Could You Point Me to Your Nearest Clay Source, Please?: A XRF Study of Barbadian Historic Era Ceramics

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Could You Point me to Your Nearest Clay Source, Please?: A XRF Study of Barbadian Historic Era Ceramics

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ABSTRACT

The goal of this project is to create a non-destructive process for the identification of Barbadian ceramics, link Barbadian ceramics to a single clay source on the island, and alleviate the problems outlined above. Unlike previous projects, which largely involve the use of macroscopic methods, such as scanning electron microscopy (SEM) (Siedow 2011), to examine the surfaces of ceramics, this project takes an extra step in the identification of ceramics through the analysis of the chemical composition of the clay matrix. It is my hope that chemical characterization can be used to create a fingerprint of Barbadian ceramics, and when coupled with knowledge of clay sources, create an unequivocal link between ceramics and their sources. Additionally, it is my goal to answer several questions concerning historic era Barbados and its ceramic industry. Firstly, did Barbadian potters obtain their clay for ceramic manufacture from Chalky Mount? If not, then where did they get it from, and why? Did an exchange network of clay and ceramics exist on Barbados in a similar vein to Hauser’s (2008) study on Jamaica? Secondly, how extensive was the ceramic industry on Barbados? Lastly, how, if at all, can information known about present day Barbadian potters translate to the past? The knowledge could prove invaluable to Caribbean archaeologists and help shed light on many aspects of historical era Barbadian life, as well as provide a method for the identification of locally produced redware ceramics elsewhere in the Caribbean.
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To my parents and Lauren, for all their love and support
CHAPTER 1: INTRODUCTION

The application of chemistry to archaeology has proved useful to archaeologists in recent years. This interdisciplinary field, referred to as either *archaeological science* or *archaeometry* has firm roots in the physical sciences, as well as in anthropology. Archaeometry aided in the advancement of several fields within archaeology, such as: absolute dating (carbon-14 dating), reconstruction of environments (paleoethnobotany), isotope analysis of faunal remains (zooarchaeology), and, sourcing studies (materials characterization techniques). This paper focuses on latter application, via X-ray fluorescence spectroscopy (XRF). Furthermore, the study builds off of previous work done by Caribbean archaeologists with respect to ceramic studies in Barbados, such as: Jerome Handler (1963a, 1963b) with his ethnographic research on the contemporary Barbadian ceramic industry, Thomas Lottfield (2011) and his study on the creolization of historic area ceramic production, and Erik Siedow (2011) in exploring the presence of radiolaria fossils in clays from Chalky Mount. However, unlike previous studies, an extra step is taken in exploring Barbadian ceramics through the use of XRF spectroscopy. Finally, this study draws from Mark Hauser (2008) and attempts to establish internal exchange networks of enslaved individuals in Jamaica, but instead revolving around Barbados.

Materials characterization in sourcing studies can yield a wealth of information concerning the historical past. Despite the scientific merit of material characterization, purely scientific approaches do not directly yield cultural practices. Instead, the application of anthropological theory is essential to transform raw chemical data into
human behavioral patterns. Additionally, chemical characterization of ceramics alone is not appropriate to create a link between ceramics and a geographical region; that is, samples of base clays from local deposits are essential. Without the base clays, any such study lacks a proper control and cannot truly be representative of a chemical fingerprint.

Ceramics, most notably red earthenware, are directly tied to the Barbadian economy since the advent of British colonial rule (Handler 1963a, 1963b). Shortly after the ill-fated attempt of the early British settlers to grow tobacco, sugar rose to prominence in Barbados (Dunn 1972:188, Smith and Watson 2009:64). The production of this luxury good quickly consumed both Barbados and the British Caribbean as a whole. Between the seventeenth and eighteenth centuries the sugar industry dictated the social, political, and economic world of Barbados (Smith 2009:63). Sugar changed the Caribbean and British society forever.

An inextricable link existed between the sugar and ceramic industries on Barbados, as industrial efficiency was maximized to elevate capital gains. Much of the ceramic industry concentrated in one geographical area of Barbados: the Scotland District, comprising of the parishes of Saint John, Saint Joseph, and Saint Andrew. Chalky Mount, the location of a primary clay deposit on Barbados, lies within this geographical area, and today remains a center for ceramic production (Handler 1963a:314). Although Caribbean wares are typically handmade and low-fired, many ceramics found in Barbados are wheel thrown and kiln-fired (Siedow 2011:3). The wheel thrown production process is indicative of European styles of manufacture and testifies to the high degree of influence the British had in the ceramic industry. Furthermore, red
earthenware ceramics were imported from England throughout the heyday of the sugar industry (Handler 1978). This change in form of Barbadian ceramics, coupled with the continual import of English ceramics, greatly impedes the identification of locally made Barbadian ceramics.

The goal of this project is to create a non-destructive process for the identification of Barbadian ceramics and link them to a single clay source on the island, in an effort to alleviate the problems outlined above. Unlike previous projects, which largely involve the use of macroscopic methods, such as scanning electron microscopy (SEM) (Siedow 2011), to examine the surfaces of ceramics, this project takes an extra step in the identification of ceramics through the analysis of the chemical composition of the clay matrix. It is my hope that chemical characterization can be used to create a fingerprint of Barbadian ceramics and, when coupled with knowledge of clay sources, create an unequivocal link between ceramics and their sources. Additionally, it is my goal to answer several questions concerning historic era Barbados and its ceramic industry. Firstly, did Barbadian potters obtain their clay for ceramic manufacture from Chalky Mount? If not, then where did they get it from, and why? Did an exchange network of clay and ceramics exist on Barbados in a similar vein to Hauser’s (2008) study on Jamaica? Secondly, how extensive was the ceramic industry on Barbados? Lastly, how, if at all, can information known about present day Barbadian potters translate to the past? The knowledge could prove invaluable to Caribbean archaeologists and help shed light on many aspects of historical era Barbadian life, as well as provide a method for the identification of locally produced redware ceramics elsewhere in the Caribbean.
CHAPTER 2: CULTURAL RELEVANCE

Barbadian redware ceramics are present at nearly every site on the island, but are difficult to distinguish from European ceramics due to a lack of diagnostic features. Locally produced utilitarian redware vessels, such as sugar molds, are nearly impossible to distinguish from their European counterparts. Because of this, little is known about the ceramic forms Barbadian potters produced during the historical period. While having nearly complete vessels greatly aids in the identification of ceramics, archaeologically this is difficult as sites typically have only fragments of vessels.

This section of the study is split into several parts, and aims at providing background information on the cultural forces at play during British colonial rule. First, I provide an overview of the sugar industry and the economic impact it had on Barbados. To understand the economic framework of colonial Barbados is to understand the role of sugar in the larger Atlantic world. Next, I investigate the historical tradition of the Barbadian redware ceramic industry, in particular the practices of potters. This section also includes the roles of historic potters in society, primarily through documentary evidence. In addition, the behavior of modern day potters on Barbados will be compared to the ways of the past in an effort to create an ethnographic link between historical and contemporary potters. Finally, a brief overview of the histories of Codrington Plantation and Pot House are given, in an attempt to bring greater historical context to the study.

It should be noted that this section focuses heavily on the British colonization of Barbados. The temporal focus is meant to neither erase or play down the history of the island prior to British rule, nor imply an Anglocentric view of the island; rather, it is my
opinion that the ceramic industry on Barbados centered on the sugar trade, which historically centers on the British.

*The Sugar Industry*

The early history of colonial Barbados is the story of clashes between England's economic titans, rapidly changing economic environments, the institution of racially based slavery, and sugar. Sugar changed Barbados forever, economically and socioculturally. This section examines the role sugar played in shaping the course of Barbadian history.

After the establishment of the colony of Barbados, Henry Powell, under the employment of Sir William Courteen, an British economic titan, departed Barbados for Dutch Guiana to bring back several species of plants in an attempt to provide Barbados with an economically viable cash crop suitable for the climate of the island. According to Larry Gragg these included, “potatoes, cassava, plantain, corn, cotton, tobacco, and sugar cane” (Gragg 2003:31). Despite the success of many of these crops in other British colonial ventures either the climate of Barbados was ill-suited to their agriculture, or they proved to not be economically practical in comparison to other British colonies.

Frederick Smith and Karl Watson note that:

After nearly two decades of economic stagnation, stemming in part from their inability to compete with their Chesapeake cousins for a substantial share of the lucrative tobacco market, [Barbados] embraced sugarcane and transformed their sleepy Chesapeake-like society into a powerful economic machine that would stand unrivaled against any other New World colony during the seventeenth century (Smith and Watson 2009:64)
By introducing sugar to the island, Powell unknowingly set into a motion a series of events that would change both Barbados and the British empire forever. The development of Bridgetown, ironically the rival and historical competitor to Sir Courteen’s Holetown, illustrates the economic impact of sugar on Barbados. By the late seventeenth century the sugar industry created enormous amounts of wealth for Bridgetown, which transformed it from a sleepy settlement into a bustling port town (Smith and Watson 2009:72). The explosive growth continued for decades following the introduction of the cash crop to the island, with the rate of change increasing with the advent of the Industrial Revolution during the late eighteenth century.

While sugar had a profound impact on the economic conditions on Barbados, it also dramatically changed the societal makeup of the island, namely through the rise of a wealthy planter class at the expense of enslaved individuals. Although the institution of slavery greatly expanded during the sugar boom of Barbados, it is interesting to note that slavery on the island predates the sugar industry. According to boatswain John Cleere, in addition to the first English colonists on Barbados there were “tenn [sic] negroes” taken from a prize ship during the voyage from England (Gragg 2003:31). In addition to the several species of plants, Henry Powell also returned with over thirty Arawaks to assist in the cultivation of the plants, and aid in the establishment of the colony. The Arawaks would prove critical in sustaining the colony during its early years (Dunn 1972:227, Gragg 2003:31, Handler 1969:41). In effect, the birth of colonial Barbados is historically linked to slavery.
Although slaves existed on Barbados since the founding of the colony, the sugar industry dramatically increased the volume of African slaves imported to Barbados. Richard S. Dunn notes that, “from the beginning sugar makers pegged their production system to black slave labor. Sugar and slavery developed hand in hand” (Dunn 1972:189). The reliance of slave labor for sugar production was staggering. The more slaves a planter owned for their plantation meant greater production, and in turn greater profits. The dramatic increase can be seen through the number of African slaves imported into Barbados between 1640 and 1700 (see Figure 1, Appendix A: Historical Charts and Graphs). According to Dunn, between 1640 and 1650 around 18,700 slaves were imported to Barbados, and increased dramatically between the years 1651 and 1675 when around 51,100 slaves were imported (Dunn 1972:230). By the end of the seventeenth century, the institution of slavery was heavily embedded into Barbadian society.

The dramatic influx of slaves into Barbados, and the relatively lower increase of the number of Europeans, created strife between the two classes. Increasingly fearing a large scale slave revolt, the British colonists instituted a comprehensive slave code in 1661 (Dunn 1972:238). The slave code stripped the basic human rights of all African slaves and their descendants, legally changed their status to chattel property, and a subsequent amendment in 1668 classified them as real estate (Dunn 1972:239-241). The slave code was kept in place until the abolition of slavery by the British Empire in the 1830s, and was largely effective in the suppression of racial tensions.

*Barbadian Ceramics and Potters*
The ubiquitous nature of redware ceramics in sites on Barbados testifies to their importance and widespread use during the historical period. Historical records note the emergence of the Barbadian ceramic industry occurred during the late seventeenth century. Jerome Handler (1963a, 1963b) notes the importance of this industry in relation to the sugar industry, and the role of enslaved individuals played in the manufacturing process. Enslaved individuals utilized European manufacturing techniques, such as kiln-firing and wheel-throwing, to produce both conical sugar molds and utilitarian vessels for everyday needs. Despite the local pottery industry, output from the island could not adequately keep up with demand. Thus, plain redware ceramics were imported from England in large amounts to fulfill both the industrial needs of the sugar factories, and the domestic needs of households (Handler and Lange 1978:139). The Scotland District was the primary center for ceramic production, and comprised of the parishes of Saint John, Saint Joseph, and Saint Andrew. While the mountainous terrain of the Scotland District made it unsuitable for sugar manufacture, it contained an abundance of clay due to the geological formations of the area, most notably Chalky Mount.

Located in Saint Andrew’s Parish on the eastern coast of Barbados, Chalky Mount is underlain by a geological formation known as the Scotland Group. The formation is characterized by a complex of Paleocene—Mid-Eocene-Aged saliciclastic sediments (Kirby and Gunter 2015:1). These sediments extend south into the parishes of Saint Joseph and Saint John and characteristically display multi-colored deposits, containing radiolaria fossils (Kirby and Gunter 2015:2). Furthermore, the formation is bounded on the west by limestone deposits, known as coral stone (Speed 2012). The
geological result is the presence of multi-colored bands of red, white, and gray clays occasionally separated by sandstone seams. Historically the Scotland District clay deposit was noted by J. B. Harrison in 1890, who described them as “thirty feet of clays and shales of very varying colours, with occasional sandstone seams” (Harrison 1890:13). The Chalky Mount clay deposit was the primary clay deposit for local potters in the parish of Saint Andrew during the seventeenth century (Handler 1963b:314). Handler and Lange (1978) noted the high concentration of kilns in the Scotland District relative to the rest of the island (see Figure 2, Appendix A: Historical Charts and Graphs). Additionally, potters further south in the parish of Saint John, the location of Codrington Plantation and Pot House, also used the multi-colored Scotland Group clays.

The ceramic industry of Barbados metamorphosed with the changing economy, in turn fueled by the sugar industry. The first potters on the island were European indentured servants, primarily poor whites from Scotland, Wales, and Ireland, which remained the case until 1670 (Beckles 1989:115). As the labor pool of the sugar industry changed to one based on slave labor, the roles of the potters switched from indentured servants to enslaved individuals, whom subsequently gained a more privileged status on plantations (Beckles 2006:77). As the sugar industry continued to expand, there was a growing demand for redware ceramics important in the processing of sugar. Logically, in order to maximize profits and become more self-sufficient, plantation owners would have decreased the volume of ceramics imported from England and increased their plantation’s production. It is likely that enslaved potters produced and sold their wares in weekend markets through internal economic structures, similar to exchange networks discussed by
Hauser (2008) in Jamaica. Ceramics at these markets were exchange between whites, free blacks, and enslaved individuals, and soon became a critical component of the Barbadian socio-economic structure.

The meshing of European techniques with Afro-Caribbean styles created a unique style of pottery which proves difficult to analyze. Hauser and Armstrong (1999) identify Caribbean ceramics as hand-built, open- or low-fired wares; but, this is not the case for Barbados, where wheel-thrown, kiln-fired traditions dominate. According to Handler and Lange, enslaved male potters in Barbados employed European techniques of ceramic manufacture during the colonial era, and these practices continued into the twentieth century (Handler and Lange 1978:139). Codrington Plantation and Pot House demonstrate the blending of Caribbean and European ceramic traditions. Ceramics found in early temporal contexts exhibit manufacturing and decorative features corresponding to African-made ceramics, including: black bodies, construction through coiling, and open firing techniques (Lottfield 2001:227). However, ceramics found in later contexts display markedly different manufacturing techniques and decorations. While most of the ceramics are wheel-thrown and kiln-fired, suggesting European manufacture, these later contexts are marked with decretive cross-hatching, typically considered characteristic of African-made wares (Lottfield 2001:231).

Modern day practices of the Barbadian ceramic industry are well documented, primarily by Handler (1963a). In the contemporary Barbadian ceramic industry, there exist three primary occupational roles: 1) throwing and producing, 2) kneading, and 3) operation of the wheel (Handler 1963a:323). The potter themselves fill the former of
these roles, and is where the brunt of the creative design process takes place. In general, the potter alone will produce wares and not allow others to participate in the process. A possible explanation for this is the desire of the potter to control the creative process, as it is their name at stake in the market, with the assistant having little to no bearing over the appearance of the work. Moreover, the name of a potter is akin to a brand name on a piece of merchandise. By signing their name, the potter acknowledges that the ceramic comes from them alone, and assumes full responsibility for the quality of the work.

Handler notes that there is no formal education required to be a potter in Barbados, and that all learning based off of observation (Handler 1963a:324). Furthermore, the status of potter seems to be an exclusive title. Individuals cannot just become potters on a whim, but rather need to be invited into the circle. According to Handler, “potters learn the art by observing, and they are usually informally recruited from the ranks of those males who assist at various stages of the productive process” (Handler 1963a:324). If an individual is brought into the world of ceramic production they engage in an informal apprenticeship and learn all aspects of production.

In general, individuals fall under one of three categories in ceramic manufacture: 1) potters, 2) apprentices or individuals associated closely with the potter, and 3) non-potters. The potters are full time specialists and engage in all aspects of the production process, including throwing clay, which they are the sole operators (Handler 1963a:324). The second group of individuals are those in close association with the potter, but possess no particular technical skills of their own. These individuals represent the “non-paid members of the potter’s household” and generally are either spouses or children (Handler
It is commonplace for the potter to throw wares and trim the pieces, while those of his household operate the crankshaft to turn the wheel. The operation of the crankshaft, though vital, requires minimal technical experience. The lack of technical skill causes this category to not be considered potters by the community at large. The final category of individuals represents an interesting aspect of the Barbadian pottery industry. While they possess intimate knowledge of the production process, they have little to no familiarity with the creative aspects. Members of this category “regularly engage in pottery production and can perform most of the operations […] but do not throw wares” (Handler 1963a:324). These individuals will commonly hire other potters to produce wares, and subsequently either hire other individuals or perform all the side work themselves (Handler 1963a:324).

Traditionally, men dominate the ceramic manufacturing process, while women and children turn the crankshaft (Handler 1963a:323). In effect, this puts the majority of the creative process in the hands of the men. Furthermore, the process of firing a kiln also falls exclusively to men. According to Handler, “firing is an adult male’s responsibility, especially those aspects that deal with tending the fire […] and the actual stacking of vessels in the kiln” (Handler 1963a:331). The reason for the gendered division of labor may stem from a desire to completely control the creative aspects of the process. By being solely responsible for both the throwing and firing of the pottery, the male maintains his dominance over both the creative process, and paramount steps in production. Women, on the other hand, are charged with the selling and distribution of
the ceramics (Handler 1963a:332). The cultural dynamics surrounding this phenomena are yet to be investigated.

The individual household of the potter is the primary unit for production, with the preparation, production, and firing of clays occurring in close proximity to the household. Handler notes that “ordinarily each household sells its own wares” (Handler 1963a:332). The fact that the majority of the pottery production process centers on the household leads me to believe that the identity of potters does not lie solely with themselves. Rather, the household as a unit identifies as being associated with potters, instead of each individual playing a separate occupational role.

The ware types produced illustrate the connection between the potters and the lower classes of Barbados; additionally, the primary consumer base for the dominant forms of ceramics demonstrates the societal positioning of the potters. For example, one of the most common ceramic forms produced in Barbados is the water jug, or monkey (Handler 1963a:322). Generally, the monkeys lack any formal decoration on the exterior, pointing to their use as a utilitarian ware. The lack of formal decoration is significant, as it requires less pooled labor to produce a single monkey. In turn, the lower amount of pooled labor points towards a lower economic value, and thus readily available to the majority of socioeconomic classes in present-day Barbados.

*Historical Overview of Codrington Plantation and Pot House*
The historical backgrounds of Codrington Plantation and Pot House are important in order to fully contextualize the ceramics used in this study. It is not my intention to provide a lengthy history of the sites, as it is not the main focus of this thesis. As a result, this section of the paper is rather succinct.

Christopher Codrington, a wealthy sugar planter in Barbados, willed the running of his three sugar plantations in 1703 to the Society for the Propagation of the Gospel to further its missionary work in the Caribbean (Klingberg 1949:15). Barbados contained two of the plantations where they were run as a single unit known as the Codrington estates (Bennet 1958:2). The Society sought to use the profits from the sugar plantations to further their missionary work in Barbados, primarily through the construction and subsequent operation of a seminary. The primary goal of this operation was to Christianize the enslaved laborers toiling in the sugar fields (Klinberg 1949:6). The first manager of the Codrington estates, John Smalridge, was tasked with evaluating the relative worth of the plantation to determine the feasibility of building the seminary (Bennet 1958:4). Smalridge’s reported profits came during a time of economic prosperity between 1713 and 1719, and inadvertently conflated an unanticipated surplus of money with regularity of profits. Despite this, construction of the seminary went underway until 1718, when a lack of funds caused a cessation of building. Despite monetary deficiencies, the seminary opened in 1745, but failed to meet its missionary goals (Bennet 1958:4-5).

The Codrington estates operated as two parts of a single plantation unit. The smaller estate, known as the *upper plantation*, cultivated sugar from a 270 acre field. Whereas the larger estate, known as the *lower plantation or Consett*, was the processing
plant of the plantation, and composed of: three stone windmills, the largest boiling house on Barbados, a distillery, and several outbuildings (Klingberg 1949:43). Consett, despite the lack of cultivable soil, with only 50 of 480 acres of field planted with sugarcane, proved valuable as a central distribution hub (Klingberg 1949:43). Consett bordered the water facilitating the relatively easy importation and exportation of goods, in comparison to schlepping wares across the mountainous terrain of Barbados. In addition, Consett, located within the Scotland District, had access to quarries, trees, and most importantly clay. The lower plantation boasted a pot house where sugar molds and other industrial wares important to the sugar industry were manufactured (Bennet 1958:2).

The will of Christopher Codrington stipulated that at least 300 slaves were to be maintained on the plantation at all times, a number which the estate’s managers had difficulty up keeping. In 1719, Smalridge noticed a dramatic decrease in the volume of pottery produced on the plantation, and blamed it on a lack of skilled potters. To remedy the situation, Smalridge employed the help of outside potters until the Society could train additional slaves in the craft (Bennet 1958:19). However, by 1762 the older enslaved individuals who had learned crafts under Codrington had all died, with no transference of skills to the younger labor force. Upon realization of this, the estate managers decreed that 25 enslaved individuals be trained for artisan work, and continually trained within the pot house so that a ready supply of ceramics would always be available (Klingberg 1949:48). Ceramics continued to be manufactured at Consett during the colonial era to support its cultivation of sugar.
While Codrington Plantation is well documented, there is a lack of documentary evidence and historical accounts of Pot House. What is known about Pot House is that there were at least three kilns located on the site, and pottery production occurred during the early colonial era. Several possible explanations prevail for the existence of Pot House, and primarily revolve around the ownership of the property. These explanations include ownership of the property by: a white slave owner, free blacks, or poor whites (Farmer 2011, Handler 1974). Whoever owned and operated Pot House is not as striking as the high concentration of kilns for the parish of Saint Phillip. Nine kilns existed within the parish (see Figure 2, Appendix A: Historical Charts and Graphs) and three were located at Pot House. It is likely that the site supplied surrounding plantations with much needed ceramics for use in the sugar industry. The location of Pot House in close proximity to Codrington Plantation strengthens this argument. The lack of properly trained craftsman noted by Smalridge created a deficiency in the industrial ceramics vital in the processing and manufacture of sugar. In turn, Codrington Plantation would have looked elsewhere for the much needed ceramics, and Pot House could easily have filled this need.
CHAPTER 3: THEORY

Theoretical perspectives have a direct impact on the interpretation of any data set, and because of this I believe it’s best to be explicit about which theoretical school I utilize in my interpretation. While a multitude of theoretical perspectives exist, I divide them into two broad groups: quantitative and qualitative. Opinions differ on which group most accurately describes human phenomena, and produces the most sound data. It is my belief that each has it’s own unique advantages and disadvantages. Although quantitative perspectives ideally are grounded in HDN methodology, and thus draw information solely based on hard numerical data and deductive reasoning, they fail to adequately address aspects of human phenomena which are harder to quantify. In contrast, qualitative perspectives, having no need for HDN methodology, are better at dealing with more subjective information, but require more interpretive leaps in answering questions.

However, it would not be fair to say that more qualitative data, such as feelings and emotions, are incompatible with HDN methodology. Data can still be collected in non-laboratory settings through interviews with individuals, as well as behavioral patterns extracted from archaeological evidence. Even though the two broad categories vary in their approaches, they are in no way incompatible with each other. In fact, if used in conjunction they have the potential to create a powerful, yet grounded, approach to dealing with human phenomena. Because of this, I combine the two categories and employ the best aspects of each in the interpretation of my data.

The main theoretical perspective I identify with is a Processual-Plus approach, as defined by Michelle Hegemon (2003). Hegemon states that scholars utilizing this
approach would “say that they are ‘generally processual’ but also interested in other perspectives, and [that] some explicitly try to combine processual and post-processual insights” (Hegemon 2003:216-217). Any discussion on Processualism versus Post-Processualism would be incomplete without an examination of the work of Lewis Binford and Ian Hodder, who championed the two camps of Processualism and Post-Processualism, respectively.

Processualism builds itself upon a positivist framework with objectivity at its foundation. Positivist structures employ the scientific method, which includes the notion that empirical data alone is admissible, and requires the elimination of value judgements in data collection (Johnson 2010:39-40). Several subschools of positivism exist including: Comtean, logical empiricism, and logical positivism (Preucel 1991:18-19). Positivist viewpoints aim to create, “general laws of cultural process capable of explaining large-scale, long-term cultural dynamics” (Wylie 2002:4). Schiffer suggests that correctly tested hypotheses, “can contribute to the eventual synthesis and systematization of an archaeological theory having both explanatory and predictive utility” (Schiffer 1972:156-157). Finally, a major component of logical positivism is the verification principle, which determines the validity of the hypothesis and conclusion through repetition of the experimental procedure, as well as comparison to other studies (Preucel 1991:18).

To Binford, a core component of scientific inquiry is the difference between *explication* and *explanation*. Explication gives the ability to discern between past cultures, and answers the *who, what, and how* questions. Whereas explanation is, “the
demonstration of a constant articulation of variables within a system” and, “presupposes concern with process, or the operation and structural modification of systems” (Binford 1962:217, emphasis added). Moreover, in order to produce adequate results the rigor of the scientific method must be adhered to. Binford saw the, “undifferentiated and unstructured view” of previous archaeologists as ineffectual (Binford 1962:218). Thus, explanation is more important as it gives the why of cultural change. It should be noted, that while Binford seeks a prime mover behind cultural change, he does not recognize a single cause behind processes (Binford 1980:12). Binford states that, “culture is multivariate, and its operation is to be understood in terms of many causally relevant variables which may function independently in varying combinations” (Binford 1965:205). Due to his positivist tendencies, Binford rejects any knowledge produced through inductive reasoning; however, he seemingly contradicts himself by acknowledging, “the explanation and differences and similarities between archaeological complexes must be offered in terms of our current knowledge” (Binford 1962:218).

Despite his influence on Processual thought, Binford later finds himself in a intellectual dilemma critiquing aspects of Processual theory. It became apparent to him that the past cannot be directly observed, but rather, “all knowledge of the dynamics of the past must be inferred” (Binford 1981:22). The use of inductive reasoning challenges a premise of the scientific method, that empirical data alone is credible. Additionally, Binford finds the coupling of theory and data inevitable, stating, “the dependence of our knowledge of the past on inference […] renders the relationship between paradigm […] and theory […] vague” (Binford 1982:29). Binford endorses middle-range theory as a
remedy to the paradox of separating data from theory. Middle-range theory, “treats the relationships between statics and dynamics, between behavior and material derivatives” and provides a way to connect data and theory, while simultaneously separating them (Binford 1982:29). Nevertheless, Binford remains resolute that, “our methods for constructing the past” should be, “independent of our theories for explaining the past” (Binford 1982:29).

Postprocessualism critiques the Processual school of thought and moves away from the rigid objectivity of logical positivism towards the interpretive subjectivity of hermeneutics. According to Preucel, hermeneutic approaches, “adopt a textual metaphor whereby understanding the meaning of a social practice is related to deciphering the meaning of a historical document” (Preucel 1991:21). Just as individuals may interpret a book in different ways, hermeneutics allows for multiple interpretations of archaeological data, but there is danger of biases arising. This is in stark contrast to the objective nature of positivism, which eliminates value judgements via a systematic methodology. Preucel explains, “Perhaps the most controversial tenet of postprocessualism is the acceptance and, indeed, active encouragement of multiple interpretations” (Preucel 1995:160). The allowance of multiple interpretations leaves many critical of Postprocessualism as, choosing the “best” conclusion seems arbitrary and subjective.

Ian Hodder champions the use of hermeneutics in archaeological interpretation (Preucel 1991:22). Hodder sees the rigidity of Processual methodology as a hinderence to archaeology reaching its full interpretive potential. According to Hodder, “Processual archaeology puts many of its eggs in the basket of methods. A universal method was
supposed to allow us to read off dynamics from statics” (Hodder 1991:8). It would not be fair to say that Hodder outright rejects scientific methods, but rather views them as, "simply another way of viewing the past” (Hodder 1997:694). Instead, Hodder supports methods that are “fluid and flexible, rather than predetermined” as opposed to the inelastic methods of the scientific method (Hodder 1997:693).

Processualists consider social institutions as adaptive and responses to biological needs, this is known as functionalism. Binford focuses his research on cultural systems, “dependent upon biological process for modification or structural definition” (Binford 1962:218). In addition, functionalist approaches deny agency to social actors, viewing cultural change as a result of external forces. Hodder heavily critiques this notion, asserting, “behaviorist models suggest that one can understand behavior, be it of humans or dogs, without going into any cognitive processes that are supposed to lie in actors” (Hodder 1985:2). To Hodder, individuals are cognizant of their actions which often incurs unintended consequences, that is, “man creates himself” (Hodder 1985:4). Agency of social actors remains an influential part of Postprocessual discourse. James Deetz and his work on landscape studies exemplifies the prominence of human agency, claiming that people, “use the landscape […] from purposes ranging from food production […] to the more or less explicit statement of their position in the world” (Hodder 1990:3).

Hodder promotes the adoption of self-reflexivity to fix the shortcomings of Processual methodology. Reflexivity requires the need to be: 1) critical of assumptions; 2) relational or contextual; 3) interactive; and, 4) multivocal (Hodder 1997:694). This methodology allows archaeologists to interpret their interpretations and be transparent.
Hodder rejects the need to keep data separate from theory, and instead draws attention to the fact that interpretation begins at the onset of excavation (Hodder 1997:692). Additionally, “interpretation occurs at many levels in archaeological research […] and it cannot be confined to a higher level” (Hodder 1997:692). It follows that it is impossible to completely separate theory from data. Finally, the hermeneutic circle employs self-reflexivity and calls for the revision of interpretation after examination of biases. Therefore, the reflexive methodology of Post-Processualism agrees with their views on knowledge production.

Regardless of the numerous critiques of Processualism, I find it difficult to label Post-Processualism as distinct for several reasons. First, the plethora of different theoretical ideologies within Post-Processual thought illustrates a lack of common ground. Preucel stresses this point stating, “If anything can be said to unite these archaeologies, it is that most share a common dissatisfaction with the standard positivist paradigm” (Preucel 1995:147). Furthermore, the various epistemological approaches and frameworks for the production of knowledge are often very contradictory (Preucel 1995:147). Third, Post-Processualists do not completely reject the scientific principles of Processualism, but rather add a new element to it. Johnson states that Hodder’s approach contains both ideological and objective components (Johnson 1992:432). It follows that the scientific method endures in Post-Processual thought. Finally, while Post-Processualists stress self-reflexive methods, no fundamental changes in methodology or techniques occur. Since Hodder acknowledges the fact that method and theory are intertwined, it logically follows that a change in one necessitates a change in the other.
Thus, in my mind, Post-Processualism is an extension of Processualism, and adds a subjective element to a preexisting objective structure. Together they are merely two faces of the same theoretical coin.
CHAPTER 4: METHODOLOGY AND INSTRUMENTATION

As with all scientific experimentation the methodological procedures behind the study is as important, if not more so, than the study itself. Due to this fact, this study aims to follow the hypothetico-deductive model (HDN), also known as the scientific method, as closely as possible, but does not try to exclude data that is not quantifiable. That is, while quantifiable data is used extensively throughout this study, there is no underlying assumption that unquantifiable data, such as interviews with contemporary potters, are incompatible. Instead, both are used in conjunction to answer anthropological questions and provide a stronger argument for the interpretation of the archaeological material. Major hallmarks of the HDN methodology include: hypothesis testing, the use of independent and dependent variables, the presence of a control variable, and the ability for repeated trials. This section of the paper aims to outline in full detail the overall methodological framework of the study. Attention is paid to explicitly defining how each part of the study fits to both the research plan at large, as well as how HDN methodology deals with unquantifiable data. Finally, statistical concerns will be addressed with the goal of making the study as statistically sound as possible.

Research Outline

The choice of research questions has a direct impact on both the data collected and the methodology chosen for statistical analysis. This study scrutinizes research questions which involve aspects of Barbadian society during the historical period, specifically during the period of British colonial rule. Firstly, did Barbadian potters
obtain their clay for ceramic manufacture from Chalky Mount? If not, then where did they get it from, and why? Did an exchange network of clay and ceramics exist on Barbados? Secondly, how extensive was the ceramic industry on Barbados? Lastly, how, if at all, can information known about present day Barbadian potters translate to the past? Each of these research questions can help shed light on colonial Barbados, specifically the exact nature of the ceramic industry during the historic era, and provides information applicable to studies of contemporary potters. That is, the actions and behaviors of modern day Barbadian potters are analogous to those of the past.

One of the major tenets of the scientific method is the testing of hypotheses, which I think of as educated guesses. That is, hypotheses draw from the questions asked and use the data set and other external sources, such as historical information, to arrive at reasonable assumptions. In the case of this study, I propose that the majority of ceramics found at Codrington Plantation and Pot House are produced from locally manufactured clay, and ceramics that do not match the predominant chemical patterning of the sample pool are from external sources. I arrive at this hypothesis based on: 1) preliminary compositional data, namely exploratory data analysis of the ceramics through the creation of histograms, boxplots, and scatterplots; and, 2) historical information of the Barbadian ceramic industry as it relates to the sugar industry.

In any study it is important to explicitly define the terms used in analysis. Confusion over terminology can lead to debates that devolve quickly into semantics and hinder the ability of scholars to fully grasp the main focus of a study. For this paper two important concepts exist, the latter of which will be discussed at length in the subsequent
section: 1) principle components analysis (PCA), and 2) X-ray fluorescence spectrometry (XRF). PCA is an inferential statistical test that seeks “to define a set of common underlying dimensions that structure the data” under scrutiny (VanPool and Leonard 2011:286). In effect, PCA takes a large number of variables and condenses similar ones together to create a fewer number of components that adequately defines the internal patterning of the data. In data sets that have a large number of variables, such as chemical characterization, this is extremely useful in understanding which variables contribute most to patterns in the data.

**Instrumentation**

In order to fully appreciate the utility of XRF in provenance studies, it helps to have a basic understanding of the mechanics that govern the instrumentation. It is not my intention, however, to overwhelm the reader with chemical principles and mathematical expressions.

Spectroscopic techniques are “the absorption by matter of electromagnetic radiation in the domain ranging from near ultraviolet to very near infrared, between 180 and 1100 nm” (Rouessac and Rouessac 2007:29). This range of wavelengths essentially encompasses the entire electromagnetic spectrum. XRF is a form of spectroscopic technique utilizing X-rays as the source of electromagnetic radiation and operates under the premise that primary X-rays are incident upon a sample creating vacancies in the inner shells of elements (Robinson 2004:544). In other words, X-rays bombard a sample and transfer their energy to the atoms contained within. If the energy of the X-ray is
sufficiently large, then an electron, referred to as a *photoelectron*, is ejected from the
atom. This process is referred to as *photo-ionization* and results in an ionized atom
(Rouessac and Rouessac 2007:265). Atoms typically do not keep these inner shells
vacant, resulting in a nearly instantaneous movement of an electron from another shell,
which tends to be a higher shell. As a rule, electrons in inner shells are less energetic than
those in outer shells. Consequently, an electron transitioning from an outer to inner shell
releases energy in the form of an X-ray, known as a *secondary X-ray* (Rouessac and
Rouessac 2007:265). The reason for the release of an X-ray, instead of any other type of
electromagnetic radiation, is due to *X-ray fluorescence*. A full discussion of X-ray
fluorescence is simply beyond the scope of this paper.

The X-rays emitted by atoms are characteristic of a specific element, which is the
foundation of XRF (Pollard 2007:101). The X-rays released from the atoms can then go
through one of two processes, absorption or scattering. Of these two processes,
absorption tends to be dominant, and occurs more frequently. The scattering of the
secondary X-rays can either be elastic, *Rayleigh scattering*, or inelastic, *Compton
scattering*. The latter is responsible for the creation of most of the XRF spectrum, making
it of extreme use. Rayleigh scattering, on the other hand, generates the majority of the
noise exhibited in the spectrum (Rouessac and Rouessac 2007:265).

It should be clear that two major shortcomings of XRF analysis derives from the
mechanics themselves. The absorption of secondary X-rays causes a loss of data, and in
turn fewer counts of secondary X-rays for an element. In effect this means that the data
given from a XRF spectrum will always be less than the true value. Rayleigh scattering
introduces background noise into the XRF spectrum and can complicate analysis.
Fortunately, these two shortcomings are easily accounted for. In the case of absorption of secondary X-rays, the Beer-Lambert law can be applied, which is as follows:

\[ T = \frac{I_t}{I_0} = \exp(-\varepsilon \lambda c) \]

Where \( T \) is the transmission of a light (with \( I_0 \) initial intensity and \( I_t \) transmitted intensity), \( \varepsilon \) is the absorptivity constant, \( \lambda \) is the distance which the light travels through the sample, and \( c \) is the concentration of the attenuating species in the material.

The Beer-Lambert law states that there is, “a linear relationship between \([I_0]\) [intensity of light] and the concentration of an absorbing species if the path length and the wavelength of incident radiation are kept constant” (Robinson 2004:80). The wavelength of light, in the form of an X-ray, and path length are easily held constant; furthermore, the absorption constant of a material is readily found through experimentation. Rayleigh scattering can be corrected by considering the attenuation length of the X-ray source. Attenuation length is the distance within a material where the probability of an electron not being absorbed has dropped to \(1/e\), approximately 67% (Pollard 2007:102).

Fortunately, Rayleigh scattering is accounted for in the same way as absorption. If the absorption constant from the Beer-Lambert law is replaced with the mass attenuation coefficient, calculated by dividing the absorption coefficient by density, the effects of both Rayleigh scattering and absorption are simultaneously taken into account (Robinson 2004:543-44). If these factors are not accounted for, then analysis by XRF can give large amounts of error.
There are several advantages and disadvantages to using XRF spectroscopy in material characterization studies. Firstly, XRF is a non-destructive technique, which is often of great concern to the archaeologist. Secondly, largely ignores surface topography making it a sub-surface rather than surface sensitive technique (Bertrand 2012:61-62). The sensitivity of XRF, as given by Pollard et al., is 0.01 at%, allowing for the calculation of chemical composition at the part-per-million (ppm) level (Pollard et al. 2007:105).

Despite the numerous advantages of XRF, several limitations exist. Firstly, XRF spectrometry requires the use of a standard that is similar in composition and contains the same elements as what is under study. The downside to this, in terms of this study, is the difficulty of creating a standard that adequately mimics the composition of clay, largely due to the variability of clay with respect to its primary components. Furthermore, it is difficult to determine which elements should be present in the sample without knowing what the sample is composed of in the first place. Secondly, XRF has limitations on which elements it is capable of analyzing. Elements with low atomic numbers, such as silicon (Si) and carbon (C), are unidentifiable by XRF instrumentation unless properly calibrated to do so. Despite these limitations, XRF spectrometry still proves to be a powerful tool in chemical characterization of ceramics.

An alternative choice for instrumentation for this study would have been X-ray photoelectric spectrometry (XPS), which in general, generates a much lower signal to noise ratio, consequently leading to more accurate results (Vickerman and Gilmore 2009:88). The mechanics that govern XPS allow for a much wider range of elements that are readily identified, provided that the concentration of said elements is at least greater
than 0.1 at%. With that being said, a major downside to XPS over XRF is its surface
sensitive nature. XPS is only able to accurately analyze the first 10 nm of a sample
(Vickerman 2009:50). Which gives rise to topographic considerations and poor data
generation for samples with topographically varied surfaces. The accessibility of the
instrumentation for use in this study was of major concern, and as such, XPS was not a
feasible option.

Methodology and Data Collection

The methodology for this study largely derives from Madeleine Gunter (2013)
and Alexandra Brown (2012) and their XRF studies on base clay samples from Barbados,
and Native American redwares from the Middle Peninsula of Virginia, respectively.
Samples used were randomly selected from a pool previously analyzed by Siedow (2010,
2011) for the presence or absence of radiolaria fossils. The sample pool was chosen due
to the extra information Siedow’s work added, to aid in the uniformity of samples, and
the sherds analyzed were previously broken into small pieces that are readily analyzed by
XRF instrumentation. Additionally, Gunter collected base clay samples from Chalky
Mount, Barbados which were analyzed against the sample pool.

The ceramic samples themselves are separated up into two main categories, based
upon the site from which they were excavated. Both sets of samples come from historical
areas of St. John Parish on Barbados, specifically either Codrington Plantation, or Pot
House (Siedow 2013:21). These sites were chosen due to the pottery traditions that
existed during the historic period, namely the Afro- and Euro-Caribbean traditions, as
well as their close proximity to each other (Siedow 2013:15). With respect to Codrington Plantation, the earlier ceramics exhibit manufacturing and decorative techniques that correspond to African made ceramics, including: black bodies, construction through coiling, and open firing techniques (Loftfield 2001:227). Sherds found in later temporal levels at Codrington exhibit different manufacturing techniques and decorations, primarily wheel-thrown and kiln-fired with crosshatch markings. While the manufacture of these newer ceramics seem more European in nature, the decoration is very much African (Loftfield 2001:231).

In a similar fashion to the sherd samples, the base clay samples can be broken into three distinct categories, based on the color of the clay. The geological formations of the Chalky Mount deposit causes three distinct bands of clay: grey, white, and red. Distinctions between the types are macroscopically evident through a simple visual inspection of the color. Interviews with Chalky Mount potters by Madeleine Gunter, Hayden Bassett, and Frederick Smith in 2013 revealed that the dominant manufacturing technique involves mixing various amounts of each category of raw clay. Because of this, each potter has their own *recipe* and it should be expected that each potters’ ceramics have different chemical compositions, dependent on the ratio of the mixed clays.

Data collection of the samples comes from the senior honors thesis of Alexandra Brown (2012). Each ceramic sherd was randomly selected from the sample pool in order to reduce the influence of human selection on the data. After ceramics were selected for analysis, they were broken into 2 cm pieces with care taken to produce a relatively “flat” surface. The topography of the surface at a microscopic level is extremely important in
producing accurate results from the XRF. Highly varied topography would produce Rayleigh backscattering from the emitted X-rays and alter the data. Admittedly, the ceramics analyzed did not necessarily have a completely flat surface microscopically, but laboratory constraints made achieving this ideal very difficult. The prepared samples were analyzed using a Spectrace QuantX XRF benchtop spectrometer at 30 kV and 15 μA for 200 seconds with the “flat” surface face up and parallel to the sample container. Due to XRF instrumentation requiring standards to test against, two standards were chosen SCO-1 and RGM-1.

The base clay samples were not prepared in accordance to Brown (2012), but instead follow procedures by Gunter (2013). Samples taken from the base clay roughly measured the same as the ceramic sherds, that is 2 cm. These pieces were then ground into a fine powder via a mortar and pestle. Care was taken to ensure the surfaces of the mortar and pestle were cleaned using distilled water and completely dried after each use. In order to ensure an uniform particle size for the powdered samples, a sieve measuring 190 microns was used to filter the powders and separate the larger particles and inclusions from the finer powder. Subsequently, the powders were loaded into samples cups provided with the XRF instrumentation and leveled to ensure an uniform thickness for testing.

The variables analyzed in this study belong to two broad categories: 1) primary elements, and 2) trace elements. These categories are from my own construction, and thus defined in my own terms. I define primary elements as elements that are common in clay and geological formations. Due to their ubiquity in geological formations, it is expected
that these elements will be found in greater abundance in both clay and the earth’s crust. In general, these elements have lower atomic numbers and are further down on the periodic table. Examples of these elements include: iron (Fe), copper (Cu), titanium (Ti), manganese (Mn), and zinc (Zn). In contrast, I define trace elements as elements not frequently found in clay or geological formations. Generally, these elements have a higher atomic number, appear further up on the periodic table, and are considered to be rare. Examples of these elements include: strontium (Sr), niobium (Nb), and yttrium (Y).

There is room for Improvement in data collection for further testing of ceramics. One recommendation includes the pulverization of the ceramic sherds using a ball-steel mill in order to mirror the composition of the base clay samples. A second improvement includes creating pellets of the base clays in order to more closely align with the composition of the ceramic sherds. Either improvement should yield better results from the XRF, although not drastically so.
CHAPTER 5: DATA ANALYSIS AND RESULTS

This section of the paper is divided into four main sections. The first section revolves around exploratory data analysis (EDA), which is in effect preliminary data analysis. From there, the presence or absence of radiolaria fossils is examined as per the study of Erik Siedow (2011). Next inferential statistics is applied, primarily through principle components analysis (PCA). Finally, the results of the study are given. It should be noted that the results in this section do not represent anthropological views as much as just explanations of the patterning of the data. The anthropological interpretation of the statistical data will occur in a later portion of this paper. In addition, in order to fully understand the statistical methodology at play, it is imperative that the readers and author are on the same page in terms of terminology. Because of this, explanations for the graphical representations, as well as the inferential statistics, are explained in full so that there is no misunderstanding.

**Exploratory Data Analysis**

Once the raw data is collected, it is important to undergo preliminary data analysis before more complicated analysis is undertaken. Several advantages to EDA exist including: 1) identifying prospective patterning of the data, 2) eliminating data points or variables that appear to have no obvious connection to the central tendency, and 3) becoming more familiar with the data set itself.

Graphical representations of statistical data often makes it easier to tease out underlying patterns that exist within the data set. For this study, I utilize three types of
graphical representations of my data: 1) histograms, 2) boxplots, and 3) scatterplots. All of the graphs and charts discussed in this section of the paper are found in Appendix B: Exploratory Data Analysis.

In order to perform proper EDA it is imperative to understand the context that you’re looking at. John Tukey likens EDA to detective work in his 1977 book *Exploratory Data Analysis*, explaining that:

As many detective stories have made it clear, one needs quite different sorts of detailed understanding to detect criminals in London’s slums, in a remote Welsh village, among Parisian aristocrats, in the cattle-raising west, or in the Australian outback. We do not expect a Scotland Yard officer to do well trailing cattle thieves, or a Texas ranger to be effective in the heart of Birmingham (Tukey 1977:1)

The analogy that Tukey brings to the table is directly applicable to this study. Different types of EDA are applicable to different situations, and there is not a single test that is necessarily applicable to every situation. This holds true for this study, as several types of EDA are used in order to best understand the data. The disjointed nature between EDA and hypothesis testing is also of great importance as it allows the analyst to step back from his own preconceived conjectures and take a more objective look at the data.

It is inherent in any data set that “many of the indications to be discerned in the bodies of data are accidental or misleading. To accept all appearances as conclusive would be destructively foolish” (Tukey 1977:3). The caveat that Tukey talks about is forcing the data to fit a model that the analyst has subconsciously predetermined. Just because there is potential patterning in the data for one type of EDA technique, it doesn’t confirm that the pattern indeed exists. In fact, EDA alone is not sufficient to tease out patterning that is statistically relevant and needs to be used in conjunction with another
method, often inferential statistics. However, EDA is a very important step when performing statistical tests and “nothing else can serve as the foundation stone” (Tukey 1977:3).

It should be noted that in my analysis of the various graphs in this section, I create an *ideal* situation against which I compare the other graphs. I fully understand that my ideal may vary drastically from others, but it is my opinion that for this study the ideal I create is the best comparison for the context.

**Histograms of Elements by Site**

Histograms prove useful in understanding both the central tendencies and internal grouping of data sets. There are two main components to a histogram: bins and frequency. The bins lie along the x-axis and represent a numerical aspect of the data, in this case the counts from the XRF, which are the number of molecules of that elemental type the instrumentation analyzed during acquisition. The frequency composes the y-axis of the graph and represents the percent that particular bin contributes to the overall element. Furthermore, the percentages of all the bins added together is always 100%.

Ideally, the histograms for each element should be normally distributed and unimodal. By normally distributed I refer to the normal distribution of statistical testing. That is, with a strong peak in the middle and gradually falling to zero as the x-values fall to positive and negative infinity. A good everyday example of a normal distribution is a bell curve for test scores. Unimodal refers to having one central peak instead of two or more, which is a hallmark of the normal distribution. The reasoning behind this model
revolves around the geological formations of Barbados, namely the Scotland District, and the lines of evidence supporting this claim arise from historical records (Harrison 1890) and archaeological sources (Handler 1963b). The presence of one clay deposit on the island, situated in Chalky Mount, was noted by Handler, who states that “in the vicinity of Chalky Mount easily accessible clay deposits, though not present in sufficient quantities for large scale commercial exploitation [...] are an important geological feature” (Handler 1963a:314). Handler also discusses the long standing practice of ceramic manufacture in the area stating that “we know that pottery was being made in the area as early as the latter 17th century” (Handler 1963b:141). Harrison confirms this fact in his 1890 study of the Geology of Barbados stating that he had found “a variety of fine-grained clays, suitable for not only making the best bricks, but also for the manufacture of ornamental tiles and pottery” (Harrison 1890:58). The historical and ethnographic evidence points to a single clay deposit on the island on which ceramic production was concentrated. In my opinion, this deposit should have one strong central peak in chemical signature, whereas the presence of two major deposits on the island would exhibit two strong peaks in chemical concentration.

Although the presence of three different bands of colored clays calls into question the underlying assumption of one central peak in chemical concentration, this can largely be dismissed by examining the historical and contemporary practices of potters. Historically potters received their clay from the Chalky Mount region (Handler 1963b), a practice which carries on into the contemporary period (Handler 1963a), and that both sets of potters seem to mix the three main colors of clay at their discretion. The three
different colored bands of clay undoubtedly have marked differences in their chemical composition, relative to their trace elements, which accounts for the disparity in coloration between them. The blending of these clays in differing amounts would result in a range of chemical compositions that would fit a normally distributed curve with a unimodal peak.

By following these guidelines for my “ideal” histogram, I was able to narrow down the data by eliminating certain elements. The data for these non-ideal elements could have been produced due to instrumental error, such as Rayleigh scattering (backscattering), or from background noise due to the instrumentation. Employing this methodology I was able to eliminate manganese and iron as two definite elements which are due to some sort of error. The histograms of these elements show a near 100% contribution by a single bin value. It is highly unlikely that the concentration of these two elements is as homogenous as the graphs represent. In addition, according to the CRC Handbook of Chemistry and Physics iron is the fifth most abundant element in the earth’s crust, contributing to 4.10% of the earth’s mass by relative proportion in parts per million (ppm) (2015: Sec 14, p 18). It would be expected that iron would show up in the chemical characterization of any geological material. The same holds true for manganese, which is the 12th most abundant element in the earth’s crust, contributing to 0.95% of the earth’s mass by relative proportion in ppm (Haynes 2015: Sec 14, p 18).

While the histograms definitively rule out the inclusion of the data for iron and manganese in the inferential statistical tests, the data for titanium, nickel, and zirconium is much harder to dismiss. Although the data does not represent a true normal
distribution, it more closely resembles it than do the graphs of iron and manganese. For example, the histogram for titanium has a strong central peak (unimodal) that tapers off to zero as the x-axis approaches positive and negative infinity. However, the distribution on either side of the central peak is skewed to the positive (right) side. That is, the positive side has a much more tapered effect than the negative (left) side, which sharply falls to a value of zero. Similar situations occur in the histograms for nickel and zirconium.

At this point, since it is more difficult to eliminate any of the elements based off their histograms alone, I turn to their relative abundance in the earth’s crust, in a similar argument as for the exclusion of iron and manganese. The relative ranks of titanium, nickel, and zirconium are: ninth, 24th, and 18th respectively; while their relative proportions in ppm are: 0.56%, 0.008%, and 0.019% respectively (Haynes 2015: Sec 14, p 18). Due to the prominence of titanium in the earth’s crust it is a safe bet to challenge the chemical data for that element. On the other hand, due to the relatively low abundance of nickel and zirconium, they prove useful as markers of the clay characterization and are included in the inferential statistical data.

**Boxplots of Elements by Site**

Boxplots, or box-and-whiskers plots, are useful in understanding similar aspects of data as histograms, but in a different way. The dispersion and skewness of the data becomes readily apparent when examining a boxplot. Furthermore, boxplots have the advantage of easily identifying outliers in the data, an attribute that histograms lack. The
primary components of a boxplot are: the median, the upper and lower first quartile, the upper and lower extremes, and outliers. The median, or middle data point, is represented by the black horizontal bar and should not be confused with the mean, or average, of the data. The upper and lower first quartile, or the “box”, represent the section of data that falls one standard deviation above and below the median, that is the 25th to 75th percentile of the data. Two standard deviations away from the median are the upper and lower extremes, which encompass 95% of the data examined. Finally, we are left with the outliers, which can take on one of two flavors: regular and extreme, represented by a circle or asterisk respectively. A regular outlier exists within one standard deviation away from the upper or lower extremes; whereas, an extreme outlier exists within two, or more, standard deviations away from the extremes. It should be noted, that the boxplots I created have the relative counts of each element on the y-axis, plotted against the site on the x-axis. The boxplots may be found in Appendix B: Exploratory Data Analysis.

My use of boxplots mirrors my use of the histograms in the previous section, that is to identify which elements are suitable for exclusion during inferential statistics. To do this, I do three things: 1) examine the shape of the box in comparison to the location of the median, 2) compare the location of the upper and lower extremes with respect to the median, and 3) take into consideration any outliers. Ideally, a boxplot which denotes good data has a median in the center of the box with the box and extremes extending evenly out from either side of the median. Any skewness of the data will manifest if the box or extremes extend unevenly away from the median. Additionally, the length of the box and extremes show the dispersion, or spread, of the data. A squished box denotes low
dispersion in the data, whereas a longer box denotes high dispersion in the data. In this ideal model, there are no outliers, which is an impossibility in the real world. Outliers don’t denote data points to be eliminated in this study, but rather can prove interesting as cases that don’t match the majority of the data set. Finally, the medians for each site should be more or less within the same location, which visually means each median should be level both with respect to each other and the clay standards. The relative equality of the median values for the boxplots denotes the practices of the potters using a single clay source with a fairly standardized blending process. The grounds of this assumption are consistent with the blending process of contemporary potters, with the majority of potters obtaining their clay from a single source (see Anthropological Interpretation, p 51).

Upon examination of boxplots for the various elements, conclusions similar to the histograms are drawn. Several elements have low dispersion of data, including: manganese, iron, titanium, nickel, and zirconium. Of these five elements, the boxplots of manganese and iron are most striking. The very low dispersion was evident in the histograms, but the extent to which it manifests becomes blatant in the boxplots. Just as with the histograms, iron and manganese are safely excluded from the inferential tests; and once again, the boxplots for titanium, nickel, and zirconium fall under scrutiny. Based upon the histograms and information concerning relative abundance in the earth’s crust, titanium alone was eliminated from the data set, which holds true based on the boxplots. Nickel and zirconium do not need to be eliminated based on results from the boxplots due to the relative equality of their medians. While the median for the clay
standards in titanium is much higher than for the other two sites, the medians for nickel and zirconium are more or less the same. Because of this, the choice to keep nickel and zirconium in the inferential statistical tests is valid.

The large disparity evident in the boxplots for some elements, namely zinc and niobium, with respect to the Chalky Mount clay samples, can be accounted for by the geological formation of the clay deposit. The different colorations of the clay is undoubtedly linked to differing concentrations of trace elements, which largely accounts for the drastically different colors present. While the blending of these three colors in various amounts would create a spectrum of relative concentration values, each color of clay by itself would exhibit much different chemical concentrations. The lower value of the median of the clay samples, with respect to the samples from Codrington and Pot House, could be due to this fact.

The ability to easily identify outliers in boxplots gives them a major advantage over histograms. While outliers in many statistical studies are eliminated from the data set, the same does not hold true for this study. Outliers in this case may prove interesting as they break the norm of the majority of the assemblage. Any foreign ceramics would show up as outliers, and thus strengthen the case for a uniquely Barbadian ceramic fingerprint. Of the various outliers that are present in the sample pool, cases 13 and 19 from Codrington show up in most of the elemental boxplots. These cases will undergo scrutiny after inferential statistics are performed, and will be discussed later in the paper.

Scatterplots of Elements by Site
Scatterplots are useful tools for visually identifying patterns between two
variables. From this information, clustering of data is easily discernible and outliers
become readily apparent. However, scatterplots have the limitation of only allowing the
plotting of two or three variables at a time. When a third variable is introduced, it creates
a three-dimensional scatterplot, which proves difficult to represent visually on a static
two-dimensional plane, such as paper or a computer screen. Because of potential
confusion arising from, and difficulty of interpreting, three-dimensional scatterplots, I
solely employ two-dimensional representations.

To create a two-dimensional scatterplot one plots one variable on the x-axis while
the other variable is plotted on the y-axis. In effect, the plotting of data in this manner
results in a graph with a Cartesian coordinate system, in which each case represents a
point and has a x- and y-value. Furthermore, the domain and range of my scatterplots are
restricted such that they exist in the first quadrant of the Cartesian coordinate system; that
is, have a domain and range of 0 to infinity.

Due to the inefficacy of creating individual scatterplots to represent many
variables, in my case ten variables, a scatterplot matrix proves more useful. A scatterplot
matrix graphs all potential variables against one another, which results in a grid like
pattern with variables composing the columns and rows of the matrix. Each cell of the
matrix is a scatterplot of two variables. When a variable is graphed against itself, a blank
space occurs. This allows for all ten variables to be easily represented, and eliminates the
need to create, in my case, a hundred and ten scatterplots.
In my scatterplots, I look for strong clustering of the cases from Codrington and Pot House with an internal clustering of clay samples. It would not be expected for the clay samples to all bunch within the same locale, due to different chemical compositions of the clay samples, which in turn leads to differing colors within the clay bands. Outliers are expected to occur, but ideally will be limited to the cases from Codrington and Pot House, and not the Chalky Mount clay samples. The Chalky Mount clay samples themselves should cluster internally within the data, such that they create their own relative cluster.

Two scatterplot matrices were created, one including all the elements present in the raw data, and the other excluding elements previously eliminated based on the histograms and boxplots. This was done in an attempt to reduce the cluttering that occurs in scatterplot matrices from plotting numerous variables. My analysis of the scatterplot matrices thus revolves around the second matrix, with the elements manganese, iron, and titanium eliminated. The scatterplot matrices may be found in Appendix B: Exploratory Data Analysis.

Many of the scatterplots exhibit strong clustering of the data in a single locale, with the clay samples either clustered internally or spread out in a line bordering the main group. In nearly every graph, a few outliers exist, which is consistent with both the histograms and the boxplots. Although most of the scatterplots seemingly depict “good” data, there is an exception with zinc. In nearly every scatterplot with zinc, the cluster for the Chalky Mount clay samples are independent of the main group. While this may prove problematic, it is my opinion that the data for zinc is consistent enough to be included in
the inferential statistical analysis. Furthermore, it is not fair to eliminate zinc as a variable solely because the cluster for the base clay samples is not consistent with the main cluster.

*Application of Siedow (2011)*

Previous work on this assemblage was conducted by Erik Siedow (2011) and centered on the presence or absence of radiolaria fossils present in some of the ceramics. To truly understand Siedow’s study, it is important to briefly explain both radiolaria as a species, and the geological conditions which govern Barbados.

According to Ernst Haeckel, radiolaria are holoplanktonic protozoa which live in water columns and lack the ability to swim. They are single-celled organisms, existing since the Precambrian Era (541 m.y.a.) and found extensively in tropical waters, with their concentrations decreasing towards either pole (Haeckel 2005:7). The bodies of radiolaria produce intricate mineral skeletons, composed primarily of silica (SiO$_2$) which is fossilized over time (Anderson 1983:5). These fossils are then deposited in surface sediments, such as clay, which are subsequently covered.

To analyze the ceramic samples from Barbados, Siedow used a Hitachi S-570 scanning electron microscope with an electron beam current 15 KeV and using a magnification between 180x and 220x (Siedow 2011:22). For each sample Siedow recorded in his lab notebook: 1) the sample name assigned by himself, 2) the context the sample came from, 3) the artifact number, 4) a description of the artifact, and 5) the abundance of radiolaria found (Siedow 2010a). The abundance of radiolaria were
described using one of four categories: none (no radiolaria found), not abundant (less than 5 radiolaria found), semi-abundant (potential for more than 5 radiolaria), and abundant (radiolaria difficult to not find) (Siedow 2010a). After analyzing the ceramics Siedow found that many of the Barbadian ceramics exhibit radiolaria, but not all of them do. Siedow came to the conclusion that, “although the absence of radiolaria does not rule out oceanic clays or other clays on the island, the presence of radiolaria within Barbadian redware has proven to be indicative of local production” (Siedow 2011:52).

In the context of this study, any outliers that come forth from the inferential statistical tests should not exhibit radiolaria within their ceramic matrices. While this is seemingly trivial in nature, the presence of radiolaria is an important diagnostic marker for locally produced Barbadian ceramics. Siedow’s study will be taken into further consideration during the interpretation of the statistical results.

**Inferential Statistics**

After conducting exploratory data analysis in the form of histograms, boxplots, and scatterplots, additional steps need to be taken in order to gain any concrete knowledge from the dataset. This next step comes in the form of inferential statistics, namely principle component analysis (PCA). In simplest terms, PCA is a type of multi-component and factor reduction analysis. A series of variables are taken into consideration and then boiled down into a number of *principle components* which best characterize the internal variation within a data set. There are three main aspects to analyze in order to comprehend the results of PCA: 1) the total variance explained, 2) the
rotated component matrix, and 3) a scatterplot matrix of the components. All graphs and charts for this section may be found in Appendix C: Inferential Statistics.

As with the majority of inferential statistical tests, there are many underlying assumptions that must be met in order for the test hold valid. Van Pool and Leonard note that PCA has “the assumptions of normality, homoscedasticity, and the presence of linear relationships” (Van Pool and Leonard 2011:293). Normality refers to the data following a normal distribution pattern, and for this study the condition is met and confirmed through EDA, namely boxplots and histograms (see Exploratory Data Analysis, pp. 38-50). Homoscedasticity is defined as, “[having] similar variances such that the amount of variation in Y around the regression line cannot increase or decrease as the value of X increases” (Van Pool and Leonard 2011:183-184). In other words, the error generated by the data acquisition of the XRF instrumentation must be consistent for each case under scrutiny. The calibration of the XRF instrumentation through the standards SCO-1 and RGM-1 confirms the uniform distribution of noise throughout the data (see Methodology and Instrumentation: Methodology and Data Collection, pp. 33-37). The presence of linear relationships can be done visually through EDA and inspection of histograms, boxplots, and scattergraphs. The scattergraphs for the data indicates the presence of patterning within the data with respect to the differing trace elements (see Scattermatrices of elements, Appendix B: Exploratory Data Analysis). The tight clustering of the ceramic samples indicates some sort of chemical patterning occurring within the data.

The total variance within the data set describes the amount of internal variance each component contributes. The SPSS software assigns an eigenvalue to each principle
component identified during analysis. When added together, the total number of eigenvalues is always less than or equal to the total number of variables analyzed, which in this case is eight, after the exclusion of titanium, iron, and manganese. The eigenvalues hold significance as they give the percentages of variance each component contributes. For example: Component 1 was assigned the eigenvalue of 2.427, and the sum of all the eigenvalues is 8, thus the percent variance is (2.427/8.000) x 100% which is approximately 30.333%. A Scree plot graphically represents the eigenvalues for each component. SPSS excludes any components that have an eigenvalue less than 1, which leaves three principle components that explain approximately 67.485% of the total variance within the data set.

Whereas the total variance explained table describes the relative weight of each component, the rotated component matrix describes the influence of each element upon that component. Elements that have an absolute value closer to 1, contribute more to that component. For example: yttrium has a value for Components 1 and 2 of 0.873 and 0.255, respectively. It can be said that yttrium contributes the most to the variance of Component 1, as it has the absolute value closest to 1, but contributes very little to Component 2. In effect, the rotated component matrix shows which elements constitute which components.

The values from PCA were extracted into the data set so each case as a value from each component. These values were plotted against one another in the form of a scatterplot matrix. Two scatterplots visually stand out against the rest, namely Components 1 versus 2, and Components 1 versus 3. A blown up scatterplot of each of
these components can be found in Appendix C: Inferential Statistics. The scatterplot of Components 1 versus 2 shows a tight clustering of the Codrington and Pot House sites, with a separate clustering of the Chalky Mount clay samples. This proves to be the most interesting of the two graphs, as Components 1 and 2 contribute 51.752% of the total variance. In contrast, the scatterplot of Components 1 versus 3 shows the same tight clustering of the Codrington and Pot House sites, but without a separate clustering of the Chalky Mount clay samples. However, in both graphs three outliers visually stand out from the rest of the assemblage: cases 13, 19, and 50. These cases will be scrutinized in the next section of this paper.

While Components 1 and 3 seem to be fairly consistent with one another, Component 2 varies drastically. The data within this component seems to be very dispersed and not consistent with the other two aspects of the data. A quick inspection of the Rotated Component Matrix table generated by SPSS gives the composition of Component 2, and denotes that both zinc and niobium contribute greatly, with eigenvalues of 0.877 and -0.866, respectively. In contrast, zinc and niobium contribute little to the values of Components 1 and 3, with zinc having eigenvalues of 0.092 and 0.136, respectively, and niobium having eigenvalues of 0.170 and 0.195, respectively. A possible explanation for this high level of dispersion in the data from Component 2 is the zinc variable itself. Zinc values of the ceramic and clay samples came under scrutiny in the EDA, notably in the histograms and boxplots. Upon comparison of the boxplots and histograms for niobium, a similar situation occurs as with zinc, with the median values for the Chalky Mount clay samples varying drastically from the ceramic samples.
Possible explanations for this include contamination of the samples before XRF analysis, the presence of another clay source on Barbados, and an unknown addition to the clay during the blending process. Contamination of the clay samples before XRF is unlikely, especially for niobium as it has a naturally low relative abundance, as no solutions of zinc and niobium were used in preparation of the samples. Of these reasons the presence of another clay source on Barbados is the most likely. The disparity in the concentrations of zinc and niobium suggest different sources relative to Chalky Mount and the two sites investigated in this study. The possibility of two clay sources on Barbados will be discussed at length in the next section of this paper.
CHAPTER 6: ANTHROPOLOGICAL INTERPRETATION

The goal of this study is to demonstrate that there is a chemical pattern within Barbadian clays that will aid in the facile identification of ceramics excavated on the island. In turn this will provide a better understanding of the roles of potters in the historic era, as well as the impact the ceramic industry had on the economy of Barbados. Two primary lines of evidence are used for this argument, including: 1) statistical information on the chemical content of ceramics from Barbados, and 2) historical and ethnographic data concerning the Barbadian ceramic industry. This section examines both lines of evidence, tying them together to create a strong argument for the presence of a uniquely Barbadian chemical fingerprint.

The statistical data from EDA and PCA indicates the presence of strong clustering of data from the Codrington and Pot House sample sherds. This is evident in the scatterplot matrix created after selected variables are eliminated, namely: manganese, titanium, and iron. However, two separate clusters appear when zinc and niobium are taken into account. That is, the Chalky Mount clay samples appear in one cluster while the Codrington and Pot House samples appear in a separate cluster (see histograms, boxplots, and scattermatrices, Appendix B: Exploratory Data Analysis). While ethnographic records, such as Handler (1963b), and historical accounts, such as Hall (1775), point towards Chalky Mount as the primary clay source for Barbados, it is not fair to assume that it is the only clay source which potters collected their clay. One possible anthropological explanation for the lack of information concerning other clay deposits on Barbados revolves around the protection of trade secrets. If excellent clay for
ceramics is known by a potter they likely would not share this information with others, especially outsiders and competing potters, in order to protect their secret recipe for processing clay.

The practices of contemporary potters sheds light on the wide range of internal clustering within the two primary groupings of data, and offers a possible explanation. Interviews with a third-generation Barbadian pottery, who will remain anonymous in an effort to protect his identity but will be referred to as Jordan, suggests a possible explanation to the trend. Jordan continues to use traditional techniques to craft his clay vessels from Chalky Mount clay. Part of his process is to blend the three types of clay present at Chalky Mount to create his own unique recipe, with a paste-color and consistency unique to his pottery. The colors of the three clays present at Chalky Mount undoubtedly contain differing concentrations of elements which give them their color. Blending of these clays in different amounts would result in mixtures that vary chemically. Thus, chemical characterization studies of ceramics with different base clay recipes would create a wide range of variance. The concept of a recipe for each potter seems to be a trend throughout the Caribbean, notably in the work of Hauser (2008-2010) with descendant communities of potters from Jamaica.

The blending the three types of clay present at Chalky Mount would also explain the shortcomings of the radiolaria studies of Siedow (2011). Similar to the way that the elemental signatures of Barbadian ceramics differ with respect to the amount of each type of clay added, the same may hold true of radiolaria. Each separate band of clay would contain differing amounts of radiolaria fossils within its matrix. In turn, when examined
by a scanning electron microscope various amounts of radiolaria fossils would exist. The result would be the inability for a simple presence and absence analysis to definitively demonstrate a ceramic as being Barbadian made.

Several outliers exist within the graphs, but the two of note are cases 13 and 19 (ES-BR1-66-2 and ES-BR1-4-1, respectively). These two cases are also prominent in the boxplots of the variables analyzed by site, and in the graphs of components generated by PCA. Chemically, these two outliers are different from the rest of the samples, and in addition, their physical characteristics are markedly different. The majority of the ceramic samples from Codrington have a salmon pink paste, with little to no visible inclusions, which is not true of cases 13 and 19. Both samples are darker in color, and have much larger inclusions than the rest of the Codrington samples, suggesting they were either not manufactured at the same kiln, or were imported into Barbados from an external source. A definitive answer for the origination of cases 13 and 19 is problematic despite the utility of the radiolaria test of Siedow (2011). Cases 13 and 19 both tested negative for the presence of radiolaria fossils (see Appendix B: Exploratory Data Analysis). While the two samples are chemically and visually different from the rest of the sample pool, it cannot be definitively stated that they are foreign to Barbados, as per Siedow (2011).

An explanation for the presence of foreign ceramics at Codrington Plantation draws from the history of the site itself, namely the actions of John Smalridge in relation to the plantation’s ceramic industry, as well as the poor accessibility of the clay deposit at Chalky Mount in the historic period. The lower plantation, also known as Consett, of
Codrington Estates worked as the central distribution hub for the plantation. The role of Consett included handling the import and export of goods, as well as the manufacture of sugar molds to support the sugar cultivation of the upper plantation (Klingberg 1949:43). After the handover of Codrington in 1703 to the Society for the Propagation of the Gospel, the new caretakers, appointed John Smalridge as manager. In 1719, Smalridge noticed a significant decrease in pottery production at the plantation, and as a quick remedy began employing outside potters until a time where more could be trained (Bennet 1958:19). Two possible consequences could result from this change in ceramic acquisition: 1) the importation of ceramics from outside Barbados, or 2) the purchase of locally made Barbadian ceramics.

The importation of foreign ceramics into Barbados during the seventeenth and eighteenth centuries is documented by Handler (1963a, 1963b). According to Handler, “the relatively abundant clay resources of Barbados […] were being exploited with some difficulty by the early settlers for reasons of their own technological deficiencies” (Handler 1963b:131). While techniques in clay acquisition certainly advanced in the seventeenth century, which can be seen in the increasing number of kilns in the Scotland District during the seventeenth century (see Figure 1, Appendix A: Historical Graphs and Charts), local production could not keep up with demand (Handler 1963b:316). Historical records by Richard Hall, writing in 1775, note the importation of ceramics, namely sugar molds, into Barbados from England (Hall 1775:10).

Despite the evidence for the importation of ceramics into Barbados from England, it is my belief that Cases 13 and 19 represent locally produced ceramics from nearby
potters or islands. In terms of economic efficiency, it would cost much less to either buy locally made ceramics or import them from nearby islands, in comparison to importation from England. The lower cost of the locally produced ceramics would undoubtedly have appealed to Smalridge judging from the uneasy financial status of Codrington Plantation following its purchase by The Society. In fact, between 1749 to 1757 profits from the two plantations were so dangerously low that The Society in London conducted a special investigation of the financial state of the plantations in 1760 (Handler 1963b:137). Pottery continued to be manufactured at other plantations across Barbados, and a vibrant internal exchange system existed between the respective plantations (Handler 1963b:136). In my mind, the continuation of this internal exchange system would have been more appealing than establishing new ceramic sources across the Atlantic Ocean.
CHAPTER 7: IMPROVEMENTS AND APPLICATIONS

Many improvements could be made to this study to greatly improve the quality of the raw data. Firstly, an expansion of the sample pool would produce more reliable results for the EDA as well as PCA. The number of ceramics analyzed, while in my opinion statistically viable, is troublesome. Any expansion should bolster the number of samples from each of the three sites, but also include ceramics from new sites around Barbados, which would lead to a better understanding of the chemical characterization of clays from Barbados. Secondly, the methodology used could be altered slightly to take into consideration the heterogenous nature of the samples, that is, not all samples were uniformly prepared and run. An alternative methodology could include either the pulverization of all samples into a powder, or creating pellets of the powdered clay samples. Either option would create more homogenous samples where the varied interaction of the emitted X-rays on topography is not a factor. Finally, the expansion of the sample pool should include ceramics from outside of Barbados, ideally known English made ceramics. These ceramics must be run with the same methodology as this study to insure uniformity of results. Raw data from other studies is not acceptable as a substitute, unless similar instrumentation and methodology are used.

The primary application of this study is the ability to know if a ceramic is definitively from Barbados. Any ceramics run should be expected to fall within the main clustering seen in the histograms, boxplots, and scatterplots. As the data set expands, more reliable values for each element can be created, resulting in a range of values from which Barbadian ceramics can take. In turn, the discovery of foreign ceramics imported
to Barbados can be traced, and exchange patterns could be created. This in turn would allow for a more complete understanding of colonial British Barbados and how the people and ceramic industry of the island were impacted by economic changes. Furthermore, the methodology and aims of this study could be applied to other islands around the Caribbean, and chemical characterizations of their clays could be added to create a more complete data set.
CHAPTER 8: CONCLUSION

Material characterization studies can yield a wealth of information about the historical period, but the quantitative aspects alone are insufficient at explaining all aspects of human behavior. In order to remedy this situation, the use of anthropological and historical information, whether in the form of historical records or ethnographic studies, is paramount to truly understand the past. In terms of this study, data collected of chemical concentrations through XRF instrumentation proved useful in the creation of clusters of ceramics from Codrington Plantation and Pot House; however, without the inclusion of base clay samples from a local clay deposit, the study would largely have failed as it would lack a proper control.

The use of qualitative data, such as interviews with contemporary potters and ethnographic accounts of Barbadian pottery practices, greatly strengthened the claim for a chemical fingerprint for Barbadian ceramics. However, there is strong evidence to support the presence of multiple clay sources on the island. The strong deviation in median values between the niobium and zinc levels in the samples when compared to the base clay samples is striking. Although this deviates from the historical record, the chemical concentrations are telling. In the end, while my hypothesis was proven to be false, the information gained proved very valuable.

In turn, the ability to readily identify ubiquitous redware ceramics in Barbados is greatly useful to archaeologists working in the area. The relative difficulty of discerning between locally made ceramics and English ceramics stems largely from the similarities in production techniques and overall forms, which is unusual for Caribbean islands as a
high degree of creolization is often seen. This study tackles and overcomes that problem with the aim of creating a uniform methodology for investigation of ceramics in other locales within the Caribbean.
APPENDIX

Appendix A: Historical Charts and Graphs

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Figure 1: "Table 22. Estimated English Slave Imports, 1640-1700" (Dunn 1972:230)

Figure 2: Map of Barbados showing parishes and their corresponding number of kilns. The Scotland District comprises the eastern coast of Barbados. (Handler and Lange 1978:142)
Appendix B: Exploratory Data Analysis

Histograms of elements by site
Boxplots of elements by site
Statistical Information by Site

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<tr>
<td>Strontium</td>
<td>163</td>
<td>185.4</td>
<td>72.657</td>
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<td>28.07</td>
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<td>Zirconium</td>
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<td>Niobium</td>
<td>28</td>
<td>27.87</td>
<td>6.556</td>
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Scattermatrix of elements (all variables included)
Scattermatrix of elements (selected variables eliminated)

Variables eliminated include: manganese, titanium, and iron
Scattermatrix of cases showing presence of radiolaria (all elements included)
Scattermatrix of cases showing presence of radiolaria (selected variables excluded)

Variables excluded include: manganese, titanium, and iron
Presence of Radiolaria Fossils (Data unknown for Chalky Mount clay samples):

<table>
<thead>
<tr>
<th>Location</th>
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<th>Radiolaria</th>
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<td>CPK L1 to L4</td>
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<td>CPK L1 to L4</td>
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<td>Pot House L1-6</td>
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<td>Pot House L1-6</td>
<td>ES-BR1-31-1</td>
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</tr>
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<td>Pot House L1-6</td>
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<td>Pot House L1-6</td>
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<td>Pot House L1-6</td>
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<td>Pot House L1-6</td>
<td>ES-BR1-38-2</td>
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<tr>
<td>Pot House L1-6</td>
<td>ES-BR1-39-1</td>
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<td>Pot House L1-6</td>
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<td>Codrington</td>
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<tr>
<td>Codrington</td>
<td>ES-BR1-18-2</td>
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<td>Location</td>
<td>ID</td>
<td>Site</td>
<td>Radiolaria</td>
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<td>----------</td>
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<td>CODRINGTON</td>
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</table>

Percent Radiolaria Present by Site (Data unknown for Chalky Mount clay samples):

<table>
<thead>
<tr>
<th>Site</th>
<th>Percent Present</th>
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<tbody>
<tr>
<td>Codrington</td>
<td>16.13%</td>
</tr>
<tr>
<td>Pot House</td>
<td>52.94%</td>
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</table>
Appendix C: Inferential Statistics

### Communalities

<table>
<thead>
<tr>
<th></th>
<th>Initial</th>
<th>Extraction</th>
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<tbody>
<tr>
<td>Nickel</td>
<td>1.000</td>
<td>.388</td>
</tr>
<tr>
<td>Copper</td>
<td>1.000</td>
<td>.718</td>
</tr>
<tr>
<td>Zinc</td>
<td>1.000</td>
<td>.796</td>
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<tr>
<td>Rubidium</td>
<td>1.000</td>
<td>.594</td>
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<tr>
<td>Strontium</td>
<td>1.000</td>
<td>.640</td>
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<tr>
<td>Yttrium</td>
<td>1.000</td>
<td>.828</td>
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<tr>
<td>Zirconium</td>
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<td>.617</td>
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<tr>
<td>Niobium</td>
<td>1.000</td>
<td>.817</td>
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Extraction Method: Principal Component Analysis.

### Total Variance Explained

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial Eigenvalues</th>
<th>Extraction Sums of Squared Loadings</th>
<th>Rotation Sums of Squared Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% of Variance</td>
<td>Cumulative %</td>
<td>Total</td>
</tr>
<tr>
<td>2</td>
<td>1.714</td>
<td>21.419</td>
<td>51.752</td>
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<tr>
<td>3</td>
<td>1.259</td>
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<td>67.485</td>
</tr>
<tr>
<td>4</td>
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<tr>
<td>5</td>
<td>.680</td>
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<td>8</td>
<td>.215</td>
<td>2.682</td>
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Extraction Method: Principal Component Analysis.

### Rotated Component Matrix

<table>
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<th>Component</th>
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</thead>
<tbody>
<tr>
<td>Nickel</td>
<td>-.517</td>
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<tr>
<td>Copper</td>
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<tr>
<td>Zinc</td>
<td>.092</td>
<td>.877</td>
<td>.136</td>
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<tr>
<td>Rubidium</td>
<td>.768</td>
<td>.029</td>
<td>-.055</td>
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<td>Strontium</td>
<td>.296</td>
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<td>-.729</td>
</tr>
<tr>
<td>Yttrium</td>
<td>.873</td>
<td>.255</td>
<td>-.017</td>
</tr>
</tbody>
</table>
Zirconium | .732 | -.271 | .090
Niobium   | .170 | -.866 | .195

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 4 iterations.

Component Transformation Matrix

<table>
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</tr>
</thead>
<tbody>
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<td>-.385</td>
<td>-.038</td>
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<td>2</td>
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<td>-.178</td>
</tr>
<tr>
<td>3</td>
<td>.103</td>
<td>.150</td>
<td>.983</td>
</tr>
</tbody>
</table>

Site
- Codrington
- Pot House
- Chalky Mount
Anderson, O. Roger  

Beckles, Hilary  

Bennet, J. Harry Jr.  

Binford, Lewis R.  

Bertrand, Loïc, with Marine Cotte, Marco Stampanoni, Mathieu Thoury, Federica Marone, and Sebastian Schöder.  

Deetz, James  

Dunn, Richard S.  

Gragg, Larry  

Gunter, Madeliene

Haeckel, Ernst

Hall, Richard

Handler, Jerome S.

Handler, Jerome S., and Frederick W. Lange

Harrison, J. B. and A. J. Jukes-Browne

Hauser, Mark W.

Hauser, Mark and Douglas V. Armstrong

Haynes, W. M., ed.

Hodder, Ian

Hegemon, Michelle

Johnson, Matthew

Johnson, H., with B. Olsen

Kirby, Ben and Madeliene Gunter

Klingberg, Frank J.

Lottfield, Thomas C.

Pollard, Mark, with Catherine Batt, Ben Stern, and Suzanne M. M. Young
2007 Chemical Analysis in Archaeology. Cambridge: Cambridge University Press.

Poyer, John

Preucel, Robert W.
Robinson, James W.  

Rouessac, Francis, and Annick Rouessac  

Schiffer, Michael B.  

Schomburgk, Robert H.  

Siedow, Erik  

Smith, Frederick, and Karl Watson  

Speed, Robert C.  

Tukey, John W.  

VanPool, Todd L., and Robert D. Leonard  

Vickerman, J. C., and Ian S. Gilmore.

Wylie, Alison