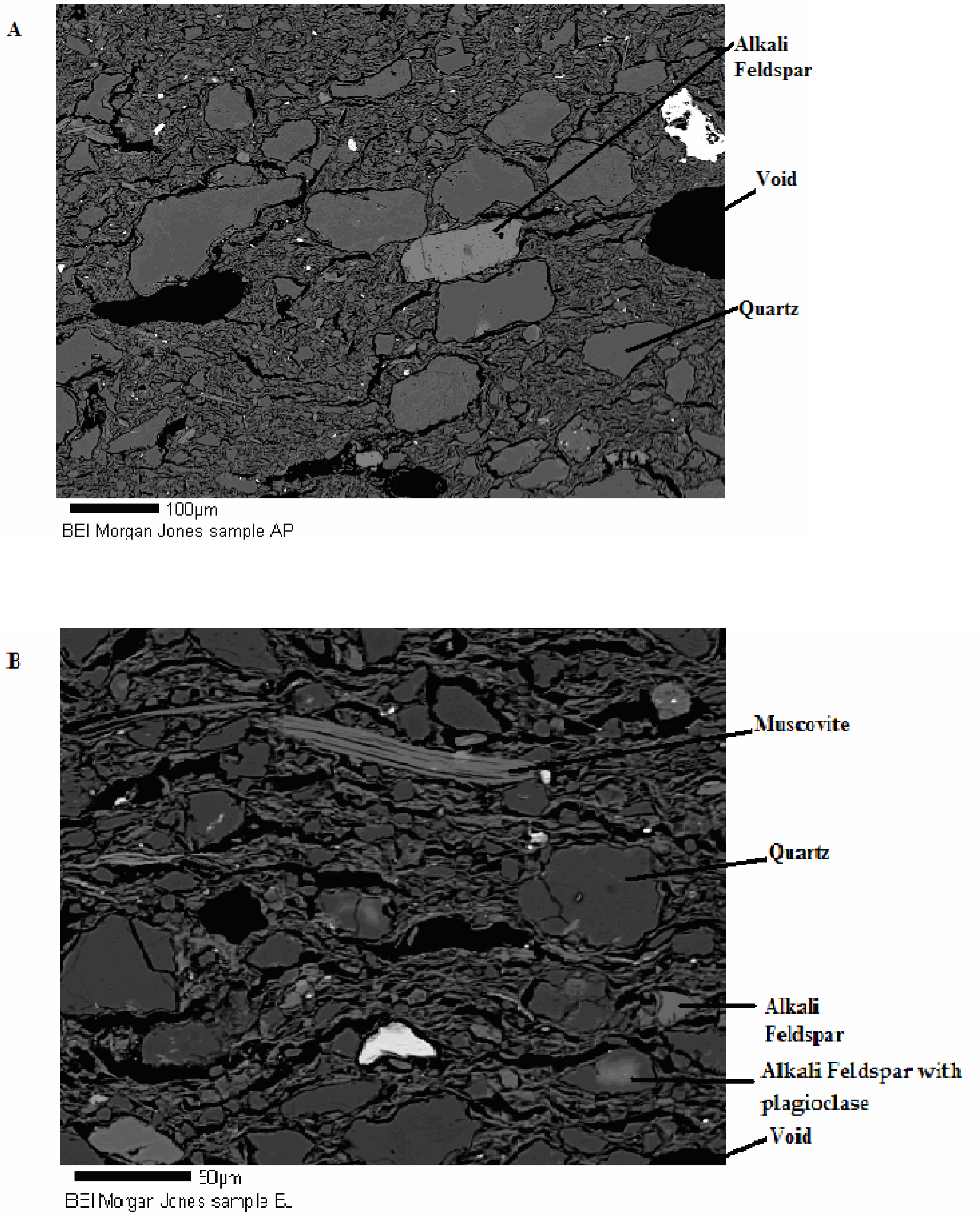


Figure 14: Backscattered electron images of Morgan Jones Samples. Image A is a sample of fabric one and image B is a sample of fabric two. Mineralogy of both fabrics is the same along with the average percentages of inclusions.

fabrics (Rice, 1987). Also, the presence of grog as tempering agent could be due to personal preferences of the potters (Straube, 1995).

Based on petrological data, clay and temper sources are the same for both fabrics. Grog was most likely added from broken vessel similar to the two used in this study (12-VA and R-VA). Quartz is dominant in all four samples along with feldspar inclusions and opaque mineral inclusions (Figure 7). Additionally, the micaceous minerals in these samples are very similar based on size and shape of these inclusions during petrographic analysis. Biotite is the most dominant occurring in all four samples. Muscovite is present in only two samples (ST1-23-47/AP and 12-VA). The presence or absence of muscovite does not coincide with the presence or absence of grog and cannot be used as criteria for differentiating fabrics. Accessory mineral inclusions include tourmaline, zircon and chlorite. Zircon inclusions are present in all four samples. Tourmaline and chlorite inclusions are variable, but do not support any differentiation of fabrics based on these inclusions. Thus based on the mineralogy of all four samples there is no way to distinguish between fabrics.

Minerals present in the samples of Morgan Jones ware provide clues to clay and temper sources. Quartz is dominant along with feldspar and opaque minerals. Crystalline igneous rock types are present in the coastal zones of Maryland and Virginia where Morgan Jones ware was produced. Quartz and feldspar is dominant in the granites present in this region (Maryland Geological Survey, 2002). Oxide minerals along with the few micaceous minerals would be present in the sedimentary deposits in these areas along with granite weathering products.

Merida ware

Petrography of Merida wares from St. Mary's City confirmed work previously completed (Cranfill 2004). In this study there were also two fabrics. Fabrics were distinguished based on paste color and the presence or absence of rutilated quartz. Mineralogically, both fabrics are the same. Quartz was the most abundant inclusion in all six samples followed by the feldspar. Minor minerals muscovite and biotite along with opaque minerals and accessory minerals were also present in similar amounts.

Fabric one represents four of the six samples of Merida ware investigated in this study (Table 7). Paste color of these samples range from moderate reddish orange to moderate reddish brown. These samples exhibited some decoration in the form of incised lines below the rim. No samples exhibited any glazing on any surface. In thin section, these samples appear foliated with the alignment of micaceous grains along the foliations (Figure 15).

Fabric two represents the remaining two samples (Table 7). Paste color of the samples is dark yellowish orange. One sample has an incised line below the rim of the sherd. Glazing is not present on any of these samples. In thin section, these samples do not exhibit any foliation (Figure 15). Also, there are no rutilated quartz fragments present in these samples.

Paste color is not a reliable observation to determine distinctions between fabrics (Rice, 1987). All six samples are some shade or hue of orange. Even coupled with the presence of rutilated quartz in one fabric is not enough to provide reliable distinctions. Rutilated quartz is not always visible in petrographic studies. The electron microprobe showed the presence of rutilated quartz in some Merida samples that were not recognized during petrographic examination.

Mineralogy of both fabrics is the same with quartz being the most dominant inclusion followed by feldspar. Micaceous minerals appear in similar abundances in both fabrics. Accessory minerals are variable between all six ceramic wares, but include tourmaline, chlorite and zircon. Some samples do not contain any accessory minerals. However, accessory minerals do not provide a way to distinguish between fabrics in the samples from Merida ware. Size ranges all inclusions are also overlap. Since paste color is not reliable and the presence or absence of rutilated quartz cannot always be determined petrographically, the two fabrics cannot be distinguished. Furthermore, past studies of Merida ware that relied on paste color as the basis for distinction are not as reliable.

Low to high grade metamorphic rocks and plutonic igneous rocks are present in Alentejo region of Portugal and Extremadura region of Spain. Gabbro and granite are dominant igneous rocks in these areas. Minerals that are dominant in the granite in this area are quartz, feldspar (plagioclase and potassium feldspar), muscovite and biotite. All of these minerals are present in varying quantities in Merida ware samples. Quartz and feldspar are dominant in all six samples of Merida ware and are dominant in the igneous rocks the regions on the Iberian Peninsula. Additionally, the perthitic nature of many of the potassium feldspar grains along with grid-iron twinning of some of the potassium feldspar grains suggest they came from granitic rocks. Compositionally, the two feldspar phases could also be from granites. Muscovite and biotite occur in the high grade metamorphic rocks (schist and gneiss) present along the shear belt running through the town of Merida. Micaceous minerals could also be present in the sedimentary basins surrounding the town of Merida. Additionally, rock fragments present in the samples of Merida ware show metamorphic qualities including foliation. Rock fragments included in the ceramic samples could be phyllite supporting temper sources from the Alentejo and Extremadura regions.

Orange micaceous ware

Originally, I thought that two fabrics could be discerned based on grain size differences present in the four samples. However, differences in the grain sizes of all four samples are small.

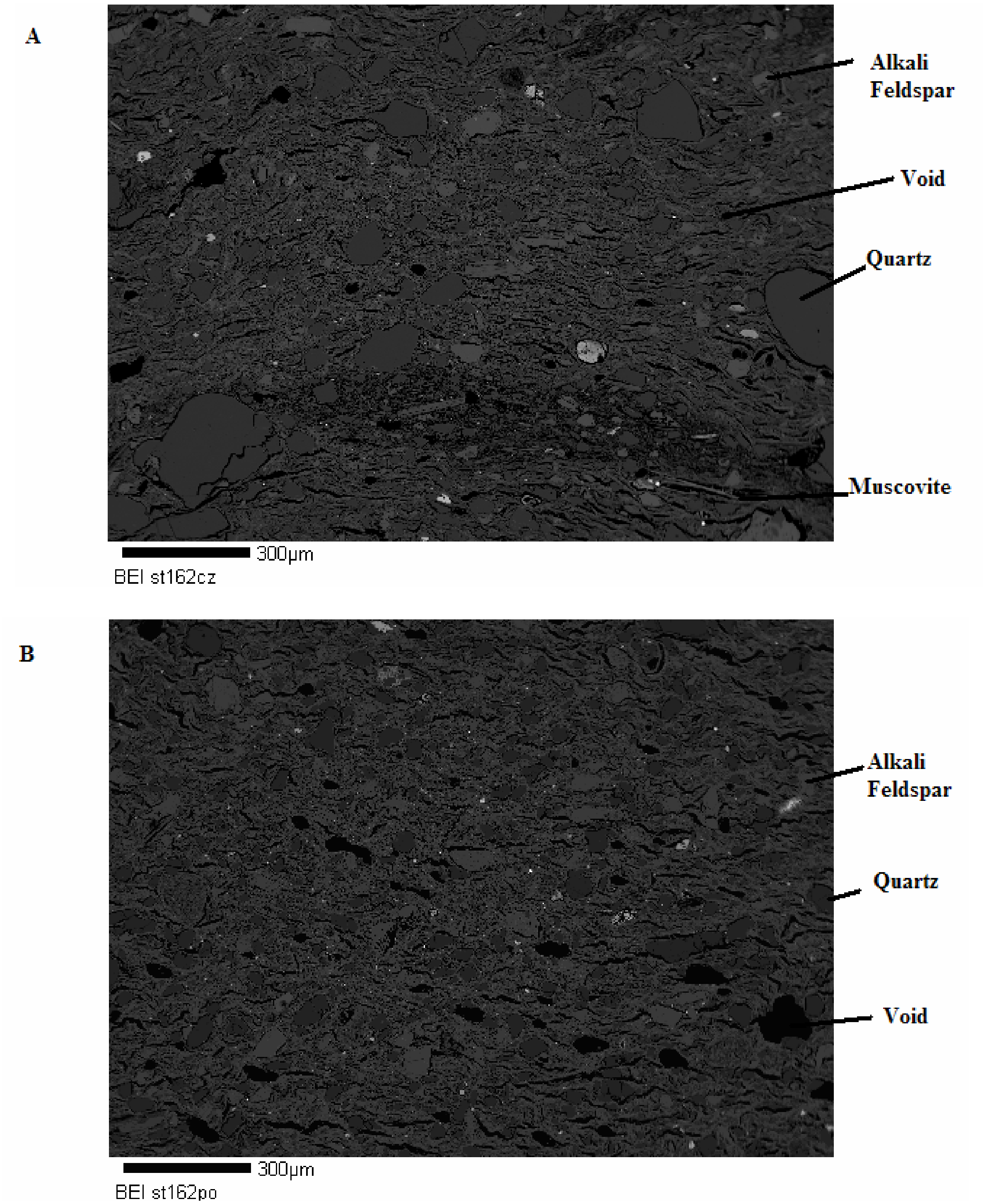


Figure 15: Fabrics of Merida ware samples. Image A is a picture of the foliation present in Fabric One. Image B lacks a foliation and is representative of Fabric Two.

For example, some quartz grains in sample 89-1-345 were as large as 0.98 millimeters while the largest quartz grain in any of the other three samples was 0.86 millimeters. Plus, the average grain size for quartz is not that different between samples. Thus distinction based on grain size is not as concrete as any differences in mineralogy would be (Figure 16).

Based on mineralogy of the four samples of orange micaceous ware some speculation to the location of clay and temper sources of this ware can be made. First, these samples are

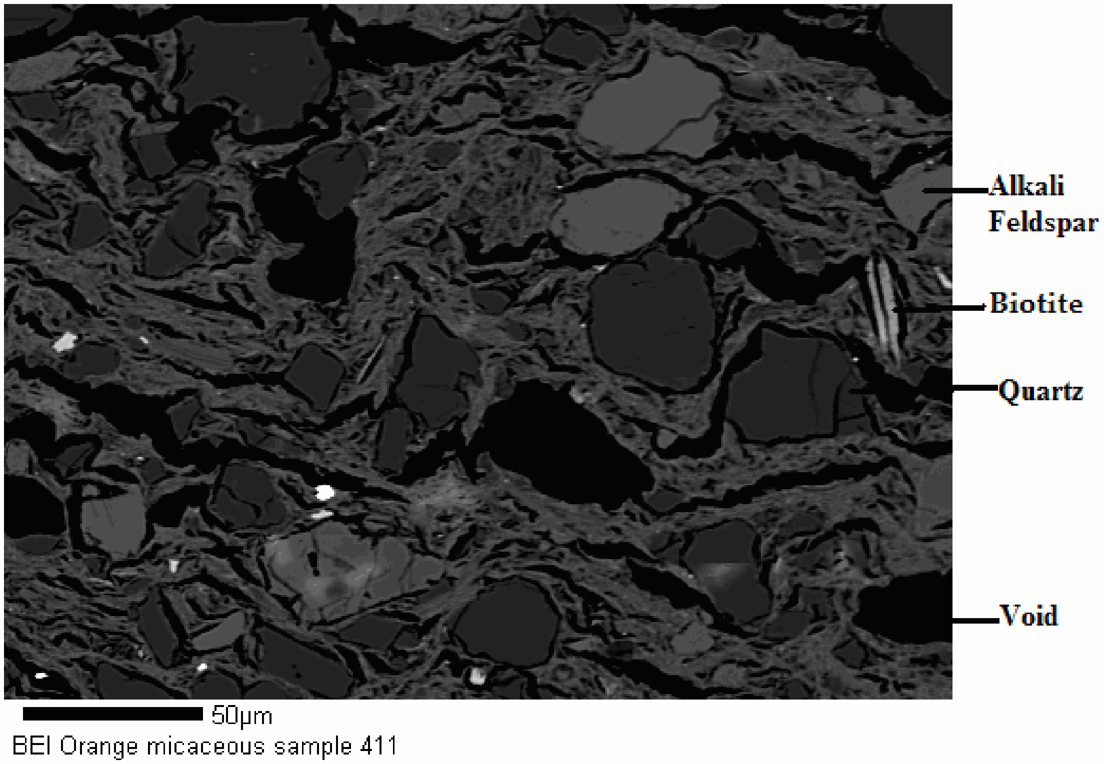


Figure 16: Back scatter image of orange micaceous ware. Quartz and feldspar are dominant phases in this sample. Muscovite is also a common inclusion.

dominated by quartz and feldspar (both plagioclase and potassium feldspar). Quartz and feldspar are dominant minerals on the Earth's surface and are present in a number of rocks. Granite is one igneous rock that is known for containing quartz, plagioclase feldspar and potassium feldspar as dominant phases. Granite could be a source for the quartz and feldspar present in these samples. Additionally, the perthitic nature of potassium feldspar along with the presence of grid-iron twinning present in some potassium feldspar grains provides more evidence for granite as a source. Muscovite and biotite are also present in the samples of orange micaceous ware. Sources of these micaceous minerals could include high grade metamorphic rocks such as schist and gneiss. Additionally, rock fragments present in samples of orange micaceous ware show characteristics of metamorphic rocks. Foliations present in the rock fragments could point to phyllite type metamorphic rocks. Other rock fragments show some clastic sedimentary rock characteristics. Temper source areas for orange micaceous samples would contain crystalline igneous and metamorphic rocks. Sedimentary basins and rocks would also need to around the temper source area for these rocks.

Comparison between the three wares

Differences between the three ceramic types are most apparent when looking at all data compiled thus far. First, there are visible petrographic differences, followed by mineralogical differences and finally compositional differences in micaceous minerals and feldspar inclusions (Figure 17).

Opaque minerals inclusions show petrographic differences between the three wares. Morgan Jones ware samples were abundant in opaque inclusions as compared to samples of Merida and orange micaceous wares (Figures 7, 10, 13). Hematite inclusions are only present in Morgan Jones wares. Rutile and ilmenite occur in all three wares. Rutile is more abundant in

Morgan Jones wares than ilmenite, while ilmenite is more abundant in the two Spanish wares. There is no significant difference in ilmenite compositions in these three wares. Rutilated quartz was present in samples of all three wares. However, only Merida ware samples had visible rutile needles in larger quartz grains. Rutilated quartz present in samples of orange micaceous ware and Morgan Jones ware were only visible during electron microprobe analysis (Figure 18). No rutile needles were in the quartz inclusion from orange micaceous and Morgan Jones ware during petrographic analysis. Mineralogical differences between these three wares are most apparent when looking at the micaceous minerals present in the samples included in this study. Muscovite, biotite and chlorite are very rare in Morgan Jones wares and only occur as accessory minerals. However, in both Merida and orange micaceous wares these micaceous minerals, especially muscovite and biotite are considered important mineral phases.

Compositions of muscovite inclusions provided another line of distinction of Morgan Jones wares from the two Spanish wares. The muscovite grains present in Merida and orange micaceous range from 8 to 10 weight percent K_2O. Typical, unaltered muscovite should have a K_2O content ranging from 10 to 11 weight percent (Deere, Howe and Zuessman, 1997). Low potassium levels can be due to a number of variables. Potassium levels of muscovite grains in the Morgan Jones ware samples range from 7.4 to 9.5 weight percent K_2O. Firing techniques may lower potassium levels of muscovite inclusions in ceramics (Rice, 1987). Muscovite from the two Spanish wares (Na/Na+K= 0.04 to 0.6) is lower in Na than Morgan Jones (Na/Na+K= 0.08-0.12).

Other compositional differences are present when comparing muscovite inclusions from Morgan Jones to the two Spanish wares. Morgan Jones ware muscovite has higher iron (FeO) weight percentages.

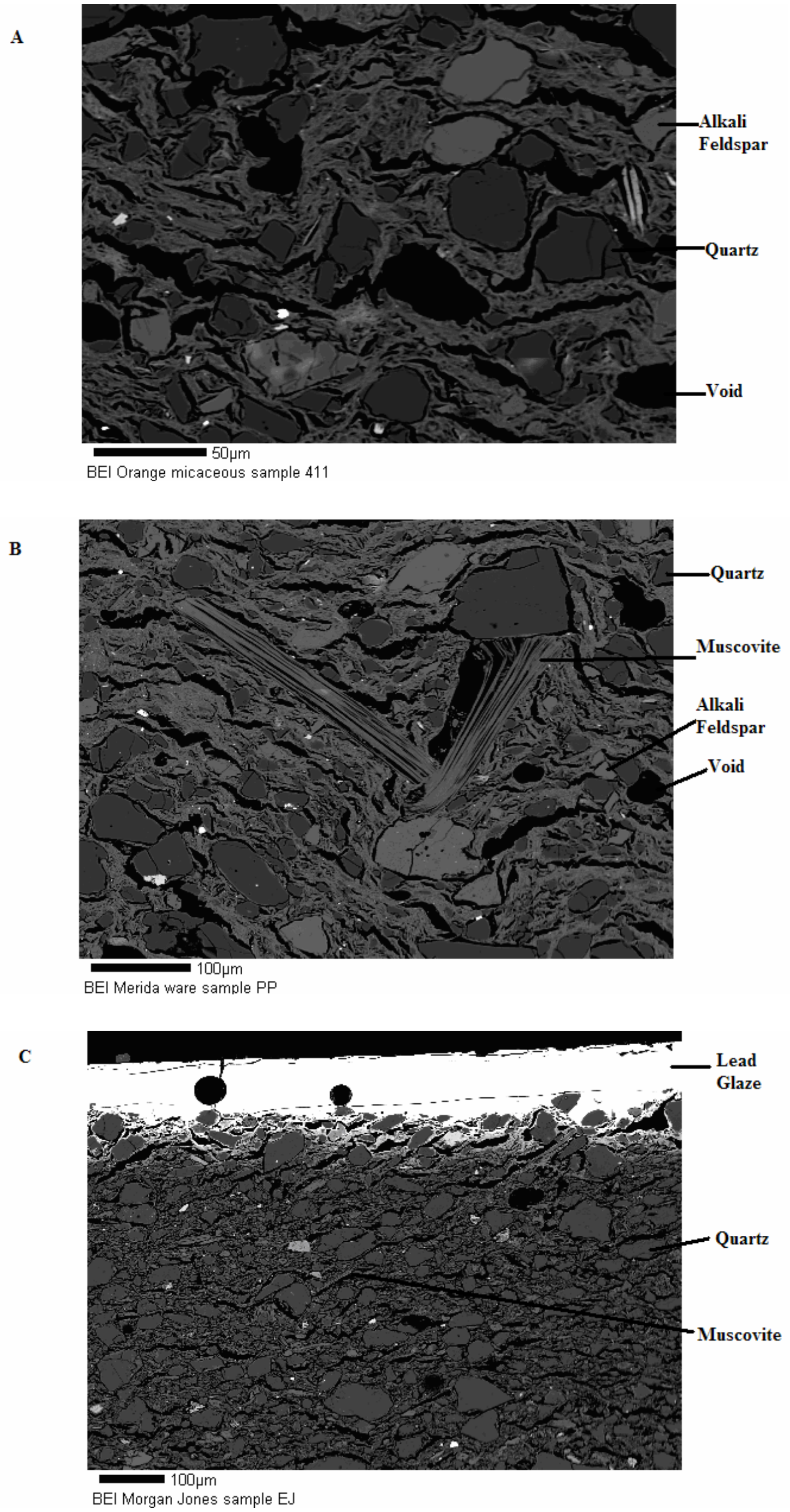


Figure 17: Comparison of the two Spanish wares (Images A and B) to Morgan Jones (image C). Note the presence of a lead glaze on the Morgan Jones ware sample.

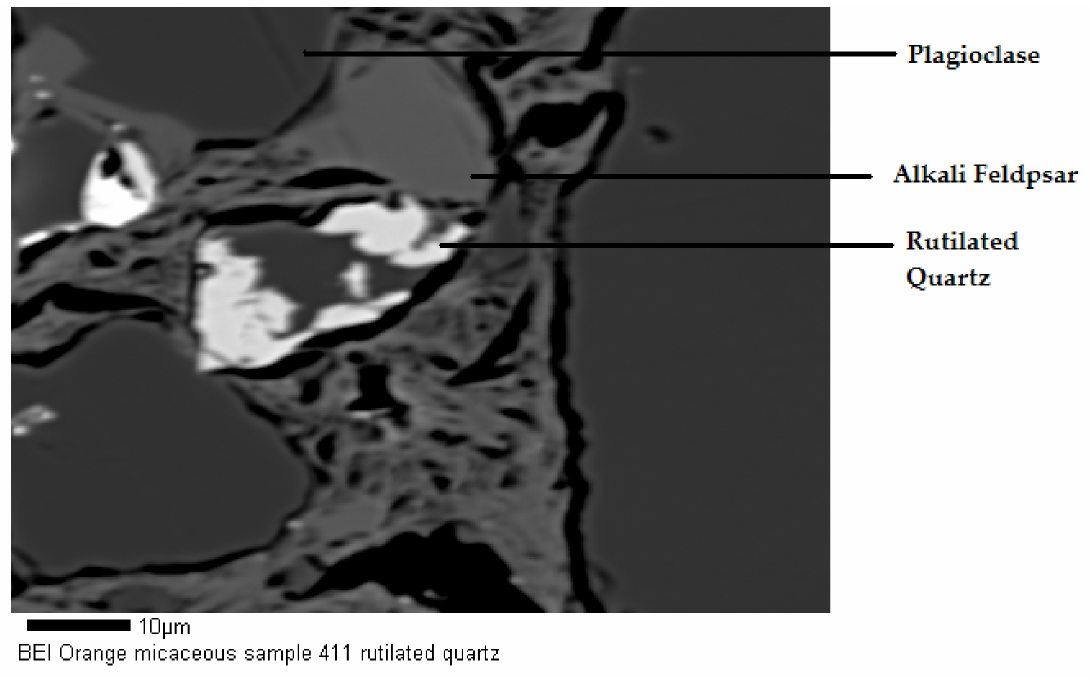


Figure 18: The image above shows rutilated quartz that is visible in electron microprobe imagery, but is not petrographically visible.

(3.04 to 5.00 weight percent FeO) compared to the two Spanish wares (0.33 to 2.63 weight percent FeO).

Biotite inclusions are rarer than muscovite and usually occur as smaller grains. Large grains are thus hard to find and analyze in these ceramics. Biotite was not analyzed in any Morgan Jones ware samples. Grains of biotite in the orange micaceous samples were too small to allow for good analyses. Potassium levels in biotite grains from Merida ware samples range from 2 to 7.4 percent K_2O. Typical unaltered biotite grains should have potassium compositions around 8 weight percent K_2O (Deere, Howe and Zuessman, 1997). Potential causes of the low potassium levels include biotite naturally low in potassium were added as temper or occurred in the clay source, firing techniques caused changes or potassium levels were reduced after the ceramic was deposited. All three ceramic wares are higher in Fe than Mg. However, titanium is higher in the two Spanish wares.

Differences between Morgan Jones and the Spanish ware groups are also visible when comparing the types of feldspar inclusions found in these two groups. Single grains of plagioclase are very abundant in Morgan Jones wares and nearly absent in the two Spanish wares. Most feldspar grains in the two Spanish wares are inclusions of plagioclase and potassium feldspar grains occurring together.

Compositional differences occur between single plagioclase grain inclusions. Morgan Jones has albite (An 1-3) and andesine (An 37-41). Merida plagioclase is mostly albite (An 0-5), but a few grains of oligoclase/andesine (An 26-32) are also found. Orange micaceous ware samples have albite (An 0-2) inclusions. Most of the alkali feldspar analyses show low-sodium potassium feldspar, but one analysis from each of the Spanish wares have appreciable sodium contents and these are best termed alkali feldspar.

Morgan Jones ware samples are the only samples in this study that are glazed. All four samples of Morgan Jones ware exhibit a poorly applied lead glaze. The typological descriptions of Merida ware and orange micaceous ware suggest that some samples may be glazed. However, none of the ten samples included in this study are glazed.

Based on mineralogical, petrographic and compositional comparisons, there are two distinct groups of the three ceramic wares. Morgan Jones wares are clearly distinct from both Merida and orange micaceous. Morgan Jones has few micaceous inclusions and different plagioclase compositions than the samples of Merida and orange micaceous wares.

Mineralogically, there is little difference between the two Spanish wares. Differences in the number of inclusions are noticeable when comparing Merida ware to orange micaceous ware. Orange micaceous samples contain fewer temper inclusions than the Merida ware samples in this study. However, due to the small sample size and the variability among Merida and orange micaceous wares, smaller amounts of temper are not significant. In fact the abundances of the mineral phases are similar between the two wares. Since the mineralogy of the two wares is the same, they could be considered the same ceramic ware (Figure 19).

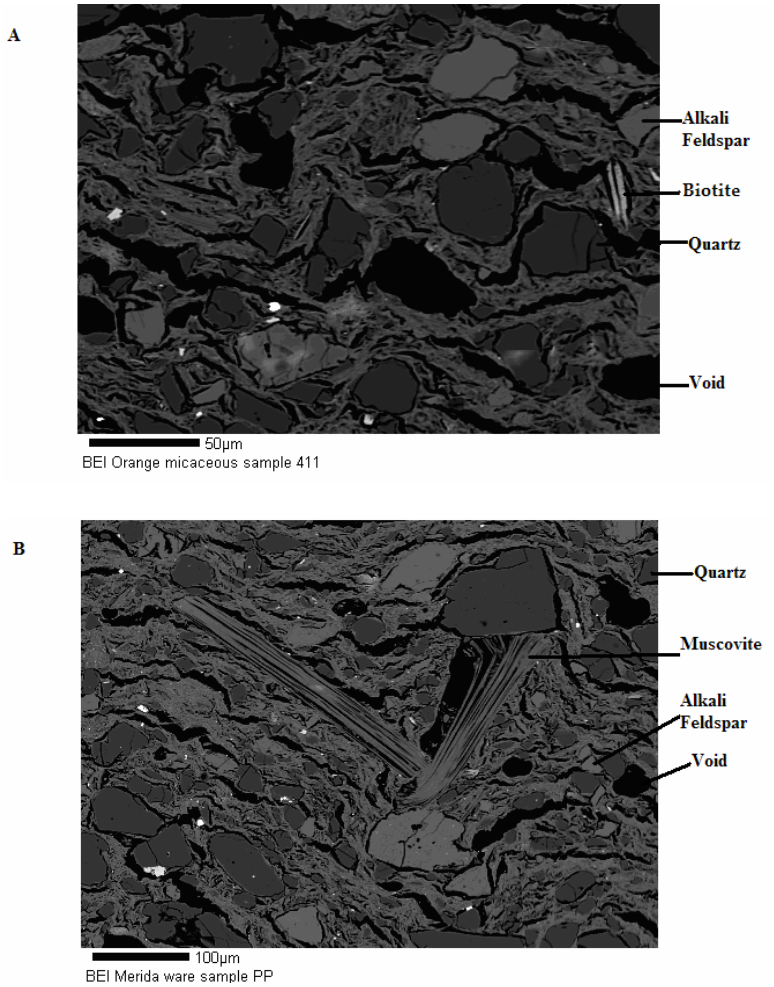


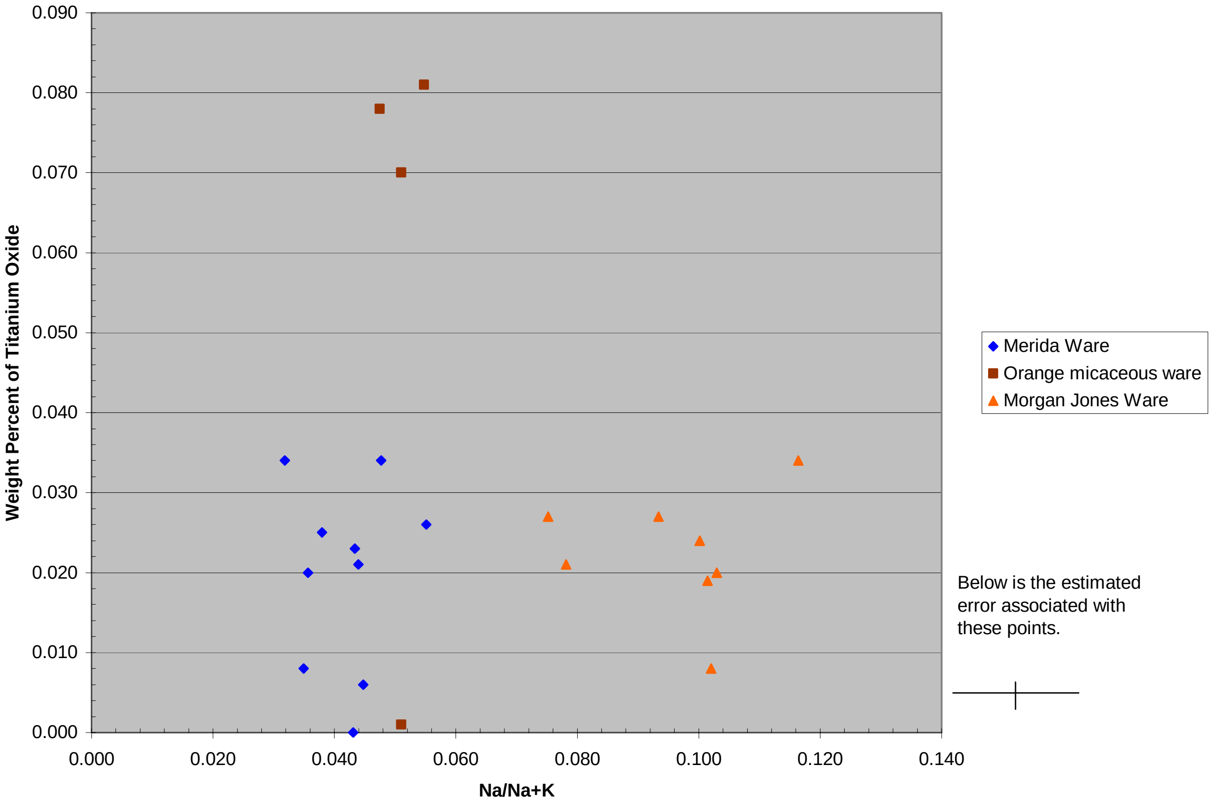
Figure 19: Comparison of Merida ware to orange micaceous ware. Merida ware sample (image A) has similar inclusions to those that are found orange micaceous ware (image B).

Compositionally there are differences in the micaceous minerals present in Merida wares and orange micaceous wares. Sodium to potassium ratios in muscovite inclusions are similar for both wares (Na/Na+K for orange micaceous = 0.05 to 0.06 and 0.03 to 0.06 for Merida); However, the weight percentages of titanium are different (Figure 20).

Compositions of oxide inclusions are also quite similar between Merida and orange micaceous wares. Ilmenite form orange micaceous ware samples (Fe/Fe+Ti= 0.40) is within the range reported for ilmenite inclusions in Merida ware (Fe/Fe+Ti= 0.37to 0.42).

Three grains of albite were analyzed in the orange micaceous ware sample. Single grain albite inclusions were also identified and analyzed in Merida ware samples. However, Merida ware plagioclase inclusions were more variable in composition with some single grain plagioclase inclusions identified as oligoclase/andesine.

Archaeologists have alluded to the origin of orange micaceous ware to be on the Iberian Peninsula. In fact Council (1975), Deagan (1987) and South (1988) state that orange micaceous ware grew out of the Merida ware tradition. If so, Merida ware and orange micaceous ware would have the same clay and temper sources. The mineralogy for orange micaceous ware supports clay and temper source areas in the Alentejo region of Portugal and Extremadura region of Spain.



Below is the estimated error associated with these points.

Figure 20: Comparison of the ratio of sodium to potassium to weight percentages of titanium in muscovite inclusions from Merida wares, orange micaceous wares and Morgan Jones wares. Estimated percentage of error is reported on the side of the graph.

Conclusions

These are distinct differences between the two Spanish wares (Merida ware and orange micaceous) and the Colonial Morgan Jones wares. Differences are apparent in the proportions and compositions of tempering phases. With the data from this study, we can conclude that there are at least two mineralogically distinct clay and temper sources for these three ceramic wares. Source areas for Morgan Jones wares do not contain abundant micaceous minerals, such as muscovite and biotite, based on scarcity of these minerals in the samples. Additionally, perthitic feldspar is not found in Morgan Jones source area. The source area for the two Spanish wares contains micaceous minerals, and perthitic alkali feldspar.

Merida ware and orange micaceous ware are very similar when compared in hand sample. Typological descriptions are so similar that they can not really be differentiated. Similarity is also seen in the mineralogy and texture of these two wares. Compositions of the feldspar, micas and oxides are similar in these two wares. Based on the results of this study, the Merida and orange micaceous wares appear to the same source for manufacturing materials.

Variation was found in each of these ceramic wares. Two fabrics of Morgan Jones and Merida wares were identified during this study, based on paste color and unique temper constituents. However, when considering all the data compiled during this study there is no clear distinction between any of these fabrics. Paste color is not reliable in distinguishing between fabrics because there are a number of variables affecting paste color. In order to distinguish fabrics based on paste color, one would need a number of ceramic samples from the same manufacturing and firing events, which is not possible when dealing with archaeological specimens. In the case of Merida ware, there are other examples of variation from prior studies by other authors. Most of the fabrics identified by other authors are also based on paste color. Based on conclusions from this study, these fabrics are also not reliable and should be discarded or the samples considered to be from one fabric. Furthermore, in order to distinguish fabrics without paste colors, significant differences in types, abundances and/or compositions of inclusions should be used.

Future Research

Further research is needed to determine the extent of variability within each ceramic type. All three ceramic types showed variability. Most often this variability was seen through differences in temper and in the color of the paste itself. Differences in manufacturing and firing techniques are the most likely reasons for the variability. Future studies would need to have a wide sample size of each ceramic type in order to determine the degree of variability. Experiments with clays and temper from the known manufacturing areas would allow for determine what determines the variability. Sources from Maryland and the Iberian Peninsula should be closely studied for their mineral content. Studies on Maryland source areas should focus on the amount of micaceous minerals present in the source material. Studies on materials from the Iberian Peninsula should focus on correlating minerals from the two Spanish ceramic wares and those found in the source material.

Additional research is also needed into the inclusion size variation between Merida and orange micaceous wares to determine its extent. Within this study, there is clear variation between these two wares. A larger and more diverse sample size may provide the data needed to better define or combine these two ceramic wares.

In this study mineral phases present in Merida and orange micaceous wares were identified and their compositions quantified. This allowed for speculation of areas of manufacture based on basic geology of proposed source areas and the location of the sites where these wares are found. A large database of mineral compositions is needed to determine exact areas of manufacture. These data could then be compared to various proposed source areas on the Iberian Peninsula. Sources of clay and temper in use today in the Merida area can also be investigated using the same techniques used in this study. This would allow for comparison of the data presented in this study to data form proposed source areas.

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Appendix 1: Samples Used in this Study

Samples included in the present study along with typological assignment, archaeological context and time period.

Sample Number	Ware	Location	Time Period
18 ST1-62Δ/PM	Merida ware	Chancellor's Point, St. Mary's City, MD	Ca. 1650-1700
18 ST1-62Δ/PP	Merida	Chancellor's Point, St. Mary's City, MD	Ca. 1650-1700
18 ST1-62Δ/PO	Merida	Chancellor's Point, St. Mary's City, MD	Ca. 1650-1700
18 ST1-62-1/CZ	Merida	Chancellor's Point, St. Mary's City, MD	Ca. 1650-1700
18 ST1-62Δ/PN	Merida	Chancellor's Point, St. Mary's City, MD	Ca. 1650-1700
18 ST1-62Δ/JB	Merida	Chancellor's Point, St. Mary's City, MD	Ca. 1650-1700
18 ST1-23-47/AP	Morgan Jones	St. John's St. Mary's City, MD	Ca. 1650-1680
18 ST1-23-27/EJ	Morgan Jones	St. John's St. Mary's City, MD	Ca. 1650-1680
12 VA	Morgan Jones	Kiln Site Glebe Harbor, VA	Ca. 1650-1680
R VA	Morgan Jones	Kiln Site Glebe Harbor, VA	Ca. 1650-1680
90-21-398	Orange Micaceous	St. Francis Barrack St. Augustine, FL	Ca. 1600-1650
90-21-411	Orange Micaceous	De Leon St. Augustine, FL	Ca. 1600-1650
89-1-345	Orange Micaceous	De Leon St. Augustine, FL	Ca. 1600-1699
90-21-402	Orange Micaceous	De Leon St. Augustine, FL	Ca. 1600-1699

Appendix 2: Petrographic Data

Descriptions of the petrographic and point count analysis for each sample used in this study are provided in this appendix. Mineral inclusions and their properties in each sample are described. Hand sample descriptions are also included. Samples are grouped based on their typological assignment and within that assignment any differences that may define a fabric.

Morgan Jones

Sample ST1-23-27/EJ came from the St. John's site at St. Mary's city. Archaeologists at St. Mary's City identified this as a fragment of a pot. The paste is grayish orange (10YR7/4). A thin poorly applied yellow green lead glaze is visible on what appears to be the outer surface. Voids occur in the paste and they are most often elongate or round. Many opaque minerals are visible under the petrographic microscope. Using a reflected light microscope the opaques were determined to be hematite, ilmenite and rutile. These grains appear homogenous under reflected light. Grains of these opaque minerals were tiny rounded to subrounded grains that ranged in size from 0.02 millimeters to 0.10 millimeters in diameter. These minerals are common in the clay and may have been added as temper or could naturally occur in the clay itself. Subrounded grains of quartz are common and ranged in size from 0.10 to 0.85 millimeters in diameter. Plagioclase also occurs frequently in this sample. These grains were also subrounded and ranged in size from 0.20 to 0.80 millimeters in diameter. Potassium feldspar grains also occur in this sample as subrounded to subangular grains that ranged in size from 0.15 millimeters to 0.65 millimeters in diameter. Grog (recycled fragments of grog) is also a common tempering agent. Grains of grog resemble the opaque minerals, but are often larger in size and contain minerals inclusions. Rounded to subrounded inclusions of grog range in size from 0.20 to 1.5 millimeters in diameter.

Micaceous minerals are rare in this sample. Biotite occurs as rounded grains that range in size form 0.20 to 0.70 millimeters in diameter. One elongate grain of muscovite is 0.90 millimeters long. Rare zircon grains are rounded to subrounded and range in size from 0.05 to 0.3 millimeters in diameter. Modal analyses generally confirmed visual estimates of mineral proportions; however, PCA revealed more quartz. A total of 201 inclusions were counted in this sample. Quartz constituted 34.3% of the tempering agents followed by the feldspars with 29.4%. Opaque minerals were also quite common and constituted 21.9% of all inclusions. Micaceous minerals (muscovite and biotite) constituted7.5 % of the total tempering agents. Accessory minerals constitute the remaining 6.9%. Grog is most abundant accessory mineral with 5.9% of all tempering agents. Zircon is by the far the least abundant and constitutes only 1% of all tempering agents.

Sample number 12VA came from a kiln site in Glebe Harbor, Westmoreland County, Virginia. This sample exhibits a poorly applied green glaze to the outer surface. The paste is dark yellowish orange (10YR6/6). Numerous elongate or rounded void spaces are visible. Opaque minerals are present and appear to be the most common inclusions. The reflected light microscope aided in the identification of these opaque minerals. Hematite, ilmenite and rutile are present as rounded to subrounded grains that range from 0.02 millimeters to 0.10 millimeters in diameter. Quartz inclusions occur frequently in this sample as subrounded to subangular grains that range from 0.15 to 0.80 millimeters in diameter. Plagioclase feldspar also occurs as subrounded to subangular range from 0.10 millimeters to 0.25 millimeters in diameter. Potassium feldspar grains are very similar to those of plagioclase. Grains sizes and shape of these inclusions are the same. Grog occurs in this sample as rounded grains that range from 0.20 millimeters to 0.90 millimeters in diameter. Zircon grains are present as subrounded to rounded inclusions that range from 0.05 to 0.20 millimeters in diameter. Only one large rock fragment is present in this sample measuring 2 millimeters in diameter and appears sedimentary in origin. Biotite grains appear elongate and range in size from 0.30 to 0.70 millimeters. Tourmaline is also present in this sample as subrounded to subangular grains and range from 0.10-0.20 millimeters in diameter. Modal analysis generally confirmed visual estimates of abundances; however, PCA proved that quartz was generally more abundant. A total of 223 inclusions were counted in this sample. Quartz is one of the most abundant tempering types constituting 34.5% of all inclusions. Feldspars are as abundant as quartz and constituting 34.6% of all inclusions. Opaque minerals consitute 18.4% of all temper inclusions. Grog is also a major temper category and constitutes 8.1% of all temper inclusions. Accessory inclusions constitute the remaining 4.4% (biotite 1.8%, rock fragments with 1.3%, zircon inclusions with 0.9% and tourmaline with 0.4%).

Sample R-VA originated at a kiln site in Westmoreland County, Virginia. In thin section this sample did not exhibit any surface treatments. The paste or clay was very pale orange (10YR8/2) in color and subrounded voids were present. Opaque minerals were the dominant inclusions. These tended to concentrate closer to the edges of the ceramic. This may have affected the color of the paste itself. The outer edges are darker than the interior. These grains are rounded to subrounded grains of hematite, rutile and ilmenite ranging in size from 0.02 millimeters to 0.10 millimeters in diameter. Quartz also occurs frequently in this sample. Grains of quartz are rounded to subrounded and ranged in size from 0.05 to 0.80 millimeters diameter. Plagioclase feldspar grains are subrounded and ranged in size from 0.10 to 0.70 millimeters in diameter. Potassium feldspar also occurred in this sample, but in smaller amounts than plagioclase. Potassium feldspar grains are subrounded and range in size from 0.10 millimeters to 0.20 millimeters in diameter. Zircon grains are small and subrounded to subangular ranging from

0.10 to 0.20 millimeters in diameter. Grog inclusions were not identified in this sample. Modal analysis generally confirmed visual estimates of abundances; however, PCA proved that quartz was generally more abundant. A total of 204 were counted in this sample. Opaque minerals were the most abundant inclusions identified in this sample and constitute 39.2% of all identified inclusions. Quartz is more abundant than previously thought and constitute 34.8% of all inclusions. Feldspar inclusions are also a major type of inclusion with a total of 20.6% of all inclusion. Accessory inclusions constitute the remaining 5.4% of all inclusions with no single type of inclusion constituting more than 3% of all inclusions. These include zircon inclusions with 2.9%, chlorite inclusions with 2.0% and biotite inclusions with 0.5%.

Sample ST1-23-47/AP is a fragment of a pitcher collected at the St. John’s site in St. Mary’s City. This sherd has a lead glaze on the outer edge. Paste or clay color is very pale orange (10YR8/2). Several subrounded voids are present in the clay. A dark red clay layer is visible in thin section near the glaze outer surface. Opaque minerals were the most abundant inclusion and were identified using reflected light microscopy. They occur as rounded to subrounded grains of hematite, rutile and ilmenite that range in diameter from 0.02 millimeters to 0.14 millimeters. Quartz occurs frequently as subrounded grains that range in diameter from 0.15 to 0.85 millimeters. Plagioclase grains are subrounded and range in size from 0.10 to 0.60 millimeters. Potassium feldspar occurs rarely in this sample, but can be distinguished from plagioclase feldspar when twinned. These grains are subangular and range from 0.15 to 0.25 millimeters in diameter. Rock fragments are also rare in this sample and are most likely sedimentary in origin. These inclusions are large and range from 0.80 to 1.5 millimeters in diameter. Biotite grains are present, but by far were the least abundant inclusion. These grains are elongate and range in size from 0.10 to 0.20 millimeters. Modal analysis generally confirmed visual estimates of abundances; however, PCA proved that quartz was generally more abundant. A total of 168 inclusions were counted in this sample. Quartz is the most abundant tempering agent constituting 43.5% of all temper. Feldspar inclusions are also common major mineral inclusions with 30.4% of all inclusions being feldspars. Opaque minerals constitute 15.5% of all temper. Micaceous minerals are also a major tempering class constituting 5.3% of tempering agents. Muscovite is more abundant with 2.9% followed by biotite with 2.4%. Accessory minerals in this sample include zircon with 2.9%, rock fragments with 1.8% and tourmaline with 0.6%.

Merida-type Ware

Sample ST1-62Δ/JB is a sherd of Merida type ware found as beach find at Chancellor's Point, St. Mary's City, Maryland. The paste of this rim sherd is moderate reddish orange (10R6/6). In thin section there are visible foliations of clay and micaceous minerals. Quartz is the most abundant mineral inclusion. These inclusions occur as monocrystalline and cryptocrystalline grains and as rock fragments. Rutile needles occur in some of the quartz inclusions that are in this sample. Individual grains occur as subrounded to subangular inclusions that vary in size from 0.05 millimeters to 0.83 millimeters. Feldspar grains are the second most abundant inclusions. These inclusions are both grains of plagioclase and potassium feldspar; however without twinned inclusions these are difficult to differentiate. Plagioclase grains occur as subrounded to subangular inclusions that vary in size from 0.04 millimeters to 0.13 millimeters. Potassium feldspar inclusions also occur as subrounded to subangular grains that tend to range between 0.05 to 0.25 millimeters. Opaque minerals include rutile, ilmenite, pyrite and monazite. These inclusions occur as rounded to subrounded grains that vary in size but tend to not be larger than 0.05 millimeters in diameter. Based on the small size, these inclusions were probably naturally occurring in the clay. Micaceous minerals are fairly abundant inclusions. Muscovite is the most common occurring as elongate grains that range in size from 0.05 millimeters to 0.55 millimeters. Biotite is present as Rectangular grains that range in size from 0.11 millimeters to 0.25 millimeters. Chlorite is the least abundant micaceous mineral in this sample occurring as subrounded inclusions that range in size from 0.11 millimeters to 0.36 millimeters. Grog inclusions are subrounded and range in size from 0.10 millimeters to 0.60 millimeters in diameter. Rock fragments are also present as tempering agents. Rock fragments are subrounded and range in size from 0.25 millimeters to 0.86 millimeters. Most are sedimentary; however, some show slight alignment grains suggesting a metamorphic origin. Zircon inclusions occur as subangular grains that are around 0.15 millimeters in diameter. Modal analysis generally confirmed visual estimates of abundances; however, PCA proved that quartz was generally more abundant. A total of 229 inclusions were counted in this sample. Quartz inclusions are the most abundant and comprise 30% of all tempering agents. Muscovite is very abundant in this sample and comprises 21% of all inclusions. Feldspar inclusions are also a major inclusion class and comprise 18% of all tempering materials. Opaque minerals comprise 11.6% of all inclusions. Accessory inclusions include biotite, rock fragments, grog, chlorite and zircon. Accessory minerals individually comprise less than 7% of all tempering agents.

Sample ST1-62Δ/PM is a Merida sample from St. Mary's City. This rim sherd has a dark yellowish orange (10YR6/6) paste and is decorated with an incised line just below the rim. Quartz is the most abundant mineral inclusion and occurs as subrounded to subangular monocrystalline and cryptocrystalline inclusions. Rutile needles occur in some of the quartz inclusions present in this sample. These rutilated quartz inclusions vary in diameter from 0.04

millimeters to 0.82 millimeters. Feldspar inclusions are the second most abundant inclusion type. These inclusions are both subangular plagioclase and potassium feldspars that range in diameter from 0.03 millimeters to 0.15 millimeters. Opaque minerals include rutile, ilmenite, pyrite and monazite. These rounded inclusions range in size from 0.02 millimeters to 0.07 millimeters. Muscovite occurs as elongate grains and range in length from 0.03 millimeters to 0.60 millimeters. Biotite inclusions are Rectangular and range in size from 0.08 millimeters to 0.14 millimeters. Rock fragments occur as rounded inclusions and vary in size from 0.20 millimeters to 0.82 millimeters. Grog occurs as rounded inclusions that vary in size from 0.08 millimeters to 0.64 millimeters. Modal analysis generally confirmed visual estimates of abundances; however, PCA proved that quartz was generally more abundant. A total of 220 inclusions were counted in this sample. Quartz inclusions are the most abundant and comprise 37.7% of all tempering agents. Muscovite is very abundant in this sample and comprises 15% of all inclusions. Feldspar inclusions are also a major inclusion class and comprise 30.9% of all tempering materials. Opaque minerals constitute a wide variety of minerals and comprise 9.5% of all inclusions. Accessory inclusions include biotite, rock fragments and grog. Accessory minerals comprise less than 6.9% of all tempering agents.

Sample ST1-62Δ/PP is a sample of Merida type ware from St. Mary's city. Decoration occurs as an incised line below the rim and has a moderate reddish brown (10R4/6). Mineral constituents in this sample are very similar to the other samples in this study. Quartz is the most common mineral constituent occurring as subrounded to subangular grains that range in size from 0.04 millimeters to 0.61 millimeters. Feldspar inclusions are the second most common tempering agent. Subangular to subrounded plagioclase and potassium feldspars range in size from 0.04 to 0.27 millimeters. Opaque minerals in this sample include rutile, ilmenite, pyrite and monazite. These rounded to subrounded inclusions range in size from 0.02 millimeters to 0.10 millimeters. Micaceous minerals found in the sample include muscovite, biotite and chlorite. Muscovite grains are elongate grains that range in size from 0.04 millimeters to 0.58 millimeters. Rectangular biotite grains are much smaller and range in size from 0.03 millimeters to 0.17 millimeters long. Chlorite grains are by far the least common of the micaceous inclusions with one isolated grain that is 0.05 millimeters. Grog inclusions are rounded to subrounded and range in size from 0.25 to 0.82 millimeters. Fragments of sedimentary and metamorphic rocks are both present as subangular inclusions that range in size from 0.20-0.90 millimeters. Modal analysis generally confirmed visual estimates of abundances; however, PCA proved that quartz was generally more abundant. In fact, quartz is the most abundant minerals inclusions comprising 38.3% of all tempering inclusions. A total of 300 inclusions were counted in this sample. Feldspar inclusions are also quite abundant and comprise 38% of all inclusions. Micaceous minerals are also a major inclusion type in this sample and comprise 14.3% of all inclusions. Muscovite is the most abundant micaceous inclusion comprising 11.7% of all tempering materials. Biotite inclusions comprise 2.3% of all inclusions. Chlorite inclusions are rare, comprising 0.3% of all inclusions and most likely included as an accessory inclusion. Other accessory minerals include grog, rock fragments, opaque minerals and tourmaline. Grog inclusions comprise 3.7% of all tempering agents. Rock fragments are also rare and constitute 1.3% of all inclusions. Opaque minerals include pyrite, ilmenite, rutile and monazite and comprise 3.3% of all inclusions. Tourmaline is also a rare inclusion in this sample comprising 0.3% of all inclusions.

Sample ST1-62Δ/PO is a Merida ware sample that belongs to fabric two. This sample is a sherd with a moderate reddish brown (10R4/6) paste that does not exhibit any decoration. Quartz is again the most common mineral constituent occurring as subrounded to subangular grains that range in size from 0.06 millimeters to 0.80 millimeters. Feldspar inclusions are the second most common tempering agent and are both plagioclase and potassium feldspars. These subangular to subrounded inclusions range in size from 0.06 to 0.50 millimeters. Micaceous minerals found in the sample include muscovite, biotite and chlorite. Muscovite grains are elongate grains that range in size from 0.04 millimeters to 0.58 millimeters. Biotite grains are much smaller than the muscovite grains and occur as blocky grains that range in size from 0.03 millimeters to 0.17 millimeters. Grog appears as subrounded to rounded inclusions that range in diameter from 0.15 millimeters to 0.85 millimeters. Inclusions of quartz can be identified within the grog grains. Opaque minerals such as rutile, pyrite, monazite and ilmenite occur as rounded inclusions that range in size from 0.03 millimeters to 0.05 millimeters. Modal analysis generally confirmed visual estimates of abundances; however, PCA proved that quartz was generally more abundant. A total of 200 inclusions were counted in this sample. Feldspar inclusions are the most abundant tempering agent in this sample comprising 45% of all inclusions. Quartz is the second most abundant tempering agent constituting 31.5% of all tempering inclusions. Micaceous minerals are also a major tempering class in this sample. Muscovite comprises 10% of all inclusions. Biotite comprises 3% of all inclusions. Opaque minerals 7% of all temper materials. Grog is also an accessory phase that comprises 3.5% of all temper.

Sample ST1-62-1/CZ is a sample of Merida ware from St. Mary's City. This sample is a body sherd with a moderate reddish orange (10R6/6) paste and does not exhibit any decoration. Quartz is again the most common mineral constituents occurring as subrounded to subangular grains that range in size from 0.05 millimeters to 0.70 millimeters . Rutile needles occur in some of the quartz inclusions. Feldspar inclusions are the second most common tempering agent. Both plagioclase and potassium feldspar occur as subangular to subrounded inclusions that range in size from 0.04 to 0.45 millimeters. Muscovite grains are elongate and range in size from 0.04 millimeters to 0.65 millimeters. Rectangular biotite grains are much smaller and range in size from 0.03 millimeters to 0.23 millimeters. Grog appears as subrounded to rounded inclusions that range in size from 0.10 millimeters to 0.90 millimeters. Inclusions of quartz can be identified within the grog phase. Opaque minerals that are present in this sample include rutile, ilmenite, pyrite and monazite. These rounded to subrounded grains range in size from 0.02 millimeters to 0.10 millimeters. Fragments of sedimentary and metamorphic rocks were included as temper and range in size from 0.20 millimeters to 0.65 millimeters and Modal analysis generally confirmed visual estimates of abundances; however, PCA proved that quartz was generally more abundant. A total of 300 inclusions were counted in this sample. Feldspar inclusions are the most abundant inclusion in this sample and comprise 32.7% of all tempering agents. Quartz temper comprises 27% of all tempering agents. Micaceous minerals are also a major tempering class. Muscovite comprises 14.7% of all inclusions. Biotite comprises 7.3% of all inclusions. Opaque minerals include pyrite, rutile, ilmenite and monazite and comprise 12.3% of all temper in this sample. Accessory inclusions present in this sample include grog and zircon. Grog comprises 3.7% of all temper. Zircon comprises the remaining 2.3% of all inclusions.

Sample ST1-62Δ/PN is a sherd of Merida ware from St. Mary’s City. This sample is a sherd with dark yellowish orange (10YR6/6) paste with no decoration. Quartz is again the most common mineral constituent occurring as subrounded to subangular grains that range in size from 0.08 millimeters to 0.81 millimeters. Rutile needles occur in some of the quartz fragments in these samples. Feldspar inclusions are the second most common tempering agent. Both plagioclase and potassium feldspars range in size from 0.07 to 0.51 millimeters and are subangular to subrounded. Muscovite occurs as elongate grains that range in size from 0.03 millimeters to 0.40 millimeters. Blocky biotite grains are much smaller than the muscovite grains and range in size from 0.03 millimeters to 0.18 millimeters. Grog appears as subrounded to rounded inclusions that range in size from 0.13 millimeters to 0.88 millimeters. Opaque minerals occur as rounded to subrounded inclusions of rutile, ilmenite, pyrite and monazite that range in size from 0.02 millimeters to 0.10 millimeters. Modal analysis generally confirmed visual estimates of abundances; however, PCA proved that quartz was generally more abundant. A total of 175 inclusions were counted. Quartz is the most abundant mineral inclusion comprising 40% of all temper inclusions. Feldspar inclusions are also quite abundant and comprise 29.4% of all inclusions. Micaceous minerals are also a major temper class and comprise 17.2% of all inclusions. Muscovite is the most abundant and comprises 12.6% of all inclusions. Biotite comprises 4.6% of all inclusions. Grog is also an abundant inclusion that comprises 13.1% of all inclusions. Opaque minerals include rutile, ilmenite, pyrite and monazite and comprise 2.9% of all inclusions.

Orange micaceous

Sample 90-21-398 is a sherd of Orange micaceous ceramic from the De Leon site in St. Augustine, Florida. This sample has a light brown (5YR5/6) paste with a few visible mica inclusions in hand sample with no decoration. Petrographically, this sample also has few inclusions. Quartz occurs as subrounded to subangular grains that range in size from 0.14 millimeters to 0.55 millimeters. These inclusions are often stained by the clay in the sample. Feldspar inclusions are also very abundant in this sample. Both plagioclase and potassium feldspar occur as subrounded to subangular inclusions that range in size from 0.12 millimeters to 0.65 millimeters. Opaque minerals present in this sample include rutile, ilmentie, pyrite and monazite. These inclusions are rounded and range in size from 0.03 millimeters to 0.08 millimeters. Grog inclusions form rounded grains that range in size from 0.15 millimeters to 0.67 millimeters. Rectangular grains of biotite are the most abundant micaceous mineral and range in size from 0.07 millimeters to 0.27 millimeters. Muscovite inclusions form elongate grains that range in size from 0.06 millimeters to 0.75 millimeters. Rock fragments occur as subangular inclusions that range in size from 0.33 millimeters to 0.80 millimeters. These rock fragments are from both sedimentary and metamorphic. Accessory minerals include chlorite and zircon. Two chlorite inclusions occur as subrounded grains that range in size from 0.12 millimeters to 0.25 millimeters. One subrounded zircon inclusion was identified in this sample and was 0.26 millimeters in diameter. Modal analysis generally confirmed visual estimates of abundances; however, PCA proved that quartz was generally more abundant. A total of 149 inclusions were counted in this sample. Opaque minerals (rutile and ilmenite) are the most abundant inclusion and constitute 24.8% of all tempering agents. Feldspar inclusions are also abundant in this sample and constitute 24.5% of all temper materials. Quartz constitutes 20.8% of all inclusions. Sedimentary and metamorphic rock fragments constitute 8.7% of all inclusions. Micaceous minerals are another major tempering material in this sample and constitute a total of 11.4% of all tempering materials. Biotite (7.4%) is more abundant than muscovite (4.0%). Inclusions of accessory phases make up the remaining 6% and include grog, zircon and chlorite. Grog is most abundant (4%), chlorite constitutes 1.3%, and zircon comprises 0.7% of all tempering agents.

Sample 90-21-411 is a sherd of Orange micaceous ware from the De Leon site in St. Augustine, Florida. The paste is moderate reddish orange (10R6/6) with very few visible mica inclusions in hand sample and no decoration. Quartz is the most abundant inclusions and occurs as subrounded to subangular grains that range in size from 0.11 millimeters to 0.66 millimeters.

Some clay staining is apparent on some of the inclusions from the surrounding clay. Feldspar inclusions are also abundant in this sample. Both plagioclase and potassium feldspar inclusions are present as subrounded to subangular grains that range in size from 0.08 millimeters to 0.62 millimeters. Opaque minerals are fairly abundant in this sample and occur rounded as inclusions of rutile, ilmenite, pyrite and monazite that range in size from 0.03 millimeters to 0.08 millimeters. Grog occurs as rounded inclusions that range in size form 0.20 millimeters to 0.67 millimeters. Muscovite occurs as elongate and blocky grains that range in size from 0.08 millimeters to 0.40 millimeters. Tabular biotite grains range in size from 0.04 millimeters to 0.36 millimeters. Modal analysis generally confirmed visual estimates of abundances; however, PCA proved that quartz was generally more abundant. A total of 200 inclusions were counted in this sample. Quartz is the most abundant and comprises 37.0% of all tempering types. Feldspar inclusions are the second most abundant tempering inclusion comprising 36.5%. Opaque minerals, rutile and ilmenite, comprise 11% of all tempering agents. Micaceous minerals include biotite and muscovite and comprise 11.5% of all inclusions. Muscovite is more abundant and comprises 9.5% of the above total. Grog comprises 5% of all inclusions.

Sample 90-21-402 is a sherd of Orange micaceous ware from the De Leon site in St. Augustine, Florida. The paste is a light brown (5YR5/6) with very few visible mica inclusions in hand sample and no decoration. Quartz is the most abundant inclusions and occurs as predominately subrounded to subangular grains that range in size from 0.10 millimeters to 0.72 millimeters. Some staining is apparent on some of the inclusions from the surrounding clay. Feldspar inclusions are also abundant in this sample. Both plagioclase and potassium feldspar inclusions are present as subrounded to subangular grains that range in size from 0.10 millimeters to 0.58 millimeters. Opaque minerals are fairly abundant in this sample and occur as rounded inclusions of rutile, ilmenite, pyrite and monazite that range in size from 0.03 millimeters to 0.08 millimeters. Grog occurs as rounded inclusions that range in size form 0.22 millimeters to 0.70 millimeters. Muscovite occurs as elongate and tabular grains that range in size from 0.08 millimeters to 0.43 millimeters. Biotite also occurs in this sample as tabular grains that range in size from 0.04 millimeters to 0.33 millimeters. Modal analysis generally confirmed visual estimates of abundances; however, PCA proved that quartz was generally more abundant. A total of 200 inclusions were counted in this sample. Quartz is the most abundant and comprises 31.5% of all tempering types. Opaque minerals (rutile and ilmenite) are abundant minerals inclusions and comprise 24.5% of all tempering agents. Feldspar inclusions are an abundant tempering inclusion comprising 20.5% of all inclusions present in this sample. This includes both potassium feldspar and plagioclase feldspar. Micaceous minerals include biotite, muscovite and chlorite and comprise 15% of all inclusions. Muscovite is more abundant and comprises 8.5% and biotite comprises 6% of all temper inclusions. Chlorite is an accessory mineral that comprises less than half a percent of all inclusions. Grog is an accessory inclusion and comprises 5.5% of all inclusions. Zircon inclusions are also rare and comprise only 1% of all temper present in this sample.

Sample 89-1-345 is a sherd of Orange micaceous ware from the St. Francis Barracks site in St. Augustine, Florida. This sample has a moderate reddish brown (10R6/6) paste and exhibits no decoration. Quartz occurs as subrounded to subangular inclusions that range in size from 0.20 millimeters to 0.88 millimeters. Feldspar inclusions are both plagioclase and potassium feldspar. Feldspars occur as subrounded to subangular grains that range in size from 0.15 millimeters to 0.76 millimeters. Both plagioclase and potassium feldspar inclusions appear nearly equal in abundance. Grog occurs as rounded inclusions that range in size from 0.15 millimeters to 0.80

millimeters. Rock fragments are subangular and range in size from 0.25 millimeters to 0.85 millimeters. These rock fragments may be sedimentary or low grade metamorphic. Opaque minerals in this sample are hematite, ilmenite and rutile. They are red to black, rounded inclusions that range in size from 0.03 millimeters to 0.08 millimeters. Micaceous mineral inclusions include biotite, muscovite and chlorite. Muscovite inclusions are the most abundant and occur as elongate or tabular grains that range in size from 0.08 millimeters to 0.65 millimeters. Tabular biotite grains range in size from 0.08 millimeters to 0.45 millimeters. Chlorite inclusions are rare and occur as subrounded grains that range in size from 0.08 millimeters to 0.25 millimeters. Zircon inclusions are very rare and occur as subangular inclusions that range in size from 0.10 millimeters to 0.20 millimeters. Modal analysis generally confirmed visual estimates of abundances; however, PCA proved that quartz was generally more abundant. A total of 180 inclusions were counted in this sample. Quartz is the most abundant inclusion and comprises 40.5% of all inclusions. Feldspar inclusions comprise 26.5% of all inclusions with both plagioclase and potassium feldspar equally abundant. Opaque inclusions comprise 20.5% of all tempering materials. Micaceous minerals comprise 8.5% of all tempering agents. Muscovite inclusions constitute 4.5% of all inclusions, followed biotite with 3.0% and chlorite with 1.0%. Grog is an accessory inclusion that constitutes 3.0%. Rock fragments and zircon inclusions are also accessory inclusions and both comprise 0.5% of all inclusions.

Appendix 3: Electron Microprobe Conditions

Compositions of inclusion mineral grains in the ceramics were determined using a JEOL JXA 8600 Superprobe in the Department of Geology at the University of Georgia. Machine conditions were: accelerating voltage of 15 kilovolts, sample current of 10 nanoamps, and a small beam diameter. The small grain size of the minerals required a small (typically one micron) beam diameter, but this small diameter produced damage in some minerals and then the beam diameter was increased (five to ten microns diameter). Natural minerals were used as standards as shown in the following tables. Online data reduction was done using phi (rho Z) corrections.

Calibration for particular elements that were found in both minor, major and trace amounts in feldspars, oxides, and micas were essential. The following table shows the element name, symbols used in the element tables, the standards that they are measured on and any special considerations for that element or sample. Some elements are measured more than once on different standards. This is because they may be found in more than one of the minerals being investigated. The standard that is used for calibration must be of similar mineral to the one being investigated

Symbol	Name	Standard	Special Notes
Ba	Barium	Benetoite	Do this analysis first, run only a Peak calibration
Mn2	Manganese	Spessartine	
Ti2	Titanium	Titanium oxide	
Ca2	Calcium	Sphene	
Si1	Silica	Diopside5a	
Mg3	Magnesium	Olivine1	Southwest quadrant of the mount
Al3	Aluminum	Spin	
K	Potassium	Orthoclase10	Widen beam to 5µm
Fe2	Iron	Fayalite	
Na1	Sodium	Albite	Widen beam to 10µm
Sia	Silica	Albite	Widen beam to 10µm
F	Fluorine	fluoro phlogopite (synthetic)	
Cl	Chlorine	Scapolite	Widen beam to 5µm
Ala	Aluminum	Anorthite	Widen beam to 5µm
Caa	Calcium	Anorthite	Widen beam to 5µm

Table 1: This table shows the elements that need to be calibrated for and the standards on which they are calibrated for muscovite and feldspar inclusions.

Symbol	Element	Standard
Si1	Silica	Diopside SA
Ti2	Titanium	Rutile (Synthetic)
Al3	Aluminum	Spinel
Mg3	Magnesium	Olivine1
Fe4	Iron	Hematite
Mn2	Manganese	Spessartine
Ca2	Calcium	Sphene (Titanite)
Cr4	Chromium	Chromite
Ni	Nickel	Nickel metal

Table 2: Elements measured in oxide analyses and the standards used for calibration of these elements. All of the standards are CM Taylor standards.

Initial investigations used electron dispersive spectroscopy (EDS) to confirm the identity of the inclusions that needed to be examined. Following this reconnisance, wavelength dispersive spectroscopy (WDS) was used to determine the compositions of the inclusions. Micaceous minerals (both muscovite and biotite), feldspar inclusions (plagioclase and potassium feldspar) and oxide inclusions (ilmenite, rutile and hematite) were all investigated in this study.

Three macros were written for this study. The first is a macro for biotite and muscovite inclusions and the second is for feldspar, plagioclase and potassium, inclusions. The final macro was used for oxide inclusions (ilmenite, rutile and hematite).

Biotite Macro

```
zaf atoms -11
get ele k;get ele f
meas k f
get ele al3
measure si1 ti2 al3 fe2 mg3 mn2 ca2 cl na1
open quant biotite
quant
```

Feldspar Macro

```
zaf atoms -8
get ele na1;get ele k
measure na1 k sia ti2 ala mg3 fe2 mn2 caa ba
open quant feldspar
quant
```

Oxide Macro

```
zaf atoms -4
edit si1 pk no
measure si1 ti2 al3 mg3 fe4 mn2 ca2 cr4 ni
quant
```

Substandards used to check calibrations the elements were chosen to be similar to the minerals being investigated. This required that a standard of both plagioclase feldspar and potassium feldspar be used. The only mica standard used in this analysis was a biotite. Only one oxide standard was needed (ilmenite).

Lemhi biotite (lemhi bio)						
	SiO_2	32.82	32.81	32.66	33.23	32.94
	TiO_2	1.41	1.34	1.48	1.42	1.35
	Al_2O_3	17.49	17.84	17.78	17.63	17.28
	FeO	2.91	2.87	2.77	2.96	2.75
	MgO	30.95	31.00	29.96	33.03	31.75
	MnO	0.00	0.08	0.00	0.04	0.07
	K_2O	8.49	9.34	8.29	8.43	8.30
	Na_2O	0.21	0.15	0.43	0.36	0.41
	F	0.22	1.16	1.36	1.08	1.12
	Cl	1.19	0.41	0.18	0.26	0.00
	Total	95.69	96.56	94.52	97.96	95.72

Labradorite (USNM 15900 U Ore F-25)		
	SiO_2	51.34
	TiO_2	0.05
	Al_2O_3	30.84
	FeO	0.42
	MgO	0.09
	MnO	0.01
	CaO	13.53
	Na_2O	3.49
	K_2O	0.20
	Total	99.97

Microcline (USNM 143966)		
	SiO_2	64.24
	TiO_2	0.01
	Al_2O_3	18.30
	FeO	0.14
	MgO	0.03
	MnO	0.04
	CaO	0.02
	Na_2O	1.30
	K_2O	15.14
	Total	99.22

Ilmenite Std USNM		
	SiO2	0.000
	TiO2	46.830
	Al2O3	0.003
	MgO	0.358
	FeO	44.06
	CaO	0.012
	MnO	4.680
	Cr2O3	0.000
	NiO	0.000
	Total	95.95

Appendix 4: Sample Preparation and Analysis

Polished thin sections were manufacture at Vancouver Petrographics Ltd. for use in the electron microprobe and under a polarizing microscope.

Petrographic analyses of ceramic samples were conducted on a Lucia polarizing microscope and an Olympus polarizing microscope with reflected light microscopy capabilities. A point counter was utilized on the Olympus scope to aid in point counting analyses. An eyepiece micrometer was used to determine the size of inclusions present in the ceramic materials.