MAYA POTTERY SPECIALIZATION AND STANDARDIZATION:

USING LATE AND TERMINAL CLASSIC CERAMICS

FROM THE UPPER BELIZE RIVER VALLEY

TO EVALUATE MARKET EXCHANGE

by

KRISTA LUCILLE GARCIA

A THESIS

Submitted in partial fulfillment of the requirements
for the degree of Master of Arts
in the Department of Anthropology
in the Graduate School of
The University of Alabama

TUSCALOOSA, AL

2008

Submitted by Krista Lucille Garcia in partial fulfillment of the requirements for the degree of Master of Arts specializing in Anthropology.

Accepted on behalf of the Faculty of the Graduate School by the thesis committee:

William W. Dressler, Ph.D.

Deborah A. Keene, Ph. D.

Allen R. Maxwell, Ph.D.

Lisa J. LeCount, Ph.D.
Chairperson

Michael D. Murphy, Ph.D.
Department Chairperson

Date

David A. Francko, Ph.D.
Dean of the Graduate School

Date

LIST OF ABBREVIATIONS AND SYMBOLS

α	The probability of rejecting the hypothesis tested when the hypothesis is actually correct
CV	Coefficient of variation: a measurement of relative variation created by dividing the sample standard deviation by the sample mean
d.f.	Degrees of freedom: the number of values free to vary after statistical restrictions are applied to the sample data
F	Fisher's F ratio: a ratio of two variances used for comparing sample means
IQR	The interquartile range: the difference between the first quartile and third quartile of a set of data. The IQR is used as a measure to determine how spread-out or how grouped the values in a data set are
n	The number of cases in a data set or sample
p	Probability associated with getting as extreme or more extreme than the observed value if the null hypothesis is correct
S.D.	Standard deviation: a measurement calculating how values in a sample vary from the sample mean
SPSS	Statistical Package for the Social Sciences software
t	Student's t distribution value: used in t-tests to compare means for two normally-distributed samples
W	The Levene test statistic: used in Levene's test for homogeneity of variance to determine whether sample variances are statistically different

$\bar{x}$ Mean: the sum of a set of values divided by the number of values in the set

χ^2 Chi-square test: a test for comparing categorical variables based on calculating expected frequencies and comparing them to observed frequencies

$=$ Equal to

ACKNOWLEDGEMENTS

Many people were instrumental in this thesis process. Dr. Lisa LeCount consistently encouraged me to excel during the thesis research and writing. Her guidance and assistance has been invaluable to me throughout my graduate studies. She and the other members of my thesis committee, Dr. William Dressler, Dr, Deborah Keene, and Dr. Charles Maxwell, gave me the support and advice I needed to clarify and express my ideas.

I would like to thank Dr. Richard M. Leventhal for granting permission to use Xunantunich Archaeological Project collections. I also would like to thank Dr. Cynthia Robin for introducing me to upper Belize River Valley archaeology. Working with her and Dr. Laura Kosakowsky provided me with an understanding of the archaeological material that greatly aided in the development and execution of my thesis research. Dr. Laura Kosakowsky also helped me learn pottery types, for which I am very grateful.

Learning how to make and read the petrographic thin-sections was a major undertaking, and without the help of others I would not have been successful. Brian Hess explained the methodological specifics of using ceramics when making petrographic thin-sections. At the University of Alabama, several people in the Geological Sciences Department also assisted me in this aspect of my research. Dr. Harold Stowell graciously allowed me to audit courses and use several Geological Sciences laboratories. Dr. Fred Andrus provided me with the lab space, training, and materials to make the thin-sections. Miguel Etayo also aided in the teaching process for making thin-sections. Rob Holler taught me the basics of optical microscopy. Dr. Deborah Keene not only served on my committee, but also explained the processes and realities of reading large numbers of thin sections. I am greatly indebted to her as her advice likely saved my vision and my sanity.

I would like to thank several members of the ministry of NICH (National Institute of Culture and History) in Belize for their involvement in this project. Drs. Jaime Awe (Director of the Institute of Archaeology) and John Morris (Director of Research and Education) gave permission for me to study archaeology and export sherds to the United States. Joyce Tun graciously processed the sherds for export.

At the Trekstop, Judy and John Yaeger provided me a wonderful place to work as well as live during my research in Belize. Furthermore, John's idea of using a saw was pure genius.

Funds were provided by a Sigma Xi Grant-in-Aid-of-Research to travel to Belize and Dean Beverly B. Roskos-Ewoldsen for the College of Arts and Sciences for outsourcing some of the thin-sectioning. A Graduate School Research and Travel Grant assisted in funding this research as well. The College of Arts and Sciences at the University of Alabama also supported me through a Graduate Council Fellowship and a Graduate Council Research Fellowship during my master's studies.

To my family and friends, especially my parents, thank you for your continued encouragement and belief in me. That you put up with those conversations about pottery sherds and thin-sections, yet still talk to me now, is a testament to how wonderful you all are. I would also like to thank Jeremy Davis, Daniel Ladu, Jenelle Townsend, and Audrey Thompson for still being my friends after helping me polish some thin-sections.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ILLUSTRATIONS

ABSTRACT

Archaeologists debate the possibility of market exchange developing in the Late Classic. An emergent market economy should affect production of goods. Market economies are expected to lead to increases in specialization during the production process, and the increases in specialization are expected to be evidenced in increased standardization of goods. This diachronic study tests the argument that a market economy developed in the Late and Terminal Classic period (AD 600-900) in the upper Belize River Valley, Belize. Two common groups of ceramics (Mount Maloney bowls and Cayo jars) are sampled from three different sites (Actuncan, Xunantunich, and San Lorenzo) to investigate potential changes in production and standardization of goods. Rim sherds are measured for formal characteristics to evaluate changes in coefficients of variation, means, and variances. Petrographic thin-section analysis (PTSA) is also used to compare paste compositions of the ceramic sample across sites and phases.

The rim diameter analyses indicate no significant differences in variation across phase or site. The PTSA data are used to run cluster analysis on the sample, which reinforces the results from the rim diameter data. While PTSA provided indication of human behavioral actions during the production process, no significant differences were found in the data over the three temporal phases or the three sites of origin.

Consistency in production, rather than increasing specialization, is the overarching trend in the data. Although it is possible, indeed likely, that a market existed

at Xunantunich during the Late Classic, the analysis of these two common pottery groups did not yield evidence for their inclusion in that possible market economy.

Chapter 1: Introduction

There is little doubt among Maya archaeologists that markets were an important component of Postclassic economies; however, the presence of markets during the Classic period is hotly debated (Freidel 1981; Potter and King 1995; Sharer 1994; West 2002). Social dynamics, between individuals of the same class and between those of different classes, would be altered if market exchange developed in the Classic period since markets provide opportunities for a renegotiation of elite and commoner power (Masson 2001). Indeed, commercialization of the economy has been suggested as one of the factors that led to the collapse of elite society in the Terminal Classic period (Rice 1987; Rathje 1975; Sabloff 1977). This diachronic study tests the argument that a market economy developed in the Late and Terminal Classic period (AD 600-900) in the upper Belize River Valley, Belize (Figure 1). Keller's (2006) work at Xunantunich provides architectural and lithic evidence pointing to a marketplace at this provincial capital (Figure 2). If this indeed was the case, I assume that common pottery vessels might have been produced for sale at this marketplace. Therefore, two locally made groups of pottery -- Mount Maloney and Cayo -- from the sites of Actuncan, San Lorenzo, and Xunantunich are used to evaluate the possibility of an emergent market economy during this time. Rim sherds from these common groups are analyzed to investigate changes in production standardization. Standardization can be an indicator of specialized production that, in some production modes, is associated with a market economy.

Hirth (1998, 2000) discusses four approaches when investigating potential markets: configurational, contextual, spatial, and distributive. Hirth's (1998, 2000) four parameters address how site architecture and organization, production of goods, site distributions of goods, and household access to goods are affected by exchange systems. Configurational approaches address how exchange systems affect work space and architecture within a site. For example, Aztec marketplaces feature specific architecture along prime roads (Hirth 1998). Contextual approaches, such as studies on craft specialization, focus on cultural features connected to the provisioning and distributing goods. Evidence of workshops or community specialization would be contextual indicators. A spatial approach addresses how exchange systems affect artifact distributions over the landscape or the arrangement of population centers. For example, Central Place Theory suggests secondary centers are located in places to facilitate the movement of goods into primary centers. Finally, a distributional approach utilizes artifact distribution among households as a means to understand variation in domestic provisioning. Hirth's (1998, 2000) distributional approach proposes that all levels of society have equal access to basic household provisions in market economies. Thus, if one were to study a market commodity, it should be present in fairly similar percentages across differing social strata.

By the Late Postclassic period, a fully commercial market economy was functioning in the Maya Lowlands. Conquistadors, impressed with Maya markets, commented on the size and variety of goods available in Yucatec Maya towns (Dahlins et al. 2007; Masson 2002; Wurtzburg 1991). Contact period accounts indicate a complex system of vendors, with some vendors selling household surplus goods, petty merchants selling locally-available goods, and professional merchants providing highly valuable imported goods (Masson 2002). Conquistador accounts also praised the large size of the outdoor Postclassic markets (Wurtzburg 1991).

Additionally, several linguistic indicators in Late Postclassic texts suggest the possibly of a merchant class responsible for facilitating trade and market exchanges between settlements. Not only are there extensive Yucatec Mayan words available to discuss trading activities, such as those words translating to “to buy,” “a purchase,” “to purchase,” “a trader,” “to value,” and “a value,” but the same term signifies both “market” and “plaza” (Wurtzburg 1991:97). The linguistic association between an economic activity and a physical place could indicate a long-standing tradition of market activities in plazas.

Research at Chunchucmil, Mexico has yielded several lines of evidence to suggest a potential market place during the Early Classic period (Dahlins et al. 2007; Dahlins and Ardren 2002). Chunchucmil is a large site with high population estimates. Near the center of the site is located a plaza that lies at the intersection of five *sacbeob* (roadways). These *sacbeob* might have directed people to civic architecture surrounding the proposed market area (Dahlins et al. 2007). The plaza also features rows of stones interpreted as the remnants of market stalls (Dahlins et al. 2007). Chemical analysis of soil samples from the plaza also found similar levels of elements as those taken from a modern Guatemalan marketplace (Dahlins et al. 2007). Phosphorus and zinc, associated with food preparation and disposal, were found in elevated levels in the modern market near food preparation, consumption, and disposal areas. Similar levels of phosphorus were also present in the Chunchucmil plaza as those found in the modern marketplace (Dahlins et al. 2007:380).

Although direct evidence of Late and Terminal Classic period markets is sparse, several lines of indirect evidence have been asserted. Following Hirth's model, the distribution of pottery at Palenque, Tikal, and Copan has been argued to indicate that major political centers held regional markets (see West 2002). At Palenque, domestic ceramics made in subordinate centers flowed into the city, while ceremonial ceramics made at Palenque flowed outward to subordinate centers. This directional movement of goods is indicative of certain market systems (West 2002). The analysis of Tikal ceramics utilized drop-off curves to ascertain how ceramic frequencies changed as one moved away from the city. The results suggest that specialist production was occurring at several locations in the greater Tikal area to provide residents with ceramics (West 2002). At Copan, polychrome ceramics appear to be distributed across all social ranks, suggesting that access to such goods was determined by buying power, not social status or household production (West 2002). Furthermore, Foias and Bishop's (1997) Petexbatun research compared standardization indices across Late and Terminal Classic monochrome red ware and polychrome types. They found that some production practices were very stable throughout the Late and Terminal Classic for monochrome red wares, but polychrome production was more heavily disturbed by political upheaval. Interestingly, while paste recipes were consistent, the mean rim diameters varied widely (Foias and Bishop 1997).

The inherent problem with understanding systems of exchange from distributional data is the lack of knowledge of production locales and techniques. Since production and exchange are linked, information is needed on both systems to best interpret exchange modes. Locations of production are affected by where and how exchange occurs (Blanton 1983, 1996; Plattner 1989; C. Smith 1976). While production areas are known for some Classic Maya goods, such as Colha chert, salt, and specific polychrome ceramic types, production areas for local domestic goods are rarely found. Additionally, barrios of producers of specific goods, as are sometimes found in Aztec cities (Smith and Berdan 2003), are also noticeably absent. Therefore, it is difficult to address exchange of craft goods between Maya producers and consumers and the nature of the commodity production in the Late and Terminal Classic periods.

Previous research has suggested that a Late Classic market existed at Xunantunich. As described earlier, Keller (2006:616) draws on configurational evidence of architectural patterns to infer a potential market at the site. A distributional approach also lends evidence to suggest a market at Xunantunich. Ash ware frequencies across households suggest that elites did not exclusively control access to polychrome vessels (LeCount 1999). While access was limited in the Late Classic period, by the Terminal Classic period, these wares circulated freely, indicating either widespread gifting of these vessels by elites to commoners (LeCount 1999) or possibly the presence of a market economy where such ash wares were readily available.

In this thesis, I address the question of a market at Xunantunich using common pottery groups. If markets arose in the Late Classic period, commonly used utilitarian items, such as pottery vessels, may reflect new economic practices. Markets bring together consumers and producers in one place on a regular basis, and for those craftspeople who participate, it stimulates demand for their products. To accommodate new consumers in an emerging market economy, ancient potters may have enlarged the scale and intensity of production. Rather than solely replacing items within their own homes, potters may have produced extra items to accommodate both the needs of farmers and other craft specialists who also produced goods for the market. Increased efforts spent on producing wares for markets could have resulted in standardized vessels as evidenced by pottery with consistent styles, sizes, and materials (Costin 1991; Rice 1981, 1987).

Alternatively, markets may not have developed in smaller polities like Xunantunich, or if they did, they might not have been as formal as those described for the Aztec. If a market economy was not active in smaller Maya polities, then pottery production would not have been affected by market forces. Pottery production of utilitarian items would have remained at the household level and oriented around maintenance of household inventories, not production for usage external to a household's needs. Alternatively, Late Classic markets may not have been fully commercial systems and therefore its producers not subject to rigorous market forces. Costin (1991) discusses several assumptions about market economies and craft standardization, including the assumption that standardization, competition, specialization, and efficiency must necessarily be linked. As she points out, producers can make highly standardized or highly idiosyncratic wares depending on what is desired by the consumers (Costin 1991:33-34). In some cases, competition for consumers need not be high enough to lead to highly efficient and standardized wares. Further, producers may choose to make standardized items not due to economic decisions but because of social organization and cultural norms. Costin (1991:37) stresses that rather than make assumptions regarding desire of efficiency in production, one should focus on where utilitarian items are embellished (such as rim or lip treatment on a storage jar) and the relative degree of standardization in specific attributes (Costin 1991:36). Elaboration may be a way for specialists to differentiate their wares from the products of rivals and attract customers. It also carries social information concerning affiliation. Relative standardization measures the *degree* of specialization since the increasing scale of production measures the relative number of potters to consumers (Costin 1991:36)

This research uses ceramic production as a possible indicator of market forces. This research aims to better understanding production in the Late and Terminal periods using two common pottery groups and forms: Mount Maloney bowls and Cayo jars. These two ceramic groups vary in paste composition, form, and usage. Changes in the organization of production should be visible in attributes of the finished product if shifts in exchange systems occurred during the Late and Terminal Classic period. It is hypothesized, therefore, that with the advent of a marketplace at Xunantunich formal pottery attributes, such as rim diameter and wall thickness, would become more standardized as fewer producers made increased volumes of pottery wares for sale. An increase in the level of pottery specialization might entail greater efficiency and proficiency, leading to greater consistency, and higher standardization.

Furthermore, changes in production should also affect the manufacturing process, specifically how ceramic paste recipes are made. Should production become specialized, less variability is expected in paste composition. Therefore, if a market economy was active in the Late and Terminal Classic period, the earliest phase should have the least variability in ceramic paste recipes within each group. Contrastingly, statistically insignificant changes in paste recipes and standardization indices among formal attributes would indicate that expected changes in production and output are not present. These patterns would lend evidence to suggest that production strategies did not change during the Late and Terminal Classic periods. If a market economy did develop, as suggested from other lines of evidence, the Xunantunich market either did not involve the ceramic groups researched for this project or the intensity and scale of ceramic production for these types did not change significantly.

I test this hypothesis by examining the aforementioned pottery groups from Actuncan, San Lorenzo, and Xunantunich across three Late and Terminal Classic phases. Regarding these materials, the phase names from LeCount et al. (2002) will be used for this thesis. The Late Classic period at Xunantunich has two phases: Samal (A.D. 600-670) and Hats' Chaak (A.D. 670-780). The Terminal Classic period at Xunantunich consists of a single phase called the Tsak' (A.D. 780-890).

Markets are most likely to have occurred around A.D. 750; therefore, pottery should show the greatest amount of standardization in the middle of this sequence. If markets existed, and were a result of centralized control of economics, standardization should peak in the Hats' Chaak phase and then drop off in the Tsak' phase, corresponding to the collapse of elite society in the Classic Maya and the diminution of activities at Xunantunich. Thus, pottery before and after this time should exhibit more diverse production techniques.

Regarding paste recipes, fewer recipes should be discernable during the Hats' Chaak phase, as the market hypothesis involves residents opting to acquire their pottery through a marketplace rather than craft it themselves. Paste recipe evidence includes treatment and size of additives to the raw clays, consistency in recipe production, and proficiency in firing activities. These compositional attributes are identified through standard petrographic analyses.

Data collection occurred during June of 2007 in San Ignacio, Belize, under Dr. Lisa LeCount (University of Alabama). In Belize I collected samples from the Xunantunich type collection and Actuncan excavation lots. At that time, I measured rim diameter, sherd thickness, presence and size of firing cores. I drew and photographed each rim sherds at this time as well. With permission from the Belize Institute of Archaeology, 124 rim sherds were exported to the University of Alabama. Subsequent analysis involving the production of petrographic thin-sections of the sherds occurred at the University of Alabama. Thin-sectioning began in September 2007 under the direction of Dr. Deborah Keene (University of Alabama) and Dr. Fred Andrus (University of Alabama). I produced roughly half the thin sections at the UA geology lab, and Brian Hess at University of Wisconsin-Madison made the other half. To identify mineral inclusions and textural attributes, I read all slides using the Department of Geological Science's polarizing microscope and followed standard point-count procedures (Stoltman 1989, 1991; Whitbread 1989, 1995).

I predicted one of two results from this data. Either, Mount Maloney bowls and Cayo jars will have the highest levels of standardization in the Hats' Chaak phase or, the Mount Maloney bowls and Cayo jars will not have differential levels of standardization in the Samal, Hats' Chaak, and Tsak' phases. Measuring attributes across time provides an understanding of the relative degree of standardization in the production of these vessels. It will also offer insight into the production practices across common household types. Should greater standardization occur in the Hats' Chaak phase of the Late Classic, it potentially reinforces the concept of an emergent market economy. However, if there is no change in standardization throughout the Late and Terminal Classic period, it could be indicative of several things. Perhaps there is, in fact, no evidence for a market economy. Alternatively, there may have been a marketplace, but its affects are not visible in my research. Ceramic production could already be specialized prior to the Late Classic period, leading to the appearance of no significant changes in the material from the Late and Terminal Classic period. Or the groups chosen for analysis may not have been exchanged in a marketplace. Finally, market forces may not have affected common pottery production significantly. I will attempt to evaluate these alternative hypotheses in the conclusion of this thesis.

The following chapters provide background information on the sites, contexts, theory, and methodology as well as statistical and petrographic analyses. Chapter 2 is comprised of a discussion of market theory, production, and standardization, as well as a review of literature on this material. Chapter 3 presents material regarding market economies and specialization specific to Maya archaeology and ethnography. It also includes site summaries, as well as information on the specific contexts of the samples. The methodology used both in data collection and ceramic petrographic analyses is the subject of Chapter 4. Formal and petrographic analyses comprise Chapter 5. Finally, Chapter 6 presents the conclusions of this research.

Figure 1.1: The Upper Belize River Valley

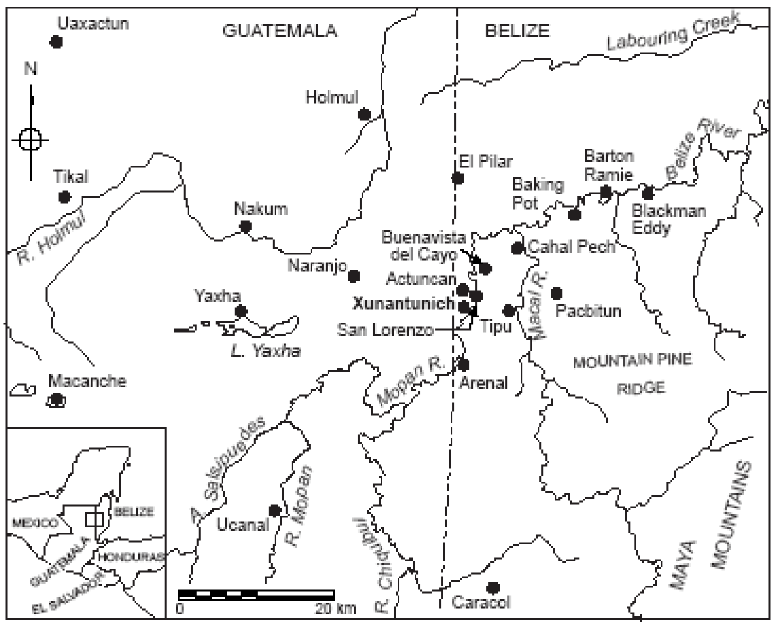
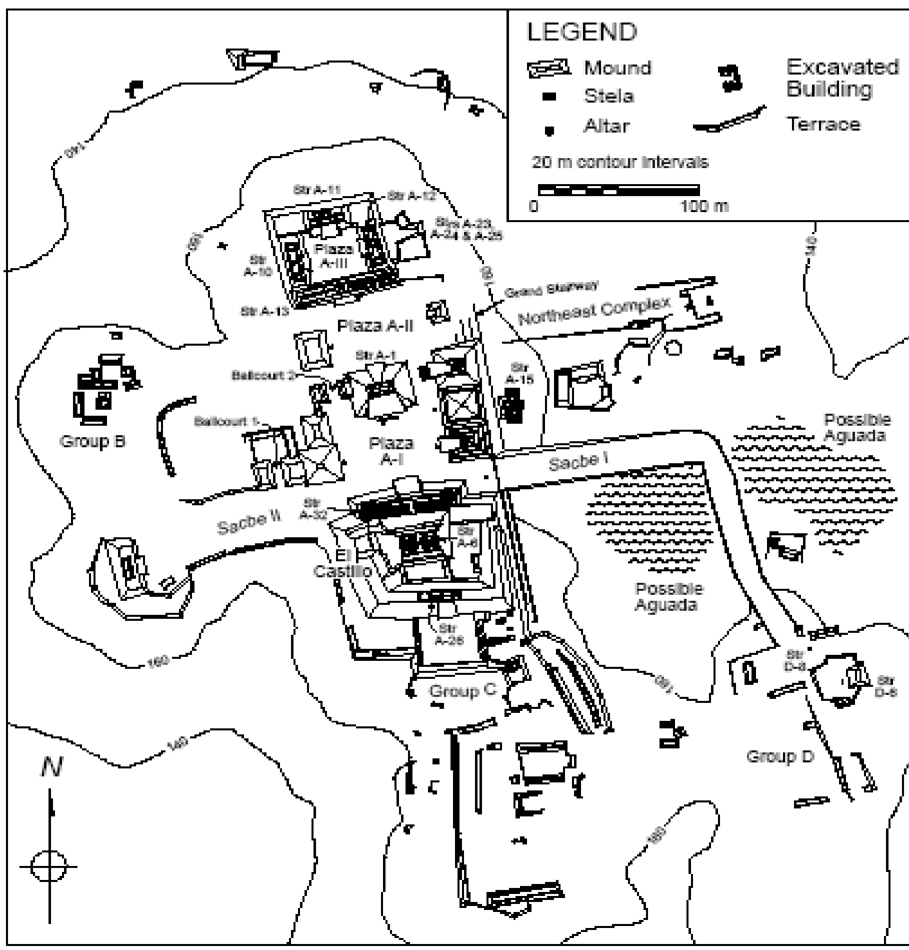


Figure 1.2: The Site of Xunantunich
(Drafted by Angela H. Keller and modified by Jason Yaeger).



Chapter 2: Theoretical Background

Modern markets have long been correlated with craft specialists since market forces affect how producers access raw materials, organize production, and exchange their finished goods (Deal 1998; Little 1989; Minc 2006; Plattner 1985, 1989; Smith 1976). Production and exchange of goods is linked through specialization. Differing exchange systems require differing production infrastructures to meet supply and demand issues of goods, and specialization of production is the strategy used to increase flow of finished goods into high-demand economies. Ethnologists and archaeologists also have documented a correlation between the organization of production and the quality and quantities of goods produced in ancient and non-western societies. In general, specialists produce more homogeneous wares than non-specialists (Arnold and Nieves 1992; Blackman et al. 1993; Costin 1991; Kvamme et al. 1996; Longacre et al. 1988; Rice 1987). Thus, in a market system, goods are expected to be more standardized than those produced by craft specialists in a non-market system (Arnold 1991; Kvamme et al. 1996; Rice 1987; Stark 1995). Given these assumptions, archaeologists have used standardization indices as proxy measures for degrees of specialization. The link between specialization and standardization, however, has not proven to be straightforward in many recent studies (Blackman et al. 1993; Costin and Hagstrum 1995; Hegmon et al. 1995; Kvamme et al. 1996; Rice 1996; Stark 1995). Therefore, additional standardization studies are needed to provide greater insights into assumptions concerning the organization of production and market systems in ancient state level societies.

This chapter focuses on how different exchange systems affect the production and distribution of goods. Material culture correlates for the various exchange systems -- reciprocity, redistribution and markets -- are compared along Hirth's (1998, 2000) four parameters (configurational, contextual, spatial, and distributive) to explore the affects of exchange systems on access to goods. Further, differing types of market systems are discussed to consider how politics, production, and access to goods are intertwined. Since this study focuses on ancient Maya pottery production, I focus on the interplay between production and exchange systems. To this end, standardization is emphasized as a means to exploring specialist production. The "standardization hypothesis," is critiqued, and alternate avenues to investigating production specialization are explored.

Types of Exchange

Reciprocal exchanges, redistributive exchanges, and market exchanges affect production systems in different manners. Understanding these effects on production allows for identifying dominant exchange systems in the archaeological record. Reciprocal exchanges involve the negotiation of social relationships in a different manner than redistribution or market exchange. Reciprocal exchanges differ from redistributive ones or market exchanges in that exchanges happen in a very personalized manner, for example between kin groups. Essentially, social relationships create exchange networks between individuals and groups, as compared to exchange occurring through administrative actions or impersonalized market trading (Hirth 2000).

Gifting is an important form of reciprocity. Beginning with Mauss's (1978) *The Gift*, gifting has been recognized as a prominent and often public means to create and maintain political and social power over others, as he or she who gives the most away gains the most prestige and status. Gifting, however, also incurs a social debt between giver and receiver. This negative balance encourages the receiver to gift something in return or to accept being indebted to the giver. Some gifts create so much debt between individuals that power imbalances between them are formalized. For example, a gift of land from medieval sovereigns institutionalized the dominant power as the sovereign over the recipient of the land (Curta 2006). Such a valuable gift could not be repaid and formalized the recipient's social and political debt to the giver.

Redistribution varies from reciprocity in that the social networks responsible for exchange are superseded by political ones. Members of a polity are required to give certain items to the political body. In return, the political elite redistribute items to their loyal supporters. In many cases, hinterland farmers provide staple goods as tribute, sending basic necessities such as foods, cloth and other craft goods (D'Altroy and Earle 1985). Wealth items, for example luxury goods made locally or acquired through trading networks, can also be tribute items that are used by leaders to reward subjects, pay debts, and fund political ambitions (D'Altroy and Earle 1985).

Redistribution, in some shape or form, is associated with complex societies (D'Altroy and Earle 1985; Earle 1997; Peebles and Kus 1977). Populations must pay tribute to their political administration, and the administration uses tribute in many ways including payments, gifts or rewards to loyalists, both elite and common. Therefore tribute affects subsistence and political economies in many ways. In some cases, tribute items are bought and sold in markets. For example, Aztec farmers exchanged foods for tribute items in political centers (Blanton 1996; Brumfiel 1987). This exchange supplied city dwellers with foodstuffs, in addition to creating a demand for items required for tribute to local kings. Political elite in turn exchanged items received as tribute for staple goods in city markets, as well as “paying” retainers and officials (Blanton 1996; Brumfiel 1987). Thus tribute and redistribution function to stimulate local economies.

Redistribution systems are often viewed as a means by which ruling elite monopolize access to long-distance trade goods and other items (Hirth 1996; Masson 2002). Hard to acquire items, such as imported exotic materials, may be reallocated by ruling elite to others based on social status and political favor. Hence, distribution of certain items should be skewed to favor elite households with more political connection over commoner households reliant on the noblesse oblige of the local elites to obtain these items. The simple application of this model however, is problematic. The practice of caching ritual items in houses can confound our understanding of redistribution networks. Caching activities can lead to confusion in distinguishing between political exchanges and religious practices, leading to the inappropriate imposing of redistribution models. Pauketat and Alt (2004), for example, argue that the caching of Mississippian greenstone axes reflects a religious activity, not evidence of political redistribution, as previously thought. Redistribution models based solely on artifact distribution are also insufficient in situations where locally produced staple goods are required as tribute items. If local ceramics are part of tribute requirements and they are widely made in households, then how can these items be identified as tribute?

Market exchange functions differently than redistribution and reciprocity. Individuals travel to the market and purchase items from someone whom they may have few, if any, personal ties. Exchange relationships may form between buyers and sellers based solely on contractual obligations. Whom a family is related to or how they fit into the political situation is less important than *contractual* transactions that take place in markets (Hirth 1998). Rather, provisioning is contingent on the ability to afford an item. Acquisition of items does not require specific social networking or political power (Hirth 1998). Markets therefore require a certain level of supply and demand to survive. Plattner (1989:181) suggests that for a market to develop and persist, it needs to be regular in occurrence, have available goods to meet the needs of those accessing the market, and have security in trading between those not joined by kinship and residential ties. Clark and Parry (1990) suggest that high population levels are a requirement for specialist production necessary to supply a market economy to exist. That being said, Arthur's (2006) research among the Gamo found that several full-time specialists produce pottery for villages with populations under 500 residents. I would argue that more important than particular population levels are the amounts of pottery vessels being consumed by those populations.

Market systems create economic and political power. Markets create income for local political agents through taxation (Minc 2006; Minc et al. 1994; Hirth 1998, 2000). They also provide a means for tribute goods to be exchanged for other valuables, and thus are beneficial politically to rulers and economically to local agents (Brumfiel 1987; Hirth

1998:452; Hirth 2000; McCormick 2001). Rulers can collect their tribute in market towns, and market towns can make a profit off of facilitating the acquisition of goods to rulers. As markets bring together consumers and producers in one place on a regular basis they stimulate demand for products. People know that on certain days, goods will consistently be available. Thus, markets stabilize the production and consumption of goods within an exchange system. For example, pre-contact Aztec markets were hierarchically organized and periodically scheduled to form a complex interlocking market system. The large Tlatelolco market offered the widest variety of goods on a daily basis, whereas smaller hinterland markets sold a limited array of goods once a week. In addition, some Aztec markets specialized in specific goods, such as dogs or slaves (Smith 2003; Smith and Berdan 2003). Market specialization is also apparent in Medieval Europe's system of regional fairs and market towns (Epstein 1994; McCormick 2001). Regional fairs tended to emphasize certain products based on intensified local industry, such as horses, wool, or wine, whereas market towns were the loci of exchange for a broader range of goods (Epstein 1994; McCormick 2001). Power struggles often occurred between rulers and leaders of economically powerful cities over rights to market exchange and control of the market economy (Epstein 1994, McCormick 2001). Allowing cities to control major economic events, such as yearly fairs, undermines centralized power.

Archaeological Correlates of Exchange Systems

Exchange systems may occur simultaneously in complex societies so it is important to understand how each system affects the archaeological record. Kin groups may rely on reciprocal exchange for certain needs. Tribute requirements will provide or require others. In addition, residents may attend a market for household provisioning. Nonetheless, each system can be identified based on a set of four archaeological correlates developed by Kenneth Hirth (1998). The following discussion briefly outlines the correlates for reciprocal, redistributive and basic market systems (see Table 2.1), but focuses more intensely on market systems.

Hirth's (1998, 2000) four parameters address how site architecture and organization, production of goods, site distributions of goods, and household access to goods are affected by exchange systems. The configurational parameter addresses how exchange systems affect work space and architecture within a site. The contextual parameter focuses on cultural features connected to the provisioning and distribution of goods, such as craft specialization. The spatial parameter addresses how exchange systems affect artifact distributions over the landscape or the arrangement of population centers. The distributional parameter utilizes artifact distribution among households as a means to understand variation in domestic provisioning. Hirth (1998:462) acknowledges that no single correlate can clearly distinguish exchange systems, since some markers are not mutually exclusive.

Reciprocal exchanges of locally made items by individual households present an archaeological challenge to identify. Unless items are made of exotic materials or clearly inscribed or otherwise documented, such as medieval letters telling of gifts between individuals (Epstein 1994), it would be difficult to differentiate reciprocal exchanges from other types of exchange in the archaeological record based solely on the item itself. Following Hirth's parameters, archaeological indicators of reciprocal exchanges may include evidence of dedicated locations for gifting ceremonies, ritualized specialization (see Spielmann 2002), long-term association between two communities (similar to Renfrew's 1975 directional exchange), or consistency of specific items within domestic groups with close kin relations.

A redistribution economy should be evidenced by widely disparate frequencies of artifact types across households ranked by social status, a pattern associated with Hirth's distributional model. Also, it could be surmised from configurational parameters including the existence of centralized storage facilities with administrative structures for specific goods and services. Because redistribution also may occurs in complex societies possessing market economies, these indicators are not sufficient alone as evidence for redistribution as the predominant economic system. Redistribution should show marked differences in availability of goods across space. In the political centers, overall artifact frequencies may reflect access to varied tribute goods from closely situated elite leaders. But hinterland production should comprise mostly utilitarian items, and hinterland households should have limited access to elite-controlled luxury goods. Therefore, elite-controlled luxury goods should decrease with distance from the political centers. Distributive data may also indicate the presence of rarer, elite-controlled goods in households belonging to local political leaders. Yet assemblages across all these households are also expected to be diverse, reflecting varying household production practices.

Market economies generally coexist with other economic systems (Hirth 2000; Lentz et al. 2005), but theoretically, they should be one of the most easily distinguishable systems to identify in the archaeological record. A market economy requires a place to hold the market, often a plaza or a formal marketplace (Hirth 1998). Therefore, a configurational correlate of market exchange is the architecture of a formal marketplace, which generally will vary from other civic and domestic architecture in a site. For instance, Contact period Aztec market places possessed a formal architectural design, were centrally located within a settlement, and occurred along main transportation routes (Hirth 1998:453). As Hirth (1998:453) comments, in situations where markets were held periodically, likely no permanent structures existed. Rather, other areas were temporarily co-opted to act as marketplaces. These areas are cleaned after usage, leaving little material in the archaeological record. Archaeologically visible evidence therefore is limited to analysis of architectural functions and civic planning.

Market exchange is correlated with cultural features, such as large cities or the presence of full-time specialists (Clark and Parry 1990; Hirth 1998:453). Archaeologists assume that urban places require market exchange to provision city dwellers. Redistribution alone cannot accommodate large urban populations, both in sheer volume of food needed as well as administrative organization to provision those living in cities. Concomitantly, occupational specialization will develop more extensively and intensively when demand for goods and services are sufficient to support craftspeople full-time. Using a contextual approach, archaeological indicators would be the presence of workshops and possibly, barrios of craftspeople, or simply the presence of very large cities requiring food and other resources. In addition, indirect evidence of craft specialization can be used to imply market exchange. Hirth (1998:453) cautions that solely using a contextual approach is problematic, since it does not address how households provision themselves. Rather, it assumes market exchange, but this need not be the case. In the Aztec Empire, tribute functioned to bring goods into centers and operated alongside markets (Hirth 1998, 2000). To assume provisioning occurs solely through market exchange ignores the operation of other forms of exchange.

A spatial approach infers market economies based on the distribution of goods or centers over geographical space. Variants of this approach have been used to investigate Aztec market systems based on extensive pottery collections from the Valley of Mexico survey data and Instrumental Neutron Activation Analysis (INAA) of pottery types to document areas of production and market zones (Minc 2006; Minc et al. 1994; Nichols et al. 2002). Other spatial approaches involve utilization of artifact fall-off curves (Renfrew 1975, 1977) and analysis of settlement patterns (Blanton 1996).

Hirth's (1998, 2000) distributional approach shifts the focus to households. In contrast with the other avenues of inference that look at how communities are affected by a market economy, Hirth (1998:454-455) analyzes how markets affect households. He argues that if a market economy is present, all households, regardless of status, have the potential to bargain, barter or buy items. Therefore, craft good distributions should be roughly equivalent across community households (Hirth 1998:455). Hirth (1998, 2000) applied this approach to obsidian and imported ceramics found within households at the site of Xochicalco, Mexico. Imported ceramics are found in similar frequencies in elite and non-elite households, indicating that society at large had equal access to these imported goods. Obsidian availability was also not affected by social status or proximity to workshops. His results correlate with the expectations of an active market system based on the distributional approach.

Central Place Theory

Much of the modeling and assumptions for market economies derives from Central Place Theory (CPT). The basic assumption behind CPT is that production and exchange are determined by market competition between centers (Smith 1976). A center has surrounding production zones that provide goods and services to its marketplace. In return, it acts as an exchange hub for materials coming from hinterlands, as well as goods produced in the center. As populations increase, additional distribution centers will arise throughout a region to accommodate demands for goods. The main constraint is the distance to a market center, both for vendors transporting goods and buyers acquiring them (Plattner 1989; Smith 1976). Central Place Theory accommodates differing levels of administrative control, but the recurring theme is movement of goods and buyers to a central location (Smith 1976).

While theoretically sound, the application of Central Place Theory is often complicated by geographical and political factors. Firstly, CPT assumes the geographic landscape is uniform and does not affect production and exchange (Plattner 1989; C. Smith 1976). Immediate complications arise when features such as mountains and lakes impede the arrangement of sites as modeled by CPT. Blanton's (1996) application of CPT to Aztec market economies demonstrates that realities are more complicated than theoretical models. His spatial analysis of the Basin of Mexico for the Late Aztec period utilized colonial accounts of the locations of markets and specialized production sites. After adjusting a simulated CPT system to better accommodate geographical features, he found that the distribution of centers, subsidiary sites, and production areas approximate CPT expectations. He also documents how the existence of political factions or the vagaries of political favor affect production and exchange. Therefore, CPT does provide a model for charting the development of economic centers across a landscape, and a framework for evaluating artifact distributions if these factors are considered.

Often, the presence of a standard value of exchange, or currency, is implied in market systems. However, Sillitoe's (2006) discussion of "spheres of exchange" suggests that in various ethnographic contexts, societies lacking monetary economies also establish a system of valuation. Goods tend to fall into one of two categories – either subsistence goods or wealth goods. Generally, goods in the subsistence category are not used to purchase wealth goods. For example, food cannot be used to purchase wives among the Tiv, as these two items are not part of the same sphere of exchange. Individuals who attempt to exchange items belonging to different spheres face social criticism, as the items do not have the same value (Sillitoe 2006). Aside from creating divisions in purchasing activities, spheres of exchange creates a system of value, one in which the values of certain classes of goods encourages and referees economic activities in a market system lacking a centralized currency (Plattner 1989).

Types of Market Systems

Not all markets are the same; the interconnectedness of politics and economy creates various types of market systems with differing effects on those able to patronize the markets. (Plattner 1989; Smith 1976). Carol Smith (1976) defines four kinds of markets (solar, overlapping, dendritic and complex), attributes of which are summarized in Table 2.2. All market systems have two components: market centers, where exchanges take place, and market zones, the region supplied by the market center (Minc 2006:83).

The availability and range of goods at market centers determines the nature of market zones (Minc 2006; Plattner 1989). Items of relatively low value and high bulk, such as local agricultural products, will not be transported far and thus have small zones. By comparison, those of high value and low transportation costs have larger market zones, since people are willing to go farther to acquire these items (Smith 1976; Minc 2006). Obviously, market zones need not be equivalent for various items, but should overlap near the marketplace.

Solar market systems comprise the simplest and most isolated of the four systems. A solar market system consists of a market center and associated subsidiary markets dispersed within a single market zone. Little to no horizontal flow of goods occurs between adjacent market zones (Smith 1976; Minc 2006). Solar centers have small market zones, and the movement of goods between the main and subsidiary markets is minimal (Minc 2006:84). In solar market systems, the market center acts as the political, as well as economic hub of the greater community (Minc 2006:84). Because of the political and economic interlock, individuals utilize only those markets within the polity (Minc 2006).

Solar market systems are identified in the archaeological record based on discontinuities in artifact styles and possibly, artifact classes. Strong controls exerted over the movement of goods by the political center create distinct, bounded units that reflect the styles and products of the craftspeople who reside there (Minc 2006). Therefore, households sharing a market zone will have similar distributions of basic craft goods; whereas households belonging to a different polity will have functionally similar, yet stylistically distinct, items (Minc 2006).

Overlapping market systems occur when market zones of adjacent centers overlap. This system varies from a solar market system in several ways. First, boundaries between centers are permeable, allowing for much more horizontal flow of goods between market centers (Minc 2006). Second, the political boundaries do not coincide with the market zones, allowing individuals more freedom in selecting the market centers they frequent (Minc 2006). Rather than creating visible boundaries between market zones, ancient overlapping market systems appear as gradual changes in distributions of items (Minc 2006). Distance provides the greatest constraint on the system as a whole, with adjacent market zones sharing more material than those associated with solar market zones.

Dendritic systems feature strong ties between the market center and subsidiary markets and weak ties between subsidiary markets (Minc 2006:86). Goods move vertically through the market system – that is, local production shifts from being broad-based for local exchange to commodities-based (salt, maize, or certain luxury goods) for exchange in more distant market centers. Dendritic systems force local, subsidiary markets to rely on political administration to ensure the movement of basic necessities to subsidiary markets for local consumption (Little 1987; Minc 2006). Exchange is control by political elites based at the market centers, and interaction between producers and consumers is extremely limited (Minc 2006). As people are reliant on goods moving vertically through the political hierarchy, it stunts local production and exchange of many goods (Little 1987). Hinterland populations focus production on basic, low-value goods for the markets in political centers. If the economic situation changes due to inflation or other factors, the already low-buying power of hinterland populations diminish, hindering people's ability to provision their households (Little 1987). Additionally, distance from the primary market center determines an individual's participation in the market system; therefore, hinterland populations are unable to participate as completely as urban populations (Minc 2006). Thus, the distribution of goods will diminish with distance from the primary center. The archaeological signature of a dendritic market system appears at a glance to be similar to that of the classic redistribution model. However, social status does not necessarily limit access to exchange items in a dendritic system. Consequently, the distribution of exchange items within smaller sites should be more widespread than if a redistribution economy is the primary means of acquiring certain resources.

Complex, interlocking market systems have both strong connections between primary market centers and subsidiary markets and between adjacent regional markets (Minc 2006; Smith 1976). As marketing networks exist between centers of varying sizes and locations, communication between producers and consumers will create similarities in goods throughout the regional system (Minc 2006:87). High levels of interaction and integration between zones precludes sharp boundaries in distribution between sites within a region (Minc 2006). Local, domestic items are distributed widely, but conform to transportation costs, while luxury goods tend to be distributed more narrowly based on who has the necessary purchasing power. Transportation costs become less relevant when considering luxury goods, as buyers are willing to spend more for the exclusiveness of the desired items. Often, political centers will institute policies that intensify production of certain goods in order to increase their economic influence within the market system (Blanton 1996). This strategy leads to increasing numbers of craft specialists in larger cities, which should be archaeologically visible by looking at craft production in cities compared to hinterlands within a market system (Blanton 1996).

Market exchange itself can occur in marketplaces or fairs, but the political and social milieu is often different between the two. Unlike markets, which are open many times throughout a year, fairs generally occur only annually. Medieval European fairs were connected to religious institutions, and early on, occurred in accordance with religious festivals held at abbeys or monasteries (Epstein 1994; McCormick 2001; Moore 1985). The income provided by tolls and taxes was removed from the towns themselves. Fairs often lasted for over two weeks at a time. In many cases, fairs became renowned for specific goods, such as wool, wine, or horses. Production of these goods tended to occur fairly close to the locations of the fairs to cut down on transport costs (Epstein 1994). Fair specialization arose from either intentional development of resources (increasing wool production) or because of preexisting important industries in the region (the annual fair in Burgundy, France, was renowned for its red wine selection) (Epstein 1994; McCormick 2001). Attendance in European and English fairs was an international affair, with foreign buyers canvassing Western Europe for commodities (Epstein 1994; McCormick 2001).

Research on Late Medieval fairs (c. A.D. 1000-1550) indicates tension between prominent towns holding markets and other towns attempting to hold fairs (Epstein 1994; Hunt and Murray 1999; McCormick 2001). Successful fairs were major economic events, as the town, monastery, or other hosting location charged an entry fee for attending, and taxes may have been levied on sellers as well (Epstein 1994; McCormick 2001). After the lucrative nature of fairs began to be noticed, other towns and regions petitioned their monarchs for approval to hold their own fairs (Epstein 1994). In this manner, granting of fairs became a political tool wielded by royalty as a means to assert authority over towns with markets, as well as a way to create a vital economic power base (Epstein 1994; Hunt and Murray 1999; McCormick 2001). Additionally, holding fairs along major trade routes insured the income from tolls as people and vendors arrived at the fairgrounds (McCormick 2001).

Markets and Specialization

Markets today are dependent on specialized production of items, and many anthropologists and archaeologists assume the development of market economies had profound effects on the organization of production. Markets represent a situation where there is consistent supply and demand for goods (Plattner 1989). Increased demands for goods necessitate increased production, a process that leads to specialization (Blanton 1983; Plattner 1989). Models to explain the development of market systems stress that producers will opt to specialize and often relocate to better access marketplaces and meet demand (Blanton 1983, 1996; Plattner 1989; C. Smith 1976). Research on Medieval European economies indicates that when new fairs developed, local producers shifted priorities to meet consumer demands at regional fairs. Producers focused their time and resources on whichever goods sold well at the fairs as opposed to a more broad-based domestic production (Epstein 1994). Domestic production essentially, was replaced by salable commodity production.

Recent political economy models propose that changes in production and distribution are the result of top-down political strategies (Earle 1997). When market exchange is imposed “top-down” on a population from the political administration, specialist production becomes the only way to participate in the market system (Minc 2006; Little 1987). A good archaeological example of this political process is seen among the Aztec. Aztec elites demanded food as tribute, which created more work for commoners and less time to produce necessary non-food items for households (Brumfiel 1987; Smith and Berdan 2003). Those living on marginal lands were not able to support themselves and maintain tribute demands; thus they focused more energy on production of goods to be exchanged for both their own food requirements and tribute requirements.

Political models assume that individuals opt to become specialists because of increased tribute demands. These individuals cease domestic production of food and instead focus on specialized production to meet tribute demands. The possibility that household groups could have had enough labor, through children, marriage, *et cetera*, to both effectively farm their land and produce or exchange goods is not addressed. However, the assumption is that even part-time specialists would significantly diminish other economic activities and increase production of a specific item to meet tribute demands is problematic (Hirth 2007). In regions where a pronounced wet and dry season dictates farming practice, the same households can support themselves with agricultural practices and specialize in the production of craft goods, albeit at a part-time level. Blanton (1983) also discusses the importance of understanding commoner work rhythms when modeling production systems. Therefore, archaeologists should hesitate in imposing western ideas of capitalism and full-time working conditions on prehistoric populations, even those in state level societies.

Adaptationalist models also link markets to specialization. The underlying assumption behind these models is that population pressure forced households to live on marginal lands. When people were unable to support themselves through farming, they were forced into craft specialization as a means to support themselves (Arnold 1991; Blanton 1983, 1996; Rice 1981, Smith 1976). These models beg the question of how marginalized individuals supported themselves in a situation of low demand. Also, if most households were already managing domestic production of goods, as well as farming, what was the impetus to increase production or patronize specialists?

Finally, specialized production is closely tied to the rise of cultural complexity, specifically highly-stratified states, urban centers and intensive agriculture (Clark and Parry 1990). When producers specialize in a specific product or class of products, this is done at the expense of other household provisioning strategies. In turn, specialists must barter or sell their wares for other items, a pattern which further stimulates demand. This shift in production activities creates a situation wherein consumers maintain a demand for specialist-produced goods (Costin 1991), and specialists depend on extra-household exchanges for their livelihood, or at least some part of it. Nonetheless, it is still likely that a percentage of any given community will continue their household production because they either (a) have the time or labor resources to do so and/or (b) cannot obtain the goods made by specialists.

Regardless of how specialized production developed, specialization occurs when the numbers of producers are low compared to the numbers of consumers (Costin 1991; Stark 1995). Rather than having all households craft their own goods, they acquire some goods from others. Therefore specialization has degrees, depending on the ratio of producers to consumers which can be measured by differential participation in economic activities and the organization of production (Costin 1991:4, 20).

Production

Specialization is seen as a set of strategies and practices that alter the production process. This research uses the framework designed by Costin (1991; Hagstrum and Costin 1996) in understanding the organization of production, and how these economic practices are linked to specialist production. Costin defines four parameters to comprehend the organization of production: context, concentration, scale and intensity. The context of production refers to the demand for the goods and the affiliation of the producers (Costin 1991). Production is either attached or independent. Attached specialists reinforce sociopolitical aspects within a society since the flow of their products is controlled by elites; whereas independent specialists, in general, create "domestic" wares for household consumption and, possibly, tribute (Costin 1991:11; Costin and Hagstrum 1995). Concentration describes the spatial organization of production. It approximates how close producers and consumers are located to each other. At one end of the continuum, producers are dispersed throughout the communities within a region. At the other end are nucleated specialists located in workshops or other specific places on the landscape (Costin 1991:13). Production scale characterizes the size of production groups, as well as how those individuals are socially connected to each other. Household production lies at one end of the organizational continuum and factory/workshop production at the other (Costin and Hagstrum 1995:620). Importantly, production groups are not necessarily mutually exclusive within any given society, since the presence of workshop production does not preclude some households making their own wares. The final parameter of production, intensity, expresses the amount of time spent on production. At one end of the continuum, non-specialists produce items as a minor supplement to other activities, specifically food production and processing. Part-time specialists devote much less time to making ceramic vessels than full-time specialists who devote the majority of their time to the production and exchange of their craft goods (Costin and Hagstrum 1995).

Archaeological correlates for investigating these parameters fall into two categories: direct indicators associated with production activities and indirect measures based on analysis of the objects themselves (Costin 1991:18-32). For ceramics, direct indicators would be workshops, kilns, and large concentrations of items connected with production (wasters, tempers, raw materials, etc.). When direct measures of specialization are not forthcoming, analysis of materials can be used as a proxy to suggest the degree of specialization, including standardization (Costin 1991:33).

Standardization

Standardization is viewed as a proxy for specialization for several reasons. Presumably, if production is occurring in a workshop setting, both finished products and utilization of raw materials should be more consistent across crafters than if production occurs at households. Greater frequency and communication, and to some extent skill, regarding production methodology in workshops creates more consistent production activities, including treatment of the clay and crafting of the vessels, than that associated with individualized domestic production events. Additionally, it is possible that knowledge regarding the appropriate forms, decorations, and treatments is more concentrated in a workshop setting than that dispersed among various households who learn their craft from a variety of tutors, such as parents, kin or other craftsmen.

Additionally, changing ratios of producers to consumers in a production system with specialists should affect standardization among assemblages (Stark 1995). When all households provision themselves, the overall assemblage reflects that variability. Simply, the more hands involved in making pottery or any other craft item, the greater the heterogeneity in recipes, styles, skills and materials visible in archaeological assemblage. Not only are metric variables (such as pottery rim diameter, vessel size, and number of shape categories) that measure standardization expected to have a larger range of values, but also treatment of the raw materials, including addition and processing of tempers, should be more variable. Transition to a system involving specialists presumably standardizes production of specific items. If, for example, 80% of the households in a community opt to acquire pottery from a select number of specialists, there will be less variability based on number of producers alone. The general assumption is that specialization, as an economic process, accompanies a decrease in the number of craftspeople producing a given item, which in turn creates less variability overall (Stark 1995).

However, it is imperative to differentiate between specialists producing more standardized goods and simply less producers overall. As Stark (1995) notes, homogenization will occur if the number of producers decreases for reasons unrelated to economic factors. She (1995:256) has referred to this relationship as the "ratio effect" (i.e. the ratio of producers to pots). If, for instance, half the pottery-producing households move away from the region, the subsequent assemblages could look as though specialized production developed because there was less variability in later assemblages than earlier ones. Thus, standardization and homogenization may be difficult to differentiate in the archaeological record. Identification of specialists, therefore, again requires additional information, such as identification of loci of production or distribution.

Standardization is also presumed to occur when intensity of production increases (Costin 1991). If specialists are making pottery, they are making it with greater frequency than traditional household producers. The specialists' investments in time and energy create a greater familiarity with the production process, which improves consistency in forming, drying, and firing (Arnold and Nieves 1992; Stark 1995). This investment is assumed to cause greater standardization in shape and size dimensions of vessels through routinization of activities (Arnold and Nieves 1992; Blackman et al. 1993; Costin 1991; Stark 1995). Increasing the scale and intensity of production also affects the treatment of raw materials. Through practice and repetition, paste recipes should become more consistent as well. A greater knowledge of the intricacies of the firing process is presumed to lead to a reduction in firing cores and other indicators of inconsistent control of firing wares. Finally, the sheer volume of output produced is expected to lead to homogeneity in assemblages (Blackman et al. 1993).

The Standardization Hypothesis

For the reasons cited above, if specialized production is occurring, items should become more standardized and non-specialized production should result in less standardized items. This has become the "standardization hypothesis," which is tested through comparison of morphological variables as well as raw material composition of ceramic vessels (Benco 1988; Blackman et. al. 1993; Deal 1998; Longacre 1985; Kvamme et. al. 1996; Stark 1995).

Once the metric data is collected, coefficients of variance (CVs) are calculated for assemblages as a standardization index (see Table 2.3). The coefficient of variation consists of the standard deviation divided by the mean, with the resulting value multiplied by one hundred to obtain a percentage. This percentage reflects how the raw data is distributed. When data clusters around the mean, the standard deviation will be low; this creates a smaller numerator in the equation, leading to a smaller percentage overall. A lower coefficient of variation is presumed to correspond to a higher level of specialization. While Costin (1991) shies away from the potential of an index corresponding to production modes, others do not. A CV of 5-10% generally can be considered to be representative of full-time specialists, and values around 15% can be considered likely for part-time specialists (Foias and Bishop 1997; Longacre, et al. 1988).

Pottery standardization indices have been used to explore varying contexts of production. Longacre (1985; 1988) found significant differences in standardization among domestic producers, part-time specialists, and full-time specialists producing for a market. Blackman et al. (1993) measured standardization among mass-produced ceramics in Syria, finding very high standardization within vessels made in the same production events. Costin and Hagstrum (1995) ran CVs on several types of Inka vessels, finding that the retainer workshop specialists produced more standardized vessels than corvée labor. Stark (1995) compared assemblages of Amazonian Shipobo-Conibo potters for domestic use, finding that standardization among individual specialist producers was high, but that when taken as a group, the specialists had lower standardization of wares. Additionally, community specialization produced highly standardized vessels, likely because consumers expected vessels to have certain dimensions (Stark 1995). Different Classic Maya collapse hypotheses in the Petexbatun region have also been tested through standardization indices (Foias and Bishop 1997). The standardization indices were used as a means to evaluate whether or not major changes in production were occurring in Late and Terminal Classic types (Foias and Bishop 1997).

Problems with the Standardization Hypothesis

The assumption that specialists produce standardized wares has been questioned repeatedly over the last ten years using modern and ancient pottery. Results of these studies lend evidence to suggest that specialization may lead to greater standardization within types in certain cases, but not across them (Stark 1995). In fact, there may be a greater diversification in pottery types when specialists are actively producing and competing for consumers (Rice 1981; Stark 1995). Indeed, in a market economy, *assemblages* are expected to become more diverse, not more standardized. Ethnographic research (Arthur 2006; Arnold and Nieves 1992) suggests specialists craft a wider range of pottery shapes and sizes as a means of appealing to the diverse needs of customers. However, a greater consistency in sizes, paste compositions, and firing technique should be apparent within individual types produced by specialists. This increased consistency reflects standardization of the production process, not necessarily the specific output.

In order to ascertain whether the assumed levels of standardization actually corresponded to the organization of production, Costin and Hagstrum (1996) tested various types of pottery from Inka Peru, finding that workshops, household production, and corvée labor often do not have the expected relative levels of standardization. However, they did find that Inka wares were more standardized than local Wanka wares, and concluded than Inka state pottery was produced by specialists. This hypothesis has been further supported by INAA studies (D'Altroy and Bishop 1990). Similar findings occurred in Stark's (1995) ethnographic research where community specialists had similar levels of standardization as full-time workshop specialists. She suggests that similar standardization indices are the result of the "ratio effect," wherein the high volume of ceramics produced skewed the sample to appear standardized (Stark 1995). Another potential issue acknowledges that some vessels have tighter emic size and shape categories than others, which make vessels produced by part-time specialists appear as if full-time workshop specialists crafted them (Arnold and Nieves 1992, Stark 1995). These issues underscore the necessity of having several avenues of investigation, beyond just measuring standardization, to discern production systems.

Stark (1995) argues that comparing ethnographic and archaeological assemblages is problematic based mainly on the differential scope of the research programs and the levels of control over variables. Archaeologists rarely have the luxury of absolute control over timeframes, production areas, and artifact distributions, whereas ethnographers often do (Stark 1995). For example, Arnold and Nieves (1992) studied ceramic production and standardization within the context of one household of producers in Ticul, Mexico. Their results indicated that the intended market for the goods has the greatest affect on standardization (Arnold and Nieves 1992). This is because middlemen purchase pottery which meet specific desired sizes. If middlemen want highly standardized wares, then potters make them as such; however, some middlemen prefer a wider range of wares, in which case the resultant pottery is less standardized in manufacture (Arnold and Nieves 1992). Another influence on standardization pertained to whether consumers desired very consistent sizes. Different forms had different uses and different levels of standardization (Arnold and Nieves 1992). Arthur's research (2006) sampled a total of fifteen households of producers spread across three Gamo villages in Ethiopia. All producers work full time, yet vessels vary considerably in dimensions. In this situation, Arthur (2006) was able to ascertain that the potters *intentionally* make several different sizes to appeal to a wider range of consumers. For Arnold and Nieves and Arthur, being able to directly question producers about the reasons for intentional variability allowed them to see that specialization was occurring, even though high levels of standardization were noticeably absent. Archaeological research does not have this luxury. Instead, high variability within a given type would strongly suggest that the potters were not full-time specialists, based on the standardization hypothesis.

By comparison, much archaeological research incorporates materials produced across several decades and subsumes a much higher number of producers (Foias and Bishop; Costin and Hagstrum 1995; Stark 1985; Blackman et al. 1993). This expanded timeframe affects standardization values through a process Blackman and colleagues (1993) refer to as "cumulative blurring." Archaeological assemblages contain material from numerous production events, which skews standardization indices upward. Their research compared both ceramics from a single production event and a larger assemblage, and found the material from the single production event to be up to five times more standardized than the larger archaeological assemblage (Blackman et al. 1993).

Ethnologists have also cautioned archaeologists about the use-life of artifacts and its effect on standardization indices. Longacre's (1985) ground-breaking work in the Philippines tracked the life-histories of pots in three communities. After analyzing breakage and use patterns among consumers, he realized that certain sizes of vessels are replaced more often than others, specifically vessels that were moved less often had longer use lives than those moved about daily. The increased demand for short-lived portable vessels led to an appearance of greater standardization. However, this occurred without any specialization in the production process. The intensity of production should be taken into consideration when comparing vessel forms (Longacre 1985).

Additionally, ethnographers are privy to details of production and distribution unavailable to archaeologists, specifically emic size categories and terminology (Arnold and Nieves 1992; Stark 1995). Lacking an understanding of emic size categories in archaeological forms, such as jars and bowls, can easily distort standardization indices of rim diameter or vessel thickness. For example, Arnold and Nieves (1992) discuss at great length the various size categories and how size affects production methods, which in turn affects potential standardization of finished products.

Measuring Standardization

Indeed, part of the difficulty in applying models of specialization and standardization lies in how researchers measure standardization. Generally archaeologists measure and compare morphological variables, although several have argued that this is inherently problematic (Arnold and Nieves 1992; Benco 1988; Stark 1995; Costin and Hagstrum 1996; Freestone 1991). First, many informal producers are able to make standardized forms with CVs similar to those made by specialists. Not only could this be undertaken with the use of molds or simple measurements (see Arnold and Nieves 1992), but it may also be a reflection of the age and skill of the producer. In other words, older potters with years of experience produce more consistent goods. Second, no concept of time and work rhythms is acknowledged. A potter working in a hurry may make less standardized pottery than an individual with less scheduling demands. Blanton (1983) discusses the importance of time, work, and seasonal scheduling with respect to craft production, arguing that intensity of production (amount of time devoted to production) may not be as significant a parameter in determining standardization as many assume.

Give the problems with measuring standardization using morphological variables, Stark (1995:232) suggest that archaeologists measure attributes which 1) reflect incentives to regulate procedures and 2) do not communicate social, political and ritual messages (also see Plog 1990). Paste recipes reflect choices regarding processing raw material during production activities, but rarely communicate cultural messages. Treatment of raw materials enables a broader understanding of the organization of production for several reasons. While morphological elements may vary with regard to popular styles, paste recipes will be more resistant to change.

Paste recipes also may be unique to production units. If craft organization changes from ubiquitous household production to smaller numbers of specialists, there should be a corresponding decrease in paste recipe variability. Paste recipes reflect skill levels as well, as differing amounts of temper and clay types affect the paste’s properties during construction and firing. Households that conduct infrequent firing may not be able to control environmental conditions as well as specialists who use special firing techniques or devices. Specialists may also have better knowledge of tempering agents, access to special tempers, or guard secret recipes that could improve firing (Arthur 2006, Day 1989). Finally, raw resources may be highly variable in a region. Access rights to certain clay deposits or tempers will create different paste recipes (Bowser 2005). Different paste recipes suggest different production groups.

Petrographic analysis can be used to investigate paste recipes. Researchers analyze samples to discern recipe groups. Often this entails forming a range of variability for each paste recipe based on mineralogical and raw material processing characteristics (Day 1989). Using this technique, Tomkins and colleagues (2004) suggest that pottery production occurred outside of Neolithic Knossos at Crete, unlike previously believed. Stoltman (1991) utilized point counting and petrography to discuss Mississippian spheres of interaction. His ceramic point-counting system enabled statistical testing of paste compositions to better understand how pastes could reflect production locations. Working with Terminal and Postclassic Maya material, Howie (2007) traced production trends over time and identified several recipe groups. A broader discussion of petrographic methods will be presented in Chapter 4.

In sum, production and specialization reflect systems of exchange as much as artifact distributions. In this chapter I have discussed the relationship between the organization of production and exchange systems, and focused on specialization as one way to indirectly approach the study of market exchange. Specialization can be explored through measuring standardization of finished goods, as context, concentration, scale and intensity of specialized production is believed to be correlated with standardized wares. After reviewing studies of standardization and their measurement, I examined how ceramic paste composition may yield information regarding production activities. In the next chapter I will focus specifically on the ancient Maya. Previous research into market economies and exchange systems will be discussed in addition to an elaboration on the research sample contexts.

Table 2.1: Types of Exchange and their Archaeological Correlates (Hirth 1998, 2000; Minc 2006)

Modes of exchange vs. identification approaches	**Configural**	**Contextual**	**Spatial**	**Distributional**
Reciprocity	Locations for gifting ceremonies	Evidence of ritual specialization via Spielmann 2002	Longterm association of items between two specific communities, similar to Renfrew's (1975) directional exchange	Specific items found in domestic groups associated with kin associations
Redistribution	Centralized storage facilities, administrative structures associated with specific goods and services	Hinterland emphasis on production of utilitarian goods and rare access to elite-controlled luxuries	Artifact frequencies reflecting tribute of goods into political centers	Households in communities with diverse assemblages indicative of household production; significant differences in assemblages across statuses
Market Exchange	Plazas for exchange locations; market structures; centrally-located plazas; specific architecture absent from other contexts	Evidence of full-time specialists; very large cities presumed incapable of supplying their own demands	Use of fall-off curves as reflecting distance from market centers; distinction among artifacts based on proximity to proposed market centers	Consistent assemblages regarding utilitarian goods across household and status in a community

Table 2.2: Types of Market Exchange and their Archaeological Correlates (Hirth 1998, 2000; Minc 2006)

Market Exchange	Plazas for exchange locations; market structures; centrally-located plazas; specific architecture absent from other contexts	Evidence of full-time specialists; very large cities presumed incapable of supplying their own demands	Use of fall-off curves as reflecting distance from market centers; distinction among artifacts based on proximity to proposed market centers	Consistent assemblages regarding utilitarian goods across household and status in a community
Solar	Main marketplace in market center with subsidiary markets occurring without set structures; limiting roads linking only to political center for exchange of goods	Community specialization likely within political boundaries	Bounded aspect of exchange system and link to political boundaries suggests rapid and sharp drop-off curve after leaving polity	Access to goods limited to what circulates in particular political sphere; within the market zone households are expected to have similar assemblages
Overlapping	Main marketplace in market center with subsidiary markets occurring without set structures	Community specialization likely to occur	Since boundaries between market zones are permeable, distance determines access to goods with artifacts showing a gradient pattern between adjacent zones; variability in frequencies between communities should reflect distance from	Access to goods is limited by distance to market centers and production locations; variability among households within a community expected to be low

			each other	
Dendritic	Main marketplace in market center with subsidiary markets occurring without set structures	Community specialization likely to occur for export to main market center; local production and exchange of utilitarian goods limited	Emphasis on production for market center, not local community, deters local exchange, spatial indicators are high frequencies of imported goods at the expense of locally-made items	High frequencies of imported goods expected among households as provisioning is based on what is imported through political channels in hinterland; greater variety of items in assemblages in market centers
Complex Integrated	Marketplace plazas and structures available throughout region with larger markets occurring at larger centers	Specialization expected: community for imports to major centers, full-time within major centers for specialty goods for export to smaller centers	Items produced locally throughout the system show a more limited distribution based on widespread availability and transport costs; scarcer items are more common at major centers with larger markets	Household assemblages are similar in utilitarian goods; higher variety of overall goods expected in major centers based on integration with hinterland production areas

Chapter 3: Contextualizing Maya Markets, Market Exchanges and Archaeological Samples

While the previous chapter focused on the relationships between market exchange, production, and specialization from a broad anthropological perspective, this chapter narrows the scope to Classic Maya materials. Archaeological research pertaining to Maya marketplaces will be discussed. After a brief commentary on research supporting market exchange, Xunantunich and its surrounding hinterland will be discussed.

Based on what is known about the Late Classic Maya, markets are expected to exist. Many Maya centers had high populations that would have created basic provisioning difficulties. Tikal, Caracol and Calakmul may have had populations over 100,000 persons (Demarest 2004:120). Dense urban populations, who were presumably not subsistence farmers, demanded provisioning of food and goods. While redistribution could have alleviated some of this demand, the remainder must have come from other systems of exchange, assumedly market exchange. The distribution of major centers on the landscape, with their secondary centers and hinterland populations, documents the geographical pattern associated with the web of supply and demand modeled for Central Place Theory (Marcus 1973).

Political and religious infrastructures were also present to support a market economy, especially one associated with a solar market. By the Late Classic period, major Maya centers were the regal-ritual capitals of small kingdoms or large superstates (Martin and Grube 2000). Antagonisms between centers reached a peak during this time, when many centers fought for political autonomy. Political boundaries therefore may have also formed the boundaries of market zones. Finally, trade routes necessary to supply a market center with rarer goods were also well-established by the Late Classic period. Thus, all the requirements for a market economy -- high and consistent demand for goods, bounded access to common goods, and infrastructure to support the market system – occurred in the Late Classic period.

However, direct evidence for a market economy is limited. Marketplace-specific architecture has yet to be identified so markets are assumed to have occurred in large open plazas. For instance, a formal marketplace has been argued to exist at Sayil, Mexico. Wurtzburg (1991) found that one areal zone (N7502E5160) was distinct from others in several ways. Architectural elements, specifically linear platforms and rubble mounds, occur only at this plaza (Wurtzburg 1991:230-231). Following Hirth's (1998) configurational indicators, architectural diversity is also higher at this plaza compared to others at Sayil. It is positioned along the main *sacbe* (Wurtzburg 1991). Further, the distribution of ceramics across the plaza yielded clusters of forms and wares that lend evidence for stalls or areas focusing on the sale of specific items (Wurtzburg 1991:242-243).

The site of Chunchucmil is also argued to have a formal marketplace (Dahlins et al. 2007). Similar to Sayil, there is an open plaza with rock alignments that could be remnants of market stalls (Dahlins et al. 2007). The marketplace also occurs at the intersection of five *sacbeob*, providing major transportation to and from the market area. While informal markets and fairs can occur in an open plaza, this hardly narrows the field for potential market sites in major Maya centers. All major Maya centers had at least one large plaza that could have been used for temporary marketplaces.

Epigraphic evidence also has not found textual references to markets or market exchange. Linguistic evidence from Late Postclassic text and historic dictionaries provides numerous words about markets, traders, and such (Wurtzburg 1991), but exactly when the words were first innovated is not known. Thus archaeologists are reliant on artifact analysis to argue for market economies.

Maya artifact studies and market economies

More research has been done on the consumption patterns of ancient Maya goods as reflecting exchange systems (West 2002). Spatial data that illustrates the circulation of ceramic vessel forms and wares are available for several Late Classic centers. The spatial distribution of various clay composition groups at Palenque indicate that ceramics made from three distinct paste groups were widely distributed at sites throughout the region including the center of Palenque itself, but wares produced in Palenque were not generally exported to hinterland sites (Rands and Bishop 1980). This spatial distribution begs the question of what was being exchanged for the imported pottery, and what system of exchange was at work (West 2002:152). Some suggest that Palenque served as a market place (Fry 1979, 1980; Hammond 1982), in which ceramic censers or other ritual paraphernalia made at Palenque may have been exchanged for common pots (West 2002). Others suggest that reciprocal exchanges occurred directly between hinterland sites (Rice 1987). It is convenient to assume items were exchanged in kind (Rice 1987), but that would assume we understand ancient Maya concepts of value and sphere of exchange. If items are exchanged in kind, then pots are exchanged for pots. But this need not be the case. Slipped and painted pots may not have occupied the same sphere of exchange as those with no surface treatment. It is problematic to assume that all pots, regardless of materials and construction, were valued equally.

The high frequencies of imported ceramics in Palenque are also significant in that Palenque was not exporting pottery back into its hinterland sites. However, INAA analysis suggests that the vast majority of incensarios in the hinterland sites originated at Palenque (West 2002). The localized production of incensarios at Palenque suggests that ritual paraphernalia were the items of choice to be exchanged for hinterland ceramics. If this is indeed the case, this pattern supports Freidel's (1981) hypothesis of Maya market exchange occurring in fairs linked to religious festivals.

Ceramic research at Tikal also suggests market exchange occurred in the Late Classic period (West 2002:158). Fry (1980) analyzed macroscopic technical and stylistic attributes of ceramic vessels recovered from sites located in a 123 km^2 area around Tikal. He proposes that each vessel class (bowls, jars, vases and plates) was produced at three to five minor centers in the greater Tikal area (West 2002:156). The spatial fall-off curve for vases and plates are multimodal with peak frequencies at Tikal and secondary sites located approximately 12 km from Tikal. Other more utilitarian forms show gradual declines in frequencies as sites' increase in distance from the center. While these patterns could be argued to reflect redistribution, they are also suggestive of a market economy. Following Smith's (1976) pattern for solar market system, basic goods are generally exchanged between individuals and specialty or rarer goods are acquired through market exchange (Smith 1976; West 2002). Thus, people were acquiring basic necessities through interpersonal exchange and getting rarer items, such as serving vessels, at markets. Fry's (1980) research documents that Tikal has the most heterogeneous and highest quality of ceramics in its immediate region, suggesting it acted as the main market center and people at the center obtained their goods in markets (West 2002:160).

Material from Late Classic Copan, Honduras also indicates a potential market economy. Distribution of Copador ceramics is widespread and found across households ranked by social statuses (Beaudry 1984). This relatively even distribution corresponds to Hirth's assertion that buying power determines acquisition in a market economy, not social status (Hirth 1998, 2000; West 2002).

Maya Fairs?

It has been suggested that for the Late Classic Maya, the nature of market exchange may have been similar to the regional fairs of Medieval Europe (Freidel 1981). If Late Classic Maya exchange systems operated along the lines of Medieval fairs, this would present a picture of economics much different than fully commercial market exchange. Utilizing regional or localized fairs as a venue for market exchange would reinforce regal-ritual power since fairs are concurrent with religious festivals. Contrastingly, the ability to sponsor a fair increases the economic power of the center, and by extension, the region holding it.

Fairs require a large area for the fair itself, as well as additional space to temporarily house vendors and buyers who travel to attend them. Medieval fairs were up to six weeks in duration (McCormick 2001). While temporary housing may leave few indicators in the archaeological record, large tracts of available space should be apparent. Fairs also are generally situated along major transportation routes in order to maximize the number of buyers and sellers who can attend (Epstein 1994).

If the ancient Maya had similar fairs, they may have occurred at or near cities situated along trade routes. The fair site itself also would likely occur near *sacbeob*, as high volumes of people needed to access it. Infrastructure was needed to feed the attendants; functionaries would have collected tolls; and leaders would have had to provide security and oversight to enforce buyers and sellers accounting for goods and services. Fairs would likely be overseen by priests, ruling elite, or some combination therein. Fairs would have occurred sporadically, either once a year or associated with a schedule of religious holidays. If artifacts are found at fairgrounds, discard could appear to have occurred periodically, with layers of artifacts separated by thin layers of soil. However, if the fairgrounds are cleaned, evidence of them could be extremely scarce.

Market Indicators from Xunantunich

Keller's (2006) research into roads at Xunantunich located a potential marketplace. Informally referred to as the "Lost Plaza," this area off the Northeast civic plaza is large and open on two sides (Keller 2006:613-614). Based on the ease to which people could have accessed the plaza, Keller suggests this area might have been used as a market place. Excavation yielded supporting evidence for this hypothesis (Keller 2006:614). *In situ* debris from the final reduction stages of imported obsidian and local chert tools was found in the plaza (Keller 2006:615). While lithic production sites have been found in the greater Xunantunich area, no other lithic production locales were found within Xunantunich itself nor did other sites yield evidence of obsidian tool production (Keller 2006:615). Importantly, no other site has evidence of the final stages of specialized tool production like that found in the Lost Plaza (Keller 2006:615). Given these lines of evidence, Keller suggests that craftsmen finished their tools in the market place while waiting for customers. She also noted that other proposed market areas within Maya sites almost always fall along roads (Keller 2006:71).

Research into access to pine and imported stone items at Xunantunich also has suggested that a market economy may have existed (Lentz et al. 2005). Access to pine, which would have been brought down to the Belize Valley from the Vaca Plateau, was extremely limited to those living at Chan, an outlying hinterland settlement, but much more available to those living at Xunantunich and its nearby settlement, San Lorenzo. Other regional imports, such as granite grinding stones, slate pendants and smoothing stones, and long-distance trade goods, such as obsidian blades, however, have been found in equivalent frequencies among the three sites. Pine notwithstanding, these data lend evidence to suggest that Hirth's unrestricted market exchange was occurring (Lentz et al. 2005:583). Pine appears to have been an item exchanged in hierarchical distribution, with Chan not being socially and politically connected enough to merit redistribution of pine (Lentz et al. 2005:582-583).

Distributional data on ceramics also suggests a potential market economy. LeCount (1999) demonstrated that common domestic ceramic groups, such as Mount Maloney and Cayo, are found in statistically similar frequencies across elite and commoner households in both the Late Classic II and Terminal Classic periods. Access to Mount Maloney and Cayo group vessels was also unrestricted in hinterland sites such as Chan Nohool (Robin 1999), San Lorenzo (Yaeger 2000) and Chaa Creek (Connell 2000) around Xunantunich. Finer serving wares made from ash tempered clay, however, were not found in equal amounts in elite and commoner households at Xunantunich and San Lorenzo. Fine wares were also found in very low frequencies in other hinterland sites such as Chan Nohool and Chaa Creek (Preziosi 2003). These patterns argue for unrestricted market exchange of common pottery goods and hierarchical elite-regulated exchange of finer ash wares.

In summary, numerous potential indicators exist suggesting a market economy at centers in the Late Classic, including Xunantunich. Large open plazas may have served as marketplaces, the spatial and household distributions of goods correspond to market exchanges (although each site displays different classes of market goods), and gross production patterns indicate centers acted as hubs drawing in large amounts of goods while exporting smaller amounts of specialty goods. As controlling location and periodicity of exchange occurrences is advantageous for political leaders, it is not surprising that Maya leaders may have wanted to encourage markets or fairs. The populations were present, the space was present, and the infrastructure was present to encourage the development of a market economy in the Late Classic period.

Site Summaries and Samples

The following section briefly describes the sites of Actuncan, Xunantunich, and San Lorenzo and breaks down the specific contexts from which the ceramic samples were collected. The three sites providing sherds create a broad range of contexts for analysis. As this project is designed to assess production variability in the archaeological record, having numerous contexts for each group and phase is critical to avoid sampling bias in the archaeological record. However, access to collections was constrained by my time in Belize and existing collections available for study. As a result, the sample is not split completely evenly across sites and phases (see Tables 3.1 and 3.2 for a basic breakdown of the sample by site, phase, and broad context and Appendix A for a more-specific discussion of sample proveniences).

The Samal phase (A.D. 600 to 670) data come almost exclusively from Actuncan. Contrastingly, the Hats' Chaak phase (A.D. 670-780) material heavily favors the sites of Xunantunich and San Lorenzo. For the Tsak' phase (A.D. 780-890), the contexts are fairly balanced across the three sites. Here, I will discuss the sample contexts by site and phase.

Actuncan

Located on a ridge above the Mopan River, Actuncan comprises over eighty structures covering about twenty-five hectares (LeCount and Blitz 2001, 2004; McGovern 2004). The site has two main areas—a formal ritual acropolis at the southern end and plaza groups at the northern end (Figure 3.1). Actuncan South consists of a triadic temple-pyramid complex atop a subplatform that measures 72 m by 120 m (LeCount and Blitz 2001:12; McGovern 2004). Structures 4, 5, and 6 form Plaza A with a U-shaped arrangement of pyramids facing north (LeCount and Blitz 2001; McGovern 2004). Of these, Structure 4 is the largest and is at least 27 m tall from the present day surface of Plaza A (LeCount and Blitz 2001; McGovern 2004:56). It is surmounted by three smaller pyramids: Structures 1, 2 and 3. A Late Preclassic carved stela, several uncarved stela fragments, and an uncarved round altar front Structure 4 (LeCount and Blitz 2001, 2004; McGovern 2004).

The structures of Actuncan North vary in function with residences, range structures, pyramids, and a ball court (LeCount and Blitz 2001, 2004). Plaza C acted as a formal civic zone, incorporating the ballcourt, range structures and pyramids (LeCount and Blitz 2001). Plazas D, E, and F have both civic buildings and elite residences (LeCount and Blitz 2001:12). House mounds are located north and west of Plaza C (LeCount and Blitz 2001).

Occupation at Actuncan began in the Middle Preclassic period and lasted into the Terminal Classic period (LeCount and Blitz 2001, 2004; McGovern 2004). Construction occurred relatively continually until the abandonment of the site (LeCount and Blitz 2001, 2004; McGovern 2004:58). While construction ceased, Actuncan was not completely abandoned after the Late Classic period. The acropolis at Actuncan South continued to be occupied in the Terminal Classic period (LeCount and Blitz 2001, 2004).

Actuncan's grand size and carved stone monuments attest to its Preclassic political clout in the upper Belize River Valley (LeCount and Blitz 2001, 2004; McGovern 2004). This importance continued into the Early Classic period, and included the construction of stucco masks on several structures (LeCount and Blitz 2001; McGovern 2004). However, the increased prominence of several competing sites throughout the area in the Late Classic period, including Naranjo, Xunantunich, and Buenavista del Cayo, likely curtailed the political autonomy seen in earlier times at Actuncan (McGovern 2004:59-60).

Xunantunich

Xunantunich is roughly 2 kilometers south of Actuncan, also located on a ridge above the Mopan River (Figure 1.2). The site layout follows basically a north-south orientation with access points along the east and west *sacbeob* (Leventhal and Ashmore 2004). The most important public civic area at Xunantunich is Plaza A-1, which, through

Xunantunich's history, became increasingly restricted in nature (Leventhal and Ashmore 2004:173). Plaza A, overall, includes both regal-ritual structures, such as two ballcourts and Structure A-6 (the Castillo), as well as the rulers' compound (Structures A-10, A-11, A-12, A-13, and A-20). East of the rulers' compound are service buildings, Structures A-23, A-24, and A-25, that acted as a kitchen and service area. Overall, the Terminal Classic alterations to Xunantunich involved minor construction projects that restricted access to peripheral areas and funneled people into the core area around Plaza A-I (Leventhal and Ashmore 2004).

Two elite groups are also present at Xunantunich: Group D and Group B. Group D comprised elite non-royal residences as evidenced by its two plain stelae, a pyramid, and an elevated plaza (Braswell 1998:30). A *sacbe* connects Group D to Group A (Braswell 1998:30). Another elite residence group, Group B, is located about 50 kilometers west of Group A. Group B lacks stelae or pyramids, and the people who lived there might have been attached, socially or economically, to individuals living in Group A (Leventhal and Ashmore 2004).

Xunantunich is bordered on the southern end by Group C. Group C consists of "a terraced area containing non-residential linear platforms, low walls, and enclosed structures," (LeCount 1996:83) and is asserted to be a semi-public special events area. Aside from the abovementioned areas, the site is fairly open. It lacks nearby plazuela groups and low platforms along its ridge, suggesting that the site's population density was fairly low (Yaeger 2003).

Although Middle Preclassic period material has been found at Xunantunich, the site was not heavily developed until the Late Classic period (LeCount et al. 2002:42).

During the Samal phase some portions of the civic core were built. But it was during the Hats' Chaak phase that Xunantunich grew into a provincial capital. Peak construction and occupation of Xunantunich occurred during the Hats' Chaak phase (Ashmore and Leventhal 2004; LeCount et al. 2002). During the Tsak' phase, political organization fragmented and Xunantunich was evidentially abandoned (LeCount et al. 2002:42).

Xunantunich's political history involved rivalries and alliances with Buenavista del Cayo and Naranjo. According to Ashmore (1998), the site's layout recalls the design of Naranjo, indicating attempts to draw on Naranjo's influence and prestige during it peak building phase in the Hats' Chaak phase. Approximately five kilometers to the north, the large site of Buenavista del Cayo may have rivaled Xunantunich in the Late Classic period, but by the Terminal Classic period, Xunantunich was the dominant polity in the area. Erection of monuments occurred during this period, and construction activities at the site altered it to deemphasize traditional regal-ritual structures and iconography (LeCount et al. 2002, Leventhal and Ashmore 2004). The rulers' compound was also abandoned by the Terminal Classic (LeCount et al. 2002).

San Lorenzo

San Lorenzo was a residential hamlet located about 1.5 kilometers northeast of Xunantunich (see Figure 3.2; Yaeger 2000). The overall settlement area incorporates roughly 86 hectares and over 100 mound groups; but the actual core area of San Lorenzo comprises 20 mound groups (Yaeger 2000). The most rapid growth at San Lorenzo occurs in the Samal phase. Growth continued into the Hats' Chaak phase and then ceases rapidly, with up to a 60% loss in habitation at the site by the Tsak' phase (Yaeger 2000:253). Therefore, the history of San Lorenzo parallels that of Xunantunich. Initial settlement began in the early portion of the Late Classic period, and by the Terminal Classic period, San Lorenzo was greatly reduced in size.

The residential structures at San Lorenzo fall into two categories. They either are patio groups, suggesting long-term investment in housing and property, or single mounds, suggesting lack of domestic development and a short occupation span (Yaeger 2000:247-248). Domestic architecture has great variability with respect to amount of labor and resources needed for construction. Of the patio groups, the three largest featured cut-limestone blocks, corbelled roofs, and benches, and their residents obtained exotic ornaments of marine shell and greenstone (Yaeger and Robin 2004). Other residents lived in wattle and daub houses built atop cobblestone platforms faced with small limestone blocks (Yaeger and Robin 2004). The poorest inhabitants of San Lorenzo lived in wattle and daub houses on minimally modified cobble platforms (Yaeger and Robin 2004).

Only one structure at San Lorenzo is considered a public ritual complex, SL-13. Architecturally, it is the only structure at San Lorenzo with two patios: an enclosed North Patio and raised South Patio (Yaeger 2000:259). SL-13 also has the greatest height and volume of any structure at San Lorenzo (Yaeger 2000:259). Ceramics recovered from SL-13 place its use beginning in the Middle Preclassic period, although ritual use of SL-13 occurred into the Hats' Chaak (Yaeger 2000). Yaeger (2003) suggest that SL-13's construction was a result of Xunantunich attempt to integrate the valley under its political aegis. He asserts the amount of labor needed for construction far surpasses that of house construction at San Lorenzo, arguing for labor acquisition beyond San Lorenzo's environs (Yaeger 2000:272). Also, SL-13's construction is contemporary with

Xunantunich’s developing political clout and SL-13 has the only staircase in the San Lorenzo settlement area oriented to face Xunantunich (Yaeger 2000:272).

In sum, the Xunantunich polity rose in the Samal phase to reach it architectural peak during the Hats’ Chaak phase. Although it claimed political authority over sites in the upper Belize River Valley during the Tsak’ phase of the Terminal Classic period, it soon declined in power. It is during the Hats’ Chaak phase that a market place most likely functioned at Xunantunich. San Lorenzo and Actuncan are located within 2 kms of the site, and people, and possibly potters, from these sites may have participated in its market.

Sample Contexts

The pottery sample was collected in San Ignacio, Belize during June of 2007. The goal of the sampling strategy was to collect roughly equal numbers of rims from the Samal, Hats’ Chaak, and Tsak’ phases (Table 3.1). But I also attempted to sample across three sites -- Actuncan, Xunantunich, and San Lorenzo -- in order to better understand spatial variability with two pottery groups. Material from the Actuncan collections was chosen with the intent of securing data from a wide range of site contexts, including civic, domestic, and ceremonial sources. An opportunistic sample was taken from the pre-existing Xunantunich Archaeological Project type collection. Unfortunately, the Xunantunich and San Lorenzo sample contexts include more fill and collapse than preferred, but time limitations prevented greater collection of data.

Table 3.1. Description of Sample by Site and Phase.

		Cayo	Mount Maloney
		number of rims	number of rims
Site	Actuncan	29	26
	Xunantunich	26	27
	San Lorenzo	12	06
Total		67	59
Phase	Samal	24	26
	Hats' Chaak	16	14
	Tsak'	26	19
Total		66*	59

*One sample lacks time phase provenience.

Based on previous research (LeCount and Blitz 2001, 2004), Dr. LeCount expected the Actuncan collections to provide limited Hats' Chaak and Tsak' phase materials, but provide a good Samal phase sample. Conversely, the Xunantunich and San Lorenzo materials were expected to yield the highest numbers of Hats' Chaak and Tsak' phase rims. Ironically, Xunantunich and San Lorenzo collections yielded lower than expected amounts of material from the Hats' Chaak phase, a situation which has resulted in relatively equal quantities of Samal and Hats' Chaak rims, but fewer rims from the Hats' Chaak phase.

The sample collected for this thesis is varied in nature in order to collect data pertaining to civic, ceremonial, and domestic settings (Table 3.2). Archaeological contexts were deliberately selected from Actuncan material to include domestic and ritual settings, with sherds coming from households, a dedicatory cache, a potential palace, and a temple structure's fill. The Xunantunich and San Lorenzo sherds were selected opportunistically from pre-existing collections. While many of the samples were excavated from fill and collapse, others came from Xunantunich's rulers' service area and elite residences, and San Lorenzo's non-elite residences and ritual structure. If a market economy existed, all residents of the three sites had equal access to the Mount Maloney bowls and Cayo jars studied. By sampling from several different contexts, this sample provides a broader picture of the distribution of these ceramics in the Late and Terminal Classic periods.

Table 3.2: Sample by Site, Phase, and Contexts

		Contexts				
		Commoner residence	Elite residence	Palace*	Regal-ritual	totals
Actuncan	Samal	35	7	1	2	45
	Hats' Chaak		3			3
	Tsak'		6		3	9
Xunantunich	Samal				2	2
	Hats' Chaak		2	14	7	23
	Tsak'		10	2	9	21
San Lorenzo	Samal	1				1
	Hats' Chaak	2				2
	Tsak'	15			3	18
		53	28	17	26	124

* Including royal service area at Xunantunich

Rim sherds from each time period were selected based on style, and, as much as possible, pulled from stratigraphically appropriate lots that contained high numbers of temporal diagnostics. Temporal variants of Mount Maloney bowls are easily identified based on lip treatment (LeCount 1996:391). Samal phase Mount Maloney bowls have vertical lips rounded at the top and bottom faces. Hats' Chaak lips bevel upward and have edged and grooved faces. Tsak' phase bowl rims are square and flat along the horizontal face (LeCount 1996:391). Cayo jar styles are not as easily classified by phase as Mount

Maloney bowls. Samal phase Cayo jars often are indistinguishable from later varieties, but some have diagnostic pinched lips and short necks. Hats' Chaak phase Cayo jars have large square lips, sometimes grooved along the vertical face (LeCount 1996:374). Terminal Classic Cayo jars are easily identified by their flaring lips, many with pie crust impressions.

Approximately half the sample is Cayo jar rims (n=67), and the other half is Mount Maloney bowl rims (n=59). Additionally, I attempted to select an equal sample of each ceramic group per temporal phase, with 50 Samal samples, 30 Hats' Chaak samples, and 45 Tsak' samples. Roughly equal sample numbers allow for more robust statistical testing and results; having widely divergent sample frequencies would thus hinder subsequent analysis.

Actuncan

<u>Samal phase sample.</u>

The Actuncan Samal phase material contexts mainly consist of domestic trash and fill. Approximately 71% of the Samal sherds originate from Unit 1D. Unit 1D is located in Structure 59, a low platform structure modified several times in the Late Classic period that may have supported a series of wattle-and-daub houses (LeCount and Blitz 2004:7-8). In addition to the structure itself, a dedicatory cache was found (LeCount and Blitz 2004:9), and two of the Cayo samples are from it. Two additional Cayo jar rims, as well as a Mount Maloney bowl rim, come from the platform fill along the western wall of Structure 59 (LeCount and Blitz 2004:79). Two Cayo samples also come from either fill or refuse along the western side of Structure 59 (LeCount and Blitz 2004:78). Over a dozen samples each of Mount Maloney and Cayo rims were pulled from the refuse deposit (lot 1D3) outside of Structure 59 (LeCount and Blitz 2004:78). Based on the presence of several ceramic indicators, this refuse deposit dates to the Samal phase. In addition to the Mount Maloney rims, other Samal phase diagnostics include Sotero Red-brown, 15 basal ridged dishes, early Benque Viejo polychrome sherds, and Platon Punctated-incised sherds. Finally, a Mount Maloney rim sherd from the platform fill of Structure 59 was also used (LeCount and Blitz 2004:78).

Unit 4A was selected for excavation based on its potential to be part of an early palace complex consisting of Structures 19, 20, and 21 (LeCount and Blitz 2004:2). The excavation unit was placed at the base of Structure 19 abutting the courtyard (LeCount and Blitz 2004:2). A single Mount Maloney sherd was pulled from this unit, it derives from collapse debris associated with a badly eroded floor, probably the final plaza surface, called Floor 0 (LeCount and Blitz 2004:86).

Six sherds came from Unit 5B. Excavations in this area were intended to collect Early Classic period collections from a trash deposit previously discovered by McGovern near Structure 18 (LeCount and Blitz 2004:98). Structure 18, a low platform, possibly served a specialized function for elite activities (LeCount and Blitz 2004). One Mount Maloney and one Cayo rim were pulled from the surface lot associated with the humus root zone (LeCount and Blitz 2004:98). Another Mount Maloney rim came from the collapse directly below the humus root zone (LeCount and Blitz 2004:98). Two additional Mount Maloney samples originate from the platform fill behind Structure 18 (LeCount and Blitz 2004:98).

A single Mount Maloney sample was found in Unit 6C materials. Unit 6C is associated with Structure 41, an elite residence bordering Plaza D (LeCount and Blitz

2004:4). The particular context of the sample is loose rubble fill or possible collapse (LeCount and Blitz 2004:104).

Unit 12G pertains to Structure 5 excavated by James McGovern. Structure 5 is a temple-platform which had at least four major construction phases (McGovern 2004:125). The single Mount Maloney sample is from the extensive looter's trench through Structure 5.

Hats' Chaak phase sample.

Only three Mount Maloney sherds came from Hats' Chaak phase materials at Actuncan. All three are from Unit 5B, discussed above. The contexts in particular include two sherds from Structure 18's collapse and the third from patio floor and foundation stones of the Structure 18 platform wall (LeCount and Blitz 2004:98).

Tsak' phase sample.

Five Cayo and four Mount Maloney rims were collected from Tsak' phase contexts. Unit 1C pertains to domestic architecture and patio fill associated with Structure 62 (LeCount and Blitz 2004:7). The two Mount Maloney samples from this unit come from collapse and fill of Structure 62's first terrace (LeCount and Blitz 2004:74). A single Cayo sherd is from Unit 6B. Similar to Unit 6C (discussed above), Unit 6B revealed information about the elite residences. Unit 6B focuses on Structure 41's southern face (LeCount and Blitz 2004:5). The Cayo sample is from large rock fill of Structure 41 (LeCount and Blitz 2004:102).

Five Cayo and two Mount Maloney rims came from Unit 6C, discussed above. All samples were from the loose rubble fill or collapse of Structure 41 (LeCount and Blitz 2004:104). Finally, a single Cayo rim was taken from the collapse material of

Structure 26. McGovern (2004:142) believes Structure 26, a range structure, to have been part of an E-group.

Xunantunich

<u>Samal phase sample.</u>

Two rims, both Mount Maloneys, are from civic contexts at Xunantunich. One sherd comes from Violet Wall construction fill of Structure A-6, the two-story summit building on the Castillo. The Castillo is the main regal-ritual building at the site (Leventhal and Ashmore 2004). The other is from a fill lot of the retaining terrace wall in Plaza C near the southwest corner of the Castillo. Deposits within Operation 18 units were stratified and yielded important ceramic collections for microseriating Mount Maloney bowls (LeCount 1996:146-150).

<u>Hats' Chaak phase sample.</u>

Twenty-three rims are dated to the Hats' Chaak phase. Fourteen Cayo rims are from Structures A-23, A-24, and A-25, which are hypothesized to have served as the rulers' service area based on location and the volume of ceramics recovered from this area (LeCount 1996:95). Rims derive from collapse, material on plaza floor, refuse, and occupation contexts.

The Mount Maloney rims come from a variety of contexts including Op 18 (see above), a grab sample from a nearby cave, the fill of the Castillo's Violet Wall, and the fill of Structure A-1. Structure A-1 consists of a pyramid built during the Hats' Chaak phase and located between the Castillo and rulers' residence. Two Mount Maloney sherds are from Structure D-7. Group D contains several elite residential structures (Braswell 1998). Structure D-7, while elaborate, faces away from the dominant platform in the group (Braswell 1998:109). Both sherd samples come from the construction fill of Structure D-7.

Tsak' phase sample.

Twenty-one of the Tsak' phase rims come from Xunantunich contexts. Four each of the Mount Maloney and Cayo rims derive from the collapse debris of Structure D-7, discussed above. Collapse debris from Structure D-4 yielded a Cayo sample. Similar to Structure D-7, Structure D-4 is another elite residence (Braswell 1998:121). Structure D-8 also provided a Mount Maloney rim. Structure D-4 is the main platform of the corporate group, and it supports Structures D-5 and D-6 (Braswell 1998:98). The rim comes from the terrace wall.

Two Cayo rims are from Structure A-24, one of the service area's platforms discussed above. The remaining two Cayo rims are from collapse debris of Structure A-1. Three of the Mount Maloney samples are from Structure A-1 collapse as well. Structure A-6 on the Castillo, yielded a Mount Maloney rim, which comes from fill of White Wall. The final two Mount Maloney rim sherds are from Structure A-4. Structure A-4 is one of the range structures flanking Plazas A-I and A-II (LeCount 1996:83). Both rims were found in collapse. A grab sample in the cave yielded an additional Mount Maloney rim for this study.

San Lorenzo

Samal phase sample.

Only one rim, a Mount Maloney, came from Samal phase contexts at San Lorenzo. It was recovered from SL-22. SL-22 is a large patio group consisting of five platforms (Yaeger 2000:204-5). Structures that surmount these platforms are varied in both construction type and amount of masonry involved in construction (Yaeger 2000:205). The rim comes from collapse debris.

Hats' Chaak phase sample.

Only two Hats' Chaak style rims from San Lorenzo are used in this research. No Mount Maloney samples from this period were acquired from the San Lorenzo contexts. One Cayo rim comes from the collapse debris of SL-22. Another comes from a refuse deposit in SL-23. SL-23 is the largest patio group at San Lorenzo, comprising four structures occupied from the Samal to the Tsak' phase (Yaeger 2000:945,949).

Tsak' phase sample.

Fourteen rims were acquired from Tsak' phase deposits at San Lorenzo. SL-22 yielded seven of the Cayo samples, four from surface deposits, one from fill, and another from a structure floor. All four of the Tsak' phase style Mount Maloney rims came from SL-22 as well, with one from surface collection and three from structure floors. A refuse deposit found in a test pit of SL-24, a multiple mound site around a single patio, provided another Cayo rim.

The remaining three Tsak' phase style rims are from SL-13. This group is the only formal group at San Lorenzo that has two patios (Yaeger 2000:259). Material from SL-13 dates from the Middle Preclassic to the Terminal Classic periods (Yaeger 2000:267). Based on its architectural features, comprising several areas able to act as "stages," SL-13 could have served ritual functions for the San Lorenzo community (Yaeger 2000:269). However, the lack of Tsak' phase incensarios, as well as the final construction efforts at SL-13, indicate the group's ritual function had ceased in the

Terminal Classic period (Yaeger 2000:268). All three samples are from SL-13 collapse debris.

In sum, 67 Cayo samples and 59 Mount Maloney samples are used in this thesis. Of the Cayo samples, 29 are from Actuncan, 26 are from Xunantunich, and 12 are from San Lorenzo. If the 67 Cayos are divided by time phase, 24 are associated with the Samal phase, 16 are associated with the Hats' Chaak phase and 26 are associated with the Tsak' phase. Regarding the Mount Maloney samples, 26 are from Actuncan, 27 are from Xunantunich, and 6 are from San Lorenzo. When looked at across time phase, 26 of the Mount Maloney samples are associated with the Samal phase, 14 are associated with the Hats' Chaak phase, and 19 are associated with the Tsak' phase.

Figure 3.1: The Site of Actuncan (Drafted by James McGovern, and modified by Lisa LeCount).

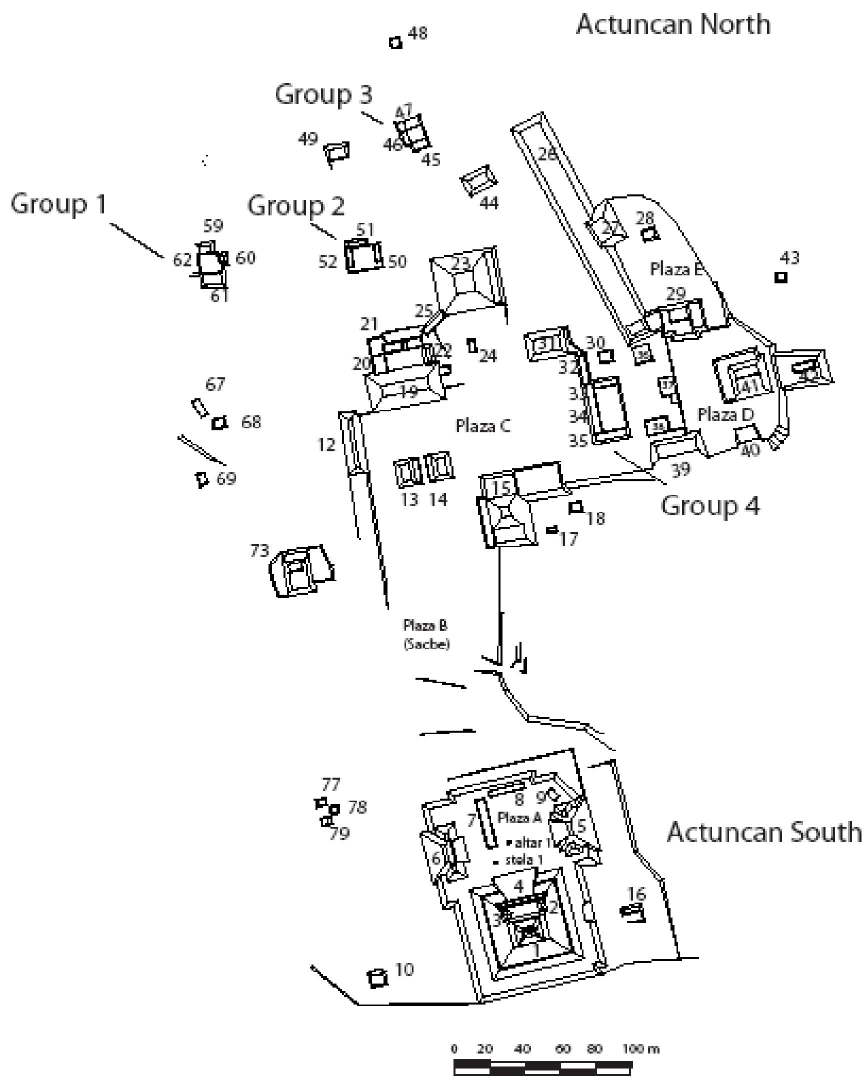
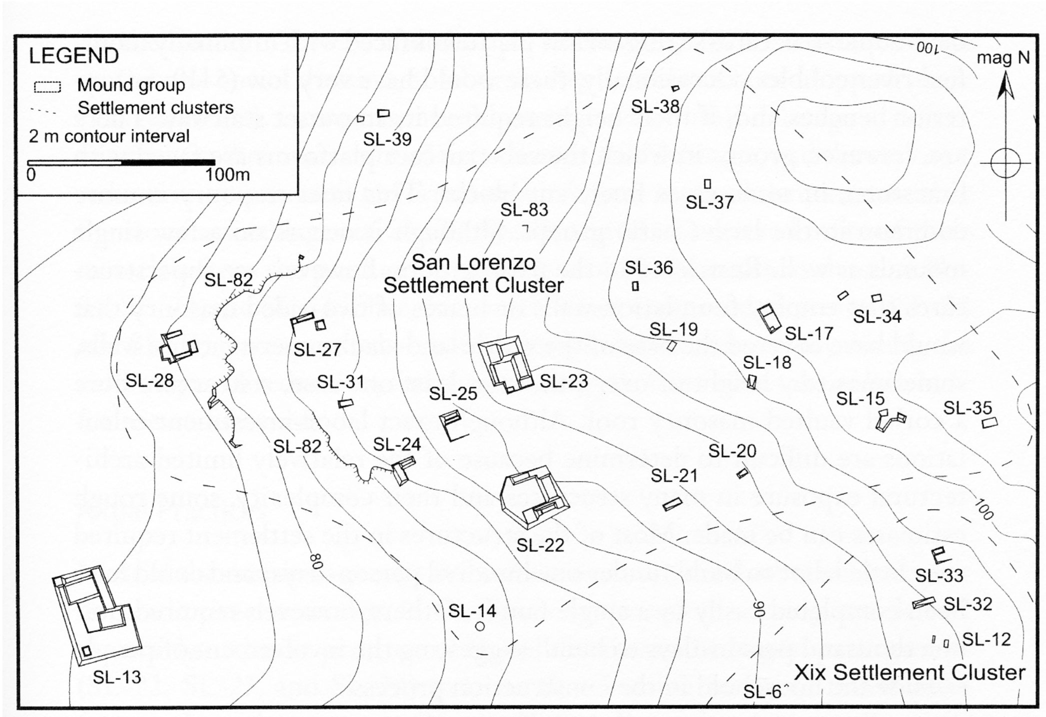


Figure 2: The Site of Actuncan

Figure 3.2: The Site of San Lorenzo (after Yaeger 2000: Fig. 4.16).



Chapter 4: Methodology

This chapter discusses the kinds of data collected for this thesis, including variables measured both in Belize and in subsequent laboratory analyses at the University of Alabama. In addition, methodologies are covered, especially a discussion of current petrographic procedures. Each variable is linked to the kinds of analyses conducted in this thesis, the results of which are reported in Chapter 5.

Nominal and Metric Data Collection

Data was collected on large rims only so that all variables could be measured for each sherd. Nominal variables recorded are: (1) provenience, (2) cultural context, (3) phase and (4) pottery group.

(1) Provenience information came from several sources, including Braswell (1998), LeCount (1996, 1999, personal communication in June 2007), LeCount and Blitz (2001, 2004), McGovern (2004), and Yaeger (2000).

(2) Cultural context material came from several sources as well, including Braswell (1998), LeCount (1996, 1999, personal communication in 2007), LeCount and Blitz (2001, 2004), Leventhal and Ashmore (2004), McGovern (1994), and Yaeger (2000). Cultural context provides information regarding what the sample context was (e.g. house floor, midden, collapse, wall fill), whereas the provenience information informs where the samples originated.

(3) Rims were phased based on existing data regarding phases of sample proveniences and LeCount's (1996) seriation of the Mount Maloney bowls when applicable (see discussion in Chapter 3).

(4) Pottery group was determined through visual inspection of the sherds from Actuncan. Mount Maloney bowls were distinguished based on shape, surface treatment, macroscopic study of pastes, and rim treatment. Cayo jars from Actuncan were selected based on paste, shape, rim treatment, and surface treatment. Research material from Xunantunich and San Lorenzo came from pre-existing type collections.

Formal metric variables were measured in order to provide comparison with other standardization studies. Standardization studies often utilize formal measurements as a means of addressing potential craft specialization (Benco 1988, Longacre et al. 1988, Rice 1981). In these and other studies (Costin and Hagstrum 1995; Foias and Bishop 1997; Hegmon, Hurst, and Allison 1995; Longacre et. al 1988), rim diameter and wall thickness are commonly used as variables for understanding specialized production of vessels, while firing cores are generally considered an indicator of proficiency in the firing process. Costin and Hagstrum (1995) found that variation in vessel thickness as well as presence of firing cores was associated with organization of production. Longacre et al. (1988) found similar results in their Philippine ethnoarchaeological research in which full-time and part-time specialists supplying wares to a market economy produced more standardized wares than non-specialist potters. For Hegmon, Hurst, and Allison's (1995) research into potential specialization among Southwest pottery production, they found that community specialization did not lead to noticeable formal metric standardization, but it was associated with standardization among ceramic compositions. Foias and Bishop (1997) used measurements of wall thickness and rim diameter to evaluate changes in production associated with differing hypotheses for the Classic Maya collapse in the Petexbatun region. Rather than sharp changes, their research indicated long-term stability in production and exchange throughout the Late and Terminal Classic periods, with little difference visible in standardization indices over time (Foias and Bishop 1997:284-285).

Thus, based on previous research into standardization and specialization, formal metric variables were measured during this research. Variables measured include (1) rim diameter, (2) vessel thickness, and (3) presence/absence and size of firing cores.

(1) Rim diameters were measured in centimeters using a rim diameter chart. Rim sherds must contain at least 20% of the total vessel diameter to be measured for this study. The rim diameter data was used in statistical analysis. Rim diameter means and standard deviations were used to create coefficients of variation. Coefficients of variation (CVs) utilize standard deviations and means to create a measure of relative variation. Thus, different groups can be compared, even if the standard deviation or mean values are vastly different. CVs are calculated by dividing the standard deviation by the sample mean. Also, Analysis of Variance (ANOVA) was run on the rim diameter data. ANOVA looks at variation among and within groups through comparing means. These analyses were run twice, once across phases and once across sites. Results are in Chapter 6.

(2) Vessel wall thickness was also measured using digital calipers. Thickness was measured at two parallel points on each sherd 2 cm from the lip on opposite sides

of the sherd to determine uniformity in vessel wall thickness. Unfortunately, these measurements could not be accurately replicated even by the same researcher. When sherds were measured repeatedly, different measurements were attained each time. This variability in values likely was the result of not consistently orienting the angle of sherd during measuring. Thus, because of the error introduced to the variable, I decided to not include it in my statistical analysis.

(3) The presence or absence of firing cores and firing core colors and widths were noted. Firing cores are the result of inconsistent oxygen-supply during the firing process, and they appear as sections of differing colors in the core of the sherd (similar to a sandwich cookie). In Belize, the widths of the sherd as well as the widths of the macroscopically visible cores were measured. However, this was not done at a uniform position across all sherds, since firing cores varied in size and location among rims. When measured macroscopically, most of the vessels had cores, suggesting inconsistency in oxygen availability during firing. The most common core occurred in the center of the sherds, indicating that oxygen levels at the beginning of firing were not maintained throughout the process. Thus, the macroscopic firing core variables are too problematic to use in analysis due to inconsistent measuring locations. Color of pastes and cores was also noted using the Munsell color system.

Interestingly, laboratory analysis of thin-sectioned rims demonstrated firing cores to be present on almost all sherds. This makes sense, as the rims are generally the thickest place on the sherds and thus the most likely to show differences in firing atmospheres. Firing cores were more visible microscopically because the thin-sections show the thickest part of the rim. Because thicker parts take longer to fire, the rims may show evidence of fire cores whereas the lower (and thinner) sections used for macroscopic variables fired more quickly and may not show the variability in firing atmosphere. Core width was not measured microscopically. While this would provide much greater accuracy than reliance on calipers in the field, it requires using a thin-sectioning method that keeps the entire width of the sherd intact. As discussed below, when making thin sections at the University of Alabama, my attempts consistently ground away portions of the sherds' edges. As this process only introduced error, subsequent microscopic measurements on this variable were not taken.

Color also was not measured microscopically for two reasons. First, the thin sections are translucent. This makes the colors appear much lighter and paler than as seen macroscopically on the actual sherd. As not all samples could successfully be made into thin sections, this would lead to two incomparable sets of color measurements. Secondly, in order to measure color microscopically, the Munsell color plates would need to be placed under the microscope with the samples. As the microscopes are lit from below, and Munsell color samples are opaque, the resultant color measurements would be inaccurate.

Petrographic Analyses

Sherds were exported to Alabama for petrographic analysis. Previous archaeological and ethnographic research (Arnold 1991; Arnold and Nieves 1992; Hegmon et al.1995; Stark 1985, 1995) has suggested that metric variables are not enough for understanding specialization and standardization. Petrographic analysis has been argued to be particularly useful in understanding and comparing ceramic paste recipes (Day 1989; Freestone 1991; Howie 2007; Rice 1996; Stoltman 1989, Stoltman et al. 2008; Whitbread 1989, 1996).

Petrographic analysis entails optical microscopy to discern composition and treatment of paste recipes. Pottery consists of two main components: clay matrices and inclusions. Inclusions can be either naturally occurring in the clay used for the pottery or can be added through human actions. In order to microscopically view clay matrices and inclusions, pottery is thin-sectioned by slicing the sample and mounting the slice onto a glass slide. Thin sections are analyzed with the use of optical microscopes that allow for utilizing optical properties (such as optic sign, interference figures, interference colors, extinction, and so forth) in order to identify various mineral components in the samples.

Whitbread (1989, 1996) focuses on the characterization of the clay matrices. His analyses address the shape and distribution of inclusions to clarify whether or not they occur naturally in the clay sources, as well as how human actions affect the recipes. In contrast, Stoltman (1989, Stoltman et al. 2008) has developed a widely-used analytical variation of point-counting for quick and systematic sampling of inclusion type. Traditional point-counting necessitates counting and identifying every inclusion in the selected sampling area on the slide. Stoltman's (1989, Stoltman et al. 2008) method relies on imposing a grid over a sample and essentially running transects to compile relative frequencies for the presence of clay matrix, voids, and temper. Stoltman (1989) suggests that a minimum of 100 non-void points is the appropriate point-count minimum per sherd. Thus, points were counted until at least 100 non-void points were recorded.

For this research, Stoltman's method was chosen as a means to collect data points for the sherds. However, aspects of Whitbread's analysis were included to better address how the clay recipes were created. Thus, my combined method is used to determine inclusion (a) shape (b) size, and (c) type. In addition to providing information about the production process itself, this methodology avoids drawing inaccurate conclusions through its acknowledgement of inclusion shape. Because I did not collect limestone or clay samples while in Belize, I needed to rely on shape of temper to distinguish between natural and added inclusions in the sherds.

The shape of the temper may indicate whether the inclusion occurs naturally in the clay or is a human additive. Naturally-occurring inclusions are round due to erosive actions on the raw material. For example, eroded limestone appears as rounded calcite inclusions in the clay matrix. Added mineral tempers are angular in nature as a result of human processing of the tempers prior to mixing them into the clay. Under a microscope, human-added tempers will feature sharp angular edges; whereas, naturally-occurring tempers have smoother and more rounded edges. For this research, tempers were labeled according to basic geological categories. Temper shapes include rounded (very circular or oval), sub-rounded (oblong or less-circular in nature, but still possessing rounded edges), sub-angular (oblong or slightly rectangular and possessing some angular edges), and angular (very rectangular and possessing sharply-defined angular areas). For this thesis, the word "temper" is used to refer to all inclusions, even those occurring naturally in the raw clays. This is because all inclusions serve a tempering purpose in the manufacturing and firing process. Distinction between inclusions and temper, thus, is based on shape.

Tempers were also placed into metric size categories. The range of temper sizes per category was determined by the geological standards used in petrography. The size of tempers can reflect the processing of clays. Ancient potters may have removed larger pieces through sieving or levigating raw clays. Large inclusions may be desired if clays need to be modified to aid in construction of larger vessels or if potters wish to encourage drying of the clays, but in general, large inclusions are problematic since they hinder attempts to smooth or burnish surfaces. Finely sorted inclusions are best when potters desire vessels that can maintain a smooth, consistent surface finish or densely packed pastes are preferred. Poorly sorted inclusions are not uncommon, and may be a result of potters not heavily processing the raw clays or a reflection of lack of knowledge about pottery construction and properties (see Rice 1996, Rye 1981). Coarse ceramics are also desirable for particular functions such as storage (See Rice 1996; Rye 1981).

Temper type was determined by visual and optical properties of the inclusions. Grog was easily distinguished by its dark reddish brown color and opacity. Other temper types were distinguished based on comparing optical properties. Simple relative frequencies of clay, temper, and voids allows for a basic understanding of paste composition. The amount of voids reflects how well the clay was mixed and compacted during manufacture. Additionally, voids surrounded by burnt material indicate where organic matter was present in manufacturing and burned out during the firing process. The frequency of voids also affects durability. Pastes filled with voids will be more porous and weaker than densely packed pastes. Densely packed pastes are generally desired for vessels that function as serving wares; whereas, more porous pastes are preferred in situations where storage is the main function (see Rye 1981). Tempering also affects physical characteristics in firing (Rye 1981). Clay recipes, for example, with more temper will dry faster than clay recipes with lower amounts of temper.

Specific point count variables and indices used in this thesis are:

(1) number of matrix points,

(2) number of void points,

(3) number of temper points,

(4) temper-specific variables,

(5) size categories for each type of temper,

(6) overall shape categories,

(7) ratio of matrix points to temper points,

(8) percentage of round and subround temper to total number of temper points,

(9) percentage of non-calcite tempers,

(10) percentage of temper larger than .50 mm compared to total temper.

The number of matrix points refers to the total number of points where clay was sampled. The number of void points indicates how many places the point sampled had neither clay nor temper. However, this variable appears to be too problematic for valid analysis of my sample for two reasons. Firstly, the voids encountered in Mount Maloney and Cayo group rims appear as long, wavy, thin lines that appeared to be a result of the production process. Thin fissures may be caused by folding clay during the mixing processes or lack of compaction during the formal fashioning of the vessels. Because it was not always clear when the void points were isolated features or part of a previously sampled void, this variable seemed to falsely inflate the number of voids. Furthermore, as the emphasis is on the recipe composition, not the frequency of voids, this variable seemed ineffective at addressing the research hypotheses. Thus, points were counted until at least 100 non-void points were recorded. The third variable, the number of temper points, pertains to the total number of any points which were neither clay nor void. Temper-specific categories were used as a means to better understand the subtleties of paste recipes. Common tempers include calcite, dolomite, aragonite, grog, and unidentified tiny carbonate (under .0625 mm). If temper could not be identified, it was assigned to a category called “other.” Each type of temper had size categories. Calcite, dolomite, and aragonite had five categories: .0625 -.24 mm, .25-.49 mm, .50-.99 mm, 1.0-1.99 mm, greater than 2.00 mm. Grog and “other” had those same categories with the addition of a “smaller than .0625 mm” category. Overall shape categories were comprised of rounded, subrounded, subangular, and angular.

As Stoltman’s methodology called for 100 non-void points, anywhere from 106 to 120 points were collected on the Belize rims. Relying on raw counts for matrix characteristics and temper types would be problematic, so I created indices to transform counts into ratios among variables. The ratio of matrix to temper points reflects the composition of the thin sections; higher numbers indicated sherds with higher concentrations of temper. The percentage of round and subround temper to total number of temper points was created to estimate what percentage of the temper was naturally occurring in the clay recipes. The percentage of non-calcite temper index is a compilation of the total number of dolomite, aragonite, grog, and “other” tempers compared to total points sampled in each thin section. Many of the samples had a few occurrences of these rarer tempers, and combining them appeared to be more beneficial than trying to run analysis on them separately. The percentage of temper larger than .50

mm compared to total amount of temper reflects the amount of tempers in the top three size categories. This index is particularly salient when looking at Cayo jars versus Mount Maloney bowls, as the latter tends to have fewer large temper inclusions than the former.

Making the Thin Sections

In order to do petrographic analysis, sherds need to be made into thin sections. Sixty-seven of the sherds were sent to Hess Petrographics (University of Wisconsin, Madison) to be made into thin sections. The remainder of the sample was made into thin sections under the guidance of Dr. Fred Andrus (University of Alabama) and Miguel Etayo (University of Alabama). Of the fifty-seven sherds processed at the University of Alabama, thirty-two were successfully made into petrographic thin sections. The remainder consistently crumbled during cutting, crumbled during mounting (or consistently did not remain mounted), or did not survive the grinding and polishing processes after multiple attempts to produce thin-sections. My failure to produce thin-sections may be partly due to poor sherd preservation, sub-par manufacturing, or my inexperience at making thin sections.

Sherds were processed into thin sections at Alabama in several steps. Sherds were cut down to size, roughly the size of a glass slide, using a hacksaw. Using the Buehler saw, the slide-sized sherd was sliced to create a flat edge for mounting. It was then recut on the other side using the Buehler saw to effectively create a sherd slice between .5 and 1 cm in thickness. The sherd slice was mounted onto a glass slide using Crystalbond epoxy and a hot plate. Pressure was used to create a very close bond without air pockets between the ceramic and the slide. The slide was then ground down to between 1 and 2 mm thickness on a mechanical grinder. No slurry was used in this process as aluminum-based slurries are inappropriate for ceramic thin-sections (Brian Hess, personal communication, October 2007). Fine grit (320 g) wet sandpaper was used for further manual grinding. While mechanically-made thin sections are 30 microns thick, this thickness was approximated based on transparency and readability under a microscope. Final polishing was done manually with 600 g grit wet sandpaper.

The process of making thin sections was difficult since grinding and polishing was done manually. It was very easy to grind away the edges of the sherd, regardless of amount of pressure exerted on the slide during sanding. However, the sherds sent to Hess Petrographics apparently did not have this problem since his technique was completely mechanized and he used a different epoxy. I can only surmise my problems were the result of my own actions and perhaps the choice of epoxy agent. Other problems included sherds not being sturdy enough to survive the pressure used to mount them to slides. While a possible solution to this would be supersaturating the mounting edge of the sherd by using a vacuum impregnator, when I attempted this technique it led to epoxy residue on the mechanical grinder. This caused problems since it degraded the grinding capabilities of the machine and led to chunks of the sherds being removed in the grinder. Thus, it was not an effective solution and these sherds were not successfully made into thin sections.

Utilizing petrographic analysis of the sherds also involves learning how to use optical microscopes. An optical mineralogy lab was created by the UA Geology Department to build students' familiarity with microscopes, as well as allow basic mineral identification techniques. Permission was gained by Dr. Harold Stowell to use the optical microscope lab for subsequent analysis.

Stoltman's (1989, Stoltman et al. 2008) method requires affixing a stage to the microscopes. The stage holds the thin section steady. It also is equipped with a ruler and x- and y- translation knobs. This allows for manipulation of the slide in a measurable and consistent manner. Thus, data can be collected across the sample grid without having to worry about shifting the slide and losing the location on the grid.

For the actual identification of matrix, tempers, and voids, the matrix was easiest to determine. The clay matrices can be easily identified through their opaque brown, red, or gray appearance material as compared to the light-colored carbonate inclusions or voids. Voids were evident based on a) visual inspection and seeing no matrix or temper and b) using cross-polarized light to ensure that the item in question was the background slide glass and not quartz.

Identification of temper type was more problematic. Grog, previously fired clay that may be added to paste recipes, was easily identified by its dark reddish-brown color and complete lack of interference colors under cross-polarized light. Interference colors under cross-polarizing light are caused by filtering all light rays into one direction. The bending of the light through the mineral's crystal system, as well as the speed of the movement of light through the crystal's structure, creates the various visible colors. Carbonates were identified based on appearance, birefringence, visible cleavage, extinction angles, and presence of lamellae and twinning, but differentiating between the carbonate minerals present in the temper involved more study. While the application of a stain is usually done to differentiate calcite from dolomite, the cover slip placed on the thin sections created at Hess Petrographics prevented this test from being preformed. Calcite, dolomite, and aragonite can all be present in limestone deposits.

Since all three were present in the ceramic sample tempers, several strategies were employed for precise identification. Interference colors under cross-polarized light are similar for all three, so this was not a solution. Optic sign presents another means to aid in identification of minerals. When light hits the mineral, it divides into a slow and a fast ray based on which direction through the sample each ray goes (also known as birefringence of a mineral). The two rays have varying refraction indices, which determine whether a mineral is optically negative (the slow ray has a lower index of refraction) or optically positive (the slow ray has a higher index of refraction). Optic sign can be determined using a Bertrand filter on a sample. However, calcite, dolomite and aragonite are all optically negative, which means that optic sign will not aid in differentiating between them.

Fortunately, the crystal system, birefringence and extinction angles differ among the calcite, dolomite, and aragonite. The crystal system is the actual crystalline shape a mineral takes in formation. Because the crystalline systems differ for calcite, dolomite, and aragonite, light travels through them differently, creating different birefringence values for each. Extinction occurs when a mineral is dark under cross-polarized light. Extinction happens along crystal boundaries and cleavage lines, and thus also is affected by the crystal system. Using the rotating stage of the optical microscope, the angle of extinction, that is, the angle where the mineral goes from being lit-up to dark under cross-polarized light, can be determined. For many minerals, including calcite, dolomite, and aragonite, this angle is a distinguishing feature.

Finally, the presence and nature of the twinning and lamellae also provided insight into mineral identification. Twinning occurs when a mineral’s crystals form along the same crystal lattice symmetrically. Twinning can be from pressure during formation, and sometimes crystals even become intergrown. Lamellae are the visual evidence of twinning, and appear as banding in a mineral under cross-polarized light. When a rotating stage is employed, the lamellae go extinct at specific angles. The twinning of a mineral is also a common diagnostic feature; because twinning varies based on crystal system (and calcite, dolomite, and aragonite have different crystal systems), this aids in distinguishing between minerals in my sample. However, it was extremely rare that solid identification beyond the level of "carbonate" could occur for the heavily eroded tiny mineral inclusions (less than .0625 mm in size). As a result, these were all referred to as unidentified carbonate minerals.

In sum, data was collected on nominal and metric variables from the rim sherds in June 2007 in Belize. From the suite of variables measured, rim diameter was particularly important for this analysis as the majority of standardization studies also use rim diameter as a key indicator in understanding levels of standardization. However, more is needed than form and shape information. In order to identify and evaluate differences in ceramic paste recipes, petrographic thin section analysis was employed. This analysis involved not only recording the basic composition of each sample measured (clay matrix, temper, or void) but also a more detailed recording of type and size of temper measured. Various optical properties were used to differentiate between calcite, dolomite, aragonite and grog inclusions in the thin sections.

Chapter 5: Statistical Analysis

Statistical testing focuses on ascertaining variability between ceramic groups, and within ceramic groups by site and phase. Based on the nature of the research, statistical results ideally should indicate differences over space and time. If a market economy developed in the Late Classic period, a decrease in variability is expected for the Hats' Chaak phase materials as compared to Samal phase materials. It may also be hypothesized that inter-site variability may decrease through time as the number of producers diminishes in proportion to consumers. Contrastingly, if no change in exchange systems occurs, material from the different sites is expected to vary as a result of the existence of multiple producers providing craft goods to individual patrons through obligatory kin-relations or other forms of reciprocal and / or hierarchical relationships.

This chapter is broken down into two parts. The first involves the accepted method for investigating standardization in formal pottery attributes, especially rim diameter. Coefficients of Variation (CV), Analyses of Variance (ANOVA), and Levene's test for homogeneity of variance are used to explore variation within pottery groups by site and phase, and to compare pottery groups to each other. If a market economy developed in the Hats' Chaak, the CVs should be lowest in that phase. Similarly, ANOVA results should show significant differences across phase, but not site. Differences across site would be suggestive of production activities occurring at all three sites. Finally, Levene's test looks at variances across sample groups. For this research, variance is used as an indicator of variability; higher variances reflect a wide range of producers whereas lower variances reflect fewer producers. If a market economy is occurring in the Hats' Chaak, the Levene's test results should indicate unequal variances across time, with the Hats' Chaak variance being the lowest variance of the three phases.

The second half of this chapter addresses the statistical patterning produced by point count data. Several single variables, as well as pottery indices, are used to compare variability within each pottery group. Median and interquartile range (IQR) are used to compare across site and phase. Consistent IQRs across site would suggest less variability in production consistent with a market economy and specialized production. Contrastingly, if the IQRs vary widely, it would be indicative of different potters producing goods at each site. Regarding comparisons based on phase, a market economy should be associated with the lowest IQR. Finally, I also ran cluster analyses as a means to investigate ceramic paste recipes. Ideally, the cluster analysis would reveal that phase is crucial to the cluster formation, with fewer clusters occurring in the Hats' Chaak relative to the previous and following phases. This result could be interpreted as indication of decreasing variability in production, with fewer producers making more goods than in the previous phase. If the clusters are focused on site, as compared to phase, it would be more indicative of localized production for local use, not for a market economy.

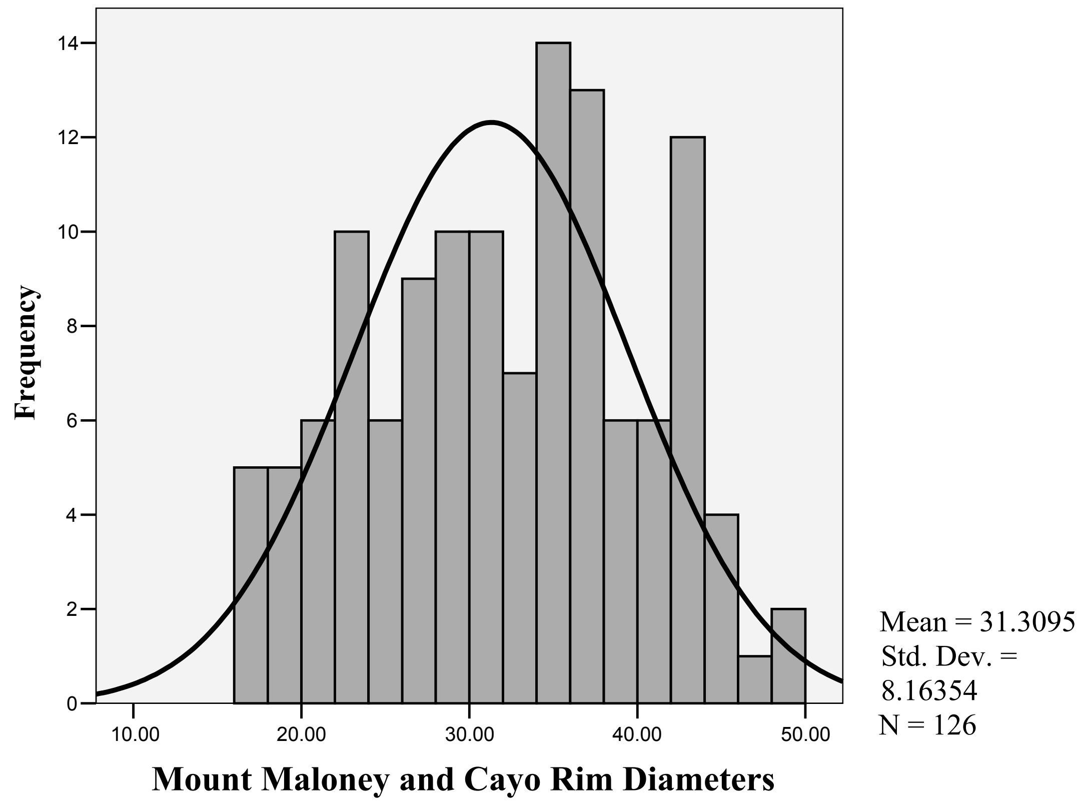
Ceramic Attributes and Descriptive Statistics

Cayo and Mount Maloney paste colors can be somewhat varied. Cayo jar pastes tend to be light gray to brown in color, with Munsell values of 10YR4/3, 5/2-4, 6/2-6, 7/2 and 7.5YR4/2, 5/3-6, and 6/3-6 (LeCount 1996:374). Mount Maloney paste colors are generally light to dark brown, reddish-yellow or light red (LeCount 1996:391). Munsell colors for the pastes include 7.5YR6/2-6, 5/3-6, 5YR6/4-6, 5/6, and 2.5YR6/6 (LeCount 1996:391). Firing cores, the result of inconsistent atmospheres during the firing process, are present in much of the sample. If firing cores were present, they were measured macroscopically. Given inconsistencies in recording firing core color and vessel wall thickness, my formal analysis is limited to rim diameter.

In order to best compare the levels of standardization present in this data, and to compare the upper Belize Valley groups with other reported Maya groups or types, I calculated coefficients of variation (CVs) of rim diameters. These are calculated by dividing the standard deviation by the sample mean. Low CVs are expected when specialists manufacture goods, whereas high CVs are generally assumed to reflect non-specialist, domestic production. Thus, if specialists are making pottery for a market economy in the Hats' Chaak, the CVs for this phase should be the lowest.

Based on total group samples, rim diameter proved to be reasonably normally distributed (Figure 5.1). But this methodology confounds ceramic group and form. In order to accurately use CVs here, normality assumptions must be met within each ceramic group.

Figure 5.1: Histogram of All Rim Diameter Values



In order to calculate CVs for each pottery group, the normality assumption must be met for each ceramic group and phase. Regarding the overall group, the Cayo group distribution appears fairly normal (Figure 5.2). Mean rim diameter is 28.24 cm, and the standard deviation is 8.10 cm. For the entire Mount Maloney group, the rim diameter distribution becomes left-skewed, meaning that there are more larger vessels than smaller ones (Figure 5.3). For the entire Mount Maloney group, the mean rim diameter is 34.80 cm, and the standard deviation is 6.77 cm.

Figure 5.2: Rim Diameters for all Cayo Group Values

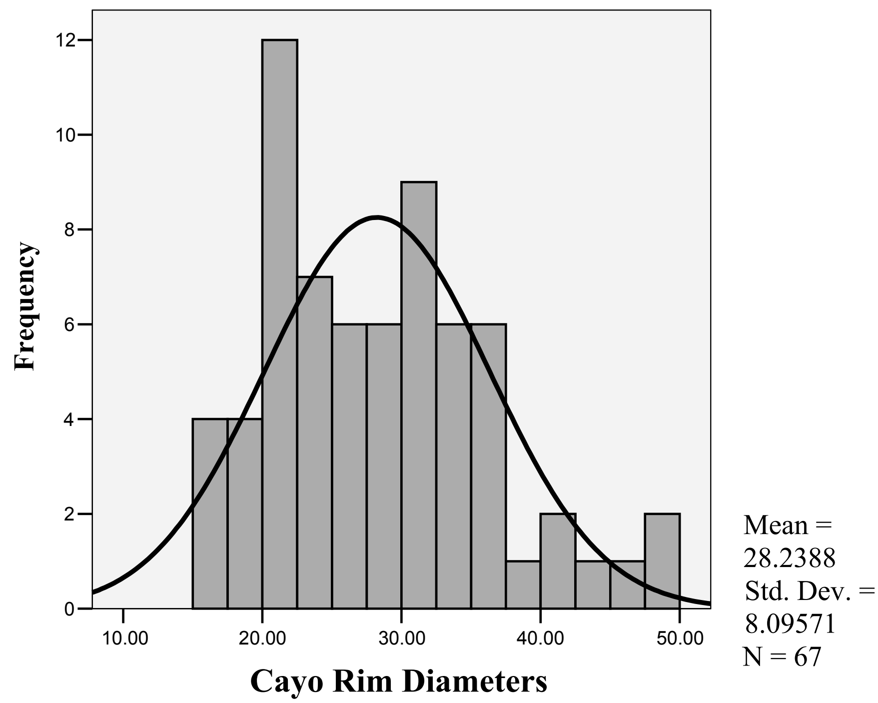
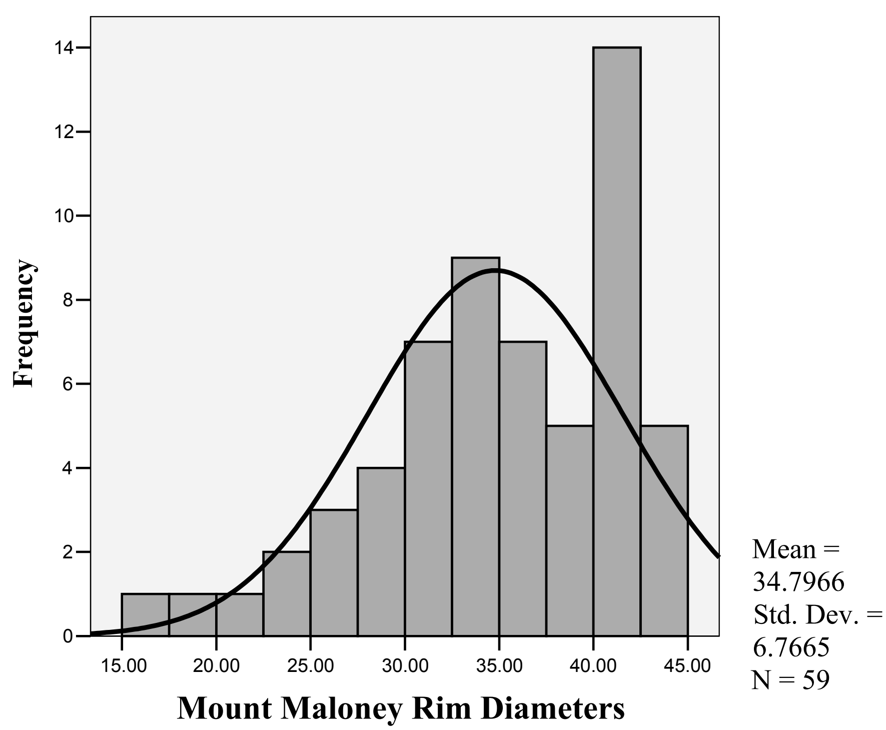


Figure 5.3: Rim Diameter Histogram of All Mount Maloney Group Values



But when the sample was divided into phase, rim diameters by group are consistently non-normal (Figures 5.4-5.9). Nonetheless, as the usual measurement for standardization is the coefficient of variation, it was calculated even though the normality assumption is not met.

The results for Cayo and Mount Maloney data are suggestive of *decreasing* standardization in rim diameter size from the Samal to Tsak' phases (Table 5.1). Rim diameters for Cayo samples are most standardized during the Samal phase ($\overline{x}$ = 26.54, S.D. = 5.73). During the Hats' Chaak phase the standard deviation increases ($\overline{x}$ = 30.25 cm, S.D. = 9.31), and levels remain about the same into the Tsak' phase ($\overline{x}$ = 28.44, S.D. = 9.22). For the Mount Maloney data, variability increases slightly through time. The Samal phase again has the most standardized values ($\overline{x}$ = 36.19 cm, S.D. = 6.18). The mean basically holds steady during the Hats' Chaak phase, although the standard deviation does increase slightly ($\overline{x}$ = 36.00 cm, S.D. = 6.32). Finally, in the Tsak' phase, the mean drops and the standard deviation increases ($\overline{x}$ = 32.00 cm, S.D. = 7.30).

Rather than seeing low CV values in the hypothesized market phase (Hats' Chaak phase), the lowest values occur in the Samal phase (Cayo group CV = 21.59%, Mount Maloney group CV = 17.08%). CV values peak in the Tsak' phase (Cayo group CV = 30.78%, Mount Maloney group CV = 17.56%). Cayo jars exhibit the highest amount of variability in rim diameters during this phase. It is likely that the low CVs in the Samal phase are a result of sampling practices. For example, no Mount Maloney samples from San Lorenzo date to the Hats' Chaak.

As mentioned previously, the CV is problematic when data distributions are not normally distributed. When the larger "Cayo" and "Mount Maloney" groups are subdivided by time period, it becomes apparent that relying on the CV for evidence of standardization is a poor idea.

For the Cayo samples, the Samal and Tsak' phase data suggest a bimodal distribution. The Samal rim diameters ($\bar{x}$ = 26.54 cm) peak from 20-22 cm and again at 35-38 cm. The Hats' Chaak rim diameters ($\bar{x}$ = 30.25 cm) are right-skewed, with a disproportionate number of the jars having rim diameters from 20-25 cm, but no additional peak around 35 cm. The Tsak' rim diameters ($\bar{x}$ = 28.44 cm) are bimodal in nature, with peaks occurring from 18-22 cm and from 33-38. The bimodal nature of the data could indicate the existence of two emic size categories within the Cayo Group jars.

The Mount Maloney Samal sample ($\bar{x}$ = 36.19 cm) is either left-skewed or potentially bimodal. A peak occurs around 40 cm, and another one may occur around 32 cm. For the Hats' Chaak phase rim diameters ($\bar{x}$ = 36 cm), the data are heavily skewed, with one case at 18 cm and the remainder above 30 cm. Finally, the Tsak' rim diameter distribution ($\bar{x}$ = 32 cm) looks approximately normal.

If the potential emic size categories truly exist, it may support the argument for an emergent marketplace dealing in Cayo jars and Mount Maloney bowls, since markets actually stimulate diversity in pottery forms and styles. If this is not the case, and there are single emic size categories of Cayo jars and Mount Maloney bowls, then the market hypothesis is not supported.

Given my sample size and distributions, I suggest that production is changing over time. Means and standard deviations are varying over time, so something is changing about the production process. However, due to the non-normal distributions of much of my data, I do not believe the CV to be a viable measure of standardization.

Table 5.1: Cayo and Mount Maloney Rim Diameters by Phase

	Phase	No.	Mean	Range	S. D.	CV (%)
Cayo	Samal	24	26.54	20	5.73	21.59
	Hats' Chaak	16	30.25	33	9.31	30.78
	Tsak'	26	28.44	34	9.22	32.42
Mount Maloney	Samal	26	36.19	20	6.18	17.08
	Hats' Chaak	14	36.00	24	6.32	17.56
	Tsak'	19	32.00	28	7.30	22.81

As CVs are heavily dependent on normally-distributed data, other tests are needed. Analysis of variance (ANOVA) was used to evaluate rim diameters for each group across time and site. ANOVA also requires normally-distributed data; however, the robustness of the test allows for usage with less than optimal data distributions (William Dressler, personal communication, May 2008). While the ANOVA statistic does not directly address standardization, the results will indicate if significant differences in rim diameter means exist within groups by phase and site. If no differences are apparent, it would be suggestive of consistency in production practices. Levene's test for homogeneity of variance is also used to assess rim diameter data. Specialized production is expected to have lower variances than non-specialized production. Thus, if variances are different between phases, it would suggest changes in production over time. If variances are different between sites, it would suggest that specific producers are making goods for specific sites, not manufacturing goods to accommodate consumers at several sites.

The ANOVA statistic for Cayo jars rim diameters across phases indicates no significant differences in means ($F = 1.016$, $p = .368$, $\alpha = .05$). Interestingly, Levene's test for homogeneity of variance indicates significant differences in variance across phase for Cayos ($W = 3.537$, $p = .035$, $\alpha = .05$). That the variances are different across time could indicate changes in their production. Similarly, there are no significant differences among Cayo jar rim diameters across the three sites ($F = 1.631$, $p = .204$, $\alpha = .05$). Again Levene's test for homogeneity of variance shows significant differences in variances ($W = 3.313$, $p = .043$, $\alpha = .05$), suggesting inconsistent production activities across sites.

Mount Maloney rim diameters, however, do show significant differences over time ($F = 2.523$, $p = .089$, $\alpha = .05$). Post Hoc tests indicate that the mean rim diameters for Samal phase ($\bar{x} = 36.19$ cm) and Tsak' phase ($\bar{x} = 32$ cm) rims are significantly different. However, this pattern may be a result of sampling bias since LeCount's (2005) larger Mount Maloney rim diameter sample (n=594) demonstrates that Mount Maloney rim diameter means in the Hats' Chaak ($\bar{x} = 30$ cm) and Tsak' phases ($\bar{x} = 31$ cm) are more consistent. Additionally, Levene's test for homogeneity of variance indicates no significant differences in variance across phase for Mount Maloney samples ($W = .772$, $p = .467$, $\alpha = .05$), suggesting consistency in production. My sample may contain higher amounts of larger sherds, especially Samal phase rims, possibly due to my strict rim size requirements. Finally, when an ANOVA was run on Mount Maloney rim diameters across the three sites, no significant difference was found ($F = .197$, $p = .821$, $\alpha = .05$). While the mean rim diameters may be different between sites, the variance of the mean rim diameters is not, suggesting consistency in production for all three sites. Levene's test for homogeneity of variance indicates variances for all three sites are not significantly different ($W = .888$, $p = .417$, $\alpha = .05$).

Overall, the lack of significant differences within pottery groups argues for consistency in production practices over time and sites. However, the significant differences in variances for the Cayo ceramics could be a result of their intended usages. Cayo jars were storage vessels, whereas the Mount Maloney bowls are serving vessels. Because of the public nature of Mount Maloney bowl usage, there may have been less leeway in acceptable sizes of vessels. By comparison, it is possible that potters making Cayo jars could be less exacting in their final sizes because usage was private.

Point Count Analysis

As discussed in the methodology section, characterizing pottery composition by point counting thin sections was the most time-intensive aspect of the analysis. Before I begin to discuss the results of my analyses, I would like to make some basic observations regarding the overall sample of 99 thin sections in terms of shape, content, and size of inclusions. First, lower than initially expected levels of angular inclusions (i.e. temper) were present. Many of the sherds had little to no angular inclusions. Following the usual convention (Rice 2006), angular inclusions are assumed to be the result of human action while rounded inclusions are assumed to occur naturally in the raw clays. This temper pattern suggests to me one of three possibilities.

One possibility is that the low amount of angular inclusions represents minimal intentional addition of temper to the clay bodies. In terms of production, the lack of angular inclusions in upper Belize River Valley sherds could indicate the presence of fine and homogeneous clays that were essentially “ready-made” for pottery production. The environment of deposition for the clay sources could have led to the natural removal, through water movement, of larger tempers as well as the settling of finer sediments in the clay beds. As no samples were taken of raw clays, it is not possible to know what the specific environments of deposition were. However, it needs to be considered that nature may have been responsible for the lack of angular inclusions, not direct human processing of raw materials. Not only does this situation lessen the time and work invested in the manufacturing process, it also potentially suggests that a detailed knowledge of necessary tempers could be replaced by simply knowing the general area to obtain clean clay. Potters producing these wares may not have needed exhaustive knowledge pertaining to the locations of, and appropriate processing strategies for, tempering agents. Rather, knowledge may be more focused on knowing which clay sources to utilize.

The second possibility is that what I am seeing is the result of heavy time investment in removing coarse inclusions from the raw clays. However, this possibility still is the result of a production technology focused on removal of unwanted materials, not requirement of detailed knowledge of additive materials and processes.

The third possibility is that processing methods led to temper that was rounded, not angular. This could possibly be accomplished through intensive grinding of very weak limestone. However, grinding would either entail usage of a mortar and pestle or a mano and metate. Since production locations are unknown, the potential for temper grinding apparatuses cannot be accounted for directly. If granite tools were used, it would be expected that some inclusions would be granitic. As discussed previously, non-carbonate mineral inclusions were practically non-existent, arguing against the usage of granite grinding tools. It is also possible that intensive grinding would lead to temper inclusions showing fractures and signs of strain. I did notice consistent or common evidence of this occurring while doing the point-counting. Based on the above reasoning, I am going to follow Rice (2006) in the general assumption that if temper is rounded it occurs in the clay naturally and if it is angular, it is a result of human action.

The presence of grog in the thin sections appeared to be accidental. The vast majority of the grog inclusions were very, very small (only 31 cases of grog larger than .25 mm were found in over 10,000 points in the Cayo and Mount Maloney slides). The occurrence of small grog could be the result of using a ceramic tool during the production process, perhaps as a scraper or mixer.

It could be argued that paste recipes for Cayo and Mount Maloney pottery was almost purely raw clay, carbonate minerals (naturally occurring and intentionally added), and grog. But occasionally other materials were identified. In 27 cases, I found evidence of burnt organic materials in the Cayo and Mount Maloney samples. Since organic remains are common in raw clay, this fact suggests great attention was paid to removing impurities from the raw clay. Only three sherds had other non-carbonate and non-grog inclusions. One Samal phase Mount Maloney from Actuncan (1D11.01) had a clay clump between .5 and 1 mm in size. Two other Samal phase sherds from Actuncan (one Cayo (1D11.02) and one Mount Maloney (5B2.03)) contain a fairly eroded green mineral. While this green mineral was not identified, it was not jadeite or chlorite based on the optical properties it demonstrated. As an ancient Maya household could be utilizing several varieties of chert, as well as jadeite, granites, pyrite, ash, and chalcedony, the lack of non-carbonate mineral inclusions in my sample points to the possible existence of dedicated production areas specifically for ceramics, or at least intensive cleaning of generalized work areas prior to the manufacture of pottery. Otherwise, a higher occurrence of inclusions unrelated to pottery production would be expected in the sample.

As discussed in the methodology chapter, point count analysis variables include (1) number of matrix points, (2) number of void points, (3) number of temper points, (4) temper-specific variables, (5) size categories for each type of temper, (6) overall shape categories, (7) ratio of matrix points to temper points, (8) percentage of round and subround temper to total number of temper points, (9) percentage of non-calcite tempers, and (10) percentage of temper larger than .50 mm compared to total temper. However, because ratio and percentage provide comparable data, the following section focuses on a discussion of these indices.

The intent of the indices was to be able to compare samples with varying numbers of total points, as well as to address how production practices may be identified in the point count data. The ratio of matrix points to temper points variable reflects an overall composition of the samples. If that ratio is very high, it suggests that either a) clay sources possess few inclusions or b) that potters removed inclusions. However, because the matrix to temper ratio does not address temper shape, either natural or human causes could be responsible for the ratio values. The percentage of round and subround temper to total number of temper points can address human behavioral issues. Unless it is a result of the existence of a very soft and easily eroded limestone being ground and added as temper, a high percentage of round and subround temper to total temper indicates that potters did not intentionally add much temper to their clays. Taken together, these two variables address both the basic composition of a paste and the issue of whether temper was added or pre-existing in the clay sources.

The two other indices are also important. The percentage of non-calcite temper is a measure of how much grog, dolomite, and aragonite were present in the samples. This variable could also be heavily affected by natural processes. Dolomite, aragonite, and calcite all occur naturally in limestone, and limestone can be highly variable within the same deposit. Furthermore, aragonite can recrystalize into calcite, which may confound my data. However, this variable could also reflect utilization of various clay sources containing varying frequencies of the carbonate minerals. I am working under the premise that while limestone can be highly variable in composition, the various frequencies of the carbonate minerals in the ceramic samples could reflect the existence of several clay sources being utilized for these vessels. Following this premise, should the variability increase or decrease noticeably, it could be suggestive of more or fewer clay sources being utilized. Finally, the percentage of temper larger than .50 mm can be directly related to human activity. Temper size affects the functional suitability of pottery. Potters use coarse temper to make vessels more porous, a particularly useful trait in water storage and cooling (Rice 1987:230). Large temper size is also correlated with large vessel size since temper improves firing characteristics of thick walled pottery (Rice 1987:74). Regardless of whether the clay sources possessed calcite, dolomite, or aragonite, potters could choose to remove or retain items larger than .50 mm. If this percentage has a small range, it suggests potters had a consistent idea for the size for inclusions during production activities. If the majority of temper larger than .50 mm is angular, it would be suggestive of potters needing to add larger material to modify their clays. If the majority of temper larger than .50 mm is round, it suggests that natural processes led to the addition of such material into the clay matrices.

Measures of dispersion:

Point counting documents variability in paste composition with the goal of creating clusters of similar pastes, which are commonly called recipes. Measures of dispersion, a set of statistics that determine how far each element is from some measure of central tendency, are effective at indicating overall variability. The most important measure is standard deviation, which provides an average distance for each element from the mean, but several others are also important including interquartile range and medium. The interquartile range, abbreviated "IQR", is the difference between the first quartile and third quartile of a set of data. The IQR is used as a measure to determine how spread-out or how grouped the values are.

In my case, the middle 50% reflects the majority of pastes' values. Decreasing or increasing variability will be evidenced in varying IQR values. If markets developed in the Hats' Chaak phase, paste recipes should become more homogeneous; therefore, this phase should have the lowest IQR values. If production was not oriented around a market economy, the IQRs should be highly variable phase and site. If production occurred locally as part of a non-market economy, the IQRs compared across the three sites should show high variability.

As discussed in the methodology chapter, point count data is available for 99 of the total 124 sherd sample. Comparison of IQR values was conducted by pottery group across phases and sites, as the paste recipes may vary along these axes. Table 5.2 displays the point count sample broken down by pottery group, phase and site. As you can see the

San Lorenzo sample is small, and this fact may limit my ability to generalize about paste characterizations for this site. Also noted earlier, the Mount Maloney sample for the Hats' Chaak phase is also smaller than that for other phases.

Table 5.2: Point Count Sample by Phase and Site

		Cayo	Mount Maloney
		number of point counts samples	number of point count samples
Phase	Samal	21	21
	Hats' Chaak	14	8
	Tsak'	18	17
Total		53	46
Site	Actuncan	25	24
	Xunantunich	20	17
	San Lorenzo	8	5
Total		53	46

Measures of Dispersion for Cayo Jars

In looking at the IQR values of Cayo jars across the three phases (Table 5.4), there is no consistent pattern across variables, a fact that suggests multiple cultural and natural processes conditioned the composition of Cayo jars. Therefore, each variable must be viewed separately to understand the behavioral implications of the patterning.

Both the ratio of matrix to temper and the percentage of non-calcite tempers show marked decreases in variability over time, with the Tsak' phase having the least variability. It could be possible that potters used different clay sources, perhaps because of exhaustion of previous sources. These two indices are important because they measure the amount and kind of tempering agents used in pottery production. Based on the matrix to temper ratio, the amount of tempering in Cayo jars increases through time, but more importantly, the declining IQR values for the percentage of non-calcite tempers suggests the recipes become more homogeneous through time. At the very least, there are fewer outliers. Since variability in non-calcite tempers could be a result of natural inclusions in the clays, this means that the increased homogeneity could reflect potters using fewer clay sources, the clay sources themselves being more homogenous in composition, or fewer potters using clay sources.

During the Hats' Chaak phase, Cayo jar rims have the smallest IQR range of percentage of round and subrounded temper, but the largest range of temper larger than .50 mm. This could indicate several things. At its simplest, it could be that the raw clay sources utilized during the Hats' Chaak phase were more consistent in nature than those of other phases. Or, the decreased variability in this phase could be a result of fewer potters producing more wares. The greater consistency in paste composition could reflect a higher percentage of vessels being produced by fewer potters. That the Hats' Chaak Phase has the highest IQR for temper larger than .50 mm suggests that 1) potters were producing larger jars, 2) clay sources contained larger inclusions, or 3) there was less concern regarding larger inclusions in the pastes. Based on ANOVA data for Cayo rim diameters by phase, there is no significant difference among phases, indicating that vessel size was not responsible for the addition of larger inclusions. Perhaps a combination of naturally-occurring inclusions and no need to stringently remove larger inclusions is responsible.

The median values for percentage of rounded and subrounded temper are very close for the Hats' Chaak and Tsak' phase Cayo jars, but their IQR values are divergent. The divergent IQRs indicate that during the Tsak' phase greater variability occurred in the percentages of rounded and subrounded tempers. While much of the pottery produced in the Tsak' phase was very similar to the previous phase, a greater number of vessels diverged from the median value. Possibly, some Tsak' phase potters utilized different clay sources, had clay that needed the addition of temper or selected to add tempers to their clays for other reasons.

Table 5.3: Measures of Dispersion for Cayo Jars by Phase

	Phase	Median	IQR	Mean	S. D.
Total number of matrix points	Samal	63.00	13.00	61.29	8.76
	Hats' Chaak	62.00	12.00	59.62	6.42
	Tsak'	54.50	10.50	55.00	7.22
Total number of temper points	Samal	40.00	10.50	44.10	7.78
	Hats' Chaak	44.00	10.00	43.00	6.35
	Tsak'	47.50	8.75	46.83	6.80
Ratio of matrix to temper points	Samal	1.58	.82	1.58	.50
	Hats' Chaak	1.36	.62	1.44	.38
	Tsak'	1.15	.43	1.22	.36
Percentage of round and sub-round points	Samal	67.74	35.13	67.81	22.15
	Hats' Chaak	85.29	21.80	78.15	18.27
	Tsak'	86.73	38.13	77.90	20.35
Percentage of temper greater than .50 mm	Samal	13.73	8.07	15.69	8.63
	Hats' Chaak	16.00	14.62	18.23	9.65
	Tsak'	12.83	9.90	12.93	6.98
Percentage of non-calcite temper	Samal	48.15	53.61	64.33	58.34
	Hats' Chaak	50.00	49.13	63.29	52.43
	Tsak'	27.54	24.60	31.06	16.25

When Cayo jars are viewed only by site (Table 5.4), there is no consistent pattern across all variables. Xunantunich, the purported market center, has the lowest IQR values for ratio of matrix to temper points and percentage of round and subround points, but it lies in the middle of IQR values for percentage of temper greater than .50 mm and percentage of non-calcite temper. Xunantunich has the largest mean and standard deviation values in temper greater than .50 mm, possibly indicating the largest jars. However, this is inconsistent with the ANOVA results, which showed no significant difference in rim diameter means between sites.

The tight IQRs for ratio of matrix to temper and percentage of round and subround points suggests perhaps that potters supplying Xunantunich were focusing on a specific clay source or shared a common recipe and understanding of production techniques. Two situations could be occurring which lead to these tight IQRs. Either, the percentage of round and subround points IQR values indicates that raw clays were fairly consistent in composition and did not require potters to augment the clays with temper. Raw clays would need to be analyzed to address this explanation of the tight IQRs. Or, these tight IQRs for the Xunantunich material could indicate a production situation where Xunantunich had a higher demand for goods, and the ceramic production was the result of specialists, with the production process being more routinized and consistent across the various potters making the wares. The tight IQRs could then indicate heavy processing of raw clays prior to ceramic manufacturing. Actuncan and San Lorenzo have larger IQR values for these variables; therefore lending evidence to suggest pottery at these sites exhibit greater diversity of production techniques or clay sources.

The Xunantunich sample lies in the middle of IQR values for percentage of non-calcite temper as compared to Actuncan and San Lorenzo. This pattern could be interpreted to support concentrated workshop production. If production was dispersed I would expect the IQR values for this variable to vary more, especially if the clay sources possessed different levels of eroded carbonate minerals. The other potential reason for similarity in these IQR values would be that all potters utilized the same general clay source. To answer these questions, samples from sites farther away from Xunantunich than Actuncan would be beneficial.

San Lorenzo samples appear more similar to the Xunantunich than the Actuncan sample. The greatest divergence in IQR values between the two sites occurs in the ratio of matrix to temper variable, where San Lorenzo has about double the IQR value of Xunantunich. However, given the 0.01 difference in median values for that variable, the large IQR could be the result of a much smaller sample than from the sites of Xunantunich and Actuncan. A larger sample could have resulted in having more sample values near the mean, leading to a smaller IQR. Indeed, the IQR values for the other variables for San Lorenzo are close to that of Xunantunich. The IQR values for percentage of round and subround points are fairly close, as are the percentage of non-calcite temper and the percentage of temper greater than .50 mm variables. Based on the IQR values, it appears that either the same potters (or potting community are supplying both San Lorenzo and Xunantunich or that potters in both communities are using the same clay sources. However, the lack of significant differences in variances (see

Levene's test for equality of variance) for the both the Cayo and the Mount Maloney samples is suggestive of greater consistency in production across sites than just utilizing the same clay sources. Because of this, I tentatively propose that the same potters or potting community could be supplying both San Lorenzo and Xunantunich. The two sites are close to each other, and the consistency in Cayo jar point count variables and rim diameter measurements supports the hypothesis of Xunantunich as potential market center.

The Actuncan samples are more divergent. While the IQR values for the ratio of matrix to temper and percentage of non-calcite temper are similar to the Xunantunich, the IQR values for percentage of round and subround temper points and the percentage of temper larger than .50 mm are divergent from the other two sites. Actuncan samples have the least variability with respect to percentage of temper larger than .50 mm, but the most variability with respect to shape of temper. The tight IQR value for percentage of temper larger than .50 mm indicates one of two things. Either potters spent more time processing and removing larger inclusions, or the clay deposits utilized did not contain larger inclusions in the first place. Additionally, high variability in shape of temper could be a reflection of potters actively modifying clays to fit desired recipes. It also suggests that Actuncan could have had the greatest variability in Cayo jar recipes, possibly indicating

Table 5.4: Measures of Dispersion for Cayo Jars by Site

Variable	Site	Median	IQR	Mean	S. D.
Total number of matrix points	Actuncan	61.00	12.50	60.08	8.93
	Xunantunich	56.50	10.75	57.55	5.67
	San Lorenzo	55.50	21.00	56.13	10.25
Total number	Actuncan	42.00	10.50	42.24	7.96

of temper points	Xunantunich	47.00	9.75	44.85	5.52
	San Lorenzo	47.00	18.50	45.38	9.72
Ratio of matrix to temper points	Actuncan	1.45	.68	1.51	.50
	Xunantunich	1.20	.51	1.32	.32
	San Lorenzo	1.19	1.05	1.34	.54
Percentage of round and sub-round points	Actuncan	79.55	39.57	70.64	22.36
	Xunantunich	85.48	25.51	77.25	20.62
	San Lorenzo	71.62	32.09	70.99	20.77
Percentage of temper greater than .50 mm	Actuncan	13.33	6.63	14.56	8.58
	Xunantunich	15.46	11.44	17.19	9.04
	San Lorenzo	12.88	13.38	15.09	8.08
Percentage of non-calcite temper	Actuncan	41.18	49.12	58.34	55.22
	Xunantunich	38.14	45.03	47.04	42.28
	San Lorenzo	29.85	39.07	42.81	39.24

access to multiple potters (or villages) through exchange networks.

Measures of Dispersion for Mount Maloney Bowls

Comparing Mount Maloney bowls across phases shows some similar patterns to those noted for Cayo jars. Again, there is decreasing variability in IQR values for the ratio of matrix to temper and, to some degree, the percentage of non-calcite tempers, with the Tsak' phase bowls having less variability than those from the Samal phase (Table 5.5). Percentage of temper larger than .50 mm shows the least variability in the Hats' Chaak phase, as does the percentage of non-calcite temper. The percentage of round and subround points shows increasing variability after the Samal phase.

The low IQR values for non-calcite temper and the size of the temper support the hypothesis of Xunantunich as a market center during the Hats' Chaak phase. Perhaps the increasing attention to size of temper reflects concerns about what consumers expect regarding Mount Maloney bowl characteristics. Given that most Mount Maloney bowls have thin walls and dense texture, the removal of large temper grains would facilitate these characteristics. Regarding the variability in non-calcite tempers, it could be that clay sources used during the Hats' Chaak phase had less variability than the other phases. It could also be that fewer clay sources provided material for more pottery during the Hats' Chaak phase. If a market economy was active, it would make sense that some producers intensified production and thus the overall distribution of the sample would be more focused around the median value.

Interestingly, the largest IQR value for percentage of round and subround points occurs in the Hats' Chaak phase, with a slightly smaller IQR value during the Tsak' phase. This pattern is contrary to the Cayo sample, but it may be a result of function of the Mount Maloney bowls. As serving vessels, they needed to be densely packed and well-made. The high IQR value may represent the necessity of modifying raw clays more to achieve the desired (and maybe required) characteristics in the bowls. The ratio of matrix to temper variable reinforces this concept. No glaringly different mean or standard deviation values are evident. Instead, these data argue for potters actively modifying raw clays in various ways to ensure the proper amount of temper needed for the Mount Maloney bowls.

Table 5.5: Measures of Dispersion for Mount Maloney Bowls by Phase

	Phase	Median	IQR	Mean	S. D.
Total number of matrix points	Samal	62.00	11.50	61.38	7.79
	Hats' Chaak	62.00	9.25	61.00	6.12
	Tsak'	60.00	5.50	60.12	5.44
Total number of temper points	Samal	40.00	8.50	41.57	6.74
	Hats' Chaak	42.00	8.00	42.25	4.74
	Tsak'	41.00	5.00	41.47	4.87
Ratio of matrix to temper points	Samal	1.58	.56	1.54	.43
	Hats' Chaak	1.51	.44	1.47	.31
	Tsak'	1.44	.29	1.48	.32
Percentage of round and sub-	Samal	87.18	19.48	80.82	15.07
	Hats' Chaak	84.89	35.58	77.53	22.05

round points	Tsak’	78.05	32.86	76.85	17.56
Percentage of temper greater than .50 mm	Samal	7.69	7.35	9.42	5.79
	Hats’ Chaak	5.91	4.87	5.53	3.02
	Tsak’	2.22	8.31	3.65	4.04
Percentage of non-calcite temper	Samal	37.50	40.77	37.90	22.22
	Hats’ Chaak	32.31	15.37	36.12	19.20
	Tsak’	27.59	20.50	31.06	16.52

The analysis of the Mount Maloney sample across sites indicates a situation similar to that of the Cayo sample (Table 5.6). The Xunantunich sample has the lowest IQR values for the ratio of matrix to temper points and percentage of non-calcite temper, but the highest IQR value for percentage of round and sub-round points. While this could be the result of natural processes affecting clay sources, it could also be indicative of potters working to modify their clays to have optimal amounts of temper. All three sites have fairly similar low IQR values for percentage of temper larger than .50 mm, reinforcing that the production process for these bowls involved limiting the amount of larger temper, be it through selecting clays naturally lacking larger inclusions or processing the clays to remove larger inclusions. The consistency in temper amount and size strongly suggests some type of overarching organized production and distribution of these bowls, possibly involving a marketplace at Xunantunich.

The IQR value for percentage of non-calcite temper is strikingly lower for the Xunantunich material than the other two sites. Given the general similarities for the other variables, perhaps this reflects a specific clay source used for Mount Maloney bowls available at Xunantunich.

The San Lorenzo sample is the most variable. It has the highest IQR values for ratio of matrix to temper points, percentage of temper greater than .50 mm and percentage of non-calcite temper. The San Lorenzo IQR values for percentage of round and sub-round points also closely rivals Xunantunich's high values. This variability may have more to do with the sample size (n=5) than cultural factors.

Actuncan IQR values appear to be more moderate than either Xunantunich or San Lorenzo, except for the percentage of non-calcite temper in which its value is more similar to San Lorenzo than Xunantunich. Actuncan's IQR value for percentage of round and subround temper shows the least variability. However, as the IQR value for percentage of matrix to tempers is very close to that of the Xunantunich sample, I believe the low IQR value for percentage of round and subround temper reflects the usage of clays that did not require much alteration through addition of temper to make the appropriate paste recipes.

The differences in IQR ranges across sites may be suggestive of localized production and exchange of Mount Maloney bowls, and not market exchange through Xunantunich. But given the fact that production techniques and recipes appear to change through time, it could be asserted that changes in exchange occurred as well. The temporal and spatial IQR values show trends suggestive of a very tight cultural concept of what a Mount Maloney bowl should look like during the Hats' Chaak phase. Specifically, the extremely low IQR value for percentage of temper greater than .50 mm denotes that potters were selecting or processing clays to exclude larger inclusions. This same variable has consistently low IQR values across the three sites, as does the ratio of matrix to temper points. As these variables reflect deliberate choices to remove or not remove larger inclusions in the clay, the tight IQR values across sites indicate a well-known concept of how to properly manufacture these bowls. Regardless of what may or may not have occurred in the raw clays, the finished products at all three sites are very consistent in their temper size. This homogeneity of temper size could be indicative of a market economy.

Table 5.6: Measures of Dispersion for Mount Maloney Rims by Site

	Site	Median	IQR	Mean	S. D.
Total number of matrix points	Actuncan	60.25	9.25	60.25	6.58
	Xunantunich	63.00	8.00	61.64	6.52
	San Lorenzo	59.00	16.00	61.00	8.22
Total number of temper points	Actuncan	43.00	7.00	42.50	5.89
	Xunantunich	41.00	4.00	40.76	5.08
	San Lorenzo	41.00	13.0	40.60	7.13
Ratio of matrix to temper points	Actuncan	1.42	.46	1.46	.35
	Xunantunich	1.54	.40	1.55	.36
	San Lorenzo	1.44	.94	1.57	.52
Percentage of round and sub-round points	Actuncan	85.81	21.57	79.53	16.77
	Xunantunich	78.05	35.91	77.68	18.70
	San Lorenzo	80.43	29.98	78.91	15.44
Percentage of temper greater than .50 mm	Actuncan	8.11	6.08	9.01	5.75
	Xunantunich	2.56	6.99	3.98	3.58
	San Lorenzo	4.17	8.01	4.04	4.03
Percentage of non-calcite temper	Actuncan	35.42	33.74	39.49	22.16
	Xunantunich	27.59	18.89	28.49	13.90
	San Lorenzo	37.50	33.98	36.17	20.46

In sum, measures of dispersion for Cayo jars and Mount Maloney bowls indicate that across time and space, the potters were selecting to control amounts of larger temper in their clay recipes. It appears as though the Mount Maloney group's potters modify the raw clays more during the production process, working to ensure an appropriate amount of temper and to keep the majority of larger inclusions out of their materials. In comparing the data across the three sites, the tight IQR values for the ratio of matrix to temper and percentage of temper larger than .50 mm, combined with the highly variable percentage of round and subround temper, indicates that the producers of these bowls had a very specific template for how Mount Maloney paste recipe should be composed.

By comparison, it seems that Cayo group jar production involved less modification of raw clays prior to usage. IQRs for the ratio of round to subround points and percentage of non-calcite tempers are quite high, which indicates heterogeneity in the sample. The variability in ranges for example, the percentage of non-calcite temper IQRs by phase vary from about 25 to 54% and from about 39 to 49% by site. The consistent high IQR values argue for dispersed community specialization where potters utilized varying clay sources to produce large amounts of pottery for others' consumption.

For both ceramic groups, I believe it can be argued that specialists were making these wares. The consistency in clay and temper recipes used for the Mount Maloney bowls suggests a set idea among potters about the desired composition of these vessels. The tight IQRs for ratio of matrix to temper and percentage of temper larger than .50 mm, combined with the divergent IQRs for percentage of non-calcite temper, indicates that even when the clay sources are variable in inclusion composition, the processing of raw clays leads to consistent results across time and space. Regardless of the actual composition of the clay sources, which may be highly variable based on the eroded limestone in the clay matrices, potters still used clay recipes involving consistent levels of temper larger than .50 mm. Whether this is a result of raw source selection or processing or raw sources, it entails a consistent idea about desired clay qualities. This homogeneity in recipe composition and/or processing argues for specialist production. Similar to the Cayo group, this production could represent community specialization or even specialist potters in one or more of the sites. If community specialization is occurring, the IQRs could be understood as reflecting different sources of clay being processed into ceramics at the same location. Thus, geological variability is high, but human behavioral modifications to the source clays are fairly homogenous. If specialists are making the ceramics in one or more of the sites, the high consistency in IQRs reflects a shared knowledge of production, even if the locations are dispersed.

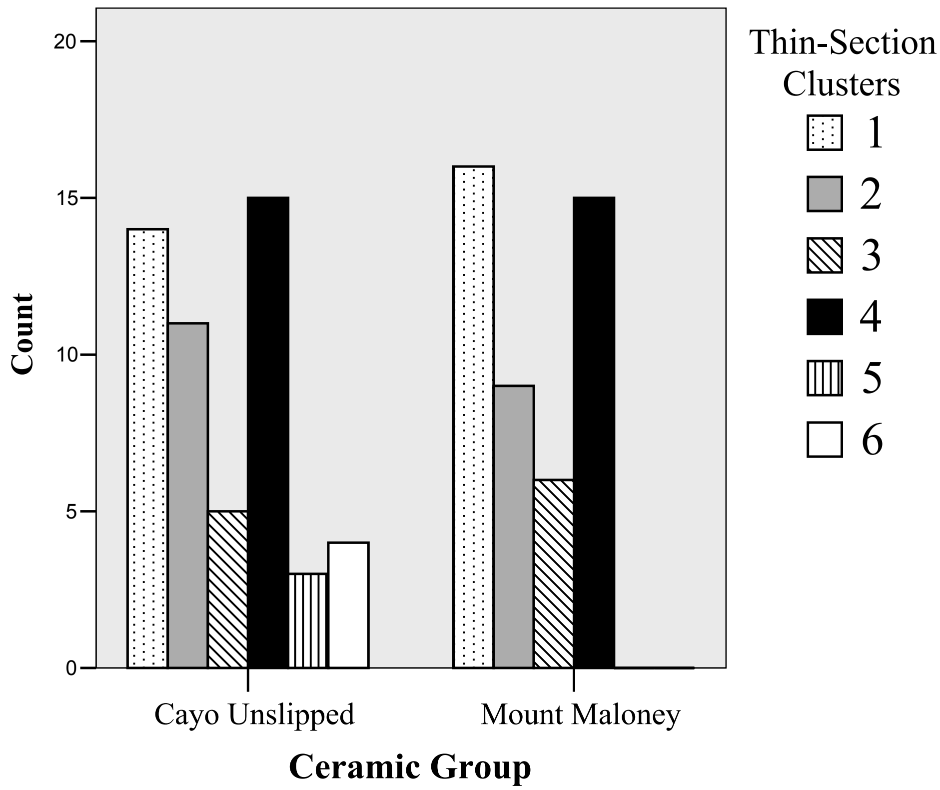
Cluster Analysis

In addition to comparing measures of dispersion across indices, a cluster analysis was run to discern if recipes could be ascertained from the grouping of indices. It was hoped that the cluster analysis would reveal groupings of samples based on site and phase. If the cluster groups were based on site, it would indicate localized production. If phase proved to be the key variable, and if there were fewer clusters during the Hats' Chaak than other phases, it would suggest that fewer producers were making ceramics during this phase. As demand did not wane, it would indicate those fewer potters would be making higher volumes of goods – exactly what is to be expected from specialist production in a market economy. If the cluster groups do not appear to be based on site or phase, it suggests a more complicated picture. It could indicate that organization of production occurred prior to the beginning of the Samal phase, or it could be a result of sampling bias, natural processes, and a need for a larger pool of data.

The variables chosen for clustering were: site, phase, ceramic group, ratio of matrix to temper, percentage of round and subround temper to total temper, percentage of non-calcite tempers, and percentage of temper larger than .50 mm. The two ceramic groups were combined for the cluster analysis for several reasons. Firstly, I had assumed ceramic group would be beneficial in parsing out the clusters, since ceramic groups have been suggested to be products of community-level specialization (Ball 1993:245). While I had not noticed excessive differences during the point counting, it seemed likely to me that ceramic group would make a key difference in formation of clusters. Second, I needed to ensure that the sample size was large enough to allow for follow-up ANOVA tests. If the data had been split by ceramic group and several clusters were apparent, then it would be highly likely several of my post-hoc tests would be statistically invalid. The problematic nature of the percentage of non-calcite temper has previously been discussed; however, it was included on the premise that it could also reflect varying raw clay sources for pottery production.

Ward's Method was used to compute the cluster solution. This method was deemed appropriate because it relies on intra-cluster variability, thus creating clusters with the most inter-cluster variability (Bill Dressler, personal communication, August 2008). As this thesis focuses on changes in production, which should be evident in changes in variability in a sample, using a cluster solution relying on variability in that sample is appropriate for the data. The cluster analysis results suggested a grouping of the data into six clusters. Four of the six clusters include both ceramic groups (Figure 5.10).

Figure 5.10: Clusters sub-divided by Ceramic Group



Clusters 5 and 6 were formed to include samples with extremely high percentages of temper larger than .50 mm. While clusters 5 and 6 are not represented in the Mount Maloney ceramic group, the formation of clusters which include fairly even amounts of two different ceramic groups was unexpected. I had assumed that the clusters would have been group-specific, not common to both ceramic groups.

These six clusters were then used as the grouping variable for an ANOVA test in hopes of discerning how the clusters were related to the individual rims in the sample. Each sample was placed into a cluster using SPSS; this allows for comparison between the clusters for each variable. The clusters are used as the grouping variable for an ANOVA test to compare means between groups. If the clusters are related to specific variables, there will be statistically significant results for the ANOVA tests. For example, if I believe the clusters to be based (at least partially) on the ratio of matrix to temper, then the ANOVA test results should be statistically significant for that variable. The continuous variables included for this ANOVA are: ratio of matrix to temper, percentage of round and subround temper to total temper, percentage of non-calcite tempers, and percentage of temper larger than .50 mm (Table 5.7, end of chapter). As ANOVA utilizes one categorical variable for grouping, the other categorical variables pertinent to this thesis must be compared across cluster groups using other methods. For the non-continuous variables of site of origin, phase, and ceramic group, chi-square tests are used.

Interpretation of the ANOVA results indicates that percentage of round and subround temper to total temper ($F = 48.596$, $p = .000$, $\alpha = .05$), percentage of non-calcite tempers ($F = 177.040$, $p = .000$, $\alpha = .05$), and percentage of temper larger than .50 mm ($F = 4.254$, $p = .002$, $\alpha = .05$) are all significant in the determination of clusters (Table 5.7). Ratio of matrix to temper was not significant for any cluster group. Based on the post-hoc tests, it appears that temper qualities are what the clusters are defined by. This makes sense, as percentage of non-calcite temper has the most differences in means of any variable, with percentage of round and subround temper and percentage of temper larger than .50 mm each having some significant differences with other groups' means as well. Percentage of non-calcite temper was significant across all six cluster groups, the percentage of round and subround temper to total temper differentiates cluster group 4 from the others, and percentage of temper larger than .50 mm differentiates cluster group 6 from the others.

Interpretation of this data suggests that different paste recipes do exist, but whether they were actively constructed of raw clays and added tempers or the result of consistent usage of specific clay sources is not known at this time. To answer this question clay and rock samples from the area would have to be analyzed. The ANOVA results did indicate that percentage of temper larger than .50 mm was significantly different among several of the groups. The temper larger than .50 mm was almost always round or subround. While this could also reflect the effects of natural processes on the raw clays, for example water movement affecting deposition of clay materials, it could also be a result of human behavior and clay processing actions. Given the general attention paid to ensuring the removal of organic materials from the raw clays, I am inclined to believe the statistical significance regarding temper larger than .50 mm reflects human action, not natural processes. If ancient Maya potters could prevent organic material from getting into their processed clays, they could select to remove larger tempers.

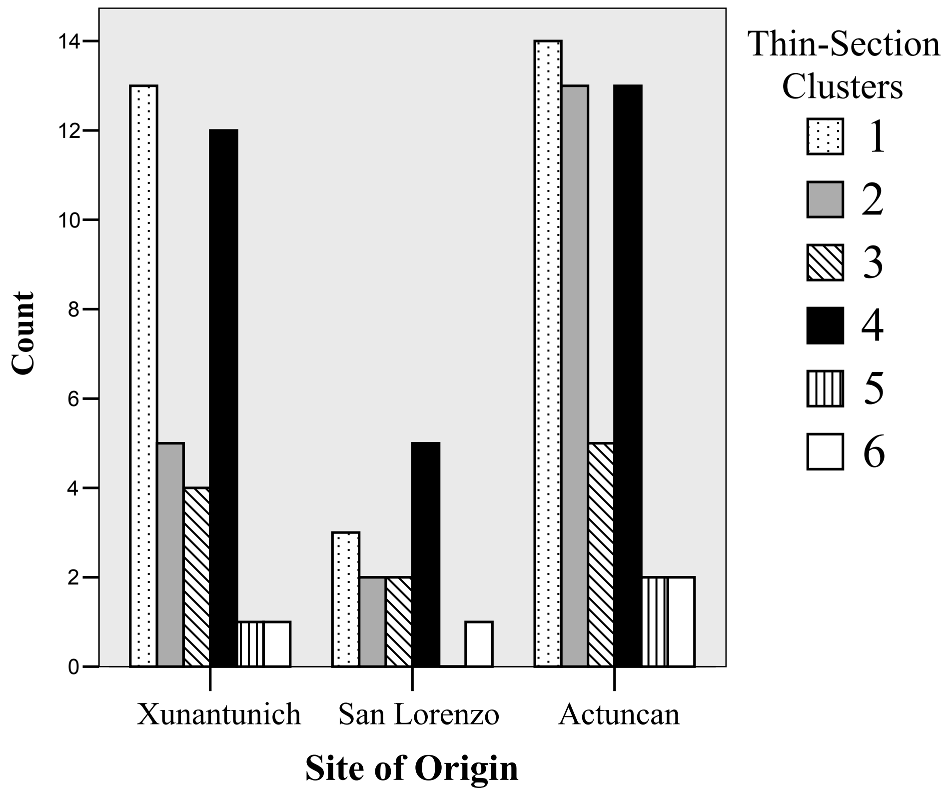
Chi-square tests comparing cluster groups to categorical data provide more information on the formation of cluster groups. A chi square test comparing cluster groups to phase indicates the clusters are distributed across all three phases ($\chi^2 = 12.395$, d.f. = 10, p = .259). This indicates that the clusters were not based on differences in variance that occur over time. The cluster groups are also distributed across all three sites of origin ($\chi^2 = 4.475$, d.f. = 10, p = .923). Similar to the phase results, it appears as though the cluster groups were not affected by differences in samples by site. Interestingly, the cluster groups are also distributed across both ceramic groups ($\chi^2 = 7.083$, d.f. = 5, p =

.215). The lack of division of cluster group by ceramic group is discussed in more detail later in the analysis chapter.

Importantly, phase, site, and ceramic group were not determining factors in cluster creation. If production and exchange systems were basically unchanging throughout the Late and Terminal Classic for Cayo and Mount Maloney ceramics, this would be the expected result. The lack of significant values for site or phase could also be indicative of community specialization at an undisclosed location.

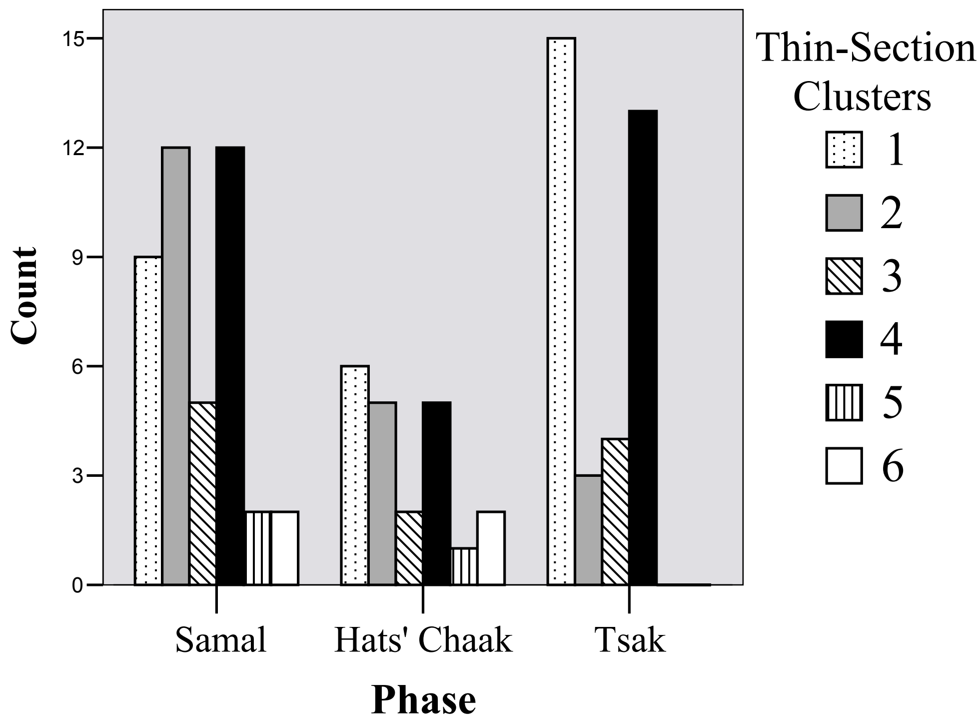
Bar graphs for cluster data by site of origin and by phase provide more information. All six clusters, or recipes, are present at Xunantunich and Actuncan (Figure 5.11). San Lorenzo, even with its much smaller sample size, still has five of the six groups present. This distribution basically indicates that all six groups were readily available at some point in time to the various sites.

Figure 5.11: Distribution of Cluster Groups by Site of Origin



When the clusters are compared across the three phases, groups 5 and 6 are not present in the Tsak' phase (Figure 5.12). Groups 5 and 6 are also comprised solely of Cayo ceramics. If my sample accurately represents the population, it appears that some potters or production centers ceased to utilize previous paste recipes for Cayo jars by the Tsak' phase. These results could also be a product of sampling bias, preservation problems, or utilization of different clay sources. If indeed some potters ceased production, the remaining pottery appears more homogenous as a result of the ratio affect and not increased standardization. This pattern is visible in the IQR values for Cayo jars, where the ratio of matrix to temper, the percentage of temper greater than .50 mm, and the percentage of non-calcite temper variables all show the low variability in IQR values in the Tsak' phase. The other four groups occur throughout the Samal, Hats' Chaak, and Tsak' phases.

Figure 5.12: Distribution of Cluster Groups by Phase



The changes in production could also reflect market economics. The reduction of paste variability in the Tsak' phase of the Terminal Classic period would make sense if a market economy existed in the Hats' Chaak phase and then slowly collapsed as the political situation worsened.

Additionally, the observation of little visual difference between ceramic groups during point counting made me question just how different these two ceramic groups actually are. While they are placed into different wares (Cayo ceramic group is a member of the Uaxactun Unslipped ware, while Mount Maloney ceramic group is classified as a Pine Ridge Carbonate ware), they appeared startlingly similar under an optical microscope. A ware is defined as a configuration of pottery types with a uniform consistency in gross technological characteristics (Gifford 1976:14). Specifically, paste, surface finishes, and methods of manufacture should be relatively consistent within a ware and noticeably different between wares (Gifford 1976:14). Thus, the lack of cluster differentiation based on ceramic group, and by extension ware, is surprising. Indeed, the only consistent observational difference between Mount Maloney and Cayo group samples is that Mount Maloneys appear to be more densely packed than Cayos. While the chi-square results comparing cluster groups also indicate that ceramic group is not a key factor in the creation of clusters, the obvious macroscopic differences between the two groups warrant additional testing to determine exactly what attributes distinguish Mount Maloneys from Cayos.

Several tests were employed to compare the two groups. Based on the normal distribution of the ratio of matrix to temper variable, a t-test compared the Cayo sample to the Mount Maloney one. Because the percentage of round and subround temper variable, the percentage of non-calcite temper variable, and the percentage of temper larger than .50 mm variable were not normally distributed, Mann-Whitney tests were used.

The Cayo and Mount Maloney mean ratios of matrix to temper are not significantly different ($t = 1.159$, $df = 97$, $p = .249$, $\alpha = .05$). The Mann-Whitney test results indicated that neither percentage of non-calcite temper ($p = .156$, $\alpha = .05$) nor percentage of round and subround temper to total temper ($p = .314$, $\alpha = .05$) are significantly different between the two ceramic groups. Indeed, the only significant Mann-Whitney test result was the percentage of temper larger than .50 mm, with the Cayo group having a higher percentage of temper larger than .50 mm. This pattern suggests that the only significant difference between Mount Maloney bowls and Cayo jars is the presence of larger pieces of temper. However, Mount Maloney and Cayo Group pastes may look distinctly different because of firing differences, paste texture, and clay content, all of which were not controlled in these analyses.

It is interesting that the differences between the compositions of the Mount Maloney and Cayo samples were not more apparent statistically. Even if rims and slips are not visible, most people can differentiate between the two groups at the macroscopic level. As the statistical analysis shows no significant difference (excepting percentage of temper larger than .50 mm), something in the fashioning technique during production, not necessarily the raw materials, must be responsible for the macroscopic differences. Based on the perceived density of the sherds, I would argue that the heavy compacting of the clay during Mount Maloney manufacturing is what differentiates the two groups. However, currently I do not know how to measure compaction in a ceramic sample. The ratio of matrix to temper hints at getting at this issue, but this variable is inherently problematic. The compaction process during production can involve the removal of clays as tempers are pressed closer and closer to each other. If a sample is heavily compacted during production, the ratio of matrix to temper should be low. However, a sample could also appear compacted based on a low matrix to temper ratio when in fact the clay sources could just have few inclusions.

Table 5.7: ANOVA using Clusters for Grouping Variable

		Sum of Squares	df	Mean Square	F	Sig.
Percentage of round and subround temper to total temper	Between Groups	25959.121	5	5191.824	48.596	.000
	Within Groups	9828.919	92	106.836		
	Total	35788.040	97			
Ratio of matrix to temper points	Between Groups	1.809	5	.362	2.278	.053
	Within Groups	14.609	92	.159		
	Total	16.418	97			
Percentage of temper that is not calcite	Between Groups	129546.254	5	25909.251	177.040	.000
	Within Groups	13463.899	92	146.347		
	Total	143010.153	97			
Percentage of temper larger than .50 mm	Between Groups	1284.811	5	256.962	4.254	.002
	Within Groups	5557.155	92	60.404		
	Total	6841.966	97			

Figure 5.4: Cayo Group Rim Diameter during the Samal Phase

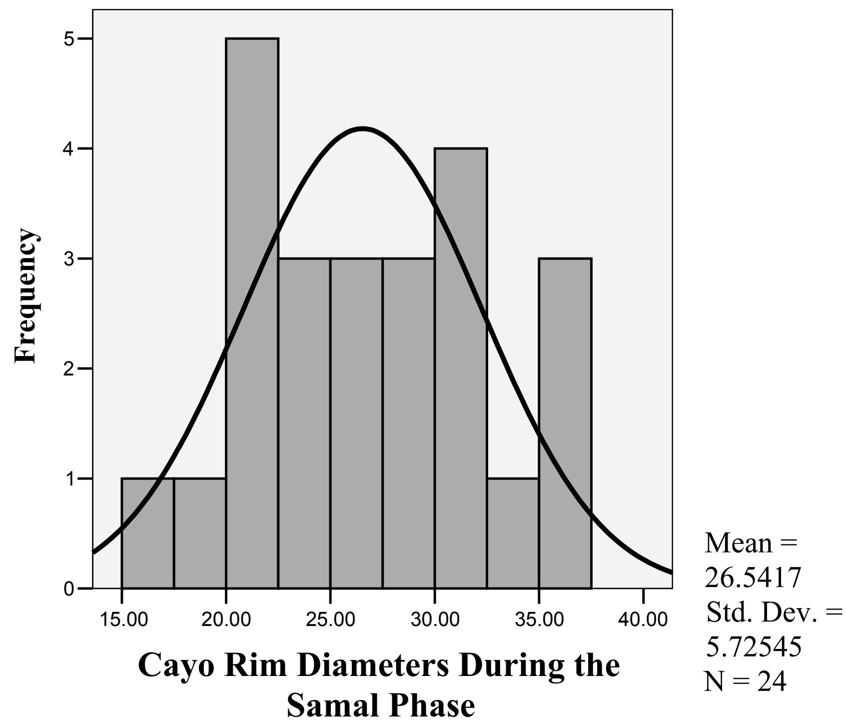


Figure 5.5: Cayo Group Rim Diameters during the Hats' Chaak Phase

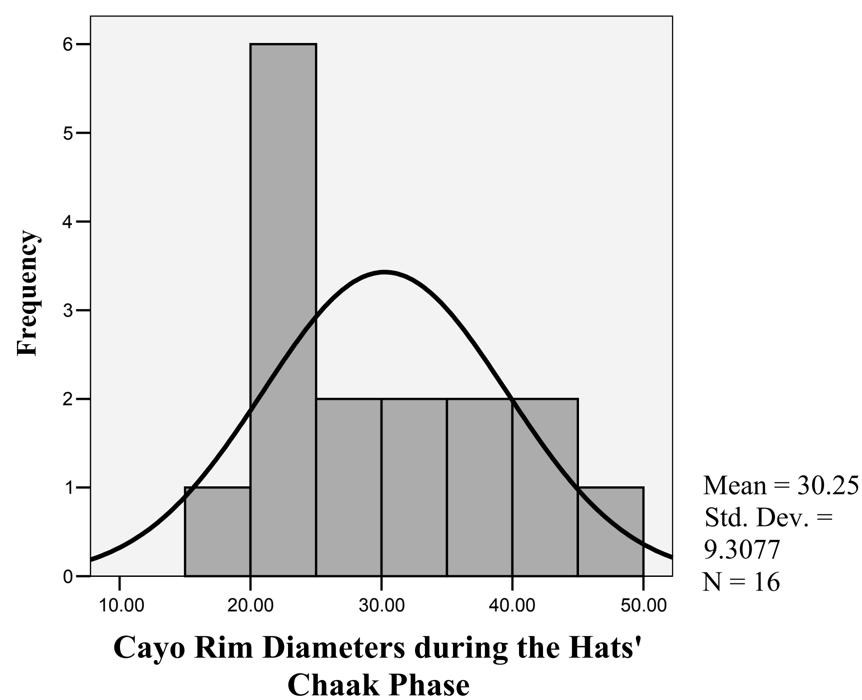


Figure 5.6: Cayo Group Rim Diameters during the Tsak’ Phase

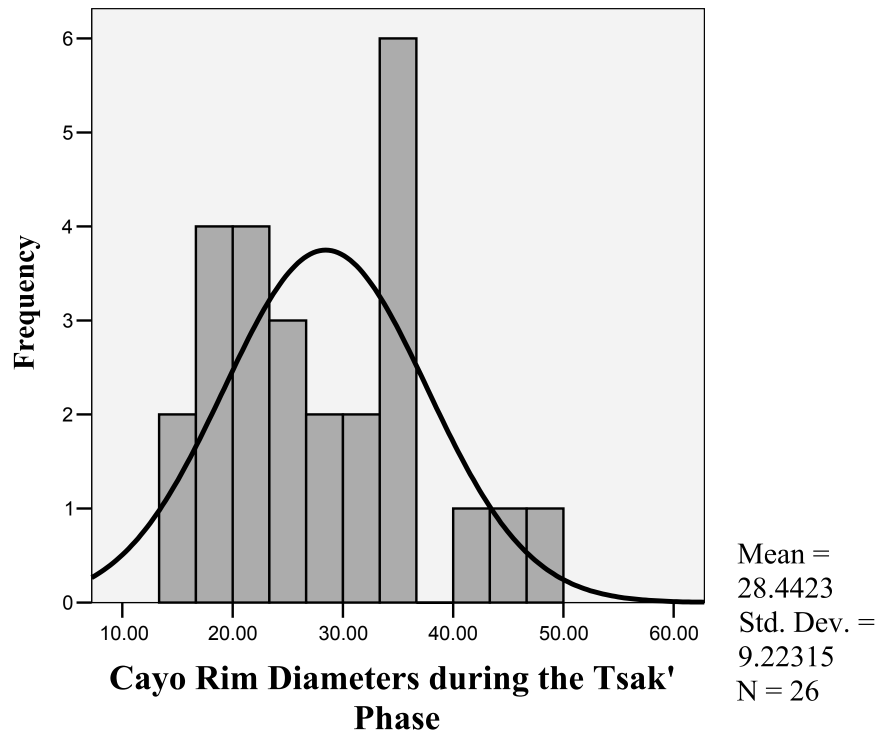


Figure 5.7 Mount Maloney Group Rim Diameters during the Samal Phase

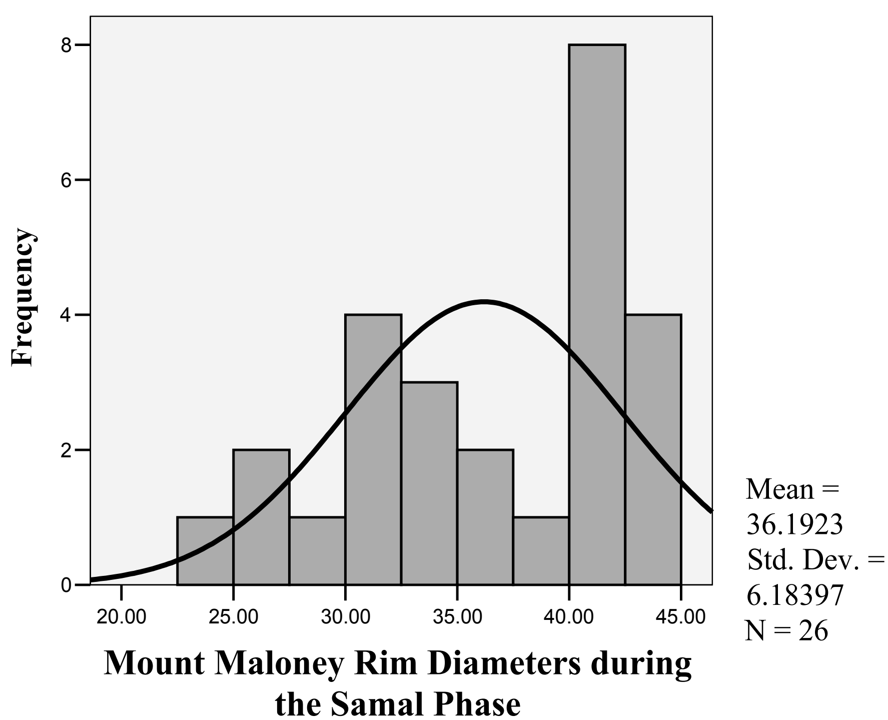


Figure 5.8: Mount Maloney Group Rim Diameters from Hats' Chaak Phase

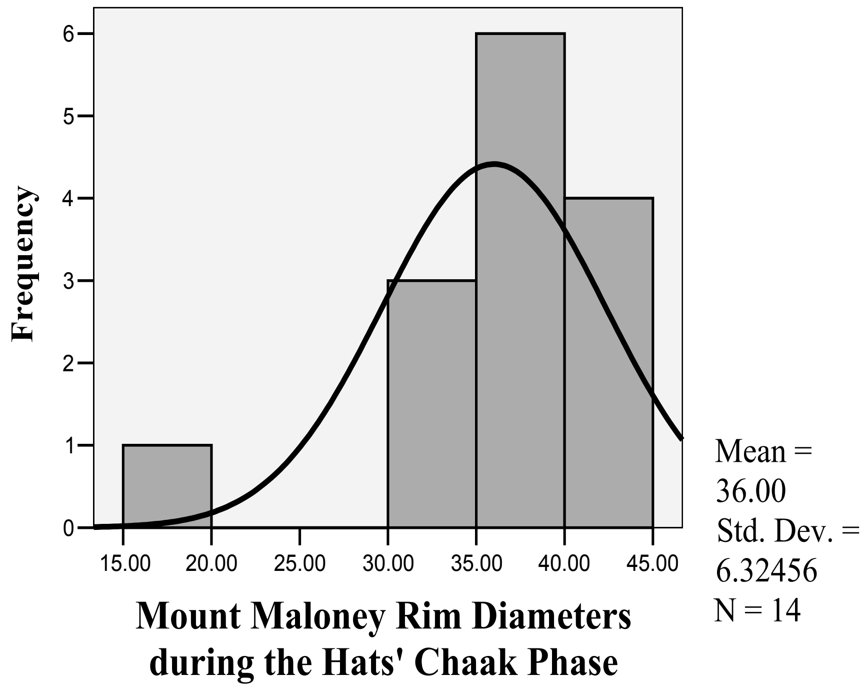
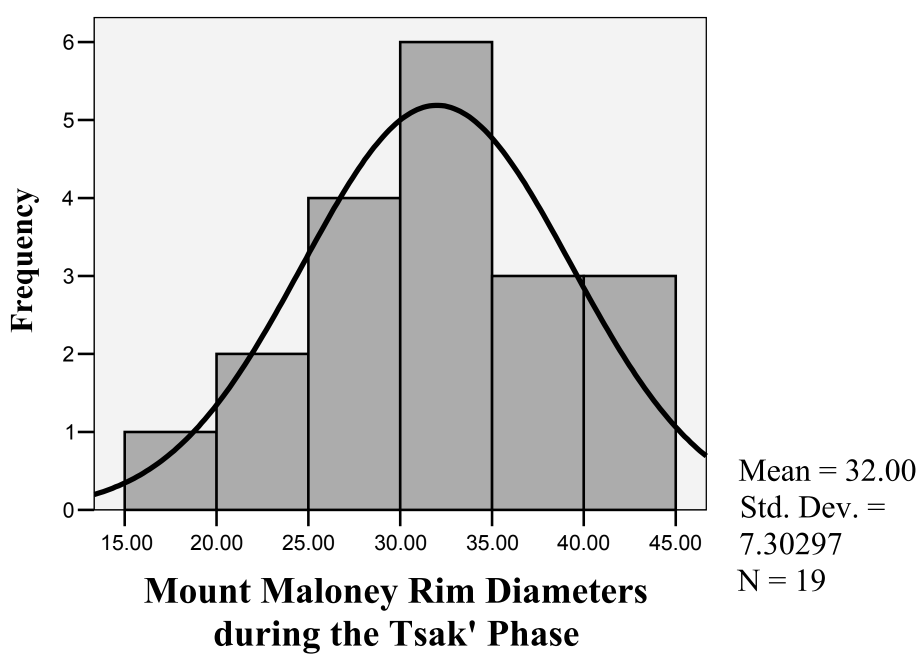


Figure 5.9: Mount Maloney Group Rim Diameters from Tsak' Phase



Chapter 6: Conclusions

The purpose of this thesis is to use a line of research, artifact analysis, to evaluate the argument of an emergent Maya market system center at Xunantunich in the Hats' Chaak phase (A.D. 680-780). Configurational, contextual, spatial, and distributional evidence all suggest the possibility of a marketplace. Location (Keller 2006), a demand-creating population, and artifact frequencies across statuses (LeCount 2002) all point to a market economy.

Keller's (2006) research suggested a marketplace near the Northeast Civic Plaza. This "Lost Plaza" is along a road and has ease of access, thus meeting Hirth's (1998, 2000) configurational parameter. Artifact assemblage from the plaza indicated two lithic production areas where artisans were finishing obsidian and chert tools, providing contextual support to the marketplace hypothesis. Not only was there a large hinterland population to provide the demand for a market, several sites are spatially oriented to allow the residents to access a marketplace at Xunantunich. Finally, LeCount's (2002) research provides distributional evidence for access to goods across social statuses by the Tsak' phase, indicating that residents had equal access to both utilitarian and serving wares, including those made of imported ash ware pastes. All four of Hirth's (1998, 2000) parameters for investigating a market economy have been satisfied at Xunantunich.

If fully commercial markets were operating, changing production strategies should affect technological aspect of goods. Market economies are associated with specialized production for several reasons. In order for producers to be successful they need to accommodate periodicity of market events by vending potentially high volume goods, acquiring and processing more raw materials to meet demand needs, and transporting finished goods to the market center (Costin 1991; Hirth 1998, 2000; Minc 2006; Plattner 1991; Rice 1987).

This thesis analyzed two ceramic groups in hopes of identifying changing levels of variability in the Late Classic period that could support a market hypothesis. One group and form, Cayo jars, is comprised of a utilitarian, unslipped large jar used for storage. They are characterized by having large inclusions in the pastes (LeCount 1996). The other group and form, Mount Maloney bowls, consist of large bowls used as multi-functional preparation and serving vessels. They have a thin black slip on the exterior, generally lack larger inclusions in the pastes, and are very densely packed during production. As multi-functional items, Mount Maloney bowls were expected to demonstrate a higher level of standardization than the single-purpose Cayo jars.

In order to support this hypothesis, the pottery must reflect increasing specialization in production. Evidence of standardization in the production process would reflect specialization. Decreased levels of variability in paste recipes during the Late Classic period may indicate specialized production for a market system.

The fallback methodology for standardization studies, the coefficient of variation, is rendered ineffective for this analysis due to non-normal data distributions. While it may accurately measure standardization for other assemblages, the sensitivity to the sample mean and standard deviation limited its utility for this research. Other statistical analysis, including ANOVA, measures of dispersion, and cluster analysis provided more benefits to this material.

For the Cayo jars, ANOVA results indicated no significant differences for mean rim diameters of different phases. Interestingly, Foias and Bishop's (1997) standardization study found rim diameters for monochrome red wares to have the opposite results. This pattern suggests that production was less specialized for utilitarian vessels in the Xunantunich area than in the Petexbatun area. ANOVA results comparing Mount Maloney bowl rim diameters over time also found there to be no significant differences. My findings are similar to previous research that shows no significant differences in chi-square tests comparing expected to observed mean rim diameters for different time periods for Mount Maloney bowls (LeCount 2005). Neither type of pottery had significantly different rim diameters when compared across sites. Given that the material spans three phases and three sites, the overall consistency in rim diameters is quite surprising. The consistency in mean rim size, regardless of the high CVs and standard deviations, is suggestive of either low-level craft specialization or consensus about the appropriate size of bowls and jars.

In addition to the statistical analysis of a formal variable, petrographic analysis was used to better understand variability in ceramic paste composition. Because formal characteristics are easy to modify to suit cultural and consumer tastes, they can be problematic indicators of specialization. How the raw materials are processed, contrastingly, is a more conservative aspect of production (Arthur 1996; Costin 1991). Using petrographic analysis allows for a detailed study of paste compositions.

When ceramic pastes were analyzed and compared, the lack of significant differences in ANOVA testing across ceramic group and phase becomes even more apparent. Variability appears to be linked to sources of raw materials and processing techniques more than time or place of production. Unlike the research from the hinterlands of Tikal and Palenque (see West 2002), there seems to be no differential access to pottery type (in this case paste group) based on distance from Xunantunich. However, more samples from distant sites would be necessary to properly evaluate this pattern.

Comparison of interquartile ranges suggests that many instances of changing variability through time could be the result of utilizing new clay sources. Because temper found in these ceramics occurred as natural inclusions, much of the variability could be the result of natural causes. Conversely, this variability could be interpreted as deliberate human choices to utilize varying clay sources. Were more clay sources utilized because of increased demand for ceramics? Did previous sources run out of good clay? Did new workshops utilize different clay sources? Currently, I have no way of evaluating between these alternative hypotheses. Additional research into raw clay and rock resources will help determine if natural or cultural factors are the cause of this variability. Some of the variability could even occur in the same general clay deposit.

Cluster analysis was run in hopes of ascertaining paste recipe groups. The cluster analysis provides the most direct information on how this sample could be grouped using statistical similarities among the variables. Similar to the other analyses conducted for this research, time and space appear to have little to no effect on paste recipe groupings. Unlike Palenque (see West 2002), paste compositions do not change rapidly as vessels are found farther away from Xunantunich. Rather, the temper composition, shape, and size determined the clusters. These results suggest that paste recipes groups are not based on site of origin of finished goods. Rather, the raw clay sources utilized for production (as reflected in temper composition) and the amount of processing (opting to remove larger inclusions or not) are what led to the formation of the clusters.

Additionally, while two clusters (clusters 5 and 6) comprised solely of Cayo ceramics were not present in the Tsak' phase, the remaining four clusters were present across all three phases. The continuity of these clusters suggests that the paste recipes, as well as the ceramic production, changed little over time. Foias and Bishop's (1997) research yielded a similar conclusion for the pastes of their utilitarian red ware vessels in the Petexbatun region during the Late and Terminal Classic periods. Considering their data, as well as mine, indicates that the production of common, everyday vessels seems to have been under little political influence, and thus able to weather political changes quite effectively.

Ceramic group also was not relevant to the paste recipe clusters. While initial ANOVA tests indicated ceramic group could be an important factor, subsequent post-hoc testing revealed that ceramic group was not as significant as originally thought. With the exception of the two, small, Cayo-only clusters, the other four clusters included both Cayo and Mount Maloney samples. As the two groups are different wares, it is particularly interesting that in this analysis, the only significant difference between them was the presence of larger temper. Perhaps a closer analysis of the clay matrix would reveal more differences. This could be accomplished through microsampling of the clay matrices with x-ray diffraction. This kind of analysis may indicate if inherent mineral differences are present between the clays of the two ceramic groups. Another avenue of future research would be to compare paste recipes of other types within the Uaxactun and Pine Ridge Carbonate wares.

The results of the cluster-grouped ANOVA tests are interesting in that they suggest the production techniques and, possibly recipes, for Mount Maloney bowls and Cayo jars appear to have been already established by the Late Classic period. Six clusters were evident during the analysis. Four of them, surprisingly, included roughly equal amounts of Mount Maloney and Cayo ceramics. The remaining two clusters were very small and only included Cayo samples.

Additionally, any changes in production technique during the Samal, Hats' Chaak, and Tsak' phases were not significant enough to be noticed by cluster analysis. However, once the clusters are mapped onto site and phase, two important distributions are visible. First, five of the six clusters are present at all three sites during the Samal and Hats' Chaak phases. Even though the samples from Xunantunich and Actuncan are *three times the size of* the San Lorenzo sample, only one of the Cayo group-only clusters is not found at San Lorenzo. This pattern argues for some level of exchange between these sites. Second, the two Cayo-only cluster groups are not present in the Tsak' phase. Constriction of the variability in paste recipes could be a result of disintegrating political administration and disruption of production units, either individual potters, workshops or communities. Potters may have emigrated to more politically-stable areas.

While increasing levels of standardization, and thus specialization, are not clearly evident in Mount Maloney and Cayo samples, the division of paste recipes by temper characteristics is not incongruent with the community specialization seen in solar and overlapping market economies. Since none of the clusters were centered on a specific site, it is possible that another site entirely is the main producer of these ceramics. Currently, it appears highly possible that specialized production of both ceramic groups was occurring during the Late and Terminal Classic in the Xunantunich area. The system of exchange for these vessels, whether it is a market economy, a redistributive one, or a combination of the two, moved finished vessels to all three sites studied in this thesis in similar frequencies. Material from a greater variety of sites in the Xunantunich area is needed to flesh out the spheres of household and spatial distributions for these two groups of pottery.

Markets may well have existed even though my results do not indicate major changes in production techniques. First, if community specialization of ceramic production had already been established prior to the advent of the Samal phase, further changes in production need not have occurred to supply a market center at Xunantunich. Second, the market economy centered on Xunantunich may not have affected the production techniques of common pottery vessels. Efficiency, in the form of labor or time saving techniques, may not have been called for if potters were not bound by market scheduling to get their wares to consumers. Third, Cayo and Mount Maloney vessels may not have been among the goods exchanged at a marketplace. Other goods besides utilitarian jars and sturdy bowls may have been the emphasis of a market system. Imported goods, such as obsidian, or highly valued perishable goods, such as feathers, could have been the preferred goods to trade.

References

Arnold, Dean E., and Alvaro L. Nieves
1992 Factors Affecting Ceramic Standardization. In *Ceramic Production and Distribution: An Integrated Approach*, edited by G. J. Bey III and C. A. Pool, pp. 93-113. Westview Press, Boulder, Colorado.

Arthur, John
2006 *Living with Pottery: Ethnoarchaeology Among the Gamo of Southwest Ethiopia*. Foundations of Archaeological Inquiry. University of Utah Press, Salt Lake City.

Benco, Nancy L.
1988 *Morphological Standardization: An Approach to the Study of Craft Specialization*. In A Pot for All Reasons, edited by D. Kolb and L. Lackey, pp. 57-72. Laboratory of Anthropology, Temple University, Philadelphia.

Beaudry, Marilyn
1984 *Ceramic Production and Distribution in the Southeastern Maya Periphery: Late Classic Painted Serving Vessels*. BAR International Series 203, Oxford.

Blackman, M. James, Gil J. Stein, and Pamela B. Vandiver
1993 The Standardization Hypothesis and Ceramic Mass Production: Technological, Compositional, and Metric Indexes of Craft Specialization at Tell Leilan, Syria. *American Antiquity* 58: 0-80.

Blanton, Richard E.
1983 Factors Underlying the Origin and Evolution of Market Systems. In *Economic Anthropology*, edited by Sutti Ortiz, pp. 51-66. University Press of America, New York.

1996 The Aztec market System and the Growth of Empire. In *Aztec Imperial Strategies*, edited by Frances F. Berdan, Richard E. Blanton, Elizabeth Hill Boone, Mary G. Hodge, Michael E. Smith, and Emily Umberger. Dumbarton Oaks, Washington, DC, pp. 47–84.

Brumfiel, E. M.
1987 Elite and Utilitarian Crafts in the Aztec State. In *Specialization, Exchange, and Complex Societies*, edited by E. M. Brumfiel and T. K. Earle, pp. 102-118. Cambridge University Press, Cambridge.

Connell, Samuel Vivian
2000 Were They Well Connected? An Exploration of Ancient Maya Regional Integration from the Middle-level Perspective of Chaa Creek, Belize. Ph.D. dissertation, University of California, Los Angeles.

Costin, C.L.
1991 Craft Specialization: Issues in Defining, Documenting, and Explaining the Organization of Production. In *Archaeological Method and Theory*, vol. 3, edited by M.B. Schiffer, pp.1-56. University of Arizona Press, Tucson.

Costin, Cathy L., and Melissa B. Hagstrum
1995 Standardization, Labor Investment, Skill, and the Organization of Ceramic Production in Late Prehispanic Highland Peru. *American Antiquity* 60:619-39.

Curta, Florin
2006 Merovingian and Carolingian Gift Giving. *Speculum* 81:671-699.

Day, Peter M.
1989 Technology and Ethnography in Petrographic Studies on Ceramics. In *Archaeometry: Proceedings of the 25th International Symposium*, edited by Y. Maniatis, pp. 139-147. Elsevier, Amsterdam.

Dahlins, Bruce H., Christopher T. Jensen, Richard E. Terry, David R. Wright, and Timothy Beach
2007 In Search of An Ancient Maya Market. *Latin American Antiquity* 18:363-384.

Demarest, Arthur
2004 *Ancient Maya : the Rise and Fall of a Rainforest Civilization*. Cambridge: Cambridge University Press.

Epstein, S.R.
1994 Regional Fairs, Institutional Innovation, and Economic Growth in Late Medieval Europe. *The Economic History Review* 47:459-482.

Foias, A. E., and R. L. Bishop
1997 Changing Ceramic Production and Exchange in the Petexbatun Region,Guatemala: Reconsidering the Classic Maya Collapse. *Ancient Mesoamerica* 8:275-91.

Freestone, Ian C.
1991 Extending Ceramic Petrology. In *Recent Developments in Ceramic Petrology*, edited by Andrew Middleton and Ian Freestone, pp. 399-410. British Museum Occasional Paper No. 81, London.

Friedel, David

1981 The Political Economies of Residential Dispersion Among the Lowland Maya. In *Lowland Maya Settlement Patterns*, edited by Wendy Ashmore, pp. 371-384. Albuquerque: University of New Mexico Press.

Gifford, J.

1976 *Prehistoric Pottery Analysis and the Ceramics of Barton Ramie in the Belize Valley*. Memoirs of the Peabody Museum of Archaeology and Ethnology, vol. 18. Harvard University, Cambridge, MA.

Gosselain, Olivier

1998 Social and Technical Identity in a Clay Crystal Ball. In *The Archaeology of Social Boundaries,* edited by Miriam T. Stark, pp. 78-106. Smithsonian Institutional Press, Washington, D.C.

Hammond, Norman

1982 *Ancient Maya Civilization*. New Brunswick: Rutgers University Press.

Hirth, Kenneth G.

1996 Political Economy and Archaeology: Perspectives on Exchange and Production, *Journal of Archaeological Research* 4:203-239.

1998 The Distributional Approach: A New Way to Identify Marketplace Exchange in the Archaeological Record. *Current Anthropology* 39:451-476.

2000 The Economies of Distribution: Marketplaces, Market Systems, and Long-Distance Trade. In *Ancient Urbanism at Xochicalco: The Evolution and Organization of a Pre-Hispanic Society*, Archaeological Research at Xochicalco Vol. 1, edited by K. Hirth, pp. 182-209. University of Utah Press, Salt Lake City.

Howie, Linda

2005 Provenance, Style, and Technology: Integrated Approaches to Ceramic Production and Exchange During the Classic to Postclassic Transition.

Hunt, Edwin S. and James R. Murray

1999 *A History of Business in Medieval Europe 1200-1550*. Cambridge University Press, New York.

Keller, Angela

2006 Roads to the Center: The Design, Use, and Meaning of Roads at Xunantunich, Belize. Ph.D. dissertation, University of California, Los Angeles.

Kvamme, Kenneth L., Miriam T. Stark, and William A. Longacre

1996 Alternative Procedures for Assessing Standardization in Ceramic Assemblages. *American Antiquity* 61: 116-26.

LeCount, Lisa J.
1996 Pottery and Power: Feasting, Gifting, and Displaying Wealth among the Late and Terminal Classic Lowland Maya, Ph.D. dissertation, University of California, Los Angeles.

1999 Polychrome Pottery and Political Strategies in Late and Terminal Classic Maya Society. *Latin American Antiquity* 10: 239-258.

2005 Continuity and Change in the Ceramic Complex at Xunantunich, Belize. In *Geographies of Power: Understanding the Nature of Terminal Classic Pottery in the Maya Lowlands*. Edited by Sandra Lopez Varela and Antonia Foias, pages 93-107. Monograph series. British Archaeological Reports.

LeCount, Lisa J., and John H. Blitz
2001 *The Actuncan Early Classic Maya Project: the 2001 Field Season*. University of Alabama, Tuscaloosa, AL and Belmopan, Belize, Central America.

LeCount, Lisa J., John H. Blitz, and Rebecca Scopa Kelso
2004 *Actuncan Early Classic Maya Project: Report of the Second Season*. University of Alabama.

Lentz, David L., Jason Yaeger, Cynthia Robin, and Wendy Ashmore
2005 Pine, Prestige, and Politics of the Late Classic Maya at Xunantunich, Belize. *Antiquity* 79:573-585.

Little, Peter D.
1987 Domestic Production and Regional Markets in Northern Kenya**.** *American Ethnologist* 14:295-308.

Longacre, William
1985 Pottery Use-Life among the Kalinga, Northern Luzon, the Philippines. In *Decoding Prehistoric Ceramics*, edited by Ben A. Nelson, pp. 153-93. Southern Illinois University Press, Carbondale.

Longacre, W., K. Kwamme, and M. Kobayashi
1988 Southwestern Pottery Standardization: An Ethnoarchaeological View from the Philippines. *Kiva* 53:101-12.

Martin, Simon and Nikolai Grube
2000 *The Chronicles of Maya Kings and Queens*. London: Thames and Hudson.

Masson, Marilyn A.
2002 Introduction. In *Ancient Maya Political Economies*, edited by Marilyn A. Masson and David A. Freidel, pp. 1-31. Walnut Creek, CA: Altamira Press.

Mauss, Marcel

1990 *The Gift: The Form and Reason for Exchange in Archaic Societies*. Translated by W.D. Halls. London: Routledge.

McCormick, Michael
2001 *The Origins of the European Economy: Communications and Commerce, A.D. 300-900*. Cambridge University Press, New York.

McGovern, James Owen
2004 Monumental Ceremonial Architecture and Political Autonomy at the Ancient Maya City of Actuncan, Belize. Ph.D. dissertation, University of California, Los Angeles.

Minc, Leah D.
2006 Monitoring Regional Market Systems in Prehistory: Models, Methods, and Metrics. *Journal of Anthropological Archaeology* 25:82-116.

Minc, Leah D., Mary G. Hodge, M. James Blackman
1994 Stylistic and Spatial Variability in Early Aztec Ceramics: Insights into Pre-Imperial Exchange Systems. In *Economies and Polities in the Aztec Realm*, edited by Mary G. Hodge and Michael E. Smith, pp. 133-173. IMS Studies on Culture and Society Series No. 6, Institute for Mesoamerican Studies, State University of New York, Albany.

Nichols, Deborah L., Elizabeth Brumfiel, Hector Neff, Mary Hodge, Thomas H. Charlton, and Michael D. Glascock
2002 Neutrons, Markets, Cities, and Empires: A 1000-year Perspective on Ceramic Production and Distribution in the Postclassic Basin of Mexico. *Journal of Anthropological Archaeology* 21:25-82.

Moore, Ellen W.
1985 *The Fairs of Medieval England: An Introductory Study.* Universa, Toronto, Ontario.

Pauketat, Timothy and Susan Alt
2004 The Making and Meaning of a Mississippian Axe-head Cache. *Antiquity* 78:779-797

Plattner, Stuart
1989 Markets and Marketplaces. In *Economic Anthropology*, edited by Stuart Plattner, pp. 171-208. Stanford University Press, Stanford.

Preziosi, Aimee Maria

2003 Patterns of Style: The Ceramic Record and Community Differentiation, a study from Xunantunich, Belize. Ph.D. dissertation, University of California, Los Angeles.

Renfrew, Colin

1975 Trade as Action at a Distance: Questions of Integration and Communication. In *Ancient Civilization and Trade*, edited by Jeremy A. Sabloff and C.C. Lamberg-Karlovsky, pp. 3-59l. University of New Mexico Press, Albuquerque.

1977 Alternative Models for Exchange and Spatial Distribution. In *Exchange Systems in Prehistory*, edited Timothy K. Earle and J.E. Erickson, pp. 71-90. Academic Press, New York.

Rice, Prudence M.

1981 Evolution of Specialized Pottery Production: A Trial Model. *Current Anthropology* 22:219-240.

1987 Economic Change in the Lowland Maya Late Classic Period. In *Specialization, Exchange, and Complex Societies*, edited by E. M. Brumfield and T. K. Earle, pp. 76-85. Cambridge University Press, Cambridge.

1996 Recent Ceramic Analysis Part 2: Composition, Production, and Theory. *Journal of Archaeological Research* 4:165-202.

2006 Pottery Analysis: A Sourcebook. University of Chicago Press, Chicago.

Robin, Cynthia

1999 Towards an Archaeology of Everyday Life: Maya Farmers of Chan Nòohol and Dos Chombitos Cik'in, Belize. Ph.D. dissertation, University of Pennsylvania, Ann Arbor.

Smith, Carol

1976 Regional Economic Systems: Linking Geographic Models and Socioeconomic Problems. In *Regional Analysis*, vol. I, edited by C. Smith, pp. 3-63. Academic Press, New York.

Smith, Michael, and Frances F. Berdan

2003 *The Postclassic Mesoamerican World*. University of Utah Press, Salt Lake City.

Stark, Barbara L.

1985 Archaeological Identification of Pottery Production Locations: Ethnoarchaeological and Archaeological Data in Mesoamerica. In *Decoding*

Prehistoric Ceramics, edited by Ben A. Nelson, pp. 154-194. Southern Illinois University Press, Carbondale.

1995 Problems in Analysis of Standardization and Specialization in Pottery. In *Ceramic Production in the American Southwest*, edited by B.J. Mills and P.L. Crown, pp. 231-268. University of Arizona Press, Tucson.

Stoltman, James

1989 A Quantitative Approach to the Petrographic Analysis of Ceramic Thin Sections. *American Antiquity* 54:147-160.

1991 Ceramic Petrography as a Technique for Documenting Cultural Interaction: An Example from the Upper Mississippi Valley. *American Antiquity* 56:103-120.

Stoltman, James B., Daniele Benden, and Robert F. Boszhardt

2008 New Evidence in the Upper Mississippi Valley for Pre-Mississippian Cultural Interaction with the American Bottom. *American Antiquity* 72:317-36.

Tomkins, Peter, Peter M. Day, and Vasillis Kilikoglou

2004 Knossos and the Earlier Neolithic Landscape of the Herakleion Basin. *In Knossos: Palace, City, State: Proceedings of the Conference in Herakleion Organised by the British School at Athens and the 23rd Ephoreia of Prehistoric and Classical Antiquities of Herakleion, in November 2000, for the Centenary of Sir Arthur Evan's Excavations at Knossos*, edited by Gerald Cadogan, Eleni M. Hatzaki, Adonis Vasilakis, Antones Vasilakes, and Arthur Evans, pp. 51-59. British School at Athens, Athens.

Sillitoe, Paul

2006 Why Spheres of Exchange? *Ethnology* 45:1-23.

Whitbread, Ian

1989 A Proposal for the Systematic Description of Thin Sections Towards the Study of Ancient Ceramic Technology. In *Archaeometry: Proceedings of the 25th International Symposium*, edited by Y. Maniatis, pp. 127-138. Elsevier, Amsterdam.

1996 Detection and Interpretation of Preferred Orientation in Ceramic Thin Sections. In Imaging the Past : Electronic Imaging and Computer Graphics in Museums and Archaeology, edited by Janet Lang, Peter Main, and Tony Higgins, pp. 413-425. British Museum, Department of Scientific Publications, London.

Yaeger, Jason

2000 Changing Patterns of Social Organization: the Late and Terminal Classic Communities at San Lorenzo, Cayo District, Belize. Ph.D. dissertation, University of Pennsylvania, Ann Arbor.

Appendix A: Detailed Table of Sample Contexts Sorted by Provenience Number

Provenience	Group*	Phase	Site**	Structure	Gross Context	Detailed Context	Thin-section
1C4.01	MM	Tsak'	Act	Str 62	Residence	terrace	yes
1C4.02	MM	Tsak'	Act	Str 62	Residence	terrace	yes
1D2.01	MM	Samal	Act	Str 59	Residence	fill	no
1D3.01	MM	Samal	Act	Str 59	Residence	trash	yes
1D3.02	MM	Samal	Act	Str 59	Residence	trash	no
1D3.03	MM	Samal	Act	Str 59	Residence	trash	no
1D3.04	MM	Samal	Act	Str 59	Residence	trash	yes
1D3.05	MM	Samal	Act	Str 59	Residence	trash	yes
1D3.06	MM	Samal	Act	Str 59	Residence	trash	no
1D3.07	MM	Samal	Act	Str 59	Residence	trash	yes
1D3.08	MM	Samal	Act	Str 59	Residence	trash	yes
1D3.10	MM	Samal	Act	Str 59	Residence	trash	yes
1D3.12	MM	Samal	Act	Str 59	Residence	trash	yes
1D3.16	MM	Samal	Act	Str 59	Residence	trash	yes
1D3.17	MM	Samal	Act	Str 59	Residence	trash	yes
1D3.18	MM	Samal	Act	Str 59	Residence	trash	yes
1D3.30	Cayo	Samal	Act	Str 59	Residence	trash	yes
1D3.31	Cayo	Samal	Act	Str 59	Residence	trash	yes
1D3.32	Cayo	Samal	Act	Str 59	Residence	trash	yes
1D3.34	Cayo	Samal	Act	Str 59	Residence	trash	yes

1D3.35	Cayo	Samal	Act	Str 59	Residence	trash	yes
1D3.41	Cayo	Samal	Act	Str 59	Residence	trash	yes
1D3.43	Cayo	Samal	Act	Str 59	Residence	trash	yes
1D3.44	Cayo	Samal	Act	Str 59	Residence	trash	yes
1D3.45	Cayo	Samal	Act	Str 59	Residence	trash	yes
1D3.50	Cayo	Samal	Act	Str 59	Residence	trash	yes
1D3.51	Cayo	Samal	Act	Str 59	Residence	trash	yes
1D3.52	Cayo	Samal	Act	Str 59	Residence	trash	yes
1D3.53	Cayo	Samal	Act	Str 59	Residence	trash	yes
1D3.54	Cayo	Samal	Act	Str 59	Residence	trash	yes
1D3.55	Cayo	Samal	Act	Str 59	Residence	trash	yes
1D3.56	Cayo	Samal	Act	Str 59	Residence	trash	yes
1D6.01	Cayo	Samal	Act	Str 59	Residence	fill/refuse	yes
1D6.02	Cayo	Samal	Act	Str 59	Residence	fill/refuse	no
1D8.01	Cayo	Samal	Act	Str 59	Regal-ritual	Cache F2	yes
1D8.02	Cayo	Samal	Act	Str 59	Regal-ritual	Cache F2	yes
1D11.01	MM	Samal	Act	Str 59	Residence	fill/wall of platform 59	yes
1D11.02	Cayo	Samal	Act	Str 59	Residence	fill/wall of platform 60	yes
1D11.03	Cayo	Samal	Act	Str 59	Residence	fill/wall of platform 61	yes
5B1.01	MM	Samal	Act	Str 18	elite activities	surface	yes
5B1.03	Cayo	Samal	Act	Str 18	elite activities	surface	no
5B2.01	MM	Hats' Chaak	Act	Str 18	elite activities	collapse	no

5B2.02	MM	Hats' Chaak	Act	Str 18	elite activities	collapse	yes
5B2.03	MM	Samal	Act	Str 18	elite activities	collapse	yes
5B5.01	MM	Samal	Act	Str 18	elite activities	platform fill	no
5B5.02	MM	Samal	Act	Str 18	elite activities	platform fill	yes
5B6.02	MM	Hats' Chaak	Act	Str 18	elite activities	patio floor and platform wall	yes
6B3.04	Cayo	Tsak'	Act	Str 41	elite residence	platform fill	no
6C2.01	Cayo	Tsak'	Act	Str 41	elite activities	fill and collapse	yes
6C2.02	Cayo	Tsak'	Act	Str 41	elite activities	fill and collapse	yes
6C2.03	Cayo	Tsak'	Act	Str 41	elite activities	fill and collapse	yes
6C2.04	Cayo	Tsak'	Act	Str 41	elite activities	fill and collapse	yes
6C2.06	Cayo	Tsak'	Act	Str 41	elite activities	fill and collapse	yes
6C2.07	MM	Tsak'	Act	Str 41	elite activities	fill and collapse	yes
6C2.12	MM	Samal	Act	Str 41	elite activities	fill and collapse	yes
12G/1	MM	Samal	Act	Str 5	Regal-ritual	Looter's trench	yes
15H/2.01	MM	Tsak'	Xunan	Str A-4	Civic	collapse	yes

15H/2.02	MM	Tsak’	Xunan	Str A-4	Civic	collapse	no
18C/6.4124	MM	Samal	Xunan	Plaza C, Group 2	non-residential	Plaza fill	no
18L/5.4048	MM	Hats’ Chaak	Xunan	Plaza C, Group 2	non-residential	Plaza fill	Yes
22L/5.4708.01	MM	Hats’ Chaak	Xunan	Str D-7	elite residence	collapse	yes
22L/5.4708.02	MM	Hats’ Chaak	Xunan	Str D-7	elite residence	collapse	no
22L/5.4708.03	MM	Hats’ Chaak	Xunan	Str D-7	elite residence	collapse	yes
22O/3.4746.01	MM	Tsak’	Xunan	Str D-7	elite residence	collapse	yes
22O/3.4746.02	MM	Tsak’	Xunan	Str D-7	elite residence	collapse	yes
22Q/4.4457	MM	Tsak’	Xunan	Str D-7	elite residence	collapse	yes
22Q/6.4783	MM	Tsak’	Xunan	Str D-7	elite residence	occupation	yes
22Q/6.4783	Cayo	Tsak’	Xunan	Str D-7	elite residence	occupation	yes
22T/1.11452	Cayo	Tsak’	Xunan	Str D-7	elite residence	undisturbed surface	yes
22T/3.11477	Cayo	Tsak’	Xunan	Str D-7	elite residence	refuse deposit	no
22V/2.11523	Cayo	Tsak’	Xunan	Str D-7	elite residence	refuse deposit	no
23G/3	MM	Tsak’	Xunan	Str D-8	elite residence	Terrace wall	yes
40ZZ/2	MM	Tsak’	Xunan	Str A-6	Regal-ritual	Fill of White wall (A-6-1st)	yes
76G/1.8025	Cayo	Tsak’	Xunan	Str A-1	Regal-ritual	collapse	yes
76I/1	MM	Tsak’	Xunan	Str A-1	Regal-ritual	collapse	no

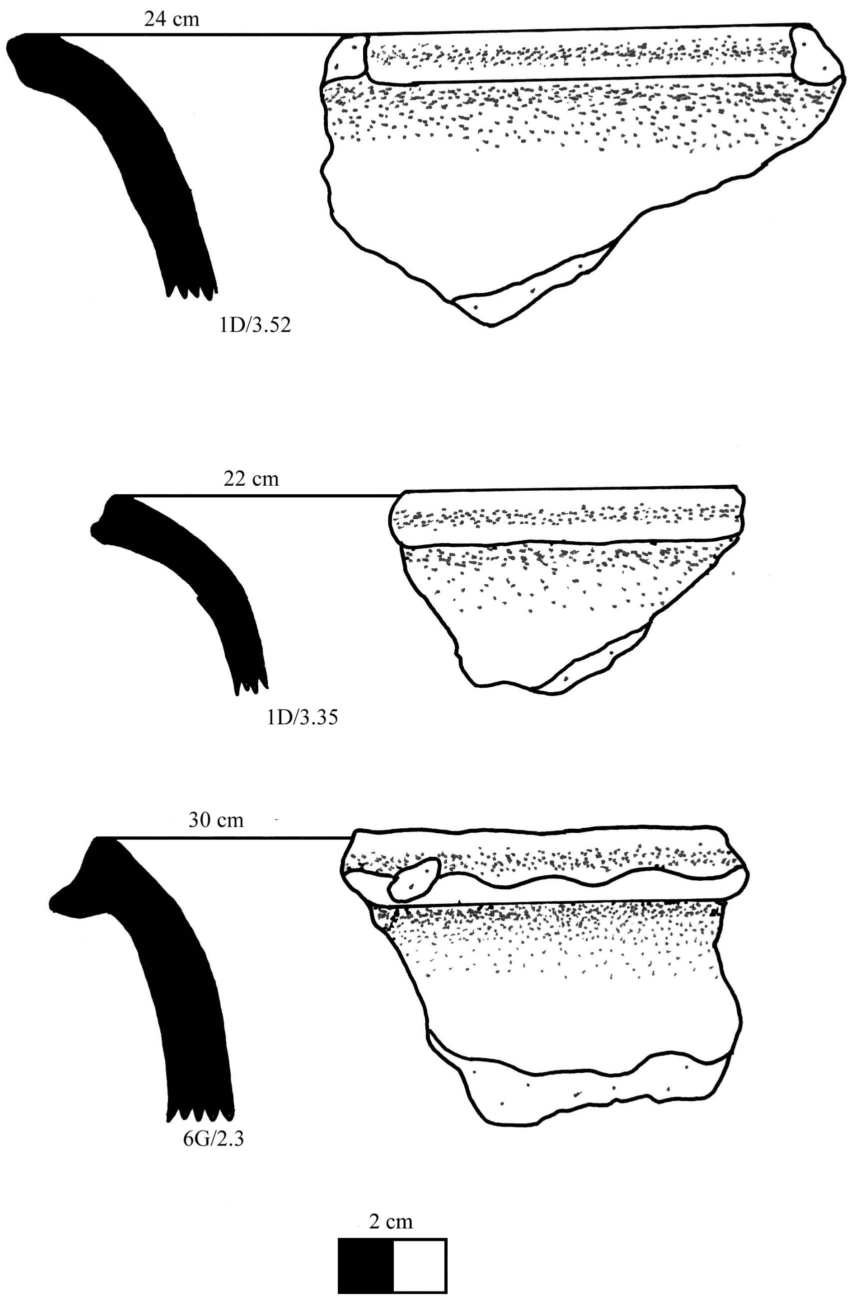
77C/1	MM	Hats' Chaak	Xunan	Cave	Regal-ritual	grab sample	yes
77C/1	MM	Hats' Chaak	Xunan	Cave	Regal-ritual	grab sample	yes
79C/5.4660	MM	Tsak'	Xunan	Str A-1	Regal-ritual	collapse	yes
79DD/3.7050	MM	Hats' Chaak	Xunan	Str A-1 sub	Regal-ritual	fill	no
79JJ/11.15018	MM	Hats' Chaak	Xunan	Str A-1 sub	Regal-ritual	Fill	no
79N/2.4990	Cayo	Tsak'	Xunan	Str A-1 sub	Regal-ritual	collapse	no
85C/1.6018	MM	Tsak'	SL	SL 22	Residence	surface	yes
85G/3.6300.01	MM	Tsak'	SL	SL 22	Residence	structure floor	yes
85G/3.6300.02	MM	Tsak'	SL	SL 22	Residence	structure floor	yes
85J/1.6456	Cayo	Tsak'	SL	SL 22	Residence	surface	no
85J/1.6458	Cayo	Tsak'	SL	SL 22	Residence	surface	yes
85O/4.6732	Cayo	Tsak'	SL	SL 22	Residence	structure floor	yes
85P/1.6762	MM	Tsak'	SL	SL 22	Residence	structure floor	yes
89J/2.7061	Cayo	Tsak'	Xunan	Str D-4	elite residence	collapse	yes
90A/2.10275	MM	Samal	SL	SL 22	Residence	collapse	yes
90C/1.10196	Cayo	Tsak'	SL	SL 22	Residence	surface	yes
90C/3.10233	Cayo	Tsak'	SL	SL 22	Residence	fill	yes
90E/1.10000	Cayo	Tsak'	SL	SL 22	Residence	surface	yes
90G/6.7486	Cayo	Hats' Chaak	SL	SL 22	Residence	collapse	no
95B/3.8289	Cayo	Hats' Chaak	SL	SL 23	Residence	refuse deposit	yes
95C/5.8462	Cayo	Tsak'	SL	SL test	Residence	refuse deposit	no
95H/2.8726	Cayo	Tsak'	SL	SL 13	Regal-ritual	collapse	yes

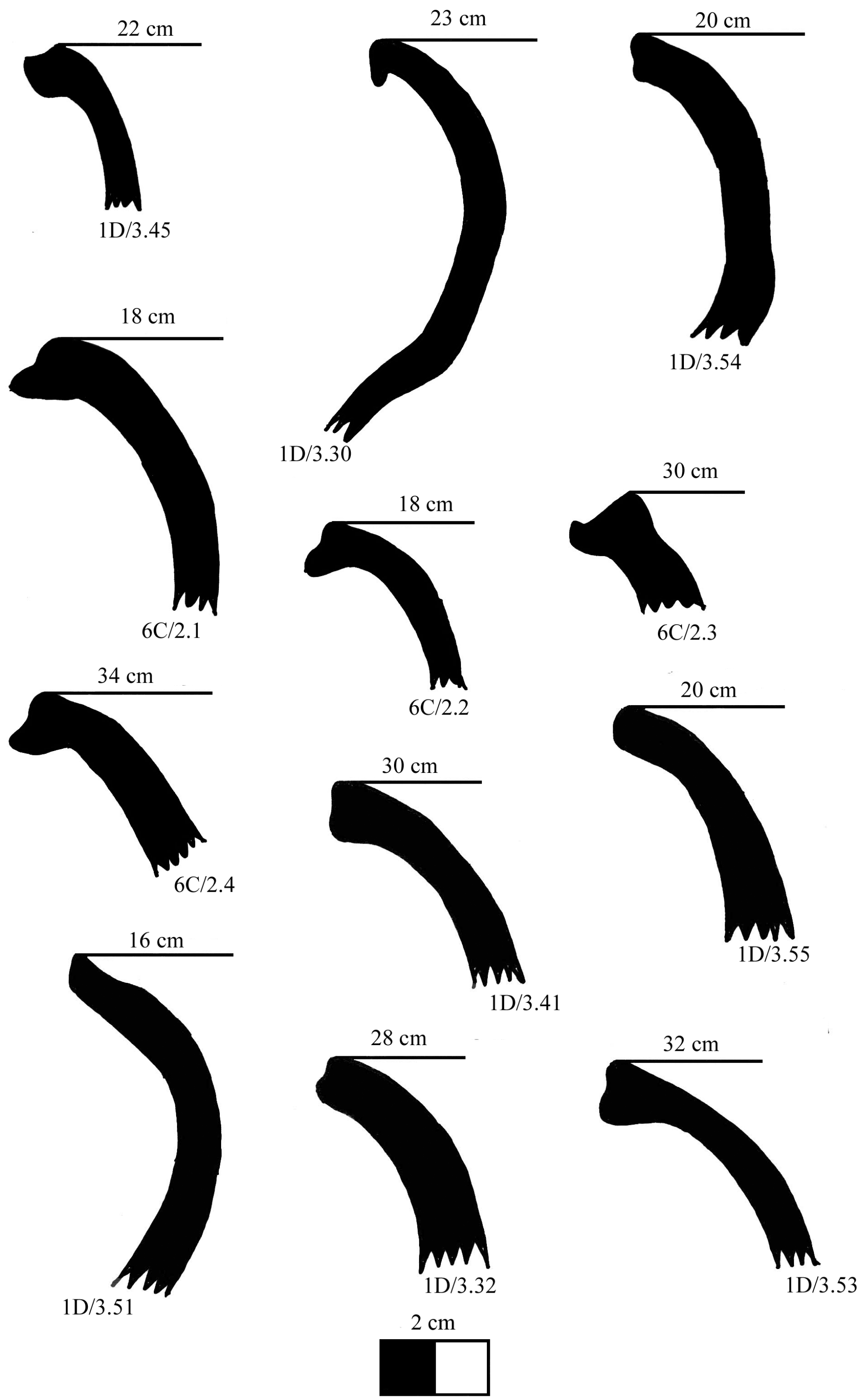
95H/2.8726.02	Cayo	Tsak’	SL	SL 13	Regal-ritual	collapse	yes
95H/2.8726.03	Cayo	Tsak’	SL	SL 13	Regal-ritual	collapse	no
96B/2.9740	Cayo	Tsak’	Xunan	Str 26	Service area	collapse	yes
102H/2.15121	MM	Hats’ Chaak	Xunan	Str A-6-1st	Regal-ritual	Fill of violet wall	yes
102H/2.15122	MM	Samal	Xunan	Str A-6-1st	Regal-ritual	Fill of violet wall	no
102H/2.15123	MM	Hats’ Chaak	Xunan	Str A-6-1st	Regal-ritual	Fill of violet wall	yes
102H/2.15124	MM	Hats’ Chaak	Xunan	Str A-6-1st	Regal-ritual	Fill of violet wall	no
110U/2.13110	Cayo	Tsak’	SL	SL 22	Residence	Collapse	yes
116A/3.10933	Cayo	Hats’ Chaak	Xunan	Str A-23	Service area	material on top of plaza floor	yes
116C/4.10968	Cayo	Hats’ Chaak	Xunan	Str A-23	Service area	refuse deposit	yes
117A/2.10523	Cayo	Hats’ Chaak	Xunan	Str A-25	Service area	Collapse	yes
117G/3.10755	Cayo	Hats’ Chaak	Xunan	Str A-25	Service area	refuse deposit	no
117G/3.10756	Cayo	Hats’ Chaak	Xunan	Str A-25	Service area	refuse deposit	yes
117I/3.10649	Cayo	Hats’ Chaak	Xunan	Str A-25	Service area	indeterminate occupation	yes
117I/4.10658	Cayo	Hats’ Chaak	Xunan	Str A-25	Service area	Collapse	yes
117I/4.10658	Cayo	Hats’ Chaak	Xunan	Str A-25	Service area	Collapse	no
117I/8.10689	Cayo	Hats’ Chaak	Xunan	Str A-25	Service area	refuse deposit	yes
123A/7.11193	Cayo	Tsak’	Xunan	Str A-24	Service area	refuse deposit	no

123A/8.11216.01	Cayo	Hats' Chaak	Xunan	Str A-24	Service area	refuse deposit	yes
123A/8.11216.02	Cayo	Hats' Chaak	Xunan	Str A-24	Service area	refuse deposit	yes
123A/10.11278	Cayo	Hats' Chaak	Xunan	Str A-24	Service area	refuse deposit	yes
123C/4.11334	Cayo	Tsak'	Xunan	Str A-24	Service area	Collapse	yes
123C/8.11382	Cayo	Hats' Chaak	Xunan	Str A-24	Service area	refuse deposit	yes
123C/8.11386	Cayo	Hats' Chaak	Xunan	Str A-24	Service area	refuse deposit	yes

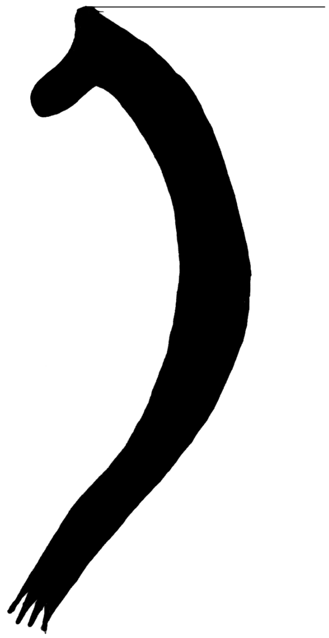
Appendix B: Illustrations of Sample Material

This appendix contains illustrations of the ceramic sample used in this thesis. The illustrations are labeled with rim diameter values at the rims of the sherds. Provenience numbers are placed immediately beneath the sherds. All the Cayo Unslipped sherd illustrations are presented first. All the Mount Maloney sherd illustrations follow. No internal organization by site of origin or phase is used.


24 cm
1D/3.52
22 cm
1D/3.35
30 cm
6G/2.3
2 cm

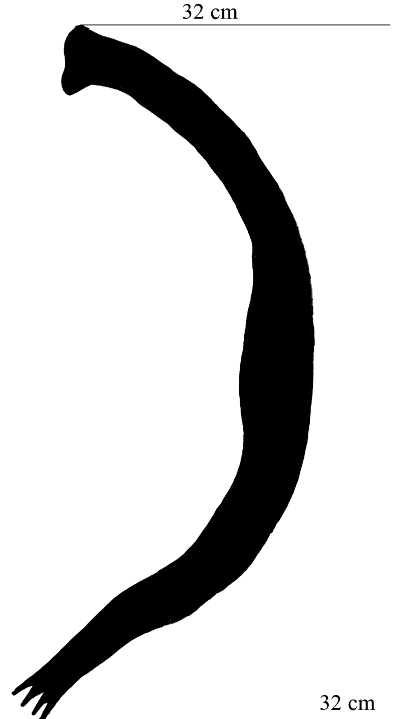

22 cm
1D/3.45
23 cm
1D/3.30
20 cm
1D/3.54
18 cm
6C/2.1
18 cm
6C/2.2
30 cm
6C/2.3
34 cm
6C/2.4
30 cm
1D/3.41
20 cm
1D/3.55
16 cm
1D/3.51
28 cm
1D/3.32
32 cm
1D/3.53
2 cm

46 cm



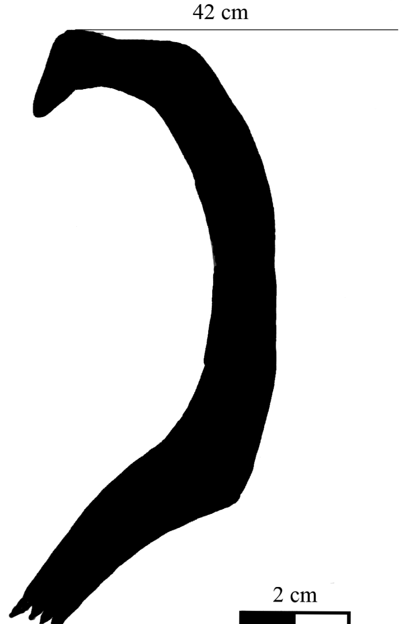
123C/4.11334

32 cm



40BB/2.7375

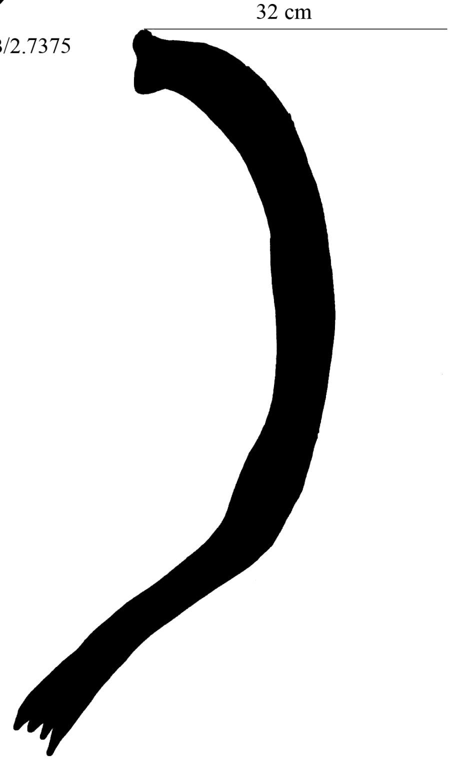
42 cm



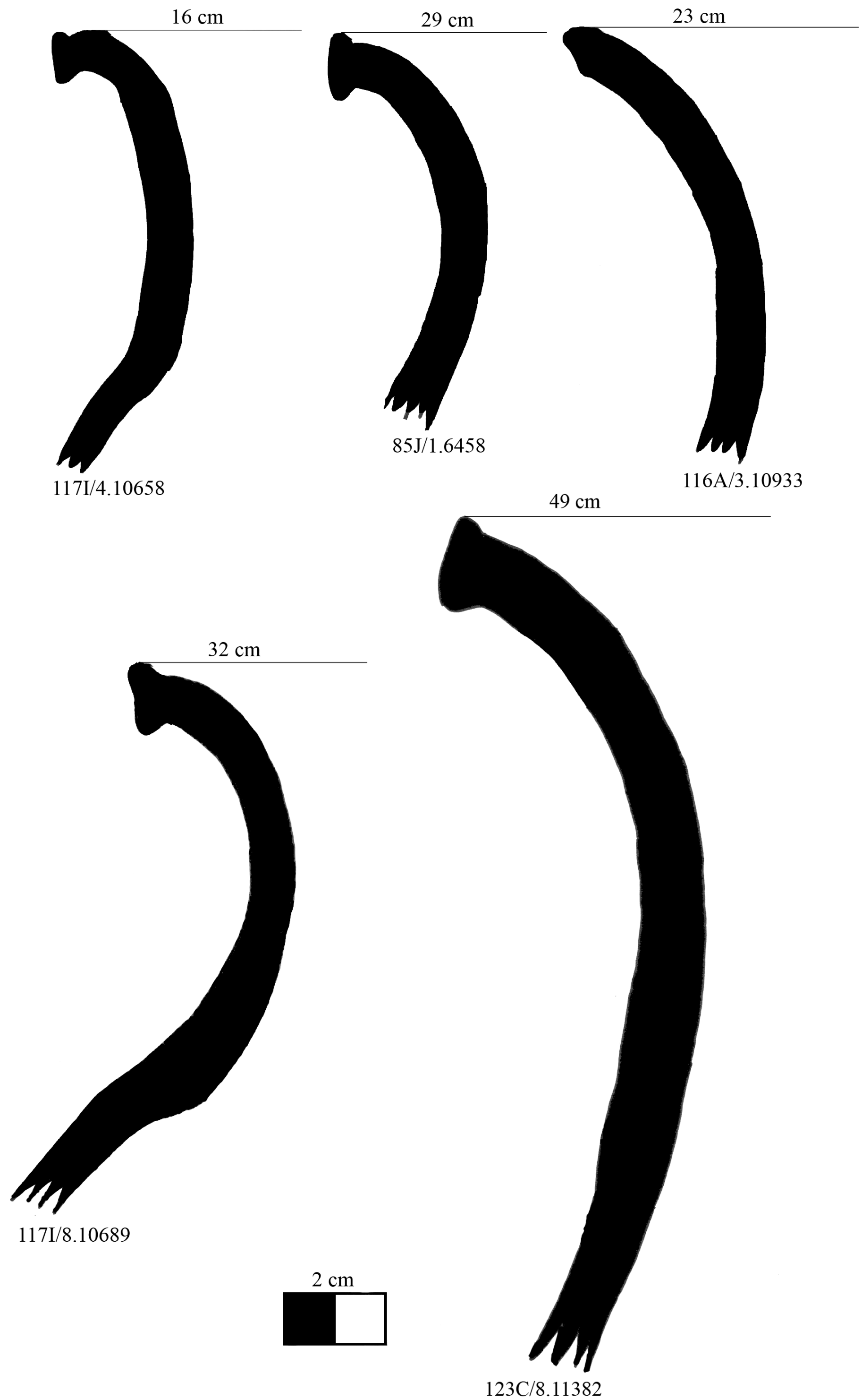
96B/2.9740

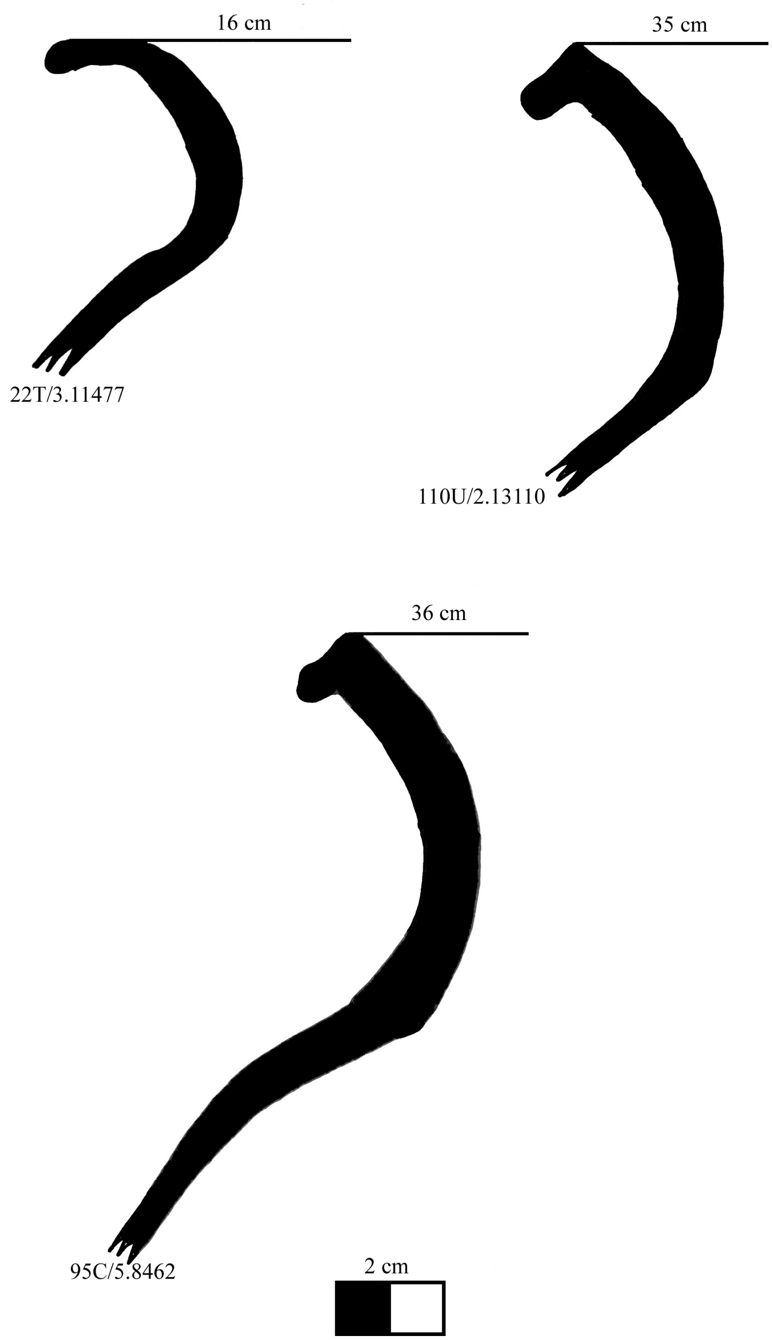
2 cm

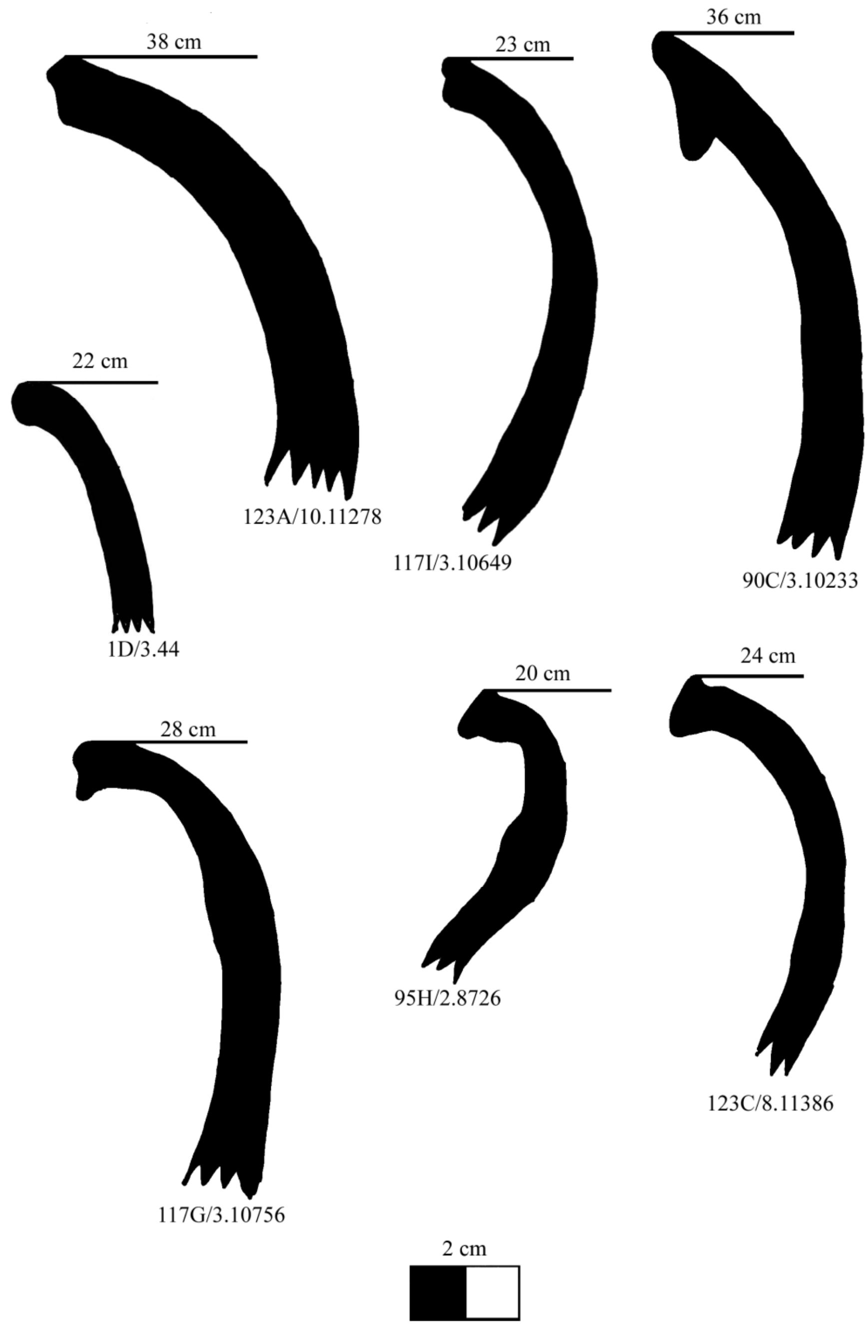
32 cm

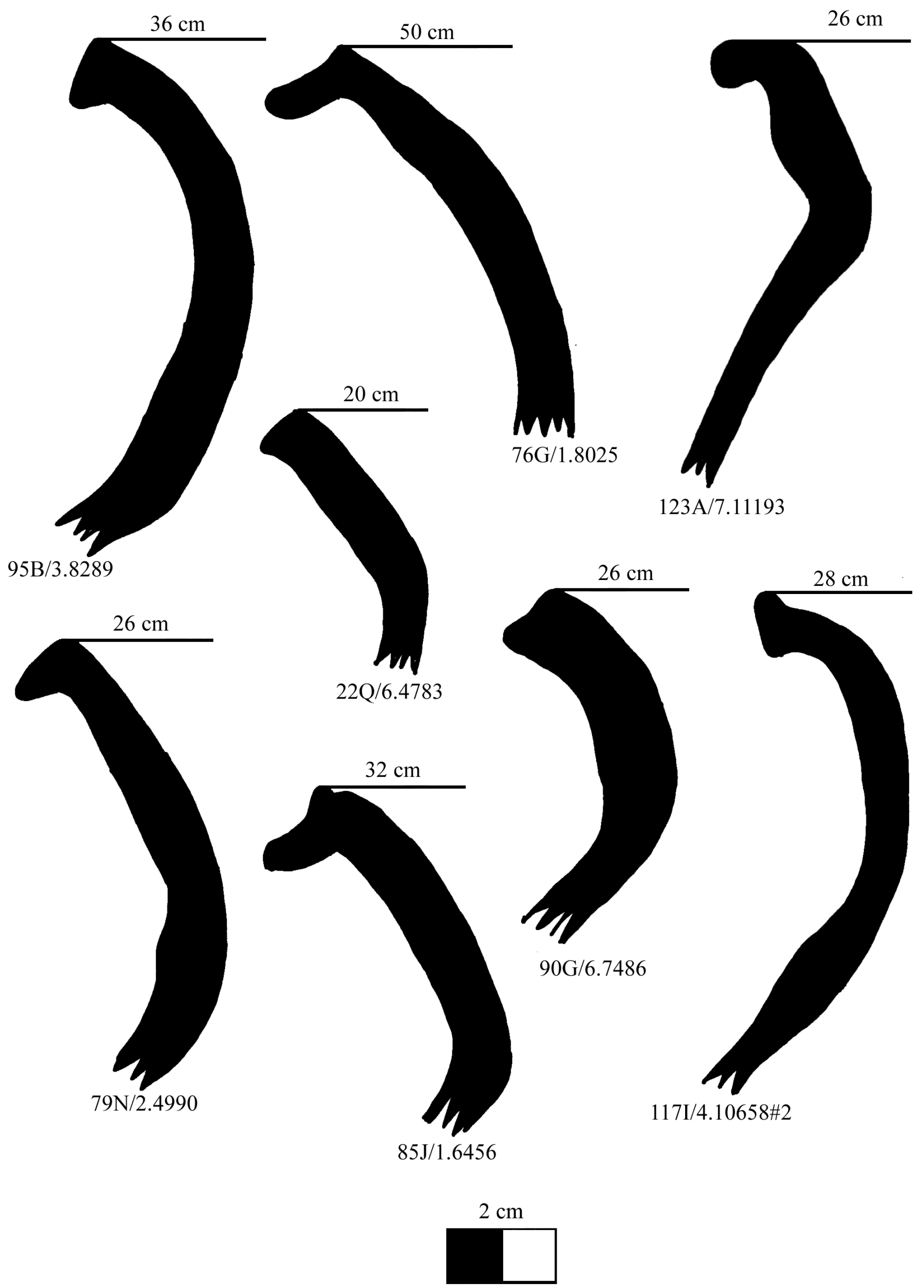


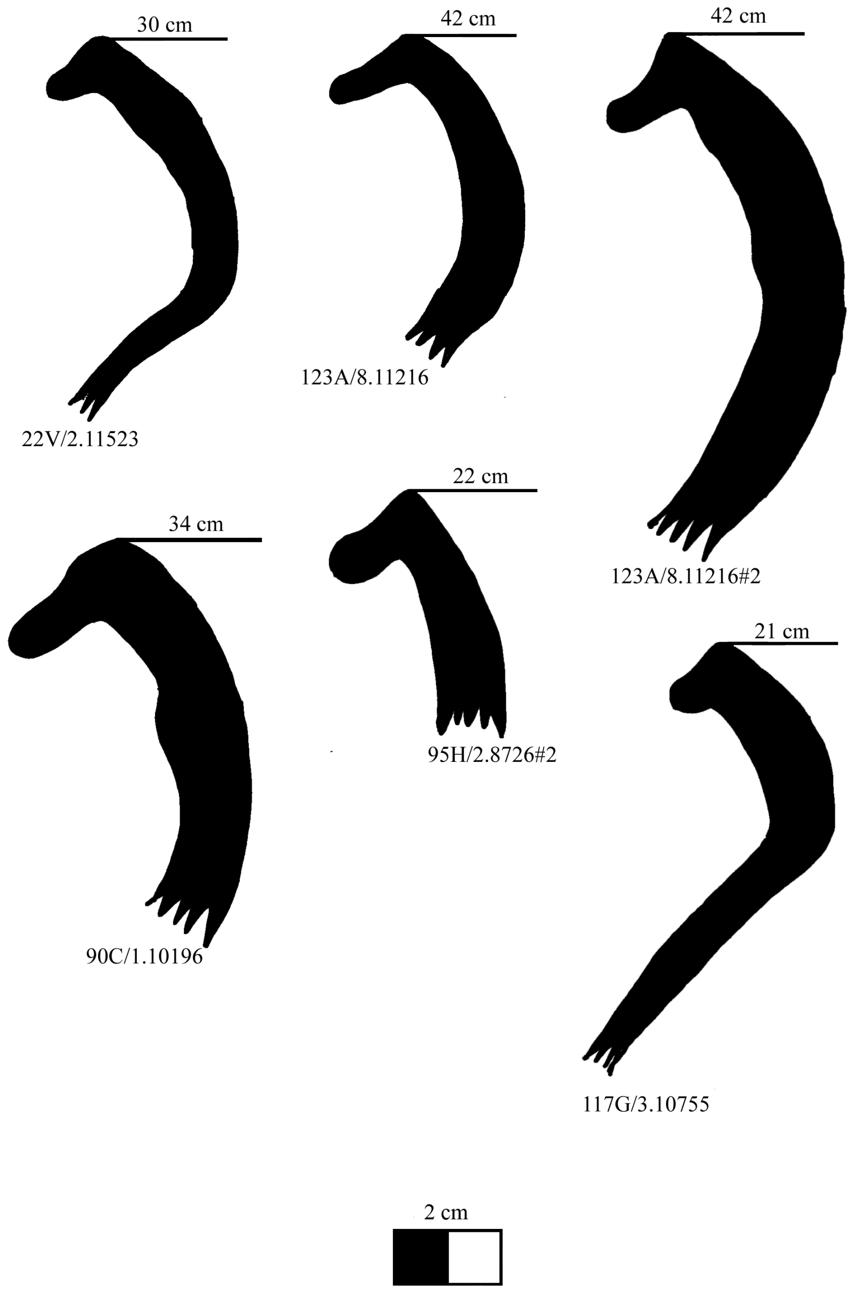
117A/2.10523

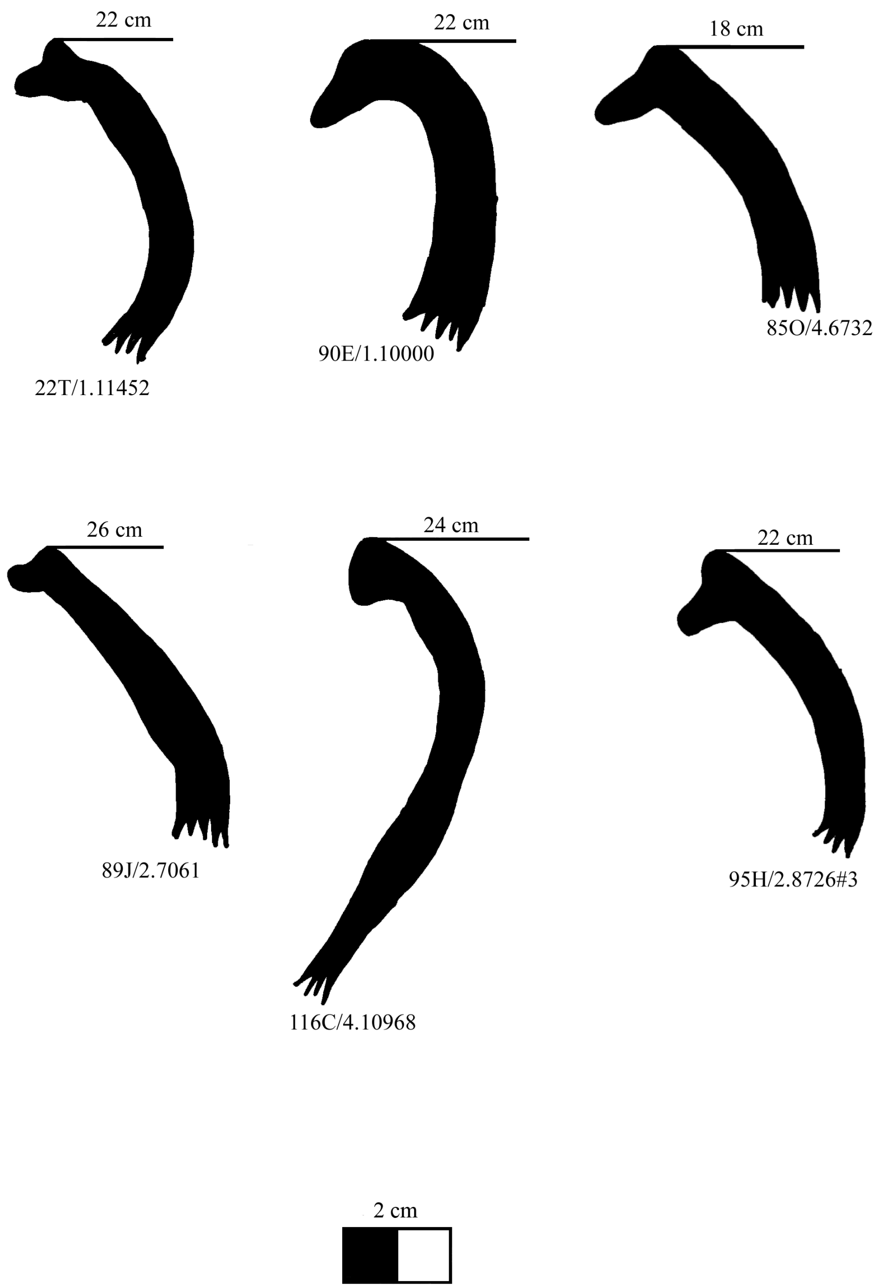

16 cm
117I/4.10658
29 cm
85J/1.6458
23 cm
116A/3.10933
49 cm
32 cm
117I/8.10689
2 cm
123C/8.11382

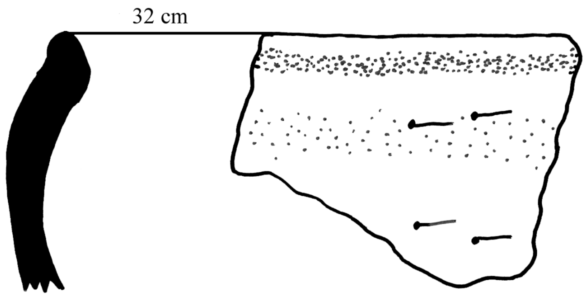

16 cm
22T/3.11477
35 cm
110U/2.13110
36 cm
95C/5.8462
2 cm


38 cm
123A/10.11278
23 cm
117I/3.10649
36 cm
90C/3.10233
22 cm
1D/3.44
20 cm
95H/2.8726
24 cm
123C/8.11386
28 cm
117G/3.10756
2 cm

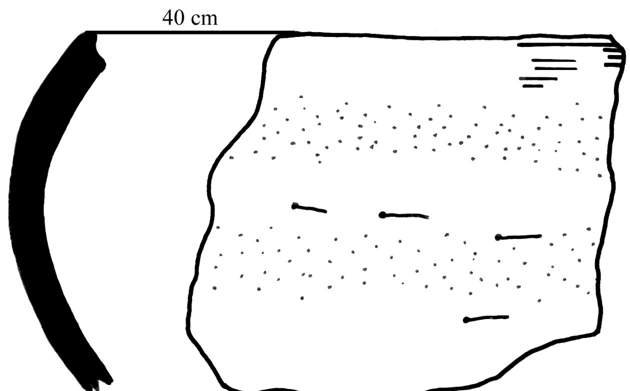

36 cm
50 cm
26 cm
76G/1.8025
20 cm
123A/7.11193
95B/3.8289
26 cm
28 cm
26 cm
22Q/6.4783
32 cm
90G/6.7486
79N/2.4990
117I/4.10658#2
85J/1.6456
2 cm


30 cm
22V/2.11523
42 cm
123A/8.11216
42 cm
123A/8.11216#2
34 cm
90C/1.10196
22 cm
95H/2.8726#2
21 cm
117G/3.10755
2 cm

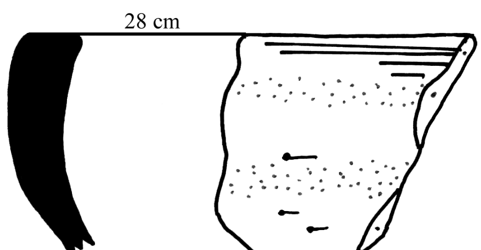

22 cm
22 cm
18 cm
22T/1.11452
90E/1.10000
85O/4.6732
26 cm
24 cm
22 cm
89J/2.7061
116C/4.10968
95H/2.8726#3
2 cm



1D/3.5

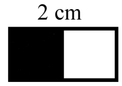


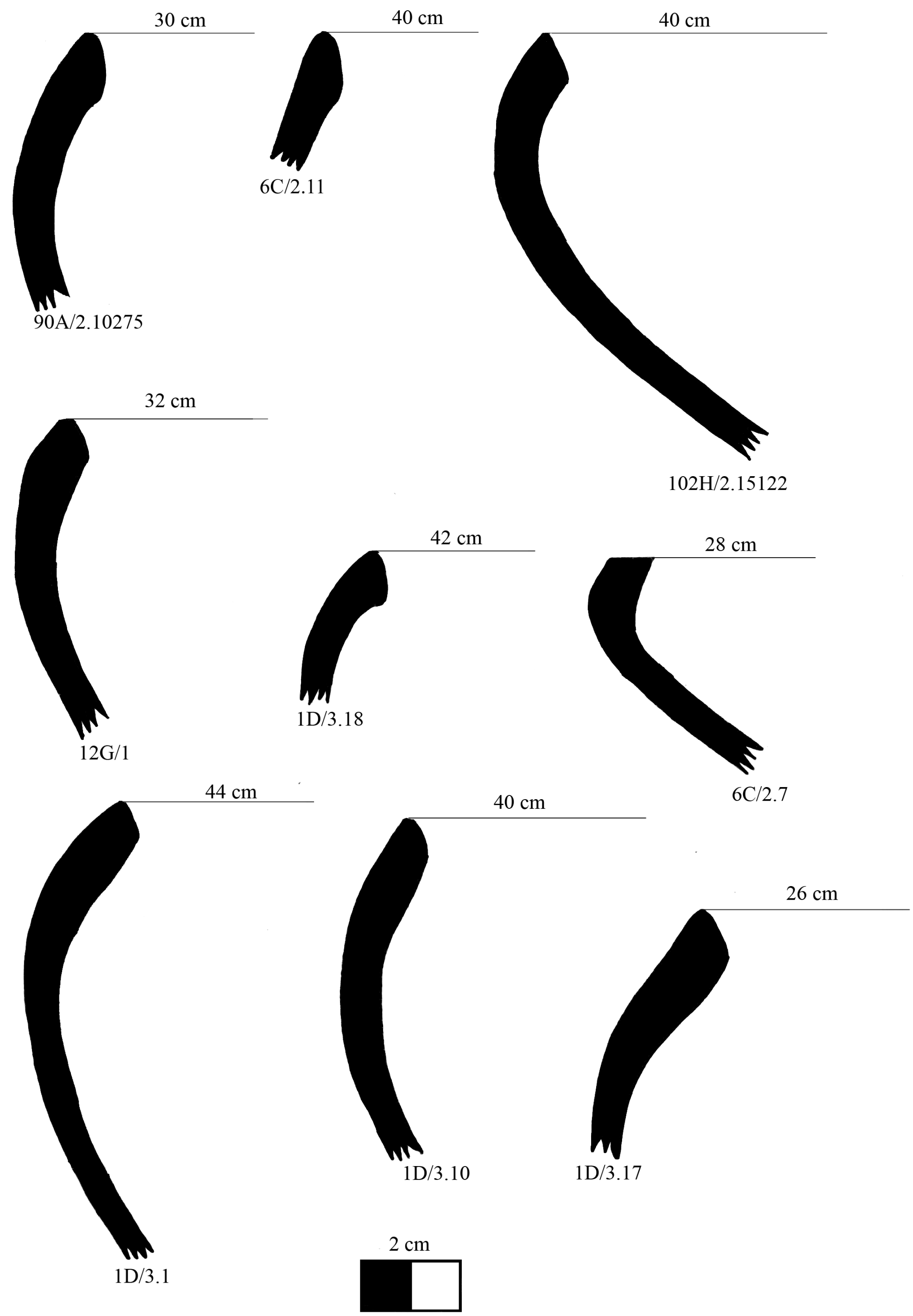
1D/3.16

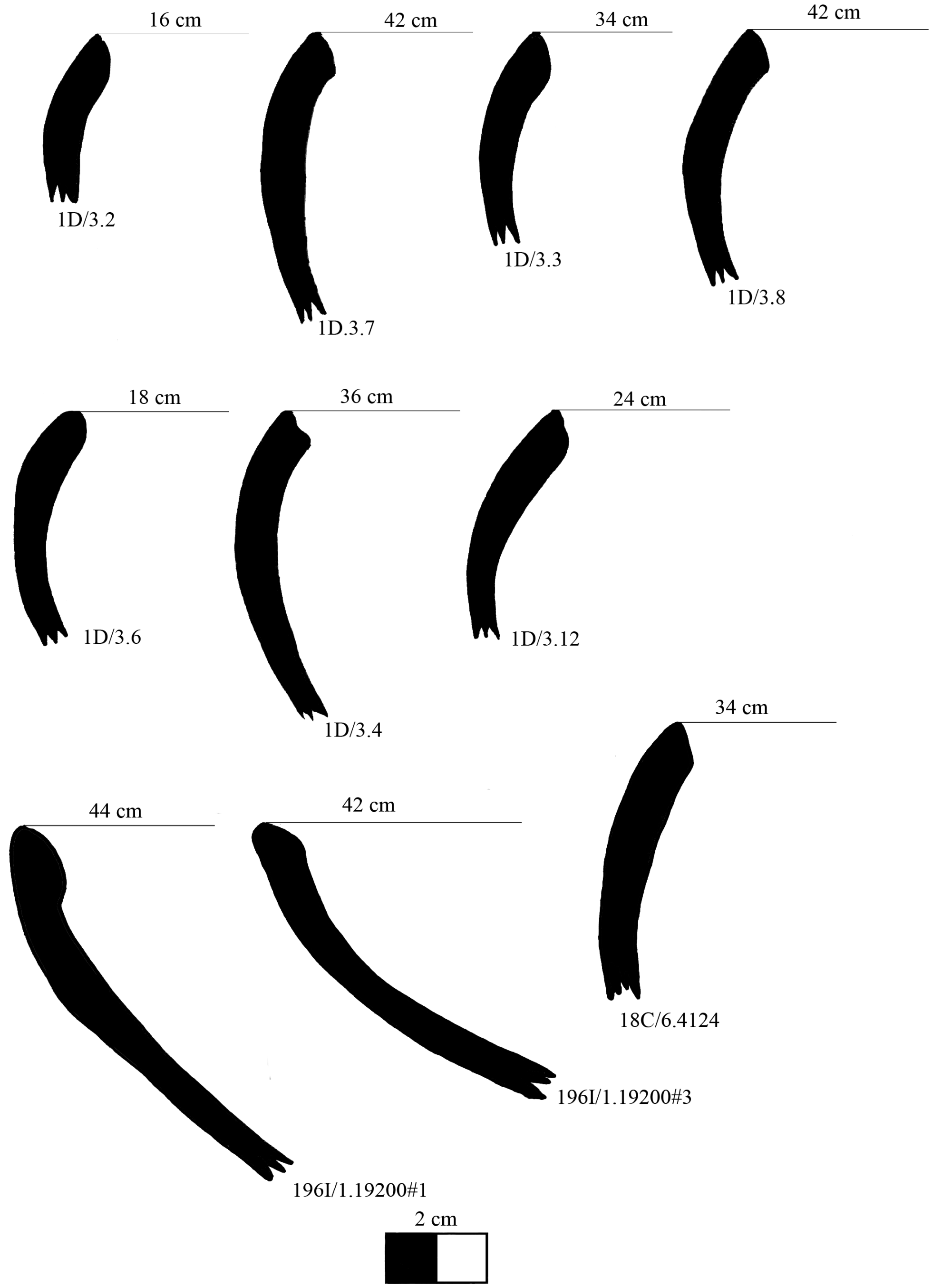


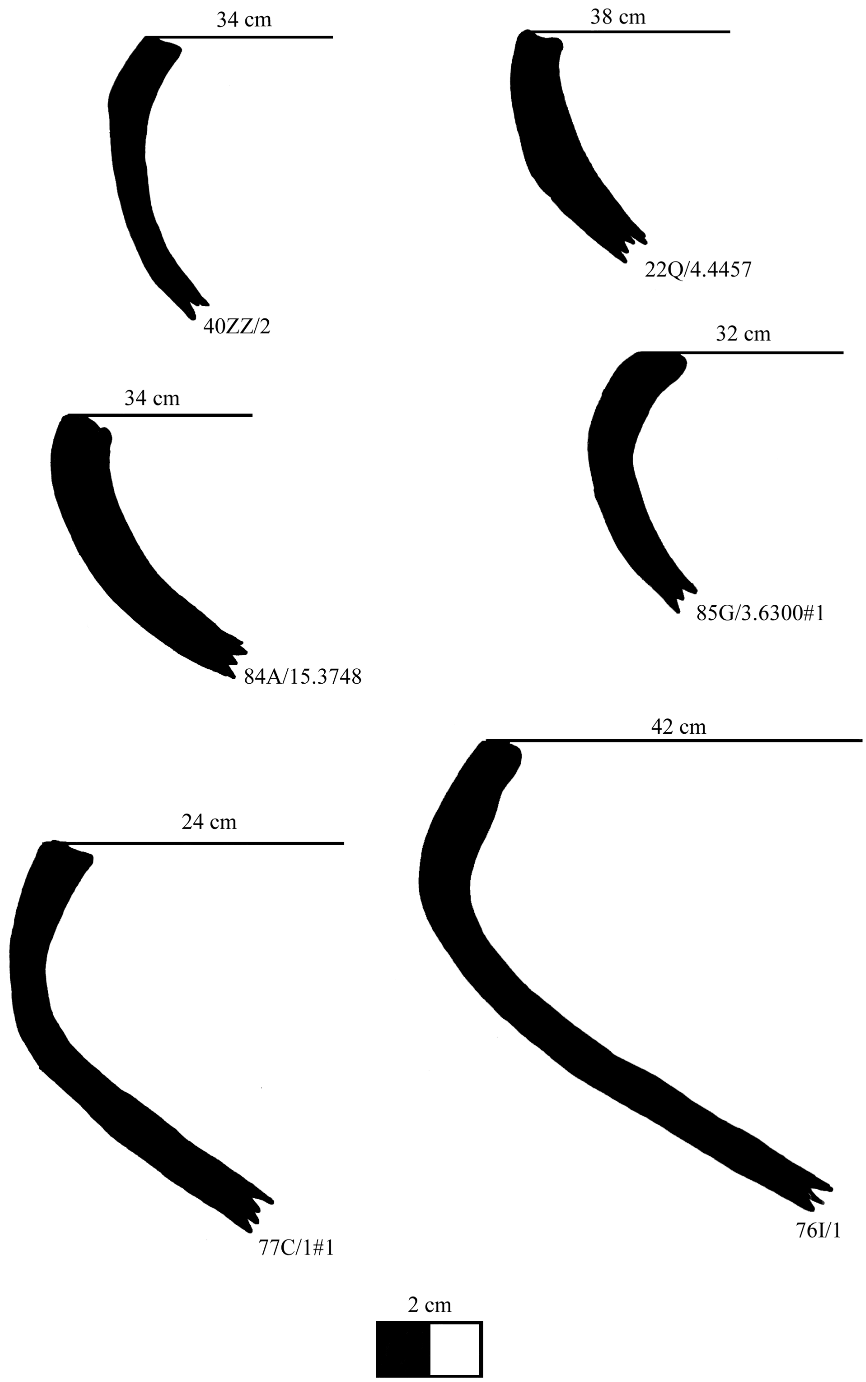
6C/2.6

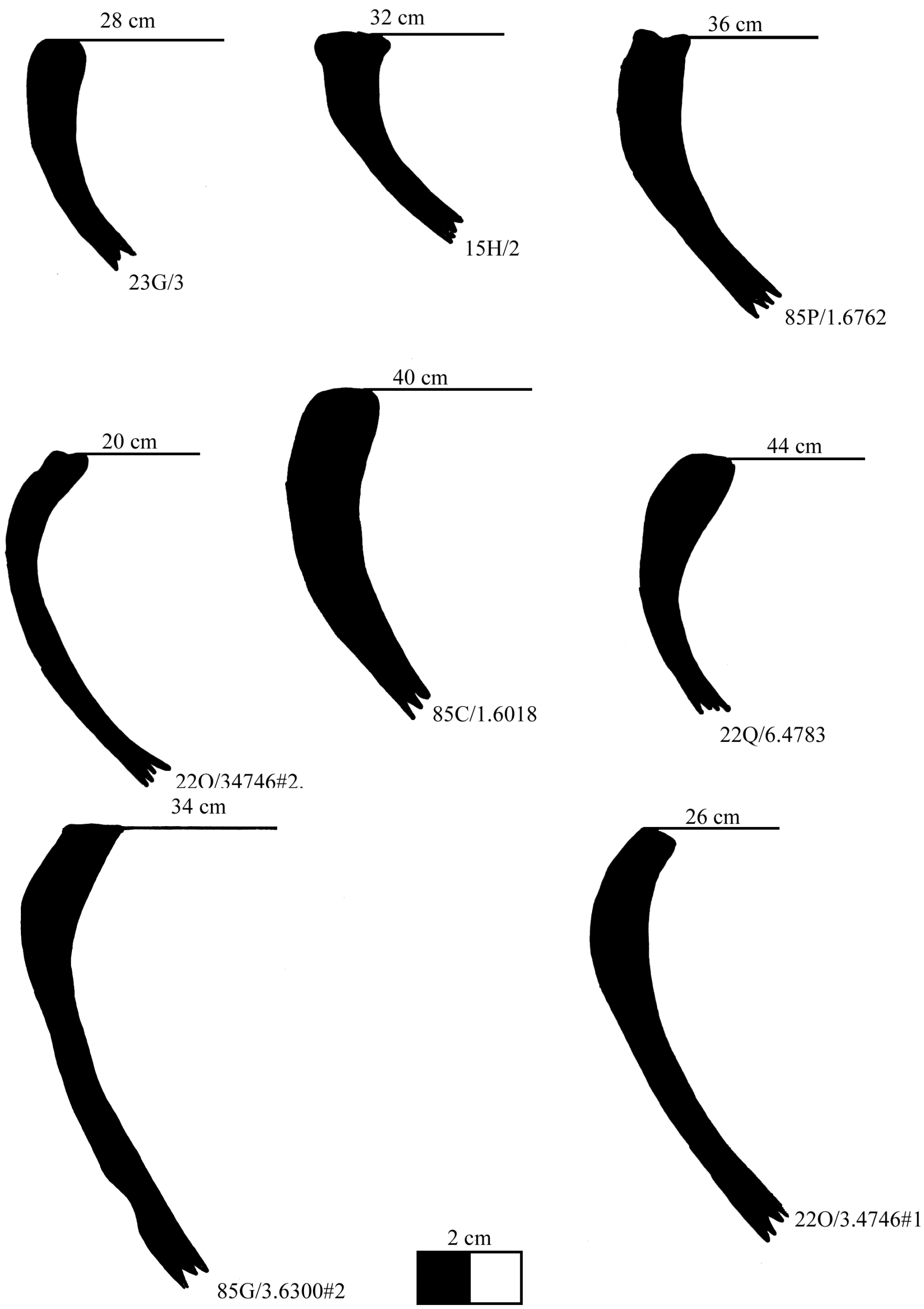
2 cm

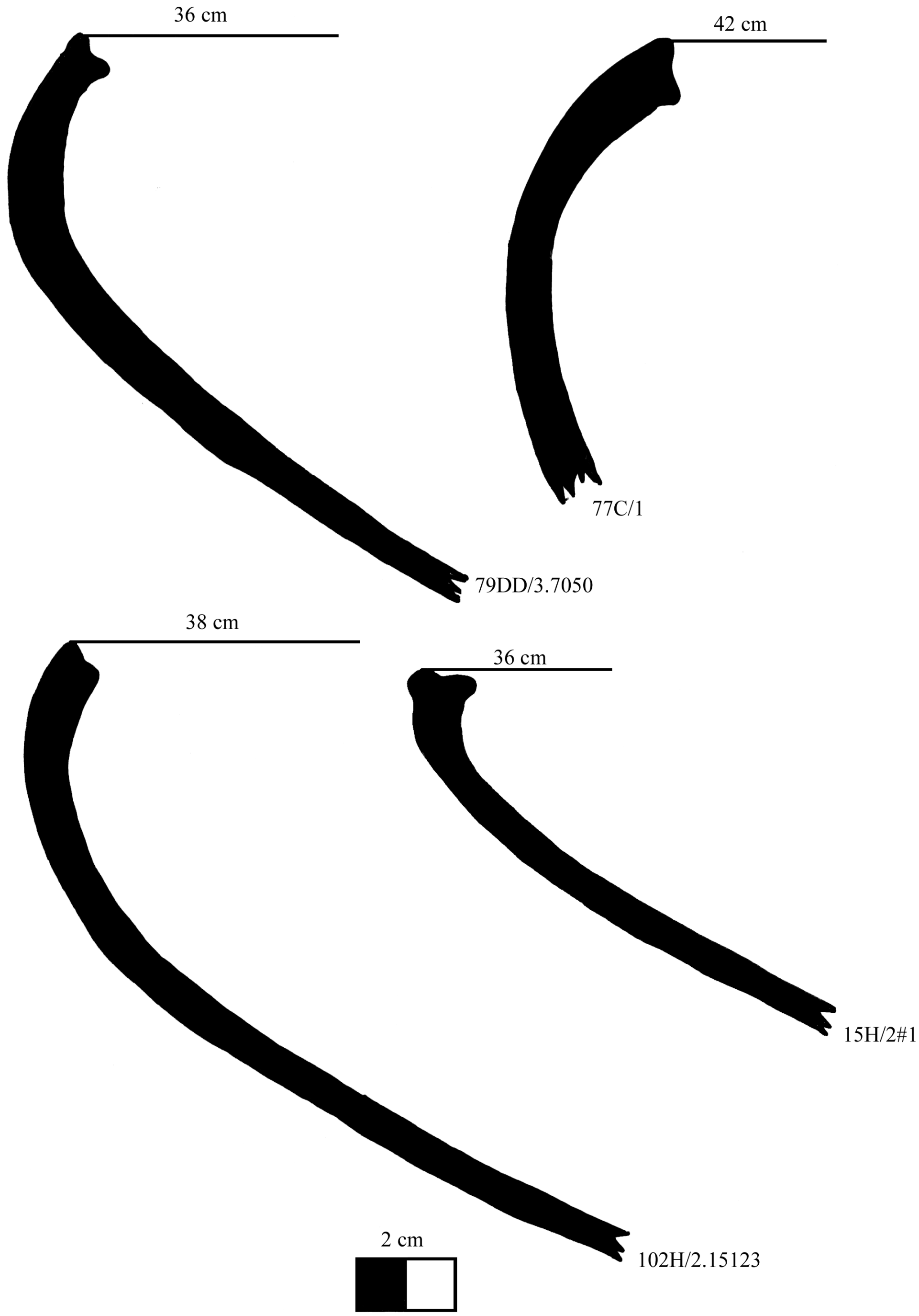


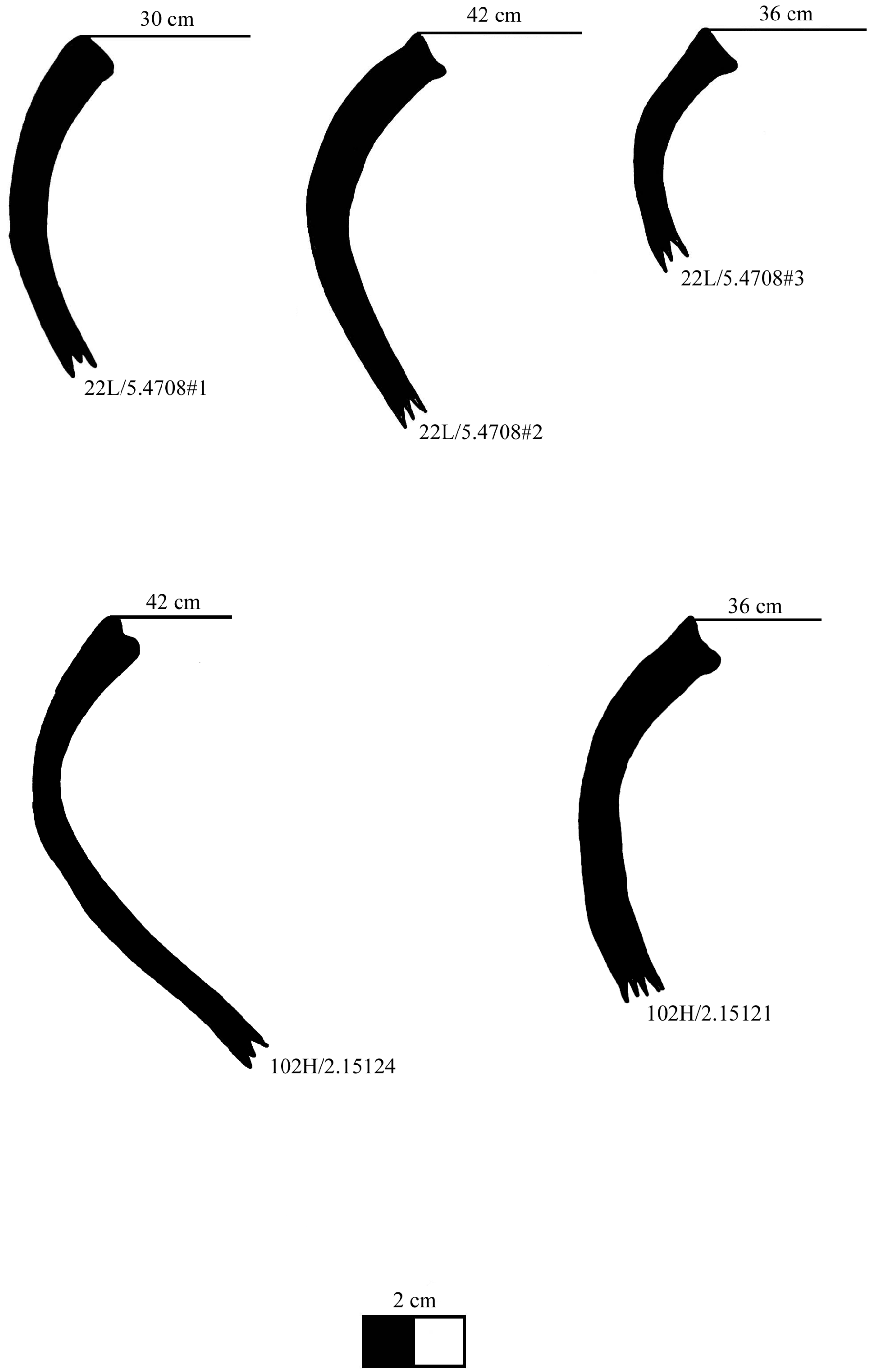

30 cm
90A/2.10275
40 cm
6C/2.11
40 cm
102H/2.15122
32 cm
12G/1
42 cm
1D/3.18
28 cm
6C/2.7
44 cm
1D/3.1
40 cm
1D/3.10
26 cm
1D/3.17
2 cm


16 cm
1D/3.2
42 cm
1D.3.7
34 cm
1D/3.3
42 cm
1D/3.8
18 cm
1D/3.6
36 cm
1D/3.4
24 cm
1D/3.12
34 cm
18C/6.4124
44 cm
196I/1.19200#1
42 cm
196I/1.19200#3
2 cm


34 cm
40ZZ/2
38 cm
22Q/4.4457
34 cm
84A/15.3748
32 cm
85G/3.6300#1
24 cm
77C/1#1
42 cm
76I/1
2 cm


28 cm
23G/3
32 cm
15H/2
36 cm
85P/1.6762
20 cm
22O/34746#2.
40 cm
85C/1.6018
44 cm
22Q/6.4783
34 cm
85G/3.6300#2
2 cm
26 cm
22O/3.4746#1


36 cm
42 cm
77C/1
79DD/3.7050
38 cm
36 cm
15H/2#1
2 cm
102H/2.15123


30 cm
42 cm
36 cm
22L/5.4708#1
22L/5.4708#2
22L/5.4708#3
42 cm
36 cm
102H/2.15124
102H/2.15121
2 cm