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ABSTRACT OF THESIS

COMPOSITIONAL PERSPECTIVES ON THE EXCHANGE OF MUNA SLATE WARES IN THE LATE AND TERMINAL CLASSIC NORTHERN MAYA LOWLANDS

This thesis presents the results of petrographic point counting analyses of Muna Slate ware, the predominant slipped ceramic ware in the Northern Maya Lowlands during the Late and Terminal Classic Periods (600-1000 A.D.) of Maya prehistory. Recently, it was hypothesized that Muna Slate wares were centrally produced and distributed from the Puuc Hills site of Sayil (Smyth and Dore 1994; Smyth et al. 1995). Given that Muna Slate wares may be considered utilitarian subsistence items (sensu Brumfiel and Earle 1987), this suggestion runs counter to several arguments that ancient Maya utilitarian ceramics production is associated with outlying communities and that their distribution is localized. In the research presented here, the model of Muna Slate ware production presented for Sayil is evaluated in terms of ceramic ecology, economic theory and models of craft distribution, the culture-historical context of Muna Slate ware use, and previous studies of ceramic production and distribution in the Maya Lowlands. Muna Slate wares from three sites in the northern Lowlands - Kiuic, Labná, and Ek Balam – were then analyzed in order to test the whether or not Sayil was the sole producer of these ceramics.

KEYWORDS: Muna Slate Ware, Puuc Region, Petrographic Analysis, Ceramic Ecology, Maya Archaeology

Christopher M. Gunn

December 20, 2002

COMPOSITIONAL PERSPECTIVES ON THE EXCHANGE OF MUNA SLATE WARES IN
THE LATE AND TERMINAL CLASSIC NORTHERN MAYA LOWLANDS

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THESIS

Christopher Michael Gunn

The Graduate School

University of Kentucky

2002

COMPOSITIONAL PERSPECTIVES ON THE EXCHANGE OF MUNA SLATE WARES IN
THE LATE AND TERMINAL CLASSIC NORTHERN MAYA LOWLANDS

THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Sciences in the
College of Arts and Sciences
at the University of Kentucky

By

Christopher Michael Gunn

Lexington, Kentucky

Director: Dr. Christopher A. Pool, Professor of Anthropology

Lexington, Kentucky

2002

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CHAPTER 1: CERAMIC PRODUCTION AND THE ANCIENT MAYA

This research presents the results of petrographic point counting analyses of Muna Slate ware, the predominant slipped ceramic ware in the Northern Maya Lowlands during the Late and Terminal Classic Periods (600-1000 A.D.) of Maya prehistory. Recently, it was hypothesized that Muna Slate wares were centrally produced and distributed from the site of Sayil, which is located in the Puuc Hills region of Yucatan, Mexico (Smyth and Dore 1994; Smyth et al. 1995). Given that Muna Slate wares may be considered utilitarian subsistence items (*sensu* Brumfiel and Earle 1987), several important questions are raised by this suggestion. The hypothesis that these ceramics were centrally produced and distributed is intriguing because it stands in contrast to several lines of argument can be used to support the contrary argument - that utilitarian ceramics production should be located at or near the place where they were used. In the research presented here, the model of Muna Slate ware production presented for Sayil is evaluated in terms of ceramic ecology, economic theory and models of craft distribution, the culture-historical context of Muna Slate ware use, and previous studies of ceramic production and distribution in the Maya Lowlands. The point counting analyses of thin sections of Muna Slate wares from three sites in the northern Lowlands - Kiuic, Labná, and Ek Balam - are used to test whether or not Sayil was the sole producer of Muna Slate wares consumed at sites in the Puuc region and beyond.

The single component site of Sayil dates to the Terminal Classic period (800-1000 AD). Settlement at this site is focused on three monumental architectural groups - the North Palace, the Mirador Complex, and the South Palace - that are linked by a series of causeways. Adjacent to the Mirador Complex, disproportionately high densities of Puuc Slate ware sherds have been recovered in association with extensive areas of burned soil as well as high proportions of Puuc Slate wasters (Smyth and Dore 1994:50). Similar data have been used at Maticapan, Veracruz, to identify ceramic production areas (Santley et al. 1989), and Smyth and Dore (1994:49-51) argue that the restriction of this distribution of artifacts and features indicated that production was organized above the household production mode (see P. Arnold 1991:92). The distribution of these sherds and soils covers approximately 15 ha (Smyth et al. 1995:130), suggesting the presence of a craft ward or *barrio* (1995:132). This area has a large ratio of *chultunes* (cisterns) to rooms (approximately 1:2) that could have provided the water necessary for the production of ceramics. Smyth et al. (1995:130) suggest that the high number of *chultunes* would have been crucial for ceramic production, especially if this was a dry season activity. Vessel forms represented in this debris were predominantly small-to-medium sized bowls and large hemispherical bowls with bolstered rims. Taking all of this evidence into consideration, Smyth and Dore (1994:50-51) conclude that the organization and scale of ceramic production made Sayil “strategically positioned to serve consumers at Sayil and throughout the Puuc Hills region.” Subsequent studies of clays and ceramics from Sayil (Smyth et al. 1995) suggest that local clays were compatible with the ceramics recovered at the site. Smyth et al. (1995:130) conclude that these data “[do] not establish definitively that Puuc Slate... [ware was] produced at Sayil, but it demonstrates clearly that clays compatible with the two wares are present in the surface deposits in the Puuc Hills.” Smyth believes that these data supports his earlier interpretations of ceramic production at Sayil, noting that:

the evidence for specialized production of certain vessel forms, particularly small-to-medium-size wide-mouth jars... and bowls that could have been stacked and transported in volume over relatively long distances, implies economic organization geared, in part, for export. This finding implies that Puuc Slate jars were not only in demand locally but were significant trade items themselves and perhaps even served as containers for special commodities traveling long distances (1995:132).

While these studies of materials from Sayil provide important baseline information, they did not include Muna Slate ceramics from other sites, and thus cannot test the presence or extent of the production and distribution network that the authors suggest exists. It remains unclear whether or not Muna Slate wares were moved in bulk from Sayil to other sites in the Puuc region or even further to other parts of the northern Lowlands.

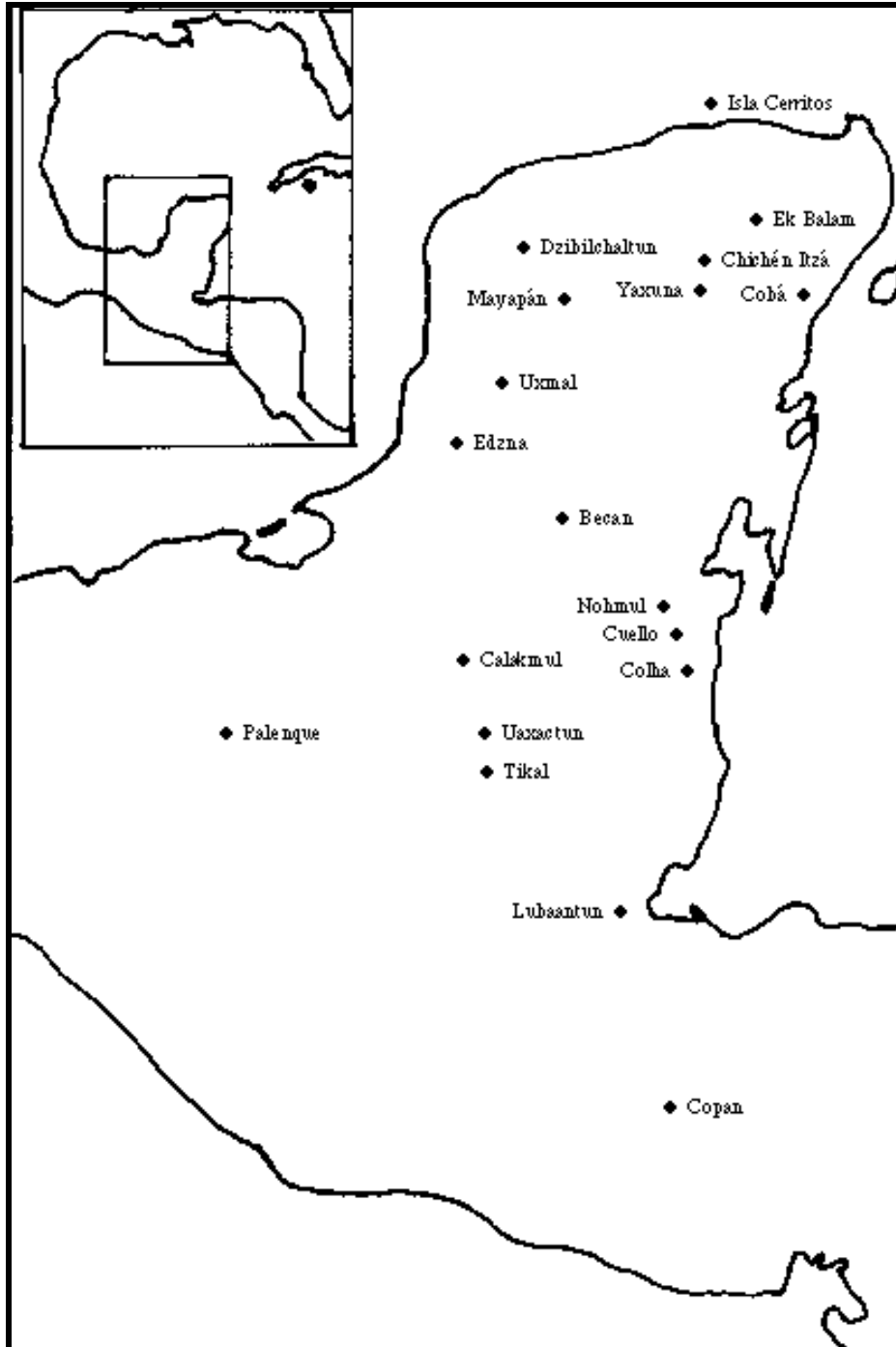
The research presented here examines variation in the composition of Muna Slate wares from three sites in order to assess the presence and range of any exclusive distributional, and by inference production, network that Sayil operated for supplying Puuc Slate wares to other sites in the region. It is important to realize, however, that the research does not, nor is designed to, address the organization of production and distribution at the community level, and can only recognize patterning between communities. It can only recognize compositional differences that may reflect whether a single or multiple production locations provided ceramics to the three sites considered here. Puuc Slate Wares from sites near Sayil to the south (Kiuic and Labná) and from farther away in the northern Lowlands to the east (Ek Balam), are examined to determine whether or not the differences in their compositions are similar enough to suggest centralized production of Muna Slate wares in the ceramic assemblages. Ek Balam is separated from Kiuic and Labná by a distance of around 170 km; the latter two sites are approximately 12 km apart (Figures 1.1, 1.2).

Because this research explores the differences in the assemblages, a methodology that explores the variability within and between samples of ceramics is important. As outlined further below, petrological analysis of sherds through point counting the individual grains in a ceramic thin section is thought to provide a reliable methodological technique for describing and quantifying these differences. The results of these analyses indicate that the samples of Muna Slate wares from Kiuic, Labná, and Ek Balam are statistically separable from one another. These findings suggest that Sayil was not the sole locus of centralized production and distribution for Muna Slate wares. While these data gathered in this research cannot rule out the possibility of trade in ceramics, they do suggest that multiple production locations existed in the past.

Primarily, the research revolves around a set of economic questions that are related to the understanding of craft production in general and within the Maya region. What do the available models and empirical data indicate about the scale and organization of production of utilitarian items? When these questions are posed for understanding ceramic production, several issues that arise from ecological consideration of pottery production are brought to light. In Chapter 2, the theoretical bases of ceramic ecology and of the microeconomic modeling of economic interaction are explored. Ceramic ecology, especially as developed by D. Arnold (1985), is used as a framework of theory and data from which to argue that ceramic production is an economically rational process in which potters attempt to maximize several interrelated aspects of their natural and social environments. Because ceramic ecology considers environment in a broad sense, potters' procurement of raw materials for ceramic production is just as important to this framework as the sets of social and economic relationships that determine ceramic

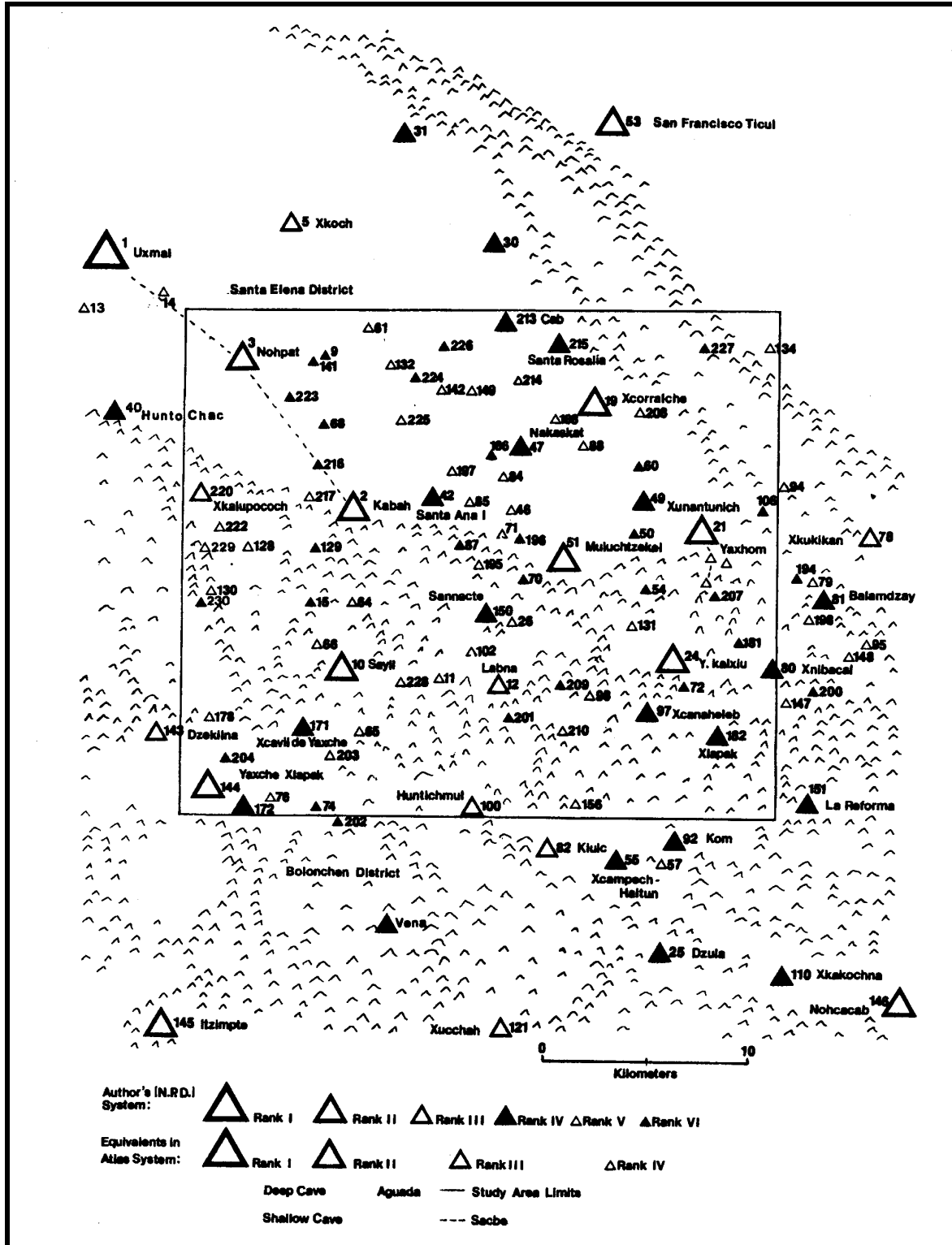
distribution and consumption. Economic models of the control of production, finance systems, and distribution systems likewise receive attention in this chapter. These concerns are considered with respect to the model of Muna Slate production suggested for Sayil.

Figure 1.1. Major archaeological sites in the Maya Lowlands^a



a. After Sharer (1994)

Figure 1.2. Archaeological sites in the Puuc region^a



a. After Dunning (1992)

These themes are further related to the ancient Maya in Chapter 3 by an exploration of the broader chronological and sociocultural context of ceramic production and distribution of slatewares during the Late and Terminal Classic periods. This chapter provides the culture-historical background within which the ancient Maya of this time lived and interacted with one another. Although previous understandings of the northern Lowlands posited the existence of large regional polities (e.g. Thompson 1954), further research in this area has led to refinements in the chronological position of many sites in this region. This realignment brings several large polities into temporal association with one another, and suggests that models of political interaction for the Late and Terminal Classic period should allow for dynamic and nuanced interaction between sites. Further, these data are used to argue that ceramic production and distribution systems, especially for utilitarian wares, would be better suited to provision local consumers.

Data from previous studies of ancient Lowland Maya ceramic production are reviewed in Chapter 4, thereby providing empirical information that informs the models and arguments presented in the preceding chapters. Important programs of ceramic research have been conducted at large centers, such as Palenque (Rands 1967; Rands and Bishop 1980) and Tikal (Fry and Cox 1974; Fry 1979, 1980), occupied during the Early through Late Classic periods. However, studies from smaller sites located throughout the Lowlands provide largely complementary results as well. From these, broad themes emerge that signal a dichotomy in the organization of production of utilitarian ceramics, such as Muna Slate wares, and the production of elite ceramic wares. Further, a comparison of their results provides an important possible insight into the nature of the organization of ceramic production units in Maya prehistory.

These data from the present research and a justification of the methodology used are presented in Chapter 6 and Chapter 5, respectively. Chapter 5 presents a discussion of the geology of the northern Yucatan peninsula and information gathered from ethnographic observation of pottery manufacture among the modern Maya of this region. Given the homogenous geological composition of the northern Lowlands, ‘point’ archaeometric techniques of ceramic characterization provide a better avenue of initial exploration of difference in ceramics than ‘bulk’ analytical techniques. Because of the level of specificity that it could provide, petrographic point counting was selected as the methodological technique for this study. The results of the point counting are then presented in Chapter 6.

Finally, a synthesis of the data is provided in Chapter 7. The results of the petrographic analysis are considered in relation to the other classes of data presented in the previous chapters with the aim of drawing out significant implications for our understanding of the production of Muna Slate ware, the related aspects of intra- and interregional exchange, and how both of these factors are related to and inform our understanding of the Terminal Classic period in the northern Maya Lowlands. Again, the statistical tests of the differences in the data indicate that significant differences exist between the samples particular to sites. While the data do establish differences, there are several issues that they cannot address, and these areas of future research are highlighted.

CHAPTER 2: ECOLOGICAL AND ECONOMIC PERSPECTIVES ON CERAMIC PRODUCTION

With the development of cultural ecology, a renewed emphasis was placed on the interaction between people and their surrounding social and natural environments. Stemming from these perspectives, new approaches to ceramic and economic analyses were developed. On the one hand, cultural ecology provided important influence for the development of ceramic ecology, which seeks to understand the role of ceramics and ceramic producers in their natural and social environments. On the other hand, the utility of microeconomic analyses of the ways potters interact with their natural and social environments was demonstrated. These approaches to ceramic analysis centered on the potter, discussing the economics of supply and demand as well as the ecology of raw materials procurement. When and where potters decide to procure raw materials and fuels, and what and how many forms to produce are questions that are just as much ecological as they are economic. This chapter uses ceramic ecology as a conceptual and organizational framework in which to apply economic principles to the understanding of the factors affecting the production and distribution of Muna Slate wares in the northern Maya Lowlands.

Ceramic Ecology and the Study of Ceramic Production

Julian Steward (1955:30-42) proposed that cultural ecology presented both a theoretical framework and a methodological approach to the study of humans and their environment. Steward reacted against both diffusionist thinking and environmental determinism for their underlying assumptions of normative forces in culture. Within the framework of cultural ecology, technologies are not adopted wholesale through diffusion, nor does the environment dictate them. Rather, the relationship of humans to their environment presents them with certain possibilities, some more important than others. To discern what factors were most important in shaping culture, Steward outlined three methodological procedures. First, the relationship between the environment and productive technologies had to be established. Second, the behaviors related to the technology of environmental exploitation were discerned. Third, the impact of a given technology on other aspects of the environment had to be understood. As this last point of inquiry suggests, Steward envisioned cultural ecology as a holistic approach. It was Steward's intent that environment be seen in a holistic sense as comprising both natural and social components. Kinship, subsistence routines, demography, craft production, and settlement were all related aspects of the same interacting system. Yet, Steward's descriptions of cultural ecology did not model individuals well. Actors within ecological systems were largely homogenous beings, all acting in accord with the specific aspects of the subsystems in which they were viewed. Rather than modeling individual actors, Steward focused more on the technological adaptations that all members of societies shared.

The obvious stress on technology was adapted to the study of ceramic production in the approach of ceramic ecology. In *Ceramics and Man*, Matson (1965:203) proposed that ceramic ecology is "one facet of cultural ecology, that... attempts to relate the raw materials and technologies that the local potter has available to the functions in his culture of the products he fashions." In his exposition, Matson linked production variables such as raw materials and fuels to the subsistence concerns that potters must face. In doing so, Matson touched on issues of replacement rates and the technological properties of pottery, seasonal resettlement, the daily

activities of pottery consumers, and deforestation. These issues were further linked to the role of potters in their societies and the influence of society in creating demand for the potter's wares. In short, these statements were an early and important demonstration of the myriad ways that potters relate to their raw materials (natural environment) and to the rest of society (social environment) (Kolb 1989:285). Further, Matson (1965:215) stated "There is a residue of the ceramic past in the present... Therefore, one can learn much by observing the village potters, brickmakers, and house builders at work". The implications for the development of ethnological and ethnoarchaeological studies of ceramic ecology are obvious. Importantly, Matson felt that the approach moved ceramic studies beyond the realm of culture-history, providing a basis on which to address social process. "It is through a combination of many interests - historical, technological, artistic, and ecological, among others - that pottery can be made to serve our objective - the better understanding of man through a study of the material remains that have been left for us to excavate" (Matson 1965:216).

Ceramic ecology incorporated several new points of view during the two decades after *Ceramics and Man*, expanding the issues raised by Matson in the process. As Kolb's (1989:286-305) review of these developments highlights, it was during this period that cultural ecology and General Systems Theory were widely employed to relate people to cultures and environments within interacting networks of inputs, outputs, and feedback mechanisms. Usually, these networks were modeled as subsystems that formed larger interactive networks. Early work under this systemic approach tended to be descriptive, but studies quickly attempted to incorporate process and explanation. Aiding these attempts, ethnoarchaeological studies provided important contextual information to aid archaeological interpretation. Additionally, replicative studies of ceramic manufacture added important technological understanding to the analysis of ceramics. Important efforts were made to link the technological, sociological, and socioeconomic data gathered through research conducted during this period under the framework of ceramic ecology.

Dean Arnold's (1985) *Ceramic Theory and Cultural Process* provided a synthesis of this work with the idea that there were several generalities and relationships about ceramic production that could be gathered from ceramic ecological work. He argued that, despite the importance of cultural ecology, ceramic analysts continued to use "the 'old' untested assumptions about the relationships between the ceramics, and environment and culture" (1985:11). To advance ceramic ecology, Arnold drew upon systems theory, cultural ecology, ethnology, and ethnoarchaeology to develop an explanatory theory of ceramic ecology. Arnold's emphasis on ethnology and ethnoarchaeology is evident in his focus "not so much on the ceramics themselves, but on the way in which pottery production is related to the environment and culture through the local community of potters" (1985:17). Potters were considered goal-oriented producers whose products were constrained by both the natural and social contexts of production.

The emphasis of D. Arnold's work, though, is on the relationship of the natural environment to the production of ceramics. While scheduling conflicts, settlement and mobility, demand for ceramics, and technological innovation are all addressed in the development of ceramic ecology, the social context is often lost in the way the systemic approach discusses the feedback loops produced by the natural environment. Kolb (1989:303) noted that Arnold's attempts came closest to developing a holistic theory of ceramic ecology, but that his treatment of the subject did not quite meet his goal.

In turn, Kolb (1989) offered a 'holistic ceramic ecology' based on a synthesis of several studies and approaches. His model is based on the interaction among five environmental

variables. These include human biology, the physical environment, the biological environment, culture, and the ceramic complex. The ceramic complex is generally concerned with the technological aspects of pottery production and how these aspects articulate with psychological, social, economic, and religious subsystems. Each of these subsystems is composed of several factors that are elaborated thoroughly by Kolb. Kolb (1989:335) states:

Holistic ceramic ecology includes not only a series of basic ecological variables (Physical Environment, Biological Environment, Humankind, and Cultural Environment) but directly links these with the Ceramic Complex and especially the three primary subsystems (Pottery Production, Economic, and Social) as well as others (Religious, and Psychological/Behavioral).

Within the Ceramic Complex, the Pottery Production subsystem links all of the various economic and social aspects of ceramic production, distribution, and consumption. The Pottery Production subsystem comprises the various indicators of the ways in which the vessels were manufactured, including raw materials, shaping, surface treatments, drying, and firing (Kolb 1989:320). Although this subsystem is linked to several other subsystems in the Ceramic Complex, the two most important of these for the present research are the Economic and Social subsystems. The Economic subsystem is concerned with economic analyses of the production and distribution of ceramics. It includes consideration of the efficiency and costs of raw materials procurement, manufacturing stages, and distribution of finished products. This subfield likewise considers the economics of time allocation to pottery manufacture (Kolb 1989:328). The Pottery Production and Economic subfields are linked to the Social subsystem. By distinguishing this subsystem, Kolb (1989:329) places emphasis on the socioeconomic and sociopolitical contexts of pottery production and distribution.

Kolb's emphasis on the Production, Economic, and Social subsystems provides a clear link between economic studies and ceramic ecology, and is perfectly in keeping with Matson's original intent for ceramic ecology. Kolb's holistic ceramic ecology provides an explicit statement of the relationship of ecology to economy that Arnold's study does not emphasize. In contrast to Arnold's emphasis on potters as the object of inquiry, Kolb suggests that ceramic types or wares are the appropriate starting point for a holistic ceramic ecology. Kolb's contribution to ceramic ecology is the detailed elaboration of a large number of factors that impact ceramic ecology, and the number of ways that these factors articulate with one another in a systemic context.

This said, Bey (1992:5) points out that Kolb's holistic ceramic ecology is only a "skeletal outline" that highlights the existence of connections, but does little to provide insight into the ways in which the variables interact with one another. He finds that Rice's (1987c:181-191) treatment of the organization of ceramic production takes necessary steps in delineating the relationships among relevant variables, not merely the presence or absence of a linkage. Specifically, Rice highlights that it is demand that structures production, and that there is no deterministic relationship between the form of the production system and the form of the distribution system (see also Lewis 1996). To this end, Arnold's (1985) work also presents several important relationships between potters and the procurement of raw materials necessary for firing. Thus, while Kolb's framework outlines the presence of interrelated sets of variables relevant to the study of ceramic ecology, the works of Rice and Arnold takes necessary steps towards delineating the relationships among these variables.

Taking a more focused approach, other studies have dealt specifically with the integration of ceramic production and distribution. The need for an integrated approach is stated by Pool (1992; see also Stark 1985; Santley et al. 1989) in his analysis of the interconnected factors influencing the production, consumption and distribution of ceramics. From the potter's perspective, production is integrated with distribution through (1) the social context, (2) the logistical considerations of moving the pottery from the location of its production to the location of its consumption, and (3) the demand for ceramics that the potter makes (Pool 1992:283). These three points of articulation between production and distribution can be seen as the effect of consumption practices and pressures on the production and distribution context.

The development of ceramic ecology, and its incorporation of economic theory, provides a useful framework through which to consider the production and distribution of ceramics. Ultimately, consumer demand creates the need for pottery production. The potter mediates these demands with the possibilities and constraints of their surrounding natural and social environments. The systemic interaction of potters with these environments has been the focus of much ceramic ecological research, and several models have been provided that delineate the linkages between them. In the following sections, several issues related to the production and distribution of pottery are presented. Specifically, the procurement of raw materials, the degree of specialization, the role of goods in the economy, and the distribution of specialized goods vis-à-vis the nature of the goods produced. In this case, the goods in question are Muna Slate wares, and this discussion strives to understand their role as a subsistence good in the economy of ceramic production and distribution.

Raw Materials

D. Arnold (1985:32-35) conceptualizes the procurement of ceramic raw materials in terms of exploitable thresholds, as discussed by Browman (1976). The basic premise behind the establishment of exploitable thresholds is that there is a geographic point beyond which the costs associated with the procurement of raw materials exceed the value of the materials to be obtained. Browman establishes three thresholds that demarcate the preferred range of exploitation, the maximum range of exploitation, and the absolute limit of exploitation. Within the preferred range, the benefits of raw materials procurement exceed the costs. When potters pass this threshold, their economic benefits decline sharply. When the costs of procurement equal the benefits received (i.e. there is no net economic gain), the limit of the maximum exploitable territory has been reached. Past this point, resources are only rarely procured.

Clays and Tempers

Based on a cross-cultural survey of potters in many different environments, D. Arnold (1985:35-50) finds that 84% of his sample procures clays and tempers within a radius of 7 km, which he states represents a maximum exploitation threshold for these raw materials. More recent studies generally support Arnold's findings. Krause (1985) describes a modern Bantu potter traveling up to 4.02 km to obtain clays, but transportation of the clay is aided by mule drawn cart. The furthest distance traveled on foot by any of his subjects to the source of the raw clay is 3.33 km, and the shortest distance traveled by any of the potters that he studied is 1.6 km (Krause 1985:91, 110). Similarly, Peruvian potters studied by Chávez (1992) obtain their clays around 3 km from town. However, tempering materials are obtained up to 10 km away from potters' residences. (Chávez 1992:57-58). P. Arnold (1991) finds that modern potters living in

the Sierra de Los Tuxtlas, Veracruz, Mexico travel an average distance of 1.81 km to procure all of the clays that they use. Volcanic ash is the predominant temper type used, and distances to sources of this material do not exceed 1.5 km (P. Arnold 1991:20-24). In all, these are not great distances, and it can be said that traditional potters live close to their sources of raw clays and tempers.

There is an apparent trend for potters to be located near the sources of their raw materials. D. Arnold's (1985:50) 7 km maximum exploitation threshold for the bulky raw materials needed for ceramic production is largely supported by subsequent studies. In terms of D. Arnold's model of ceramic ecology, this proximity to the necessary raw materials provides a deviation amplifying (reinforcing) feedback for the production of ceramics. These spatial data on the location of potters vis-à-vis their raw materials provides important bases for inferring information about the sources likely exploited by ancient potters. This is especially important due to the low visibility that ceramic raw materials usually have in archaeological contexts. In terms of the research presented here, the 7 km maximum exploitable ranges of Sayil, Kiuic, and Labná all overlap one another (see also Chapter 4). Although the distribution of clay resources between the latter two sites is presently unknown, geological studies conducted in several locations across the peninsula indicate that clay minerals are present in the soils (see Chapter 5). Clay deposits utilized by modern potters in the Yucatan peninsula occur in discreet mines (Arnold 1971; Arnold et al. 2000). This finding suggests the possibility that potting clays suitable for potting occur in a more limited distribution than the abundant presence of clay minerals in Yucatec soils would suggest. If Sayil were the single production location for Muna Slate ware, then several of these deposits would have to have been utilized to meet the demand for ceramics. If this were true, then Sayil would either have to be located in a clay-rich zone, or possibly would have been faced with the challenge of transporting raw clays in bulk to the site. D. Arnold's exploitation thresholds do not suggest this latter possibility. So, it seems more likely that Sayil is either located in a clay-rich zone, or that additional production locations should be present.

The majority of the aplastic inclusions found in the ceramics analyzed in the present research (see Chapter 6) can be found close to any of the sites in the northern Yucatan. The soils of the northern Yucatan peninsula are colored red by the presence of oxidized iron in the soils, and the peninsula is a limestone shelf. The presence of hematite and carbonates in Muna Slate wares is not surprising, and it is difficult or impossible to say if these inclusions were added to raw clays during the formation process or if they were natural inclusions in the raw. The volcanic ash encountered in several of the samples analyzed in this research, on the other hand, presents something of a problem in terms of Arnold's 7 km maximum exploitation threshold. There are no sources of volcanic ash in the Yucatan peninsula; the closest source is around 150 km away (see Chapter 5). Given that the ash found in Muna Slate wares is imported, this forces a consideration of the broader social and political context of Muna Slate producers. While this context is more fully elaborated below (see Chapter 3), suffice it to say here that Sayil occupies a second tier position, along with several other sites in the Puuc region (Garza T. and Kurjack 1980). Given this position, Sayil should have had fairly good access to the trade routes, but may have been in a position to monopolize the trade in ash for the region. This would be especially likely if Sayil were the sole producer of Muna Slate ceramics. The relationship between trade systems and production is further addressed below.

Fuels

The procurement of fuels for firing pottery is also of utmost importance for ceramic manufacture. D. Arnold (1985:53) has difficulty in finding specific information on the distances potters travel to procure fuels for firing ceramics. He finds that sources of fuels are either local (within 6 km), or are made so through the conveniences of modern transportation. The examples that he does find are largely echoed in the examples provided below. Bantu potters use fuels that are locally available, such as wood, bark, grasses, and cow dung. All of these are usually available at the firing locations and are gathered when needed (Krause 1985:85-86, 104-105, 121-122). Sillar (2000) also finds that highland potters in Peru and Bolivia use readily available supplies of dung. Elsewhere in the Andes, potters use several different fuels for firing. These include locally available fuels such as grasses, eucalyptus wood, wood from other trees, and dung from cattle, sheep, and burros (Chávez 1991:58). Conversely, potters in the Tuxtlas use fuels that usually come from beyond the extent of temper and raw clay procurement radii. This is especially so for those potters who utilize hardwoods during firing. However, most hardwood is bought from vendors that bring their product to the potting community (P. Arnold 1991:25-26). In terms of economic costs, the distance that the potters must travel to get fuel is minimized when vendors bring hardwood to potting communities. From this perspective, the fuel can be considered a locally available resource. Overall, then, it is fair to say that locally available fuels are utilized by potters preferentially before they will travel long distances to procure these resources that are usually heavy, cumbersome, or both. This finding echoes D. Arnold's and others' evidence for local procurement of clays for potting.

Fuel is readily available in the Puuc region, and some of the best forests in northern Yucatan are located in this region. The valley floors of the Puuc region were periodically cleared of their forests for shifting cultivation of swidden plots. If Sayil were the sole producer of Muna Slate wares, then its demand for fuels would have been high. Although the exploitation radius for fuel is poorly understood, it is a bulky raw material, and the evidence presented above suggests that a 7 km maximum procurement radius for fuels is not unreasonable. Also, the materials used for firing may have been in demand for other things, such as housing materials, and fires for cooking and the production of lime for plaster. It is likely that Sayil, if the sole producer of Muna Slate wares for the Puuc region, would have experienced a shortage of fuels during the 400 year span of the Late and Terminal Classic periods.

Summary

Ceramic ecology, by analyzing the procurement of raw materials in the context of its natural and social environments, alerts researchers to the possible constraints faced by ancient potters in the production of ceramics. The above discussion demonstrates the ways that ceramic producers can be seen as economizing the amount of time and energy expended in the procurement of raw materials for ceramic production. Thereby, the close association of ceramic ecology and micro-economic models of rationality is demonstrated. That is, potters evaluate the possibilities and constraints of their surrounding environment in order to maximize their return for the investments they make. They are knowledgeable of the forces that operate in exchange relationships and have the foresight to realize the outcome that provides them with the most net benefit (Dalton 1961; Plattner 1989a). In the procurement of raw materials, D. Arnold's 7 km maximum procurement threshold can be seen both literally and economically as a point past which the returns to the potter will not exceed their inputs of time and effort. In terms of the centralized production of Muna Slate wares at Sayil, ceramic ecology provides a framework that

highlights some of the challenges that would have been faced by ceramic producers at that site (and others in the northern Yucatan). The management of these challenges relates to both the natural and the social environments of potters.

Specialized Craft Production and Finance Systems

Potters not only balance expenditures in material procurement, preparation, and firing, but also must consider the question of how much time to devote to the production of ceramics. In some respects, potters may be presented with time constraints that stem from their natural environment. Because it is important that pottery be thoroughly dry before being fired, it may be difficult to form pottery during rainy seasons of the year (Arnold 1985:77-82). Seasonality may additionally provide structure in the timing of pottery production when potters are also farmers. In the northern Yucatan peninsula, there is a pronounced dry season lasting from November through April (Dunning 1992:24-28), during which rainfall averages less than 40 mm per month. During the rainy season, rainfall dramatically rises with peaks in July and September, and average rainfall amounts ranging from 100 to 220 mm. These climatological and environmental conditions are systemic constraints to pottery production across the Yucatan peninsula, and would have affected all ceramic producers. To the extent that production was full-time, the constraints imposed by seasonality on pottery production would have made it likely that pottery producers did not produce all of the time. Rather, it is likely that they were seasonal producers. Part-time, seasonally constrained pottery production is suggested for Sayil (Smyth et al. 1995:130).

Though it is likely that ceramic producers in the northern Yucatan peninsula were part-time producers, it is more difficult to model whether they were specialized craft producers. Discussions of craft production often question the degree of specialization exhibited by the producers in question. Sahlins' (1972) Domestic Mode of Production models the precapitalist household-level organization of production. As families and kin groups attempt to meet the basic needs of their livelihoods, they may differentiate between 'men's work' and 'women's work,' thereby creating a simple division of labor based on sex. For Sahlins (1972:79), this constitutes economic specialization. In a literal sense, this is true; if a distinction exists between tasks that either sex perform then labor can be said to be specialized because there are more consumers of a product than producers. Under the Domestic Mode of Production, each household is capable of meeting its needs (although Sahlins (1972:101) does note that households do fail), which implies that interdependence is low. In terms of classical economic theory, however, specialization is defined by the presence of extra-household economic interdependencies between producers and consumers. So, not only does specialization involve a devotion of productive capabilities to a particular good or service, but it also implies that others are specializing in the production of other crafts and services for consumption outside of their household (Costin 1991:4). If ceramic production at Sayil were indeed geared towards export throughout the Puuc Region, and possibly beyond, then it also suggests the control of this industry by elite managers who would have likewise received economic benefit from the control of ceramic production. The role of elites in the organization of ancient Maya craft production is heavily debated (e.g. Lewis 1996; McAnany 1993a). To some extent, this debate stems from the ability to characterize goods as both utilitarian and as prestige goods, or that economic control of utilitarian and prestige goods can co-exist (Potter and King 1995)

In Earle's (1981) discussion of state economic systems, he discusses two modes of finance: wealth finance and staple finance. Therein, he develops the distinction between attached and independent specialists in order to explain the relationship between economic specialization and the development of complex society (see also Brumfiel and Earle 1987). Attached specialization is defined as the production of goods for elites, with the understanding that elites structured the demand for these goods (see also Costin 1991:11). These items are predominantly prestige goods, and enter into wealth finance economies. The management of the production and distribution of wealth items is more efficient for elites because these items are generally low in bulk and high in value. In wealth finance economies, states use specific items as currency, which are then allotted to state personnel who exchange them to secure their livelihood. Wealth is utilized either in its pervasive circulation, or by restricting access to it. In the first case, the production of wealth items rests in the hands of several independent specialists that have exclusive control over production. In these cases, it is argued that social institutions, such as age or rank, allow one to specialize in the production of wealth items. In the second case, the production of wealth items rests in the hands of attached specialists whose labor and products are appropriated and distributed by elites. This second dimension of wealth finance is usually what archaeologists have in mind when they discuss attached specialization.

Independent specialists, on the other hand, produced goods necessary for everyday survival for unspecified consumers (Brumfiel and Earle 1987:5; Costin 1991:11; Lewis 1996:358). These mundane subsistence items enter into staple finance economies. In a staple finance economy, "subsistence goods are collected by the state 'as a share of commoner produce, as a specified levy, or as produce from land worked with corvee labor'... The goods are then paid out to state personnel who use them to meet basic household needs" (Brumfiel and Earle 1987:6). Specialization in the production of subsistence goods is argued to be largely independent of elite control. Subsistence goods are bulky, and especially in ancient economies, were difficult to centrally store and redistribute. Across Mesoamerica generally, all transport was by human power prior to Spanish Contact, thereby limiting the movement of bulky items for great distances. Additionally, subsistence producers are resistant to centralized control of items so important to daily life (Brumfiel and Earle 1987:6-7).

As mentioned above, Muna Slate wares are the predominant slipped ware in the northern Maya Lowlands during the Late and Terminal Classic periods (600-1000 AD). They appear in contexts ranging from elite residences to lone house mound in the hinterland. In collections for Late to Terminal Classic sites, Muna Slate wares number second only to the Chum Unslipped group of ceramics. Given their ubiquity and high numbers, Muna Slate wares can be considered to be subsistence goods, and centralized control of their distribution would have formed part of a staple finance economy. Staple finance systems in large states are known in the archaeological record (e.g. Mesopotamia, see Galvin 1987), but Brumfiel and Earle (1987:6) note the difficulty of the coordination of demand and distribution under staple finance systems. Thus, with distance from the central distribution point of subsistence goods, the administrative and labor costs of distribution become increasingly uneconomical, and the range of the distribution system should decrease accordingly. The argument that Sayil was the locus of centralized production and distribution of Muna Slate wares juxtaposes elements from both of the definitions of staple and wealth finance systems. On the one hand, the spatial evidence from Sayil is suggestive of elite administration. The nature of the craft item, on the other hand, suggests independent specialization. It is unclear how this juxtaposition could have been resolved.

Models of Craft Distribution Systems

If ceramics producers occupy one pole in an economic system, then it is ceramic consumers that occupy the other end. It is the consumers of ceramics that create the demand for a producer's product. This demand may be related to the use-life of the pot (DeBoer and Lathrap 1979, P. Arnold 1991; Nelson 1991), or it may be related to other social factors related to natural and social contexts of pottery consumption (Reina and Hill 1978; D. Arnold 1985:144- 145; Chávez 1992:83-84). The demand for a product acts to create parameters for the distribution of that good. The scale, intensity, and segregation of consumption as well as the spatial organization of consumption all affect the distribution (and production) of ceramics (Pool 1992:280-282). Staple finance systems are based on the movement of goods from producers to consumers through a centralized agency. The mode of economic interaction and the form that distribution systems take are relevant considerations in ceramic ecological analyses for they place constraints as well as provide opportunities for specialized craft producers by creating more opportunities for interdependent economic relationships.

Polanyi (1957:250-256) identified three forms of economic interaction - reciprocity, redistribution, and (market) exchange. Reciprocal exchanges are conceived as the movement of goods between "symmetrically arranged groups" (Polanyi 1957:250). While it is not denied that reciprocal economic interaction was a part of ancient Maya economies, the presence of settlement hierarchies suggests that the precondition of symmetrical groups precludes the characterization of all exchange in the Late and Terminal Classic northern Lowlands as reciprocal. Redistributive and exchange forms of economic interaction, then, are more relevant to the analysis of the movement of Muna Slate wares between producers and consumers. Redistribution connotes the movement of goods through a central agency before reaching consumers (Polanyi 1957:253-254). This form of economic integration characterizes the wealth and staple finance systems discussed by Brumfiel and Earle (1987), in which the state oversees the "mobilization" of goods to meet its political ends (D'Altroy and Earle 1985). Exchange, for Polanyi (1957:254- 255), refers to market exchange in which the mechanisms of price-making serve to integrate the economy. In classical microeconomic theory, market exchange is subject to the forces of supply and demand, and prices should fluctuate accordingly. However, centrally administered markets may also exist in which prices are fixed and subject to enforcement. Market systems encourage economic specialization because they create regular demand for a product, an adequate number of other available specialists in other goods, and security that market exchange can proceed without interruption. Markets become regular when regions are economically, socially, and politically integrated. Economic integration is fostered by sufficient and reasonably priced transportation, sufficient and reasonably priced storage facilities, efficient communication of supply, demand, and value, political security for exchange across regions, and knowledgeable individuals that can act as facilitators and middle men in exchange relationships (Plattner 1989b). As noted above, transportation costs would have accumulated rapidly in the Maya Lowlands because of the lack of developed transportation technologies in this region. Further, as is highlighted in Chapter 3, political integration in the Maya Lowlands may not be extensive due to the presence of numerous competing polities of various sizes during the Late and Terminal Classic period. These factors work against the existence of extensive market systems that would have integrated portions of the Maya Lowlands. Considerations of redistributive economies, then, seem to be least problematic for this region.

Redistributive and exchange economies have been the focus of several types of locational analyses (Lösch 1954; Christaller 1966; Smith 1976; Crumley 1979). Gravity models provide many of the basic assumptions incorporated in more elaborate spatial analyses (Crumley 1979:145-146). The social sciences gravity model posits that interaction between two communities will be directly proportional to the populations in those two places and inversely proportional to the distance between them, raised to some k power. In terms of the economics of distribution, as distance increases, so do transportation costs. For this reason, Brumfiel and Earle (1987:6) see the high value to weight ratio of wealth items as a more efficient means of finance in state economies. Crumley (1979:149, 151) suggests that gravity models are potentially useful “as an initial assessment of two centers’ economic interaction,” but notes that gravity models do not model the interaction among sites. Central place theory was developed to model these interactions (Smith 1976). Central place models attempt to explain the distribution of interacting nodes in the economic system. To do so, these models assume several features, including: (1) a featureless plain free from constraints on movement, and containing evenly distributed agricultural populations without markets; (2) commercial activity is economical motivated and conforms to microeconomic principles; (3) there are no social or political barriers to trade; and (4) there is a constant demand for goods and services that is equally distributed over the landscape (Crumley 1979; Plattner 1989b). There are several potential limitations to the application of central place theory (see Crumley 1979:155), but by examining the variables involved in these models, relevant aspects of distribution systems can be identified, and the possible functions of sites can be approached in terms of their ‘fit’ to the model.

Central place theory, as developed by Christaller (1966), describes three types of central place arrangements that create landscapes geared towards different economic functions, marketing, transportation, and administration. These three basic systems were expanded by Lösch (1954) who suggested overlapping and nested configurations of central place locational hierarchies in an attempt to model real world conditions with greater precision. Yet these overlapping and nested systems all contain aspects of the three forms identified by Christaller (Smith 1976:19). Marcus (1993:153-154), however, sees Lösch’s models of Central Place more applicable for the Maya because they allow for similarly ranked centers to have different functions, and larger ranked centers to lack some functions. Predominantly, Marcus (1993:154) suggests that the function of centers in the Maya Lowlands was predominantly ceremonial, and that services were provided by these centers in exchange for labor and maintenance of the architecture, and presumably other services and goods as well. This finds some empirical support from studies of ceramic production in the Maya Lowlands that demonstrate that ceramic production occurred in centers, but that consumers in those centers were largely dependent on hinterland producers for utilitarian ceramics (see Chapter 4). This economic model of central places contrasts with the suggestion that Sayil, one of several major centers in the Puuc (Garza T. and Kurjack 1980), was a major producer and exporter of Muna Slate wares, the predominant slipped utilitarian ware of the Late and Terminal Classic periods.

The above discussion of production and distribution is couched in terms of economic central places. Large Maya centers were undoubtedly central places but there has been much debate over *what kind* of central places they were. Urban central places have different configurations of economic, political, and ritual functions, and Sanders and Webster (1988) argue that Maya centers are best characterized as regal-ritual centers. Marcus (1973, 1993), on the other hand, argues for the application of central place marketing models specifically for the site of Calakmul, but also to other large sites in the southern Lowlands such as Tikal, Copán, and

Palenque. She argues for the existence of high degrees of centralized political control at large Maya centers whereby these places exerted control over large regions. Ball and Taschek (1991:156) provide a moderate position between these two extreme positions, distinguish between cities, centers, and rural plazuela groups in order to emphasize the lack of centrality in Maya states, and at the same time recognize the presence of different levels within settlement hierarchies. While not wholly dependent on economic models, the models above rely on economic data to advance arguments for and against high degrees of centrality in Maya polity. These different conceptions of Maya economy should produce different spatial patterning of sites.

The argument made here is that the hypothesis that Sayil was the sole producer and distributor of Muna Slate wares for the Puuc region, or beyond, is problematic in light of several basic models of economic systems. Economies like those of the ancient Maya could be expected to either maximize the efficiency of distribution systems, or to limit their scale, thereby minimizing the cost. On the one hand, these conditions should create situations that favor higher number of producing units geared towards fewer producers. This is especially relevant to distribution systems of bulky subsistence items like Muna Slate wares. On the other hand, long-range economic integration could be achieved through the distribution of items with higher value and less bulk, as is modeled in wealth finance systems. Potter and King (1995) suggest that small-scale subsistence economies and broader prestige goods economies co-existed during the Classic period Maya. The characterization of Muna Slate ware production and distribution made for Sayil suggests that conflicting elements of both staple and wealth finance economies coexisted. Because Muna Slate wares may be considered utilitarian goods, their production and distribution should be relatively independent of centralized control.

Summary

This discussion of the economics of pottery production and distribution was approached through the framework of ceramic ecology. The utility of this framework of analysis is that it specifically addresses the linkages between potters and their holistic natural and social environments. In particular, this chapter was geared towards conceptualizing the place of Muna Slate wares in the ceramic economy of the Late and Terminal Classic Maya of the northern Lowlands. Although some of the relevant data are still poorly known, it seems that the distribution of raw clays and fuels may have made it difficult to centralize large scale production of ceramics. Likewise, the seasonal variation in rains would seem to reinforce part-time specialization in the production of ceramics. The nature of Muna Slate wares - bulky subsistence goods - argues against their centralized control for two reasons. First, the bulk of these items suggests that their centralized distribution would have been very costly. The extra labor associated with the distribution of Muna Slate wares over long distances would have added increasing cost to this subsistence good with increasing distance from the production location. Second, because Muna Slate wares can be fairly characterized as subsistence goods, then the demand for this product should serve to keep the costs low and the supply high. The combined insights gained from considering Muna Slate ware production and distribution in its holistic economic context suggest that the centralized production and distribution of these ceramics would have been costly and difficult to administer. Yet, the issue remains to be explored further through testing of the suggestion that Sayil was the centralized production and distribution point for Muna Slate ware. This hypothesis is partially tested by this research. In the following

chapters, further background is provided on the organization of Late and Terminal Classic Maya society, thereby providing culture-historical context for the sites of Ek Balam, Kiuic, and Labná (and Sayil). Previous studies of ceramic production are likewise reviewed; these largely support the argument that Muna Slate production should be predominantly located outside of larger centers.

CHAPTER 3: THE LATE AND TERMINAL CLASSIC PERIODS IN THE NORTHERN LOWLANDS

The Carnegie Institution's archaeological research at Mayapán and Chichén Itzá (Beyer 1937; Morley 1946; Thompson 1954; Pollock et al. 1962; Smith 1971) were early and extremely influential programs of archaeological research in the northern Lowlands; they established the chronological and culture historical frameworks used in northern Yucatan research for decades. Since the 1970's, the growing number of archaeological projects in the Puuc hills and the northern plains have brought this culture historical framework into question, and have led to revisions in our understanding of the transition from the Classic to Postclassic periods. Continuing research projects focus not only on the chronological placement of the ceramic complexes that span the Classic to Postclassic transition, but also the implications for broader socio-political interaction that the chronological realignments of these spheres suggests. Further, advances in the deciphering of hieroglyphic inscriptions as well as detailed analyses of monumental art provide a rich, if not altogether clear, supporting database for the chronological modifications. As a result, knowledge of Maya socio-political dynamics during the Late and Terminal Classic period is much richer, and a great deal more variation is recognized. In this chapter, data concerning revisions in the chronology of the Late and Terminal Classic periods, and the hierarchy of settlements that characterized the northern Yucatan during this time is presented in order to argue that the territorial extent of polity in the northern Lowlands was smaller than has been previously argued. This situation suggests that political interaction was fluid and dynamic during this time period, and that the negotiation of long-distance exchange of subsistence goods would have been difficult.

Early Models

Early understandings of the culture history of the northern Yucatan attributed most of its cultural development to the southern Lowlands. The rich, elaborate artistic expression found in southern Lowland sites was contrasted to the paucity of stelae and hieroglyphic inscriptions in the northern Lowlands to suggest that the Maya of the northern Lowlands were somehow lacking in cultural achievements. Sylvanus Morley and J.E.S. Thompson, the leading Maya scholars of their day, provided two early and highly influential explanations of the differences in the southern and northern Lowlands sites (Sabloff 1990:27-30). In his model, Morley (1946) placed the rise of the Puuc region sometime at the end of the Classic period following the decline of the "Old Empire" in the southern Lowlands (Table 3.1). The Puuc centers, it was thought, were founded by displaced southern Maya moving north, while another population of invading Mexicans founded Chichén Itzá. The rise of this latter site signaled the rise of the "New Empire" in the northern Lowlands and marked the beginning of the Postclassic period. Chichén Itzá and the Puuc sites were thought to have coexisted until the rise of Mayapán in 1200 A.D. While Morley's arguments were influential, Thompson's (1954) model had more lasting effect (e.g. Coe 1966). Thompson's model differs in the placement of key chronological events in the Late Classic to Postclassic transition. Thompson proposed the rapid succession of three regional polities, centered at Uxmal, Chichén Itzá, and Mayapán, respectively. Arguing that the Puuc sites were roughly coeval with the large southern centers (such as Tikal, Copán, and Palenque), Thompson placed the fall of Uxmal with the collapse of contemporary sites in the southern Lowlands. Shortly thereafter, Toltecs exiled from their capital of Tula (in the modern state of

Hidalgo) invaded the site of Chichén Itzá, establishing a regional state hegemony over much of the northern plains. After the collapse of Chichén Itzá, a new regional state rose at Mayapán for a brief period of time until its power waned and a set of small regional polities emerged as “the whole peninsula fell into a condition of feudal anarchy” (Coe 1966:131).

Table 3.1. General chronological sequences and associated ceramic spheres*

	Chronological Period	Morley’s (1946) Historical Sequence	Thompson’s (1954) Historical Sequence	Smith’s (1971) Ceramic Chronology	Revised Ceramic Chronology*
1500 AD					
1400	Late Postclassic	Mayapán’s Reign	Mayapán Empire	----- Tases	
1300	-----	“New Empire”		----- Hocaba	----- Hocaba-
1200		-----	-----	-----	Tases
1100	Early Postclassic	“Old Empire”	Chichén Itzá Empire	Sotuta	----- Sotuta- Hocaba
1000	-----	Puuc Region and Chichén	-----	-----	-----
900	Terminal Classic	Itzá come to power	Uxmal Empire	Cehpech	Sotuta and Cehpech
800	-----	-----	-----	-----	
700	Late Classic	Southern Lowland			-----
600 AD		Collapse			

* Chronology follows Ringle et al. (1998) for the chronology of Chichén Itzá.

In their respective studies of the ceramics of the northern Yucatan, both Brainerd (1958) and Smith (1971) accepted the reality of Thompson's argument for three successive empires in the northern Lowlands (Anderson 1998). Smith's use of this chronology to inform his application of a ceramic type-variety classification system in the northern Lowlands established the standard typological nomenclature used from the time of its publication. Smith's (1971) work established three ceramic spheres for the northern Yucatan peninsula. These three spheres were named Cehpech, Sotuta, and Hocaba/Tases, and each was assigned to one of Thompson's regional capitals; Cehpech was associated with Uxmal, Sotuta with Chichén Itzá, and Hocaba/Tases with Mayapán (Table 3.1). (For the present research, the Hocaba and Tases spheres are largely irrelevant, and are not discussed further.) The Cehpech and Sotuta spheres both contain ceramics belonging to the slateware tradition in the northern Yucatan, but two different types of slateware were established for each of the ceramic. Each of these spheres additionally contains important unslipped and red wares that are not examined in this study. The slateware variant for the Terminal Classic Cehpech complex occupations of Uxmal and the Puuc region was labeled Puuc Slate Ware. Puuc Slate wares were defined by the presence of grey slips and their brown to buff pastes containing carbonates. In the Early Postclassic Sotuta Sphere, the slateware variant was labeled Dzitás Slate. Dzitás Slate wares, on the other hand, were noted for their white slip color over a red paste tempered almost exclusively with volcanic ash.

Although Smith considered the Cehpech slateware and Sotuta slateware complexes to be chronologically and culturally distinct, he discussed difficulty in distinguishing the two complexes from one another. In his description of Cehpech slatewares, he notes, "In ware attributes [Puuc Slipped Ware] differs little from Chichén Slate Ware" (1971:28). Yet, he maintained that Cehpech and Sotuta spheres contained distinctive vessel forms. So, with Thompson's model of three successive empires in mind, Smith decided that the differences in the ceramics outweighed the similarities. The resulting Cehpech and Sotuta spheres were placed in chronological succession, and their presence or absence was thought to indicate the presence of Mayan and Mexican influence, respectively. The presence of three successive regional empires in the northern Lowlands would suggest fairly high degrees of economic and political integration that united the large territories. However, it now seems clear that Chichén Itzá and Uxmal were both occupied during much of the Late and Terminal Classic periods. This adds additional complexity to the regional political and economic dynamics of the time period.

Revisions of Early Models

Thompson's model of successive empires in the northern Lowlands had a great deal of influence in the archaeology of the northern Maya Lowlands, but it is not without its problems. Continuing research throughout the Maya Lowlands demonstrates that two key concepts associated with Thompson's model - the Classic Maya 'collapse' and the chronological placement of the ceramics used to develop the culture historical sequence of the northern Lowlands - are problematic.

The Classic Maya Collapse

The "collapse" of the southern Lowland Maya was thought to be a demographic devastation of the southern Lowlands, with a concomitant abandonment of large sites. Based on dates inscribed on monumental architecture, the collapse occurred around 800-900 A.D. This decline in population was explained as either an actual disappearance (death) of the southern

Lowland Maya, or as the mass migration of the southern populations to the north, where they carried on the greater cultural traditions of the south until the Toltec invasion of the Postclassic period (see Culbert 1973:17-18; Sabloff 1973:38-39). Various internal social and natural causes (disease, natural disasters, warfare, climate change, declining soil productivity) as well as external social factors (invasion, shifting economic spheres) have been used to explain the apparent collapse (see Adams 1973; Sabloff 1973; see also Webster 2002).

Subsequent research, however, suggested that the Classic Maya collapse was more apparent than real, and that large populations continued to occupy the southern Lowlands for some time. Adams (1973:22) discusses three interrelated aspects of the southern Lowland decline: the disruption of the elite power structure and its material indicators; the depopulation of the region; and the short span of time over which these changes took place (ca. 50-100 years). In his first point, Adams correctly points to the source of one fallacy of interpreting the ‘collapse’ of the southern Lowland centers. It was assumed that when monumental architecture and hieroglyphic inscriptions were no longer produced, that the populations of the southern Lowlands had disappeared. It is now understood that the decline of the southern Lowland centers was not a uniform process in terms of space and time (Jones 1991; Mathews and Willey 1991; Webster 2002). The Late Classic period represented a volatile time in the southern Lowlands, especially for members of elite dynasties. Importantly, the collapse does not represent the decline of Mayan civilization as a whole, but represents a temporally and geographically restricted set of phenomena.

Further, these revisions in our understanding of the collapse highlight the growing awareness of the divergent developmental histories of the northern and southern Lowlands (Bey et al. 1998:118). Population movements of displaced southern Lowland Maya cannot be used to explain the culture history of the northern Lowlands during the Terminal Classic. The Late and Terminal Classic developments in the northern Yucatan may be understood as the *in situ* elaboration of social and political processes. As a result of this, more attention must be given to the understanding of the history of the northern Yucatan and the interaction between sites within it. Particularly important to these views is the realignment of the chronology of the northern Yucatan.

The Ceramic Sequence

Anderson’s (1998) analysis of the development of the culture-history of the northern Yucatan provides valuable insight into the development and persistence of Thompson’s model. As she indicates, the Carnegie Institution was instrumental in conducting some of the first large-scale excavations in the northern Yucatan. Robert Smith, who developed and first applied the type-variety system used today for the northern Maya Lowlands, was a Carnegie archaeologist. His contribution to the Mayapán project (Smith 1971) ultimately supported the model of Uxmal’s regional polity falling to Toltec Chichén Itzá, and, in turn, to Mayapán. The ceramic samples used to construct the regional ceramic chronology were taken from the region to which Smith considered them to be temporally diagnostic. So, the ceramics of the Cehpech sphere came from Uxmal and Kabah in the Puuc region, Sotuta sphere ceramics from Chichén Itzá, and ceramics belonging to the Hocaba and Tases spheres were drawn from the collections at Mayapán. However, Smith did not work from stratigraphically secure deposits, and so it seems that his preconceived ideas about the culture history of the northern Yucatan drove his conclusions about the chronological and cultural associations of the various types of ceramics that he encountered (Anderson 1998:156-157; see also Ringle et al. 1998:189).

As noted above, Smith considered the Cehpech slateware and Sotuta slateware complexes to be chronologically and culturally distinct, and distinguishable by paste, surface treatment, and vessel form. However, pastes, slips, and some vessel forms seem to be shared in both Cehpech and Sotuta spheres (Lincoln 1986:175-183; see also Stanton and Gallareta N. 2001), and the differences in the two spheres are not always readily apparent. Further, the distributions of Cehpech and Sotuta sphere ceramics appear to be largely coeval. Sotuta sphere ceramics are largely confined to the area immediately surrounding Chichén Itzá, secondary centers, including the trade port of Isla Cerritos and the saltworks at Emal, that extend to the north, and the adjacent Chikinchel region to the east (Kepecs 1998:127). While the majority of ceramics recovered at Chichén Itzá are associated with the Sotuta sphere, stratigraphic excavations there have demonstrated that Cehpech ceramics co-occur in small numbers with Sotuta sherds (Lincoln 1990:220, 324; cited in Ringle et al. 1998:190; Chung 2000). Along the margins of the distribution of Sotuta sphere ceramics, Kepecs notes an increasing presence of Cehpech slatewares with Sotuta deposits (Kepecs 1998:127-128; see also Ringle et al. 1991, Andrews et al. 1988). A complementary distribution of Cehpech and Sotuta sherds occurs outside of the Sotuta region. In the other portions of the northern Lowlands, small numbers of Sotuta sherds have been found mixed with larger Cehpech deposits. Close to Chichén Itzá, Sotuta ceramics have been found in secure contexts with Cehpech ceramics at Ek Balam (Bey, et al. 1998:116), Yula (Anderson 1998), and Yaxuna (Suhler et al. 1998). Further away, small numbers of Sotuta sphere ceramics have been recovered from the Main Plaza at Uxmal (Schele and Freidel 1990:499, footnote 20; Dunning and Kowalski 1994), as well as Nohmul in Belize, and Becan in Campeche (see Stanton and Gallareta N. 2001: 230, footnote 3).

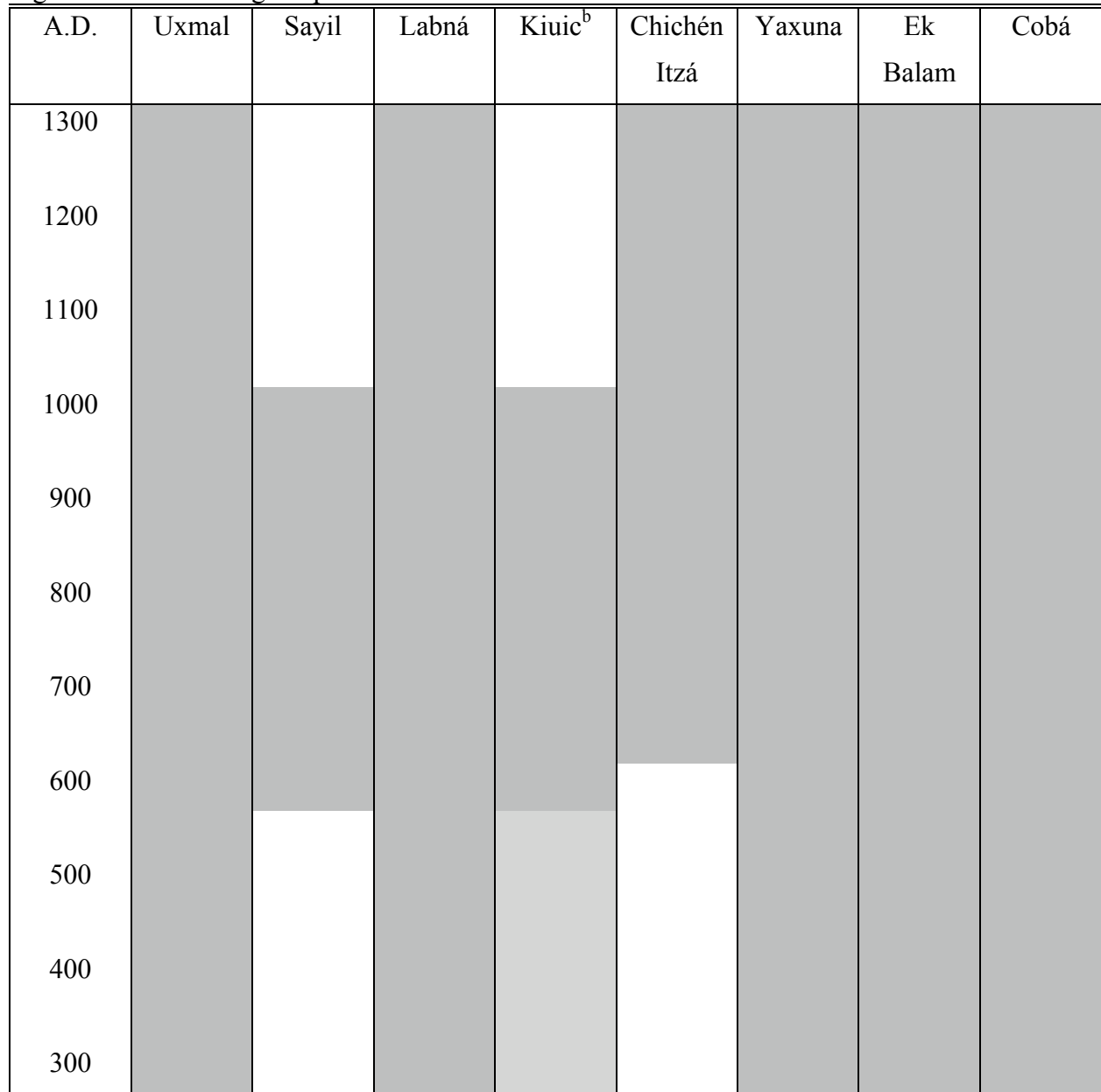
The conclusion reached from this reassessment of the cultural and chronological contexts of Cehpech and Sotuta slatewares is that they are best conceptualized as belonging to a similar technological tradition dating to at least the Late Classic period at sites in the eastern portions of the peninsula (Bey et al. 1992; Bey et al. 1998; Robles C. 1987:103-104). This technological tradition extended from the Puuc region eastward to the Caribbean coast, and to the south. Sites in northern Belize (Chase and Chase 1987:61), the Chenes regions of Campeche (Williams-Beck 1989), and south-central Quintana Roo (Fry 1987) utilized this slateware technology, and, as discussed in the previous chapter, these slatewares can be considered common subsistence items. While the ceramics belong to a similar technological tradition, it is also apparent that there are sub-traditions, or regional variants in terms of paste composition, surface color, and forms. As noted above, Sotuta slateware pastes are characterized by a high content of volcanic ash temper, while the Cehpech ceramics contain larger amounts of carbonates. Further, on the basis of forms and surface color, the Cehpech slatewares may be subdivided into at least two divisions - an eastern and a western sub-sphere (Bey et al. 1992). Thus, Sotuta ceramics are predominantly associated with Chichén Itzá, and with sites between it and its port at Isla Cerritos, and in the Chikinchel region. Surrounding these regions on all sides, regional variants of Cehpech ceramics predominate in Late and Terminal Classic deposits.

Late and Terminal Classic Polity in the Northern Yucatan

The distribution of Cehpech and Sotuta ceramics implies that Chichén Itzá did exert influence over a territory in the northern Yucatan, but that territory is much smaller than Thompson's model of the Early Postclassic Itzá empire suggested (Anderson 1998; Kepecs 1998; Ringle et al. 1998). The regional variants of Cehpech ceramics likewise suggest that socio-

political integration of the rest of the northern Lowlands may not have been extensive. While settlement hierarchies are apparent in the northern Lowlands, these can be deceiving if one equates position in the settlement hierarchy with the extent of territorial control. In this section, the ways in which the sites of Ek Balam, Kiuic, and Labná articulated with their surrounding sites is discussed. Considering these sites in their regional context highlights the potential for dynamic political interaction between these sites (Figure 3.1).

Figure 3.1. Chronological placement of selected sites in the northern Lowlands^a



a. After Benevides C. (1994); Suhler et al. (1998)

b. Dashed area indicates possible occupation based on architectural chronology

Ek Balam

Research at the site of Ek Balam has demonstrated its importance as one of the major centers in the northern Yucatan plains (Ringle and Bey 1995; Ringle et al. 2000; Bey et al. 1998; Bey et al. 1997). The site is located 51 km northeast of Chichén Itzá and 60 km northwest of Cobá. Work at the site concentrated not only on the architectural core with its surrounding wall, but also incorporated a survey of the outlying settlement in modern agricultural swidden fields (*milpa*). These surveys determined that settlement extended approximately 1.8-2 km beyond the site center. Further, several other outlying communities were sampled as part of a transect survey between Ek Balam and Chichén Itzá, as well as other sites in the region.

The results of this research indicate that initial occupation of the site dates to Middle Preclassic times and continues into the Colonial period. Principal occupation of the site dates from the Late to Terminal Classic periods, and is associated with the Yumcab ceramic complex. This complex can be subdivided into early and late facets, and it is the Late Yumcab complex that represents the florescence of this regional variant of the Cehpech sphere. At Ek Balam, the Late Yumcab spans the time from 700 A.D. to 1050/1100 A.D. Evidence for intersite interaction seems to have been directed towards western portions of the peninsula during this time, as indicated by the high percentages of Puuc Unslipped wares (Bey et al. 1997). The presence of Puuc Unslipped wares stands in contrast to the ceramic assemblage from Cobá, where Vista Alegre Striated is the Late to Terminal Classic unslipped ware (Robles C. 1990:177-178).

One of the goals of the Ek Balam project was to determine the relationship between this site and Chichén Itzá. The combined architectural, settlement, lithic, and ceramic data gathered in and around Ek Balam indicate that this site was not under the control of Chichén Itzá. Sotuta sphere ceramics constitute less than 0.1% of the total ceramics recovered from Ek Balam. By 600 A.D., Ek Balam came to regional dominance, and held this position during the rise of Chichén Itzá, which controlled its own, separate territory. A transect survey between Ek Balam and Chichén Itzá revealed a fluid and complex pattern. Distance to the largest center does not correlate well with the distribution of obsidian and ceramics characteristic of either of the two large centers. Further, there seems to be a fairly close packing of sites within the areas surrounding Ek Balam within a distance of 17 km, suggesting that the range of regional control exercised by large sites in the northern plains was not extensive, covering perhaps 900 km² (Ringle et al. 2000:64-65). Overall, the data derived from the work at Ek Balam and its surrounding region is argued to support the interpretation that extensive regional polities did not exist in the northern Plains during the Late and Terminal Classic periods. Rather, segmentary state models seem to apply to this site and its surrounding area.

The Puuc Region, Labná, and Kiuic

The Puuc region is notable for its relatively high topographic relief. It is the only region in the Northern Yucatan that contains sizeable and extensive hills - *puuc* is Yucatec Maya for 'hill'. Because of this higher elevation, the *cenotes* - sinkholes that expose the water table - that dot the other portions of the northern Yucatan plains are non-existent in this region. Yet, these limitations did not prohibit the Puuc region from becoming a center of high population density and cultural elaboration during the Late and Terminal Classic periods. The constraints presented by the natural environment, however, do seem to suggest the timing of occupation and florescence in this region. General trends in the regional settlement record indicate that both the light, but pervasive, Middle to Late Preclassic and the heavier Late to Terminal Classic occupations of the Puuc region are associated with cooler, wetter climatic periods. These

conditions allowed the exploitation of the generally fertile soils that occur in the region. After the Middle to Late Preclassic occupation of the region, the area seems to have been largely depopulated until improving weather patterns allowed the reoccupation of the region (Dunning 1992:24-28; 1994:9-10, 27-28). Once environmental conditions improved within the region, it was rapidly and intensively re-occupied.

This intensive re-occupation may help to explain certain aspects of the Puuc Region settlement pattern. Although a settlement hierarchy has been proposed for the region (Garza T. and Kurjack 1980), there are no clear distinctions between several of the sites that are placed in different levels in the hierarchy (Kurjack 1994:314). Further, it is not clear to what extent the settlement hierarchy equates to a control hierarchy. Dunning and Kowalski (1994) support the idea that Uxmal came to control a regional political system during the Terminal Classic on the basis of symbolic and iconographic analyses of this site's architecture and the presence of a *sacbe* system connecting Uxmal to Nohpat and Kabah. Analyses of the iconographic content of Uxmal's monumental art suggest that over the course of its occupation, a single ruler ruled Uxmal at any given time. The most famous of these rulers, "Lord Chac," directed the construction of several of the site's largest edifices during Uxmal's Terminal Classic height of occupation (Robertson 1994:209-211). Given these interpretations, Uxmal seems to represent the controlling center of an extensive network of sites that would not have been out of place in the Classic period southern Lowlands.

But, if such a regional hierarchy did exist, it was relatively short lived, especially given the brief - around 400 years - Late and Terminal Classic expansion of the Puuc region. Further, Uxmal did not reach regional importance above other sites around it until late in its history (Dunning and Kowalski 1994:80). Given the relatively short-lived height of the Puuc, power hierarchies did not have long to crystallize, and political interaction may have been more fluid. Data from Sayil suggest that leadership was dispersed (Carmean 1998). Indicators of wealth, political leadership, and religious leadership do not relate to one another in definite ways, suggesting that power was dispersed throughout the site. However, commoners did not occupy positions of community-wide leadership. "Rather, political and religious leadership spread from the central core and into the nonroyal, nonruling elite hands of the lineage heads or... into the hand of high-ranking members of Sayil's principal lineages" (Carmean 1998:269).

These two statements suggest that power relationships common throughout Maya society were also utilized in the Puuc to a greater or lesser extent. For any given site, power seems to have ultimately rested in the hands of one person. However, Carmean's observations at Sayil suggest that the social distance between rulers and subordinate elites in Puuc polities was not that great. Further, this suggests only weak centrality in government. By extension, highly centralized control of economic interaction would seem unlikely in these conditions. The settlement hierarchy proposed for the region, while problematic, does suggest that there are some differences in the size of sites, but it is unclear to what extent that the differences in size are related to differences in regional control.

The sites of Labná and Kiuc occupy intermediate positions in the site hierarchies applied to the Puuc region. Garza T. and Kurjack assign Kiuc and Labná to Rank-III positions in their four-tiered settlement hierarchy. Dunning provisionally lists the site in a similar position in his six-tiered refinement of their settlement hierarchy (Dunning 1992:86). The past decade of work at the site of Labná (Gallareta N. 1998) reveals similarities between occupations at Labná and Sayil (see Sabloff and Tourtellot 1991; Tourtellot and Sabloff 1994). The principal architectural groups containing civic architecture occupy the floor of a valley, with residential groups

arranged around the sides of the valley and on some hilltops (Gallareta N. 1998:30-38). Labná's center comprises two main architectural groups; a palace structure in the north part of the site's center is joined by a *sacbe* extending south to an elite residential compound. Surrounding the site center are several residential architectural groups.

The ceramic complexes defined for the site extend from the Late Preclassic period until the middle of the 20th century. Preclassic occupation is light, and despite the presence of Early Classic ceramics, there seems to have been a hiatus in the occupation of the site during the Early and Middle Classic periods. Late and Terminal Classic occupation can be divided into two architectural periods, but there are currently no apparent differences in the ceramics from these subdivisions. In other words, the Modelo complex Cehpech ceramics associated with Puuc Mosaic style architecture (830-950 AD) appear to be the same as those that appear with Early Puuc (670-770 AD) and Puuc Colonette (770-830 AD) style architecture. The early facets of Late to Terminal Classic occupation are additionally noted by the presence of Preclassic ceramics mixed with later Cehpech ceramics.

Work at Kiuic (Gallareta N. et al. 2001) is only just beginning, but initial similarities between Kiuic and Labná can be recognized. Like Labná, Kiuic's site center is composed of two primary groups of civic and elite residential architecture, Groups Colomte and Yaxche, respectively. These groups are connected by a short *sacbe* running west from the Yaxche Group to the Colomte Group. The former is composed of several smaller stone buildings enclosing several plazas. The largest of these enclosures, Plaza Dzunun contains a large pyramidal or multi-storied rectangular structure on its north side. The Colomte Group is composed of a series of several multi-storied palace structures that flank a large raised plaza on the south and the west. This plaza is open to the north and to the east. This configuration of elite residential spaces connected to public architectural groups is mirrored at Labná. The emerging ceramic chronology for the site indicates a hiatus in occupation at Kiuic, similar to that suggested for Labná. While Early Puuc, Puuc Colonette, and Puuc Mosaic architecture are apparent in various structures located within Kiuic's site center, excavations have focused on locating plaza floors to date. At this time it is not possible to comment on the manner in which the Cehpech ceramics from Kiuic articulate with the architectural sequence.

An ongoing transect survey running between Labná and Kiuic reveals a dense settlement pattern. Sites are scattered throughout the intervening expanses of land, and range in size from small hamlets to the large site of Huntichmul. This site is located about 4 km to the northwest of Kiuic and about 7 km to the south of Labná. Huntichmul occupies a Rank-III position in both Garza T. and Kurjack's and Dunning's settlement hierarchies (Dunning 1992:86). Settlement location and size in the transect seems to have been determined by the irregular topography and by the presence of agricultural land (Dunning 1992:129; see also Sabloff and Tourtellot 1991; Gallareta N. 1998). The apparent settlement pattern suggests that most non-agricultural land was used for settlements, leaving valley floors open for crop lands and large civic architectural groups. Additionally, there is some evidence of land reclamation through the use of terraces on hillsides in the Kiuic-Labná transect. Settlement appears to have been dense, and larger sites of equal size are spaced at roughly even intervals of 6 km.

Given that these sites share an equal rank in the settlement hierarchy, then population for Kiuic, Huntichmul, and Labná should have been similar. Dunning places population estimates for the territories of Huntichmul and Labná at 10,400 and 15,000, respectively (Dunning 1992:126- 127). Kiuic's population estimate is reported by Dunning (1992:127) as 2,600, but the accuracy of this estimate is questionable. Dunning's population figures for Labná and

Huntichmul both include estimates for these sites as well as sites thought to be under the influence of these sites. Estimates for Kiuic omit a specific estimate for the site. For this reason the estimate seems to be out of order with the other estimates provided by Dunning.

Kiuic, Labná, and Huntichmul occupy similar positions in the settlement hierarchy, and the closest higher-order center, Sayil, is located about 8 km to the west of Labná. This position makes Sayil one of two second order sites located within the Bolonchen District, of which Kiuic, Labná, and Huntichmul are a part. Considering the other sites in the Puuc Region, Dunning's (1992:90) survey area includes 8 Rank II, 3 Rank III, 10 Rank IV, 36 Rank V, and 26 Rank VI sites were located. Visual inspection of Dunning's map indicates that the longest distance between Rank II centers does not exceed 10 km. The high number of second order centers in such a small area suggests that there were numerous polities interacting and competing with one another for primacy in the region. Given that Uxmal did not reach a first order ranking until late in its history, it may have likewise participated as an equal partner in these interactions until its Terminal Classic rise. In short, the settlement hierarchy of the Puuc region seems to indicate a high probability for dynamic interaction as numerous small polities attempted to retain autonomy. Again, if Carmean's data from Sayil apply to other Puuc sites, then there seems to be fairly decentralized power at the intrasite level as well.

If these characterizations of Puuc social dynamics during the Late and Terminal Classic period are correct, then there seems to be adequate grounds to suspect that sites in that region may have been independently provisioning their own needs, rather than relying on alliances that were in a state of flux. Again, it would have been costly for Sayil to centrally distribute Muna Slate wares from that site to others in the Puuc region and beyond, and as distance increased from Sayil, it would be increasingly expensive to procure these objects from the consumer's point of view. It seems much more likely that Kiuic, Labná, and Huntichmul procured their ceramics from closer to their settlement. Elsewhere, the difference in the ceramic assemblages between Ek Balam and Chichén Itzá, on the one hand, and Ek Balam and Cobá, on the other, suggest that Ek Balam was probably also provisioning its own needs. The evidence from Ek Balam suggests that, while this site was a major center in its region, the extent of its territorial control was not great. Again, this situation argues for both a dynamic political situation and a context in which it is more likely that the provisioning of utilitarian goods should be organized locally if at all possible.

Polity and Expectations for Economic Specialization

In this chapter, the socio-political milieu of Ek Balam, Kiuic, and Labná has been provided in order to provide the culture-historical context of Muna Slate ware production and distribution. Although previously it had been hypothesized that the northern Yucatan was not occupied extensively before the Late and Terminal Classic periods, it is now understood that this is not the case. Population movements from the southern Lowlands associated with the "collapse" are not responsible for the settlement of the northern portions of the peninsula. The development of this region was due more to local processes with long histories. We see in the Late and Terminal Classic periods that regional states, centered on Uxmal and Chichén Itzá did not succeed each other in time, as was suggested in Thompson's model. Yet, the existence of site hierarchies is not denied. In this study, Ek Balam is the largest site sampled, and is the only one of the three that can be considered a primary regional center. Any level of regional integration around Ek Balam would have focused on this site. Kiuic and Labná, on the other hand, occupy

lower positions in the Puuc Region settlement hierarchy that is topped briefly by Uxmal. This might suggest that these sites should fall under the jurisdiction of Sayil, which is the closest higher-ranked site, if the Puuc settlement hierarchy mirrors a control hierarchy. While this is possible, it may not necessarily be the case (Crumley 1995:2), and an a priori assumption of domination should not be assumed.

While Maya scholars generally agree that the Maya could be called a state level society, the nature of that state is open to debate (Fox et al. 1996). Some researchers view Maya polity as highly centralized, arguing that the size, internal complexity, architectural elaboration, and complex settlement hierarchy of large Maya centers as well as the epigraphically documented royal lineages and records of conquest and warfare encountered there, are indicative of a centralized state (Chase et al. 1990; Culbert 1991; Chase 1992; Folan 1992; Marcus 1993). The sheer size and complexity of large Maya centers and their subject centers in the settlement hierarchy is seen as demonstrating the necessity of centralized managerial control. Others propose much more fluidity in the ancient Maya polity. These scholars propose that the sheer number of Maya settlements that can be considered regional centers argues for low smaller territories and interaction that are better modeled by segmentary state, feudal state, and galactic polity models (Adams and Smith 1981; Sanders and Webster 1988; Ball and Taschek 1991; Mathews and Willey 1991; Demarest 1992; Tourtellot et al. 1992). Within these models, lineage based social segments choose to participate in larger political groups, and may shift political affiliation when they feel that their current situation is not to their liking. Drawing on the work of Fox (1977), many decentralists see Maya centers as serving largely regal-ritual (as opposed to mercantile or administrative) functions.

It is confounding that arguments for and against a centralist or decentralist positions can usually be made adequately for any given site. Much of the problem stems from the ability to reach different conclusions using the same sets and classes of data (Chase et al. 1990). As Tourtellot et al. (1992) demonstrate, analyzing the same class of data from different sites through the same approach can produce conflicting results. They argue that it is not classes of data that are important, but that these classes of data are probably variable in their use between regions. A contextual approach is best for understanding how different classes of data reflect social organization of polity between different regions. Further, Demarest (1996) points out that it was probably the case that multiple polities that exhibited multiple configurations of social and political power existed in the Maya region at any given time.

The purpose of this chapter has been to provide the context of Muna Slate ware production and distribution. In the previous chapter, it was argued that Sayil's position in its regional settlement hierarchy, while possibly suggesting control, is at odds with central place models that are usually proposed for the Maya Lowlands. In most Lowland Maya models, centers are seen as providing mostly services, and as net consumers of the goods and labor of subordinate settlements. The suggestion that Sayil fulfills a major productive and distributive function for the movement of Muna Slate wares contrast with this model of central places. In this chapter, the argument was advanced that polities in the Late and Terminal Classic northern Maya Lowlands were the context of fluid political interaction and that the organization of trade networks to supply subsistence items throughout near and far regions may have been particularly difficult. By extension, there seems to be no a priori reason to assume that Sayil should control the production of Puuc Slate wares. To foreshadow the following chapter, there is ample evidence from studies of Maya Lowland pottery production that suggests that civic centers are better characterized as net consumers of pottery rather than as net producers. Further, ceramic

production, especially of utilitarian wares, seems to be more characteristic of craft production in smaller outlying communities. Again, this feature of ceramic production systems in the Maya Lowlands fits well with traditional applications of central place models. In terms of specialization, the smaller communities should exhibit more specialized production of ceramics.

CHAPTER 4: STUDIES OF LOWLAND MAYAN CERAMIC PRODUCTION

Given the long history of research in the Maya Lowlands, there are surprisingly few studies of the production and distribution of ceramics in these regions. However, those that have been conducted present important results for understanding ceramic production in Maya prehistory. Important programmatic studies have been completed at large important centers throughout the southern Lowlands, with smaller projects undertaken for sites ranging from the Petexbatun region, the central Peten, the central Lakes districts, the eastern frontier zone, and Belize. The overall picture to emerge from these studies is that Maya centers seem to be net consumers of ceramics rather than net producers. This is not to say that ceramic production did not occur within large centers, but that the number of producers in these places was not sufficient to meet the demand of the other residents. In turn, these findings are important for understandings the ways that craft production and specialization is used to support models of Maya polity. Additionally, these studies of ceramic production provide data that suggest that many ceramic production locations are located outside of site centers.

Tikal

Ceramic production and distribution at Tikal has been examined diachronically through analyses of formal and chemical variation. In an early study of occupational specialization, Becker (1973:399) proposed that Group 4H-1 was a location of ceramic production, as evidenced by the midden deposits rich in sherds of censers, figurines, whistles, bowls, “candlesticks”, and decorated vessels. Additionally, figurine molds and mold fragments were recovered. These molds recovered from the middens at group 4H-1 are the strongest indicators of occupational specialization in ceramic manufacture. Fry (1974) notes that this structure is located in proximity to the site’s centers and adjacent to a *sacbe*, and interprets Group 4H-1 as a marketplace. (It is interesting to note that these data are almost identical to those used at Sayil to argue for ceramic production and marketing at that site.) While these associations are somewhat circumstantial, Culbert and Schwalbe’s (1987:649) study of polychrome pottery supports them. Therein, these researchers found a high degree of homogeneity in paste composition for this group’s ceramics, again suggesting that ceramics were produced at this location.

The production and distribution of serving vessels - “those vessels with shapes and sizes more appropriate for serving of solid and liquid foods than for preparation or storage” (Fry 1979:496) - was investigated at Tikal through multidimensional scaling analysis on a set of technological and stylistic attributes. Initial analyses indicated that there were several production areas within the greater Tikal area (Fry and Cox 1974) for the Imix phase of the site’s occupation (700-830 A.D.). Adding chronological depth to the study, Fry (1979) noted changes in the scale of production from the Ik phase (600-700 A.D.) to the Imix phase (700-850 A.D.). Additionally, greater variation in ceramics accompanies the transition from the Ik to Imix phase. However, both studies supported the idea that serving vessels at Tikal were circulated through a market system that was focused on Tikal, possibly through a proposed marketplace located next to one of the *sacbeob* in the site’s center.

This interpretation was modified after Ik and Imix phase ceramics sampled from south-central Quintana Roo were also analyzed (Fry 1980). Fry finds that there is an overall lack of evidence for highly centralized control of the market system at Tikal. Rather than serving as a major redistributive node, Tikal seems to have been a major node of consumption. Further, “If

there was a central Tikal market... it did not traffic heavily in utilitarian pottery” (Fry 1980:16). Serving vessels did show a greater range of distribution, but not to the extent that would imply highly centralized marketing. Rather, Fry perceives that there may have been separate distribution systems for utilitarian and serving vessels, and that this complexity is attributable to Tikal’s role as a major Mayan sociopolitical (and possibly economic) center.

Expanding the formal studies of Fry, Culbert and Schwalbe (1987) investigated chemical patterning within Tikal’s ceramics. For the Imix complex, “numerous specialized centres producing several kinds of pottery differing in both surface characteristics and chemical composition” (Culbert and Schwalbe 1987:652) is indicated. Importantly, the Imix complex is associated with Tikal’s height of population. During the following Eznab phase (850-900 A.D.), utilitarian pottery continues to be well made, but polychromes decrease substantially in numbers and in the quality of their surface decoration and control of their firing. Culbert and Schwalbe suggest that these changes are indicative of a continuation of specialization in the production of domestic pottery, while elite polychromes became unnecessary after the decline of Tikal’s rulers. Distinctions between two paste classes - calcite-tempered, and non-calcite tempered - continue, from the Imix to the Eznab phase. Yet, calcite-tempered pastes begin to be used for vessels other than unslipped ceramics. Culbert and Schwalbe note that “although several other kinds of evidence indicate the existence of multiple production centres, [they] cannot separate their products in [their] analyses” (654).

Palenque

Utilizing petrological analyses of clays and ceramics from Palenque and its surrounding region, Rands (1967) found differences in the clay resources and ceramics made from them. Phytolith inclusions in the clays distinguished Fine Cream, Fine Black, and Fine Gray pastes from Fine Orange and carbonate-tempered Red-brown pottery pastes. Red-Brown ware, the most abundant ware at Palenque presented interesting patterning in paste classes. The presence of two paste classes – one defined by the presence of phytoliths and one defined by their absence - indicated that only some of the Red-Brown ware recovered from Palenque was produced from clays local to the site. Because opal phytoliths, however, are well represented in the ceramics of neighboring, smaller sites, these are believed to be the location of manufacture of much of the Red-Brown pottery recovered at Palenque. On this basis, ceramic exchange at Palenque “may be characterized as short-range, intensive, and domestic, rather than far-flung, exotic, and foreign” (Rands 1967:139).

Subsequent studies (Rands and Bishop 1980) used petrographic and chemical analyses to define four compositional groups of ceramic pastes. They assumed that the greatest concentrations of ceramics should center within the region of their manufacture, and plotted the distribution of these compositional groups. Patterning in the distribution indicated that Palenque was a net consumer of ceramics, and that the bulk of the ceramics consumed in that center were produced at its surrounding outlying communities. Some specialization in form did occur, and there appears to be a smaller number of producers of serving vessels than utilitarian vessels around Palenque. These vessels were manufactured in the plains to the north of the site, and imported. In fact, the only class of ceramic artifacts distributed from Palenque on a regular basis was incensario supports. Overall, Rands and Bishop support an outward-focused model of ceramic production in which producers around Palenque were not tied to that site exclusively for their livelihood. Yet, they also point out that an inward-looking model could be supported in the

case of incensario supports, which potters at Palenque seem to have produced and distributed. As with Tikal, it seems that distinct economic spheres operated for different classes of ceramics.

The Eastern Frontier

Analyses of ceramic production at Copán were conducted on domestic, utilitarian vessels and elite-associated polychromes. Bishop et al. (1986) find that there is a distinct difference in the compositions of fine cream-paste wares from a Copán-focus and El Salvador-focus group, on the one hand, and a Motagua (Quirigua)-focus group on the other. They believe that the similarity between Western El Salvador's and Copán's fine-paste wares indicates a shared procurement zone, probably located in the Copán valley. The Copador and Gualpopa pottery produced by Copán with these clays is thought to be an export item (1986:166). Subsequent analyses defined a total of nine compositional groups represented in Copán's pottery (Bishop and Beaudry 1994). These groups represent both site-related and ceramic type-related distinctions. However, no indication of the organization of production was recovered at Copán.

To the east of Copán, Urban et al. (1997) have identified several circular structures which they believe are kilns at the La Sierra site in the Naco Valley, Honduras. These structures, taken with evidence from other rectilinear structures, suggest a tradition of using enclosed spaces for firing pottery. Five sets of evidence are thought to indicate kilns in the Naco Valley: (1) they are generally round; (2) daub recovered in these structures differs in quality from that used in domestic construction; (3) daub and stones from the kiln features show thermal alteration; (4) they are associated with relatively high densities of sherds, and; (5) they are associated with ash and charcoal deposits. The identification of these structures as kilns rests mostly on the daub that differs in formal characteristics from daub used for domestic structures. Thermally altered sherds, such as wasters, cracked, spalled, or bubbled sherds are lacking in most deposits recovered throughout the valley, and are not used as a major indicator of ceramic production. Additionally, there is little evidence of significant association of particular vessel forms with the proposed firing locations that would suggest specialized production. Interestingly, Urban et al. find that other possible indicators of ceramic production, such as over-fired sherds, tools, clay resources, and molds, do not correlate well with proposed firing locations. Although La Sierra is the Late Classic capital of the Naco Valley, there is evidence for multiple firing locations throughout the Naco Valley, and localized control of production is suggested (Urban et al. 1997:173).

Northern Guatemala

Ceramic research in the Postclassic Peten central lakes regions focused on technological variation in the ceramics to address the nature of production and distribution (Rice 1980). It is thought that the potters whose wares are represented in the Paxcaman group of ceramics at the Macanche site were recent migrants into the area at this time. In the Early Postclassic, there is a high degree of variation within the Paxcaman group, interpreted as the products of several non-specialist production episodes. Later during the Postclassic, variation in paste and surface color decreases and surface decoration increases within the Paxcaman Group. Rice attributes the decrease in variability to a greater familiarity with the raw materials and their firing properties gained over time as specialization in ceramic production increased at the site. However, there

appear to be a number of specialists, and production is not thought to be highly centralized (Rice 1986).

In the Petexbatun region, Foias and Bishop (1997) combine measurements of vessel standardization with instrumental neutron activation analysis (INAA) to address changes in the organization of production locations. Their study covers a period of time from the Late to Terminal Classic (600-950 A.D.). Measures of standardization, expressed as coefficients of variation in rim diameter, ridge or neck height, and wall thickness, indicate that variation decreased and then increased through time for monochrome pottery, indicating “a small-scale disturbance in the pottery productions and exchange system, and a shift towards more producers or more localized production and exchange” (1997:280).

Polychrome production, on the other hand, shows a marked increase in the variation of vessel heights and diameters through time, but only slight changes in vessel thickness. Foias and Bishop (1997) suggest that these changes indicate that polychrome production was directly related to elite activities, and the political disruption of the collapse led to a decrease in elite sponsored activities that required the production of polychrome vessels. Results of INAA testing suggested that there were numerous production locations within the Dos Pilas polity, and that each site seems to have produced the bulk of its own ceramics. Trade pieces, such as polychromes tempered with volcanic materials, and fine-paste ceramics were exchanged over a wide area incorporating the Usamacinta, Petexbatun, and Central Peten regions. Yet, “these regional exchange networks were not crucial to the economic base of the Petexbatun polities, because most pottery was made and exchanged locally” (1997:283).

Bishop and Rands (1982) utilized petrographic thin section and neutron activation analysis (NAA) in order to discuss the production and distribution of elite fine-paste wares, ceramics from several sites in the Usamacinta drainage and elsewhere. While the authors believed that the results of their study were somewhat inconclusive, they were able to define several groups of fine paste ceramics that held broad compositional similarity, both in terms of their mineralogy and in terms of their chemistry. Overall differences in the chemical patterning suggest a division between Mayan and non-Mayan fine paste wares. More specifically, a broad distinction could be made in ‘upstream’ and ‘downstream’ fine paste wares found at sites located along the Usamacinta. This suggested that there was more than one production center for fine-paste ceramics in the southern Lowlands. Additionally, Bishop and Rands (1982) found that Silho Fine Orange ceramics, those associated most with Palenque, Chichén Itzá, and coastal sites in Campeche, formed a distinct group, and suggest trade relationships between sites in these regions (see also Ringle et al. 1998).

Belize

Data from Lubaantun, in southern Belize, indicate that this center was also a consumer of pottery, rather than a producer (Hammond et al. 1976; Hammond 1982:227-228). Neutron activation analyses of pottery and clays from around the site indicated several production patterns. Utilitarian and serving wares were produced from clays within 6 km of the site. Interestingly, there were several examples of dishes imported from Barton Ramie, over 100 km away. Hammond believes that these dishes were serving dishes, and that they were imported to Lubaantun for this purpose rather than as containers for some other item. Polychromes and figurines were produced at Lubaantun; the figurines exported to other sites. Hammond believes that these data indicate an inward-looking pattern of distribution similar to the patterns at

Palenque.

Kosakowsky and Hammond (1991) believe that most ceramic production at Cuello took place as open firings, as evidenced by smudges on plaster floors of houses. However, possible “firepits” were also located. These small pits are usually lined with clay, pottery, or both. They are additionally lined with stones and large sherds in some examples dating to the Cocos Chicanel (Late to Terminal Preclassic; ca. 400 BC - 200 AD). These additional features are thought to act as heat baffles to protect ceramics from direct heating. Provisionally, Hammond and Kosakowsky also identify evidence for waster dumps (large sherds in the bottom of a cenote), clay balls thought to be raw materials, and low-fired areas of sludge thought to represent slip preparation areas. Thin-section analysis of some sherds indicates localized manufacture with local materials, “yet no identifiable ceramic production areas were located nor dumps of firing rejects” (Kosakowsky and Hammond 1991:173).

At Pulltrouser Swamp, Fry (1989) observed decreasing variation in slips and vessel forms in locally manufactured ceramics from the Preclassic Swasey to Bladen phases and continuing into the Lopez Mamon phase. In the Late Preclassic and Protoclassic periods, ceramic styles at Pulltrouser are affiliated with ceramic styles at sites throughout this and neighboring regions. During the transition from the Protoclassic to the Early Classic period, the Pulltrouser region experiences a slight depopulation, and ceramic types become more heterogeneous. Fry suggests that at this point, ceramics were imported into the site. During the Early Classic, there is an increase in population, and ceramics are technologically well made. Fry notes a localization of foot (support) styles on tripod plates, and notes that the wide variety encountered at Pulltrouser suggests that non-local pottery was imported to the site. This is additionally supported by the presence of several different paste-types. In the Late Classic, there is a growing regionalism in ceramic styles, indicating restricted interaction among communities. In the Terminal Classic, “[t]he regional uniformity in ceramics is greater than at any other time in the sequence, even including the Late Preclassic. Apparently, there was centralized production of pottery, which was then distributed over an extensive area. Given the evidence of increased regionwide distribution of pottery, cost cutting [evidenced by only interior slipping of vessels], and decline in ceramic quality, we suspect that there may have been more state intervention in the pottery production process” (105).

Analyses of utilitarian wares from Kichpanha and Colha, however, demonstrate the existence of a regionalization of ceramic technology during the Late Classic (Iceland and Goldberg 1999), thereby indicating a lack of broad state-level control. Paste compositions of Subin Red, Palmar Orange Polychrome, and some Encanto Striated vessels switch from carbonate inclusions to quartz inclusions. Tinaja Red ceramics, however, continue to contain carbonate inclusions. Ceramics at Kichpanha and Colha, including polychromes, seem to have been produced at numerous locations, and production “may have become less centralized at the site level than during earlier times” (1999:964). Although their study does not directly address organization of production at the site level, they do suggest that similarities in paste classes in utilitarian wares between Colha and Kichpanha indicates a technological spread, rather than the development of a regional ceramic exchange economy.

Ceramic production at Buenavista del Cayo (Reents-Budet et al. 2000) was examined through stylistic and epigraphic data gathered through art historical analyses, and chemical data gathered with neutron activation testing. On these bases, imported specimens of Cabrito Cream-Polychrome and Chinos Black-on-Cream were distinguished from those produced locally at the site. Chemical and stylistic diversity in these polychrome ceramics “indicate[s] the simultaneous

presence of two ceramic-paste traditions within a single stylistic school such as one might find in two different workshops producing elite ceramics for the same audience” (2000:113). Further, similarities in the chemical composition among elite polychromes and other bi-chromes and monochrome ceramics recovered from the same “palace dumps,” suggesting a similar point of manufacture. The authors suggest that ceramics recovered in the palace dumps of Buenavista del Cayo were produced in a ‘palace school’ (see Ball 1993) or attached workshop. Importantly, the authors found evidence for different paste traditions within the same stylistic tradition of polychrome decoration.

The Northern Lowlands

Production and distribution studies in the Northern Yucatan have been few. As it was mentioned earlier, the work of Smyth et al. (1995) provides an important base of information from which to proceed with studies of production and distribution of ceramics. INAA analysis of the clay samples analyzed in their study indicates that the clays local to Sayil were used to manufacture the Puuc Slate, Puuc Red, and Puuc Unslipped wares also included in the sample. This evidence is used to support the evidence for a production location located next to a market. Although centralized production and regional distribution is suggested from these data, regional distribution is not tested.

Varela T. and LeClaire (1999) conducted a petrographic thin section analysis of the Cehpech sphere ceramics from Oxkintok. Methodologically, they found that X-ray diffraction and neutron activation analyses were inadequate for the examination of production in the northern Lowlands given the homogeneous nature of the geology and the lack of precision in defining which constituents of the ceramic body contributed to the overall chemical signature of the ceramic. This last factor was especially important for their study because INAA would be unable to distinguish whether and in what proportions sodium, cesium, and rubidium were contributed by volcanic glass (1999:122). Volcanic glass is absent in Puuc Slate Wares from Oxkintok, a finding that contrasts noticeably with other ash-tempered stonewares from elsewhere in the northern Lowlands. Because of this difference, Varela T. and LeClaire argue that Oxkintok “fue probablemente un centro de producción de Pizarra Puuc autónomo” (1999:125). However, they also found that clay lumps were unevenly distributed in the ceramic pastes examined, and seem to co-occur with the presence of volcanic glass. From this they suggest that Kabah, whose ceramic pastes do contain clay lumps, was the production and distribution center for Puuc Red wares.

Although having a production origin outside of the Maya Lowlands, Plumbate wares deserve mention here for their marked presence at Chichén Itzá. Neff and Bishop (1988) discuss the evidence for plumbate manufacture at the SM54 site in coastal Guatemala. Besides the abundance of plumbate sherds at this site, evidence for its manufacture included “several small, amorphous lumps of poorly fired clay... interpreted as by-products of pottery making...” and several sherds that exhibited “spalling and malformation indicating they may have been wasters” (508). However, no evidence for firing localities was recovered. By comparing the SM54 sherds with others gathered in the area, Neff and Bishop were able to demonstrate through INAA that the sherds grouped into three compositional subcategories: San Juan, Guayabal, and Tohil (509). Neff and Bishop suggest that the production of Tohil Plumbate represents a departure from the background tradition of San Juan Plumbate. In their interpretation, the decorative elaboration of plumbate seen in Tohil production is attributable to increased market demand due to increasing

export of these vessels (1988:519; see also Ringle et al. 1998).

Though not directly addressing the production of ceramics, Chung's (2000) analysis of slatewares from Chichén Itzá, Mayapán, Labná, and Edzná provides several interesting insights that are useful here. Her petrographic and chemical analyses of raw clays and ceramics pastes and non-plastic inclusions revealed several different paste types within several categories of slateware. Her research at the site of Chichén Itzá revealed both Dzitás (Sotuta) and Muna (Cehpech) slatewares in stratigraphic association with one another. Further, her petrographic and microprobe analyses of the volcanic ash included in those sherds suggested that the ash used in both of these probably was imported from Chiapas, Veracruz, or Tabasco (Chung 2000:151). Chung believes that these regions provided the impetus for the development of the slateware tradition in the northern Yucatan, but that slateware production was conducted only in the northern Yucatan peninsula.

Discussion

In this review of Maya ceramic production studies, several important trends emerge which provide information about the ways that ceramic production and distribution were integrated in ancient Maya society. First, Maya centers seem to be net consumers of ceramics rather than net producers. This trend seems apparent for both small and large centers. At Palenque, Tikal, and Buena Vista del Cayo, evidence suggests that utilitarian ceramics were manufactured within these centers, but the majority of kinds of vessels produced in these centers seem to be predominantly elite-wares, such as fine-paste and polychromes, or items thought to be used in ritual contexts, such as the incensario supports manufactured at Palenque. This suggests multiple economic networks associated with the production of pottery at Maya sites that are specific to the class of pottery being produced.

Several scholars link the rise of specialization with the inability of a household to produce its own livelihood (Fry 1980; Rands and Bishop 1980:16; Arnold 1985:179; McAnany 1993b). As sites grow in population, the amount of arable land would, at some point, have become a scarce asset. Potting communities may have been increasingly located in lands that were not viable for agriculture. If these lands were away from larger site centers, as is suggested for the Puuc region (Smyth and Dore 1994; Dunning 1992, 1994), then it may have been that these communities produced ceramics largely free from the control of the larger centers. Further, it seems that producers in these outlying communities would choose to service the broadest consuming audience by specializing in the production of utilitarian pottery. The data reviewed above suggest that more ceramics were consumed within the centers than were produced. Arguably, the majority of these ceramics should be utilitarian wares. The production of elite wares, for which there is better evidence for production within site centers, may have been more tightly controlled as an attached specialized productive activity. It is argued that the scenario outlined here is not out of line with suggestions that utilitarian and elite items moved in different economic circles.

There is little evidence that the majority of ceramic producers were full-time specialists (Rice 1987b:536). However, there are interesting arguments that can be advanced from these data in relation to the organization of production. Rice (1987:536) suggests that specialization is marked by the decrease in variability over time at Macanche (Rice: 1980). Alternatively, both Rands and Bishop (1980) and Fry (1980) see an increase in the inter-assemblage variation through time after they argue specialized production is already in place. From this, they argue

that there is an increase in the number of producing units. Several researchers (Reina and Hill 1978; Arnold 1978; Ball 1993) suggest that ethnographically known examples of Maya community-level specialization in the production of ceramics are an appropriate model for understanding the organization of ancient Maya ceramic production. Following the logic of the model, then, it is possible that the increase in number of production units noted by Tikal and Palenque is an increase in the number of specialized producing communities (Ball 1993:249, footnote 6; see also Rice 1987a, and Potter and King 1995 for comparisons of obsidian and ceramics). Highly elaborate elite ceramics seem to be the products of highly specialized, full-time, specialists (Reents-Budet et al. 2000). Further, these elite wares were sometimes moved (exchanged) over large distance. Yet, the predominance of information from studies of utilitarian and serving ceramics suggests that these were not circulated widely outside of their area of manufacture.

Although centers are understood to be consumers of ceramics, there is still some debate over the organization of economies in these places (Rice 1987b:534-536). In the studies above, the degree of centripetal economic force that large and small population centers exhibit is a central question. Both inward-looking and outward-looking economic organization are believed to fit data from various centers. As Rands and Bishop (1980:42-44) discuss, these are analytical constructs, and various aspects of each pole in the dichotomy can be seen in the Palenque data. Additionally, given the amount of variation between specific centers, there should be no reason to expect that one pole should characterize *all* centers in the Lowlands. It may have been the case that larger centers of population served as central foci for public attention and interaction. Yet, there is little evidence of any direct control of production within these centers, or evidence for centers directly controlling production in outlying centers.

In sum, the set of relationships that emerge out of these studies of utilitarian ceramic production in the Maya Lowlands suggest that production locations should be located outside of major centers. While centers, on the other hand, consume the bulk of these ceramics, there is little evidence to suggest centralized control of these outlying centers. The control of production seems to be modeled fairly well by microeconomic theories of market interaction (Plattner 1989b). Utilitarian ceramics are in high enough demand from consumers that they are products that lend themselves well to (1) trade, and (2) specialized production. This is not to say that urban centers directed marketplaces, but that they served as magnets for several kinds of interaction - they can be considered as a nexus for social interaction. The community of consumers should have been relatively large compared to the number of producers, and (as indicated in the Tikal and Palenque data), the number of producing units expanded in relation to the population. In other words, the scale of production, measured as the volume of output of any particular production unit, did not increase with the population, but the number of production units increased. In turn, this lends credibility to ethnographic models of community or household specialization, like those discussed by Reina and Hill (1978), Arnold (1979), and Ball (1993).

Although the data presented in the present research cannot address the organization of production, they do provide information on the distribution of Muna Slate wares. This review of production studies is intended to provide the background against which to view the results of the present research, and to argue against the hypothesis that Muna Slate wares were centrally produced and distributed from Sayil. The studies reviewed in this chapter suggest that ceramic production in the Maya Lowlands was a dynamic industry that was organized at various scales and intensities. Yet, these patterns do suggest that if Sayil were a centralized production point for Muna Slate Wares, then it would stand out as an exception to the organization of utilitarian

pottery production noted for other locations in the Maya Lowlands. Ecological, economic, culture-historical, and ceramic data have been offered to argue against the existence of centralized control of the production and distribution of Muna Slate Wares at Sayil, but the hypothesis remains to be tested. It is to this end that the research is directed and which the following chapters on methodology and findings are directed.

CHAPTER 5: CERAMIC PROVENIENCE, SAMPLING, AND ANALYTICAL TECHNIQUES

Archaeometric studies of ceramics rely on the chemical and mineralogical patterning exhibited by the various constituents that make up a pot. Several techniques from mineralogy and physics have been applied to the study of archaeological ceramics, predominantly towards identifying the ‘source’ of ceramics. Yet, each study presents its own sets of problems and limitations that must be considered when selecting a methodological approach. In this chapter, issues involved in selecting methodological approaches to ceramic analysis are provided in reference to general issues of ceramic archaeometry and specifically to the conditions presented by the geology of the northern Lowlands. These considerations serve as the basis for the methodological approach to the analysis conducted in this research.

The Structure and Properties of Clays

Clay minerals are the product of the chemical weathering of parent rock materials – primarily feldspars - that are high in alumina and silica content (Rice 1987c:35-36; Klein and Hurlbut 1993:532-541; Perkins 1998:97-103). The chemical, and to some extent physical, weathering of feldspars generates the many characteristics on which clays may be defined. Clays may be defined in terms of their depositional context, their granulometry, their chemical compositions, and their mineralogical properties (Rice 1987c:36-45). The two definitions that are of most importance here are those based on chemical and mineralogical properties. Chemical classifications of clays are highly related to the chemical content of their parent materials. Generally, clays are described chemically as hydrous aluminum silicates (Rice 1987c:40-41; Klein and Hurlbut 1993:512) and can be characterized by the general formula: $Al_2O_3 \cdot 2SiO_4 \cdot 2H_2O$. Chemical substitution is common in the formation of clay minerals, with Mg^{2+} and Fe^{2+} cations substituting for Al^{3+} in Al_2O_3 , and Al^{3+} cations substituting for Si^{4+} in SiO_4 . These substitutions lead to several general formulas for the main groups of clay minerals (Table 5.1).

Table 5.1. Clay Minerals Discussed In Text

Two-Layer Clays	
kaolinite	$Al_4(Si_4O_{10})(OH)_8$
halloysite	$Al_4(Si_4O_{10})(OH)_8$
Three-Layer Clays	
smectite	$(Ca, Na)_{0.2-0.4} (Al, Mg, Fe)_2(Si, Al)_4O_{10}(OH)_2 \cdot nH_2O$
illite	$K_{1-1.5}Al_4(Si, Al)_8O_{20}(OH)_4$
Lath-Structure Clays	
palygorskite	$MgAl_2(Si_4O_{10})(OH)_2 \cdot 4H_2O$
sepiolite	$Mg_3(Si_4O_{11})H_2O \cdot 11H_2O$

Most clays, mineralogically defined, are phyllosilicates or ‘sheet silicates, and are composed of bonded sheets of silicate tetrahedra (a t-sheet) and alumina octahedra (an o-sheet). Broadly, phyllosilicates can be divided into two-layer (t-o sheet sequence) and three-layer varieties (t-o-t sheet sequence). Two-layer and three-layer clays can occur in ‘pure’ deposits in

which all of the clay minerals are the same, or they can occur in mixed-layer deposits in which different clay minerals are interlayered with one another (see discussion of Puuc clays below). The chemical structures of these different clay minerals determine the ways in which they bond water molecules. The amount of water bonded to the surface and held between the layers of clay minerals determines its plasticity, which is the quality of clays that makes it appropriate for potting (Rice 1987c:43-50; Klein and Hurlbut 1993:512; Perkins 1998:122-124). The importance of this absorbed and bonded water for pottery manufacture is discussed below.

Kaolinite and halloysite are examples of two-layer clay minerals (see Table 5.1). Halloysite and kaolinite differ slightly in the arrangement of their atoms. In kaolinites, the octahedral and tetrahedral sheets exhibit strong bonding and do not absorb much interlayer water. This provides low shrinkage of the clay mass during drying. Halloysites are stacked in irregular layers, which cause them to absorb more water (Rice 1987c:45-48). Arnold notes that the plastic and liquid limits of halloysites and smectites are fairly similar (Arnold 1971:36).

Three-layer clays differ significantly in their chemical formulae from two-layer clays (Table 5.1). These clays exhibit a wide variety of compositions, and can be further subdivided into two general categories: smectites and illites. Smectites are composed of a layer of alumina octahedra in between two layers of silica tetrahedra. The compositional variation among smectites is the result of Al^{3+} substitution for Si^{4+} , and Fe^{2+} and Mg^{2+} substitution for Al^{3+} in the octahedral layer. Bonding between lattice units in smectites is weak, and the lattice may incorporate substantial amounts of water. This tendency of smectites to incorporate substantial amounts of interlayer water combined with their small particle size gives these clays high plasticity. Additionally, these clays have high rates of shrinkage as interlayer water evaporates. The second general class of three-layer clays is illites. These clay minerals tend to have decreased rates of ionic substitution of Al^{3+} for Si^{4+} in the tetrahedral sheet and no substitution of Fe^{2+} or Mg^{2+} for Al^{3+} in the octahedral layer. They are compositionally similar to smectites, but with higher alumina substitution for silica tetrahedra. Illites differ from smectites in that they incorporate potassium cations, and do not incorporate Na^+ and Ca^{2+} between their layers. Potassium (K^+) cations help satisfy ionic charge deficiencies between layers, and lead to a lowered degree of lattice expansion. Illites have small particle size, and relatively high plasticity.

In addition to phyllosilicates, there are also lath-structure clays (Table 5.1). These clay minerals tend to form tubes or long chains. The two of importance for this discussion are palygorskite and sepiolite. Palygorskite and sepiolite often occur together, and are thought to occur in direct precipitation in marine, non-marine hyper-saline, and fresh-water environments with low alumina to silica ratios and the presence of Mg^{2+} cations (Isphording 1973:393-394). It is worth mentioning here that palygorskite-sepiolite clays have a higher plastic and liquid point than smectites (Arnold 1971:35). These clays are important additives (tempers) in the modern production of ceramics in the Yucatan (see below).

Mineralogical, chemical, granulometric, and depositional definitions all highlight important aspects of clays, and form an interrelated set of properties that are important for pottery manufacture (Rice 1987c:36-50). The geological contexts of clays can alter their chemical and mineralogical properties through increased rates of chemical weathering, decomposition, ionic substitution, and the heightened effects of physical weathering. Also, depositional context, in some ways, structures the presence of coarse inclusions in raw clay beds. The grain size of clays and their chemical properties influence their ability to adsorb water, and thus their plasticity, drying, and firing properties (Rice 1987c:36-39). The outcome of these interrelated processes - raw clay beds - is acted upon by potters who evaluate the usefulness of

raw clays for the formation of pottery. However, potters do not have to accept raw clays as they are, and may manipulate their properties to achieve the qualities of workability and strength needed for pottery production.

Geology of the Northern Yucatan Peninsula: Ceramic Raw Materials

While clays have been discovered across the Yucatan Peninsula, the identification and origins of these clays have been the source of much debate. Schultz et al. (1971) subjected samples from three locations in the Puuc region to physical and chemical analyses. Their results indicated the presence of mixed layer kaolinite-smectite clays that formed during the lower Eocene and Pliocene. Kaolinite ranged between 38% and 48%. These clays were found in tabular deposits 1-2 meters thick between layers of limestone. The bases of clay layers were well defined, and exhibited variable degrees of intermixing in upper transition layers. In addition to these clay beds, X-ray diffraction (Isphording 1984:61-62, see Figure 2; see also Schultz et al. 1971:139) revealed kaolinite as the only crystalline clay mineral present in the soils of the Central Hills (Puuc) region and in the Northeast Coastal Plain (in which Ek Balam is located).

The origins of Yucatan's clays are debated. Schultz et al. (1971) suggested that these clays developed from the diagenesis of volcanic materials. Volcanic materials are prevalent in the sediments of the western Gulf of Mexico and Gulf Coast region, but are absent in geological deposits in the Yucatan Peninsula. Countering this argument, Isphording (1973, 1984) cites both pedogenic processes and direct crystallization as sources for Yucatan's clays. The accumulation of pedogenic clays is highest in the Central Hills Region, where they sometimes reach 20 m in thickness. Elsewhere across the northern part of the peninsula, soils were thinner, and contained some limestone fragments. X-ray diffraction of samples reveals that mineralogically, soils in the Central Hills and in the Northeast Coastal Plain are almost identical. The soils are interpreted to have derived from talc, chlorite, and small amounts of smectites and mixed-layer clays (Isphording 1984:61-65). The explanation offered by Isphording is important because it provides a non-volcanic explanation for the geology of the Yucatan Peninsula's clays. Thus, the volcanic glass observed in thin sections of ceramics from throughout the Maya Lowlands must be imported (see Chapter 6 for discussion).

Modern Mayan potters procure minerals belonging to their emic category of *k'at* (clay) to produce pottery (Arnold 1971:28-32). *K'at* is a general category, and potters employ several tests to discern whether the clay is suitable for pottery. Primarily these tests revolve around the behavior of the clay when it dries and the saltiness of the clay (assessed by taste). Both of these properties are related to the clay's ability to absorb water; potters desire clays that do not shrink excessively in the sun. Chemically, the presence of sodium and chlorine ions helps to balance the pH of the clay, thereby satisfying unfilled charges on the surfaces of clay particles. Arnold (1971:28-30) finds that potter's clay is composed of partially dehydrated halloysite, yet Isphording's studies (mentioned above) revealed only kaolinites. This presents contrasting reasons to add temper. Kaolinites do not absorb as much water as smectites or halloysites, and are consequently less plastic. Temper may be added to clays with a low plasticity to make them more workable. On the other hand, if halloysite is the primary mineral used for potting, water absorption becomes more of a detriment to vessel strength during drying. In this case, temper should be added to decrease the amount of interlayer water found in the ceramic matrix after forming.

Because two-layer clays do not absorb much water, they are less plastic than three-layer

clays. This helps to explain why Ticul potters temper their ceramics and why they select the particular tempers that they do. The most important category of temper is *sah kab*, or “white powder” (Arnold 1971:32-33). *Sah kab* is a generic term for white rock-like materials, containing varying degrees of *sak lu’um*, or white earth. *Sah kab* without *sak lu’um* is not used in pottery production. *Sak lu’um* (Arnold 1971:35-36) is lightweight and becomes plastic when water is added to it - these features distinguish it from rocks and clay (*k’at*). Good *sah kab* (i.e. containing *sak lu’um*) absorbs water and becomes plastic, and will remain dry when powdered samples are mixed to wet clay. Mineralogically, *sak lu’um* has been identified as attapulgitite, or palygorskite (Arnold 1971:35). Palygorskite minerals are rare and are often accompanied by a related mineral - sepiolite. In the Yucatan palygorskite-sepiolite deposits occur interbedded with limestones and dolomites, but are not associated with smectite clays (Isphording 1973:396). Palygorskite and sepiolite are lath-structure clays, and have lower rates of water absorption than smectites and halloysites. This property makes them logical tempering materials for halloysites.

However, Isphording notes that palygorskite and sepiolite deposits have only been recovered in the western portion of the peninsula, in and around the Puuc region (1973:397, Figure 3; 1984:68, Figure 4). The rare occurrence of this mineral brings into question the extension of Arnold’s (1971) findings on modern Puuc ceramics production to the ancient ceramics of other portions of the Yucatan Peninsula. Assuming that halloysites were indeed used for ceramic production at Ek Balam, then a temper that did not absorb a similar amount of interlayer water would be preferable. Palygorskite would fulfill this requirement, but so could other materials, such as volcanic glass. On the other hand, palygorskite may not have been a necessary additive if a suitably workable kaolinite was used as potting clay. Thus, palygorskite as a temper may or may not have been used in the past for the production of Muna Slate wares across the peninsula.

In summary, the evidence for the differences in the raw materials provide a basis on which to understand the potting behavior of ancient Maya potters. Potters may or may not have had to alter the raw clays to make them suitable for potting. Foreshadowing the results of the present study, volcanic glass was prevalent in the samples from all sites. This substance does not occur naturally in the Yucatan Peninsula, and it is thus a true temper. However, what is not clear is the degree to which the amount of volcanic temper, or any of the other inclusions found in the ceramics, reflects differences in the working properties of the raw clays or to what extent they represent idiosyncratic variation within a technological tradition. Also, ethnoarchaeological studies of potting in the Yucatan (mentioned above) show the use of other clay minerals as temper. Geological studies are equivocal on the identification of minerals used for potting clays. On the one hand, there is abundant evidence of kaolinitic clays in the northern Yucatan. On the other hand, the minerals identified in clay used for potting were halloysites. While these can be separated from one another, it is difficult (Schultz et al. 1971). Again, each of these minerals has different plastic properties that affect their inherent suitability as potting clays. Further, each of these minerals should be altered for different reasons to make them suitable for pottery production. The consequence of these modifications should be detectable in the composition of the sherds, and the following section discusses the methods used explore the mineralogical variation in the sherds.

Sourcing and Studies of Provenience

The central issue in reconstructing prehistoric exchange of ceramics is to establish how the ceramics found at one point on the landscape got to be there in the first place. Usually this involves establishing the ‘source’ or provenience of ceramics. However, ‘source’ is an ambiguously used term, and can be used to address several levels of spatial specificity. The range of specificity may include “a single mine, a single widespread clay stratum, all clays in a single drainage, a single community of potters, or perhaps even a group of such communities” (Arnold, et al. 1991:70). These spatial frameworks are important in interpreting the patterning in compositional data.

Provenience studies in ceramic archaeometry were initially predicated on an assumption about the resemblance of clay deposits and the pots produced with those clays. Weigand et al. (1977) stated these assumptions in the Provenience Postulate (Bishop et al. 1982:301; Rice 1978:413-414). In terms of ceramic studies, the postulate holds that (1) it is possible to recognize differences between sources of ceramic raw materials, and that (2) any variation observed within the ceramics from one location will be less than the variation that exists between two producing locations. Yet, the particular phrasing of this postulate depends on the particular technique used in the ceramic analysis. Shepard’s (1980:165-168) discussion of petrographic analysis of tempers notes that petrographic analyses are often used for the identification of production locations, and for separating trade wares from ceramics of local origin. The differences in the mineral inclusions within the ceramic body may indicate separate origins for pottery that initially appears similar (e.g., Muna Slate wares). Rice (1978) discusses the implication of the Provenience Postulate with regard to chemical analyses. Such analyses often attempt to link ceramics with specific clay sources, or with specific regions of clays. The compositional variation of clay beds is dependant first, on the depositional history of the bed and may be variable throughout the formation. This is true for small, distinct beds as well as beds that cover large areas, especially if these are differentially exposed. It is also important to hypothesize that the clays used by ancient potters are still available today (Rice 1978:516). This assumption can be seen in the work of Neff et al. (1992) in the sampling of clay sources in Pacific Guatemala to establish regional trends in raw materials composition (also Smyth et al. 1995 for the Puuc).

The above discussion is phrased in terms of a division between research questions addressed by chemical and petrographic studies. However, the difference in research questions is not really dependent on whether a technique is based in geology or in chemistry. Rather, it has to do with the way that the samples are prepared, for this part of any analytic procedure structures the nature of the data that will be recovered. The following discussion of the effects of potting behaviors is provided as a background for understanding the types of information about provenience that can be explored through various techniques.

Potting Behaviors and Provenience Studies

Potters often modify raw clays by addition or subtraction of water and coarse inclusions to make them more workable. Clays are extremely fine-grained (2-10 μm) minerals that bond water to their surfaces to satisfy deficient ionic charges (Rice 1987c:59). This bonded water, with an additional amount of free interlayer water gives the sheets of clay particles the ability to slide past one another. This is, in effect, the physical explanation of clay’s plasticity, and potters manage this plasticity through regulating the amount of water in the clay body. Overall, the aim

is to achieve potting clays that have the correct stickiness, porosity, rates of shrinkage, drying times, and strength before and after firing (Rice 1987c:74). Because potters often modify raw clays, implications that these behaviors present for the identification of similarities and differences in archaeometric studies of ceramics must be considered.

Levigation, or soaking, can be used to thoroughly wet raw clays, to balance pH levels and to remove unwanted coarse inclusions from raw clays (Rice 1987c:118; Blackman 1992). Soaking clays may also alter their chemical characteristics. Soaking clays improves their plasticity by thoroughly exposing clay minerals to water, but it may also promote ion exchange whereby highly mobile cations like sodium and potassium move into solution (Bishop et al. 1982:294). If excess soaking water is poured off, then these ions will be lost, and the elemental concentration profile of the clay changes. Thus, the chemical signature of the processed clay is shifted from its raw state. Similarly, if levigation is employed to remove undesired coarse inclusions, the resultant clay body will be compositionally different from the raw materials.

On the other hand, coarse particles are sometimes a desirable aspect of potting clays because they act to decrease the amount of water in the clay body and to add strength to the finished vessel. When coarse inclusions are added to clays, they are termed ‘temper’ to distinguish them from the natural inclusions in clays. Shell, sponge spicules, humus, diatomaceous earth, plant fibers, and dung are examples of organic substances that can occur naturally in clays or may be added as temper (Shepard 1980:26; Rice 1987c:78, 118, 407). Non-siliceous organic substances (humus, plant fibers, and dung) are usually volatilized during firing, and leave the clay matrix. In turn this increases the porosity of the vessel, aiding in the escape of bonded water during firing. This aids the release of steam from the interior of the vessel wall that otherwise could cause the vessel to explode (Rice 1987c:102-104; Gosselain 1992:257). Biosilicates (sponge spicules and diatoms), shell, and inorganic substances, such as limestone, quartz, volcanic glass, and feldspars, usually do not leave the clay fabric during firing.

Through adding materials, tempers, potters can modify the properties of raw clays to make them more suitable for potting. The addition of temper to raw clays would modify their chemical signatures. In studies designed to match ceramics with clay resources, the presence of temper was traditionally conceived as ‘diluting’ the signature of the clay (Fry 1980; Bishop 1980), and several studies have addressed this issue (Neff et al. 1988b, 1989; Elam et al. 1992). There are two issues involved in researching the dilution of raw clay chemical signatures through the addition of temper. First, ‘temper’ can be used in an uncritical way to talk about all inclusions within the ceramic matrix. This implies that these inclusions were placed there by the potters, and were not included in the naturally occurring clay beds (Rice 1987c:406-409). On the other hand, tempers may also “enrich” the presence (increase the concentration) of some elements not found in clays (Bishop 1980). For instance, the addition of limestone temper enriches the relative amount of calcium in ceramic body.

Second, dilution is problematic only when the objective of provenience studies is to locate specific raw clay deposits. By shifting the scale of analysis from raw clays to finished pots, dilution ceases to be problematic in sourcing studies. The ethnoarchaeological and chemical data gathered by D. Arnold (1971, 1985, 1992; Arnold et al. 1991) demonstrate that not only do communities of potters share common cognitive models of how to make ceramics, but that these commonly held models result in chemically distinct assemblages of pottery. This conclusion was recently confirmed (D. Arnold et al. 2000) by testing whether or not individual workshops within the same community, each utilizing a separate clay source, can be distinguished. This research was conducted in the northern Yucatan, and presents a number of results that are of importance

to this study. Potters living in the modern town of Ticul, Yucatan traditionally procured their clays close to town in a mine located at the hacienda Yo' Kat. After this source became unavailable, Ticul potters began procuring clays from sources in the state of Campeche. Although each of the potters utilized a separate source of Campeche clay, these sources were within 3 km of one another. For the purposes of the analysis, clays and tempers were sampled at the sources, and from the potters. Kiln wasters from these potting workshops were also taken for NAA analysis, and the results were compared to previously analyzed samples for the northern Yucatan. D. Arnold et al. (2000:313-314) conclude:

These results suggest that it is not possible to infer workshops, whether ancient or modern, with unique clay sources in a homogenous geological environment when clay sources are 3 km or less from one another.... Rather than revealing workshops, these data... confirm the conclusion... that compositional analysis can reveal a distinct chemical pattern of a community of potters.

Again, these data support the ethnoarchaeological work already discussed in Chapter 2 that were used to formulate one of the testable hypotheses in the research presented here - that pottery produced by one community of potters should be compositionally distinct from pottery produced by other communities of potters. For the purposes of examining the distribution of ceramics produced at one location, the manner in which ceramic compositions pattern in space is the central issue.

In developing a methodological approach for this study, it was important to design a study that would highlight variation within pottery, especially in a homogenous environment. Ceramic archaeometric techniques are usually grouped according to methodological approach - either chemical or mineralogical techniques. However, the techniques used to prepare ceramic samples for analysis also provide a useful way to categorize analytical techniques into two distinct classes. These two classes can be called 'bulk' techniques and 'point' techniques, and each of these has important implications for the types of data that can be gathered.

Bulk techniques

One of the most widely used chemical analytical techniques used today in ceramic studies is instrumental neutron activation analysis, or NAA (Bishop et al. 1982:292; Rice 1987c:396-398). In this analytical technique powdered samples are irradiated in a nuclear reactor along with reference samples, and thus become radioactive. Because the samples are radioactive, they experience radioactive decay, and individual elemental concentrations are quantified by measuring their characteristic wavelength of the energy released during their decay (Rice 1987c:389). It is an extremely sensitive technique, capable of identifying 75 of the 92 naturally occurring elements in concentrations as low as parts per billion. While the samples do become radioactive, it is possible to utilize the samples again, and laboratories compile extensive databases of elemental data that can be used in comparative studies (Harbottle and Bishop 1992:29).

Bulk analyses are used in geological studies as well. Most analytical techniques that use spectrometry and X-rays require that samples be crushed and/or vaporized in order to collect mineralogical and chemical data (Bishop et al. 1982; Rice 1987c; Perkins 1998; Burton and Simon 1993). While these techniques are usually extremely sensitive to trace elements, crushing the samples obscures information about the relative contribution of any particular constituent in

the ceramic matrix. Without prior knowledge of the chemistry of the raw clay beds and tempers, it is impossible to say what percentage of a given element is attributable to the ceramic matrix or to the inclusions within it (see Varela T. and LeClaire 1999). If the raw materials are known, it is possible to mathematically model different signatures produced by different ratios of clays to tempers (Neff et al. 1988). While many bulk techniques are sensitive to trace amounts of elements, they tend to obscure other types of data on specific constituents of the ceramic matrix that may be of importance, especially in a homogenous geological environment.

Point techniques

The main concern in selecting samples from two sites that were close to one another (Kiuic and Labná) is that they may have similar chemical and petrographic signatures, given the apparent homogeneity of the northern Yucatan peninsula's geology. To avoid missing significant variation within the populations of Muna Slate wares, it was necessary to use a technique that did not aggregate data. Point counting petrographic thin sections was selected as an appropriate methodology. The benefit of this methodology is that it is possible to get precise data on particular constituents of ceramics, and to sample several of these discreet constituents in a systematic manner. Petrographic studies of thin sections of ceramics have a long history of application in archaeological studies. In Mesoamerica, most of this work can be attributed to Anna O. Shepard and her systematic analyses of several types of Maya ceramics. Yet, as the previous chapter demonstrates, much of the subsequent work that has been published on the production of ceramics has utilized NAA. As a result, there is generally a lack of petrographic studies available for comparison.

Petrographic thin sections utilize the crystalline structure of minerals in order to identify them. When crystals are sliced into thin sections (0.030 mm in thickness), light may pass through them. Petrographic microscopes illuminate thin sections from below, using plane-polarized light. In plane-polarized transmitted light, characteristic features of minerals such as relief, color, cleavage and mineral grain shape can be clearly seen. When the second polarizing filter on the petrographic microscope is moved into place, additional characteristics of minerals can be seen in cross-polarized light. When this cross-polarizing filter is moved into place, it blocks the transmission of light in isotropic minerals; these minerals transmit light in all directions equally. Isotropic constituents appear black ("extinct") under cross-polarized light, regardless of the position of the stage. Anisotropic minerals, minerals that do not pass light equally in all directions, produce interference colors under cross-polarized light. Anisotropic minerals do go extinct, but only when cross-polarized light is passed parallel to their optic axis. Further, mineral crystal twinning can be readily observed under crossed polars. Each mineral has a characteristic assemblage of these features (isotropy, interference colors, twinning) that allow its identification under the petrographic microscope (Perkins 1998:61-89).

Thin section analyses are usually concerned with the identification and quantification of mineral inclusions in ceramic pastes (Bishop et al. 1982:285). While volumetric information may be gathered, the usual goal of point counting is to gather a representative sample of the frequency of different mineral grains. Quantification can be achieved through a systematic counting of points along the surface of the thin section (Rice 1987c:379-381). Applications of point counting are related to general sampling theory in archaeology (Stoltman 1989:148). Basically, point counting is a systematic survey of points imposed across the surface of the thin section. Stoltman suggests that the sampling interval in thin section petrography should be related to the size of the largest grain in the section. If the sampling interval is too small, then large grains may be counted

more than once. So, some degree of trial and error is necessary to arrive at the proper sampling interval.

Point counting petrographic thin sections provides a means to assess variation within ceramics at a level of detail that is not accessible through bulk analytical techniques. It is argued here that a point technique, here point counting, has the potential to discover significant variation in ceramics produced in relatively homogenous geological environments, like the Yucatan Peninsula, that may be obscured by other analytical techniques.

Sampling and Methodology

Sampling Design and the Study Sample

Consideration of the human aspects of pottery production influenced the ways in which samples selected for study should be chosen. Bishop et al. (1982:278-280) suggest that sampling strategies should encompass the diversity in the assemblage. The composition of a vessel may vary with the intended use of the vessel, vessel form, vessel size, or other morphological and functional characteristics of the vessel. Classification may also compact important aspects of variation in ceramic assemblages. As Neff (1993:25, 29-31) argues, the type-variety system of ceramic taxonomy subsumes significant variation in ceramic assemblages both through time and across space if the assumption is made that all vessel forms represented within the type possess a similar composition. For example, a ceramic type may contain two forms - water jars and cooking pots - that both contain carbonate inclusions. Because of the strengthening properties of these inclusions, it may be desirable to include more carbonates, but the properties of carbonates in high temperature environments (see Chapter 6) should create situations in which it is less desirable. So, in this hypothetical example, the water jars could conceivably contain more carbonate tempers than the cooking pots. Treating ceramics types as monolithic entities can serve to hide variation.

In relation to the Muna Slate wares examined in this study, differences in the composition that may be due to differences in the production location are an important object of inquiry. Because little is known about the distribution modes for utilitarian pottery at Ek Balam, Kiuic, and Labná, it was considered important to maximize the number of excavation contexts sampled, thereby hoping to include any variation that may be due to consumption patterns. Further, it is important to account for variation between the various vessel forms, and an attempt was made to construct samples that represented vessel forms equally. Additionally the sites from which the samples were drawn were selected to test the degree to which Muna Slate wares may have been distributed from Sayil. One site, Ek Balam is located roughly 170 km away from Sayil, Labná, and Kiuic. The geographic distance from Labná to Kiuic is roughly 12 km. These two sites fall along a northwest to southeast arc with Kiuic at the southern end, and Sayil at the north. Labná and Sayil are separated by no more than 15 km of geographic distance. Thirty-five sherds were selected from Ek Balam, Labná, and Kiuic, resulting in a total of 105 sherds in the total samples.

The samples from Ek Balam were the least systematically sampled set of ceramics used here, and the sampling strategy for these ceramics was opportunistic. The thin sections from Ek Balam that were analyzed in this study were prepared for previous studies, and loaned to me for this research. Unfortunately, the epoxy used to adhere the thin sections to the sherd had deteriorated over time, and several of the thin sections were spalling from their slides, and their use in this research would have caused further damage. So, only the thin sections that had adhered best to their slides were used.

Better sampling control was achieved with the Labná sample. Sherds were selected from the permanent collection at the ceramoteca, Centro Regional Yucatan, Instituto Nacional de Antropología e Historia, Mérida. When these samples were selected, the researcher had no prior knowledge of the provenience of the sherds. Individual numbers were assigned to each lot from Labná, and these were used as a proxy for provenience. This strategy did not guarantee that different lots from the same unit were not selected, but an attempt was made to select sherds from a particular lot only once. With the exception of two sherds from lot LN220, this goal was met. The ceramics from Labná were arranged by vessel form in the ceramoteca, and it was easy to draw equal numbers of each vessel form. Once selected, the ceramics were sent to Lori Suskin at the University of Oregon for thin section preparation.

The most thorough application of sampling strategy was achieved with the samples from Kiuic. In order to select the lots for sampling at Kiuic, I first randomly selected 35 individual units that produced Muna Slate wares, excluding surface collections. I then randomly selected individual lots from each provenience in which there were two or more lots that contained Muna Slate wares. A limiting factor at Kiuic is that excavations have only been conducted in the site's center, and are not representative of all depositional contexts at the site. Once the lots were selected, I used a mixture of opportunistic and random sampling to select individual sherds. Some of the selected lots contained few sherds, and even fewer of these were Muna. In these lots, I selected the sherd most appropriate for thin sectioning. Because of the small numbers of sherds, there was rarely a representative sample of vessel forms in these small lots. I selected sherds from these lots first, and the results of this portion of the selection partially structured the remaining selections. When the remaining sherds were selected from larger lots, some initial pulls were rejected because they were already adequately represented in the total sample. Thin sections were partially prepared in the Department of Geology, Millsaps College, Jackson, Mississippi. During the preparation, however, the machine used to lap the sherds to the proper thickness broke, and Lori Suskin at the University of Oregon performed the remaining work.

As this discussion highlights, the ideal objectives of a sampling strategy aimed towards representing the range of variation possible within these Muna Slate wares met with varying degrees of success. It is argued here that this does not negate the findings of the research presented here. This research utilized a non-parametric statistical test – the Kolmogorov-Smirnov two-sample test - to evaluate the significance of the differences in the distribution of the constituents of the ceramics. Because the samples are small, the potential effect of outliers on the dispersion of the data becomes greater. The use of the non-parametric techniques, however, alleviates the dependency of the statistical test on measures of central tendency, and outliers do not pose a problem for the interpretation of these results. Statistical analyses performed here do show significant differences between the samples from each of these sites for particular variables. It is argued that, even though some variation in the Muna Slate wares from each of the three sites was undoubtedly missed, the variation that was captured and quantified in this study is a valid indicator of the differences in the ceramic compositions at those sites. The issue of most importance to this study is whether or not the samples recovered at each of these sites represent the work of a single production location, or whether multiple locations are represented. To foreshadow the following chapter, the results indicate multiple pottery producers provided ceramics to Kiuic, Labná, and Ek Balam.

Thin Section Petrography

Thin section analyses were conducted in the Department of Geological Sciences, University of Kentucky. The first step was to determine the sampling interval to be used in this study. After scanning several slides under the microscope, it was determined that the largest measurement taken on a majority of the minerals did not exceed 0.2 mm. To ensure consistent grid spacing, a point counting stage calibrated to move a predetermined distance was used. The smallest distance that this stage could move was 0.33 mm, and this was taken as the sampling interval. The visual scanning also allowed the researcher to become familiar with the various constituents in these sherds, and to prepare a data recording sheet.

With one exception, at least 150 points were sampled on each thin section. Some of the Ek Balam thin sections were small, and only allowed 150 points to be taken. In one instance, only 142 points were recorded on one sherd from Ek Balam. In order to avoid over-representing minerals in larger thin sections, a standard of 150 individual counts were collected for each sherd. Sometimes a particular mineral or void was large (but did not exceed 1.0 mm), and covered more than one grid point. In such instances, the stage was simply moved to the next grid point not occupied by that inclusion. The thin sections were cut along the vertical sections of the pots, so that by moving along the long axis of the thin section, points at different heights on the vessel wall were sampled. Points were sampled along a straight line until the edge of the sherd was reached. At this point, I moved three sampling intervals (1.0 mm) laterally from the sample line, and then continued along that line until 150 points had been counted or a shift in grid line was required. A 1.0 mm lateral shift additionally ensured that large grains were not counted more than once. The point counting information was recorded on data sheets, with a separate entry for each point. This facilitated keeping track of how many points had been counted. After these data had been collected, the results were entered into a spreadsheet, and analyzed with the SPSS statistical package.

Summary

This chapter presented the rationale for selecting the methodology used in this research and the samples analyzed through that methodology. The geology of the northern Yucatan peninsula, characterized in the literature as homogenous, is not well understood, and a methodology was sought that would highlight specific sources of variation in the raw materials that were used to construct the pottery examined here. Point counting of petrographic thin sections provides a means of exploring the variation in the composition of ceramics that can be attributable to raw materials and to potters' attempts to manage the properties of these raw materials in order to produce pottery. The methods outlined in this section were selected because they could provide specific data about individual points in the ceramic matrix that would otherwise be obscured with a bulk analytical technique. Likewise, the sampling strategy was designed with the intent of including at least some of the range of variation that is present in Muna Slate wares from Ek Balam, Kiuic, and Labná. Although it is unlikely that all of the variation in the slatewares from each of these sites was represented in the samples, it is argued that the samples are adequate enough to produce representative results. The following chapter presents the results of this research.

CHAPTER 6: MINERALOGICAL COMPOSITION OF MUNA SLATE WARES

The statistical tests used in this analysis were chosen because they facilitated the comparison of distribution between samples. General descriptive statistics for each category of data were generated and distributions were plotted as box-and-whisker graphs. In the graphs used in this section, a central box is displayed, with two T-shaped lines extending from it. The ends of the box indicate the first and third quartiles, and represent 50% of the variation within the distribution. The 'whiskers' indicate the first and ninth nonile, and represent 80% of the variation in the cases. In the box and whisker plots used to display the data in this chapter, circles represent statistical outliers, and an asterisk indicates extreme outliers.

After a preliminary examination of the distribution of the data, it was apparent that several of the variables exhibited a non-normal distribution. Because of this, a non-parametric technique of comparing distributions was needed. In the analysis below, a Kolmogorov-Smirnov two-sample test is used to compare the distributions of the different variables. This test examines the differences in cumulative frequencies of data for a single variable to test whether or not the frequencies represent different populations of data (Thomas 1986:322-326). There are several techniques available to test non-parametric data, but the Kolmogorov-Smirnov test handles tied cases better than other techniques, such as the Wilcoxon two-sample test. An additional benefit of the Kolmogorov-Smirnov test is that a critical value can be calculated to examine statistical significance. In the following sections, the results of the Kolmogorov-Smirnov tests are presented as Z-scores. Z-scores represents the number of standard deviations away from the mean a score is, and present a standardized way to examine deviation from the mean between groups of data (Shennan 1997:75).

In addition to the tables of summary data presented below, ogives were also used to represent the data. Ogives (Thomas 1986:49-52) are line graphs that demonstrate the cumulative frequency of data, and in this case, always sum to 35 (the number of samples for each site). Individual lines can be plotted for each site, thus aiding in visual comparisons. Ogives provide a nuanced demonstration of the specific points at which the data for any of the sites depart from the other sites. Because ogives are a representation of cumulative frequency, they best illustrate the divergences between variables that are assessed by the Kolmogorov-Smirnov test.

The SPSS statistical package was used to produce the statistics and graphs used in this analysis. There were seven variables considered: matrix, carbonates, partially calcined carbonates, volcanic glass, hematite, voids, and a minor constituents category. These categories subsume all of the points counted. The relationships among the various constituents are presented as proportions of overall counts and as proportions of all aplastics in the text.

Matrix, Total Aplastic Inclusions, and Voids

At a broad level, ceramic bodies are composed of three components - matrix, aplastic inclusions and voids. Matrix refers to the bulk of the clay materials that make up the ceramic. In this study, grain size was not systematically recorded, but it is related to the recognition of aplastic inclusions. Conceivably, matrix, as recorded here, can include non-clay minerals that are too small to be distinguished from their surrounding clay minerals. If a mineral could not be distinguished from its surrounding matrix, then it was counted as matrix. Unless a pure clay mineral has been used to form a pot, then the ceramic body usually contains aplastic inclusions either due to the potter's modification of the clay body, or from natural inclusions within the raw

clay source (or both of these). Again, the identification of minerals in this category depended on their ability to be distinguished from their surrounding minerals, and aplastic inclusions were recognized when they were large enough to be distinguished from their surrounding matrix. Additionally, spaces, here called voids, may form either by pore formation during the preparation of the clay body or from the removal of aplastic inclusions. Temper may be removed naturally from the ceramic body through firing (e.g., fiber temper) or by poor depositional contexts (e.g. acid leaching of carbonates). Additionally, temper may be lost through the preparation of thin sections. The impact of this possibility on the present study is addressed below.

Measures of dispersion in counts of matrix indicate some degree of similarity between ceramics from the three sites, with mean matrix ranging from 71-78%. Total aplastic inclusions within the matrix followed an inverse relationship to matrix at each site, with means ranging from 15-23%. Ek Balam's ceramics contain the highest proportion of matrix, Kiuic's the next highest, and Labná the lowest (Table 6.1; Figures 6.1, 6.2). On the other hand, Labná ceramics had the highest counts of aplastics, Kiuic's the next highest, and Ek Balam's had the lowest. Considering all of the samples, the 7% overall difference in matrix counts and the 8% overall difference in aplastics counts initially suggest similarities, rather than differences.

Table 6.1. Proportion of matrix and total aplastics in total count

Site ^a		min.	1 st quartile	mean	median	3 rd quartile	max.	st. dev.
Ek Balam	<i>P</i> matrix	0.53	0.7267	0.7763	0.7867	0.8200	0.91	0.0696
	<i>P</i> aplastics	0.05	0.1200	0.1533	0.1467	0.1800	0.34	0.0580
Kiuic	<i>P</i> matrix	0.57	0.7000	0.7330	0.7400	0.7733	0.85	0.0626
	<i>P</i> aplastics	0.10	0.1533	0.1901	0.1733	0.2200	0.33	0.0557
Labná	<i>P</i> matrix	0.54	0.6667	0.7105	0.6933	0.7933	0.85	0.0872
	<i>P</i> aplastics	0.07	0.1467	0.2288	0.2400	0.2867	0.39	0.0799

a. n=35 for all cases

Figure 6.1. Proportion of matrix in total counts

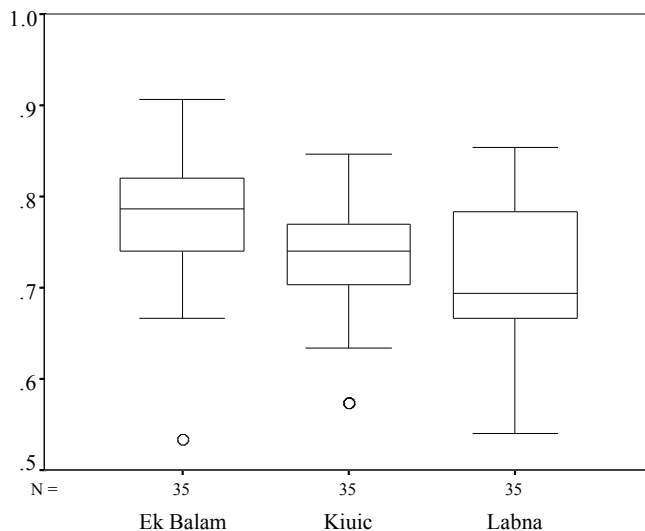
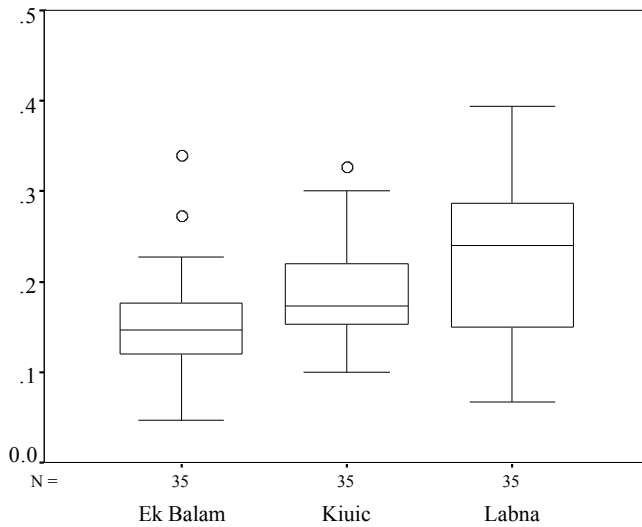


Figure 6.2. Proportion of aplastics in total counts



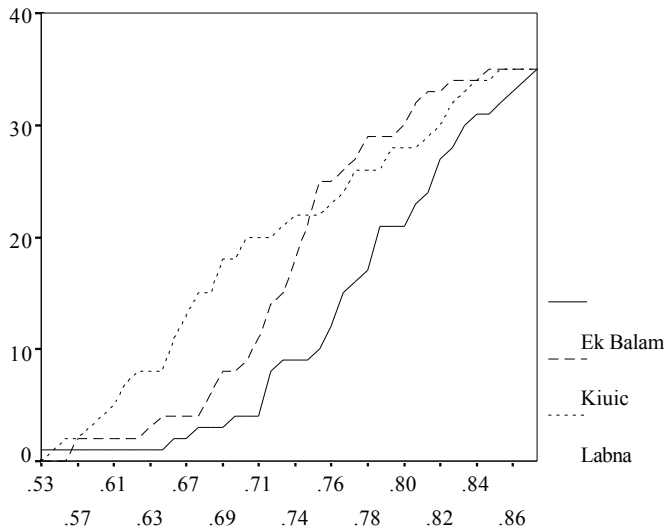
However, the Kolmogorov-Smirnov values indicate that the differences that do exist are outside of the variation expected if these samples all came from the same statistical population (Table 6.2; Figure 6.3). In terms of this analysis, ceramics that belong to the same sampling population for a given variable should indicate a common production location. In terms of matrix counts, Ek Balam clearly stands out as different from the Puuc sites, with differences significant at a 99.0% confidence level. The differences between Labná and Kiuic failed to meet the 95.0% confidence level used in this study to indicate statistical significance. In terms of counts of matrix, then, the sherds from Kiuic and Labná show some degree of similarity at this broad level of comparison. This could be related to several factors, such as the nature of the raw materials used in vessel manufacture, or a shared technological knowledge among potters at several sites. These issues will be explored with the data on the specific constituents.

Table 6.2. Kolmogorov-Smirnov results for matrix and total aplastics

		K-S Z-score ^a	significance
Ek Balam - Kiuic	matrix	1.793	0.003
	aplastics	1.434	0.003
Ek Balam - Labná	matrix	1.912	0.001
	aplastics	1.912	0.001
Labná - Kiuic	matrix	1.315	0.063
	aplastics	1.434	0.033

a. For 95% confidence level $Z=1.36$; for 99.9%, $Z=1.95$

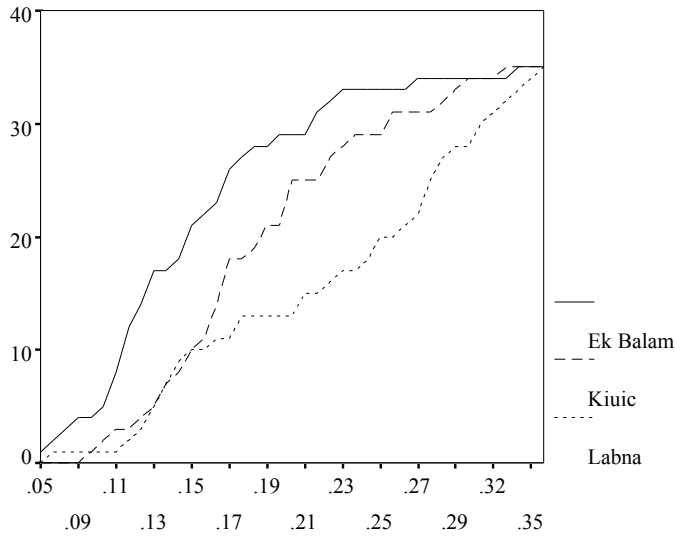
Figure 6.3. Cumulative frequency of proportions of matrix in total counts



The tests of significant difference between total aplastic counts for the respective samples reveal significant variation between ceramics from all of the sites (Table 6.2; Figure 6.4). The Z-scores for tests between Ek Balam and Kiuic, and Ek Balam and Labná, are both significant beyond a 99% confidence level; the difference between Ek Balam and Labná is most significant. Tests between Labná and Kiuic were significant beyond a 95% confidence interval. These significant differences between proportions of matrix and aplastic inclusions suggest that there are significant differences between Muna Slate wares from each of these sites, but before this can be suggested, it is necessary to account for the differences in the sample preparation, and the effects that these differences may have on the proportions of matrix and aplastic inclusions. Again, all of the thin sections from Ek Balam and some of the Kiuic thin sections were prepared at Millsaps College without the benefits of epoxy impregnation. Therefore, if the preparation of the samples had an effect on the counts, then it would be logical to assume that Ek Balam's and Kiuic's ceramics would be more similar to each other than they are to Labná ceramics. In order to assess this possibility, the counts of voids were considered for any information that they could present on preparation technique.

Thin section petrography, as noted above, was developed as an analytical technique in geology. The techniques used in the preparation of thin sections were designed to cut materials (rocks) that are much harder than archaeological ceramics. During the preparation of ceramic thin sections, there is a possibility that harder minerals will be "plucked" from their softer surrounding matrix. Thus, the number and shape of voids in the ceramic fabric could indicate differences in sample preparation, thereby alerting the researcher to any problems with comparability between the three sites. The integrity of ceramic thin sections can be improved by impregnating them with epoxy in a vacuum before trimming them to 0.03 mm. This was done for all of the samples from Labná, but not for the Ek Balam and Kiuic ceramics. It was thus important to evaluate the comparability of the samples prepared in different locations.

Figure 6.4. Cumulative frequency of proportions of aplastics in total counts



The ceramics from each of the sites have similar means and distributions for proportions of voids; means range from 6% to 7.7% (Table 6.3; Figure 6.5). Kolmogorov-Smirnov values indicate a significant difference between the total voids between Labná and the other two sites; Kiuic and Ek Balam are fairly similar (Table 6.4; Figure 6.6). This suggested that plucking might have skewed the counts of aplastic inclusions, and it was important to assess this possibility. If minerals were indeed plucked from the thin sections, then a void would be produced. Thus, differences in the presence and characteristics of voids provide a means to evaluate the effects of sample preparation.

Table 6.3. Proportion of voids in total count

Site ^a		min.	1 st quartile	mean	median	3 rd quartile	max.	st. dev.
Ek Balam	<i>P</i> total	0.00	0.0600	0.0705	0.0667	0.0933	0.13	0.0296
	<i>P</i> angular	0.00	0.0200	0.0334	0.0333	0.0400	0.09	0.0189
	<i>P</i> sub-angular	0.00	0.0067	0.0204	0.0200	0.0267	0.05	0.0152
	<i>P</i> rounded	0.00	0.0067	0.0166	0.0133	0.0267	0.06	0.0132
Kiuic	<i>P</i> total	0.01	0.0533	0.0770	0.0667	0.1067	0.13	0.0293
	<i>P</i> angular	0.01	0.0200	0.0333	0.0333	0.0467	0.07	0.0149
	<i>P</i> sub-angular	0.00	0.0133	0.0257	0.0200	0.0467	0.07	0.0191
	<i>P</i> rounded	0.00	0.0067	0.0179	0.0200	0.0267	0.05	0.0112
Labná	<i>P</i> total	0.01	0.0400	0.0608	0.0533	0.0800	0.12	0.0296
	<i>P</i> angular	0.00	0.0067	0.0179	0.0133	0.0267	0.05	0.0138
	<i>P</i> sub-angular	0.00	0.0067	0.0208	0.0133	0.0333	0.07	0.0184
	<i>P</i> rounded	0.00	0.0067	0.0221	0.0200	0.0333	0.06	0.0157

a. n=35 for all cases

Figure 6.5. Proportion of proportion of total voids in total counts

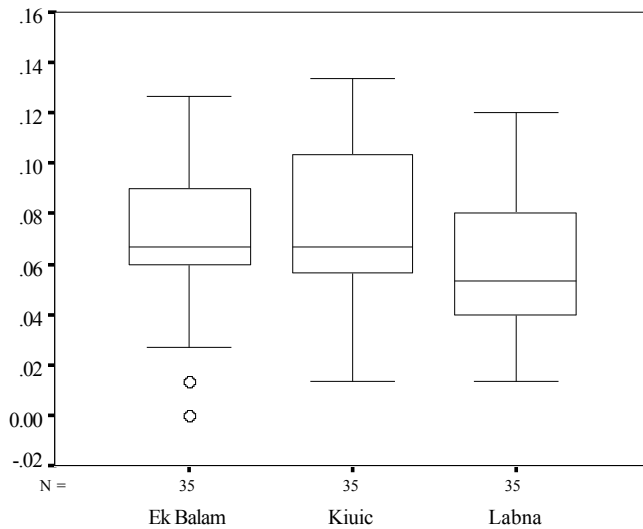


Table 6.4. Kolmogorov-Smirnov results for voids

		K-S Z-score ^a	significance
Ek Balam - Kiuc	<i>P</i> total	0.589	0.867
	<i>P</i> angular	0.359	1.000
	<i>P</i> sub-angular	0.598	0.867
	<i>P</i> rounded	0.598	0.867
Ek Balam - Labná	<i>P</i> total	1.434	0.033
	<i>P</i> angular	1.793	0.003
	<i>P</i> sub-angular	0.478	0.967
	<i>P</i> rounded	0.837	0.486
Labná - Kiuc	<i>P</i> total	1.434	0.003
	<i>P</i> angular	1.793	0.003
	<i>P</i> sub-angular	0.837	0.486
	<i>P</i> rounded	0.717	0.683

a. For 95% confidence level $Z=1.36$; for 99.9%, $Z=1.95$

Both the presence and the shape of voids were recorded in this analysis. It is common practice to distinguish between four shape categories in petrographic analyses - angular, subangular, subrounded, and rounded. In this analysis, the subangular and subrounded categories are combined under the subangular category. The proportions of angular voids presented the only significant differences for these ceramics. Again, Labná was significantly different from Ek Balam and Kiuc, which showed fairly similar patterns (Tables 6.4; Figures 6.7, 6.8). It is argued that these angular voids represent plucking during preparation more than do the sub-angular (Figure 6.9) and rounded (Figure 6.10) voids. The shape of the void indicates that an angular constituent was plucked from the ceramic body. Angular voids observed in these ceramics are roughly proportionate in length and width. This suggests that long, lunar, and Y-shaped pieces of ash were not being plucked. Rather, it seems more likely that crystalline carbonates were being plucked from the ceramic body. To test whether the significant differences in angular voids

represented differences inherent in the ceramics or if it was related to the preparation technique, the proportions of angular voids and angular carbonates were combined, and their distributions examined. If significant difference were still observed between Labná and the other two sites, then an inherent difference in ceramics from each of these sites would be indicated. If the differences disappeared, however, then this would suggest that the different preparation techniques did have an impact on the counts of the various constituents. The results indicate no significant differences between any of the samples (Table 6.5; Figure 6.11), and preparation techniques seem to be the cause. The impact of this is addressed at the end of the following section.

Figure 6.6. Cumulative frequency of proportions of voids in total counts

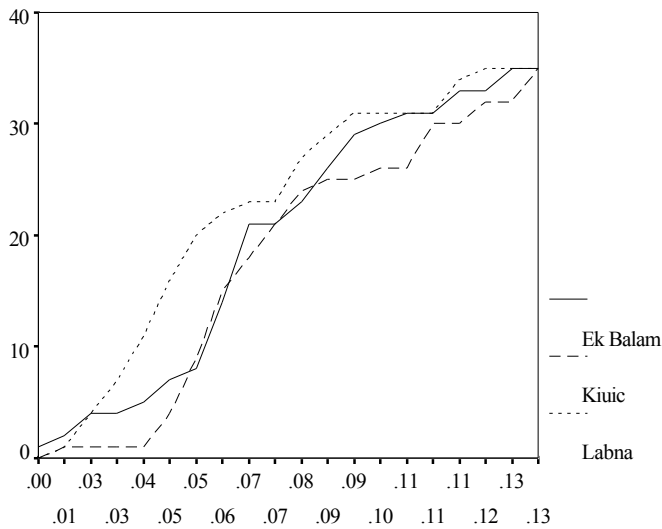


Figure 6.7. Proportion of angular voids in total counts

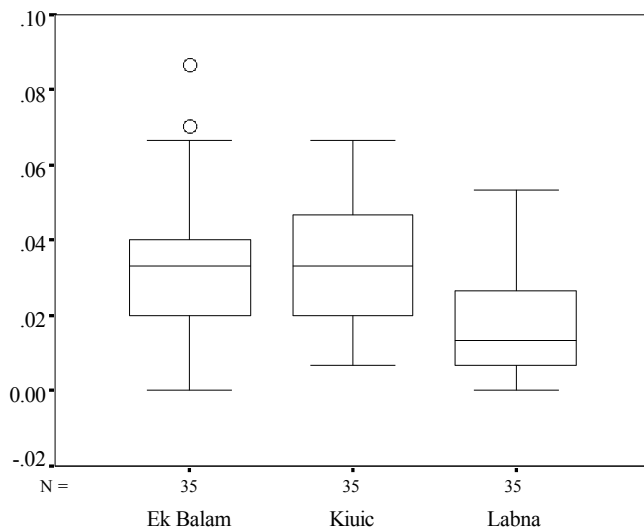


Figure 6.8. Cumulative frequency of angular voids in total counts

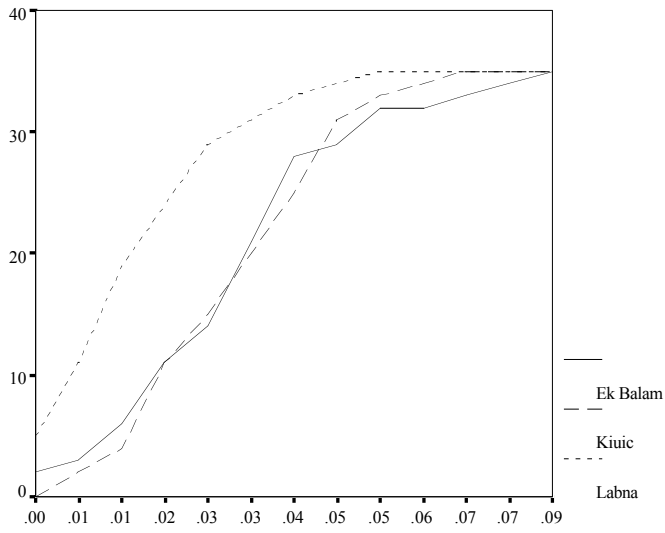


Figure 6.9. Cumulative frequency of subangular voids in total counts

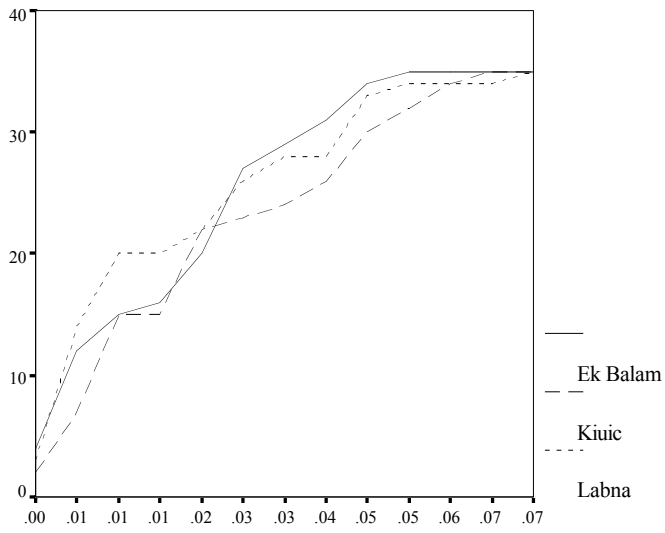


Figure 6.10. Cumulative frequency of rounded voids in total counts

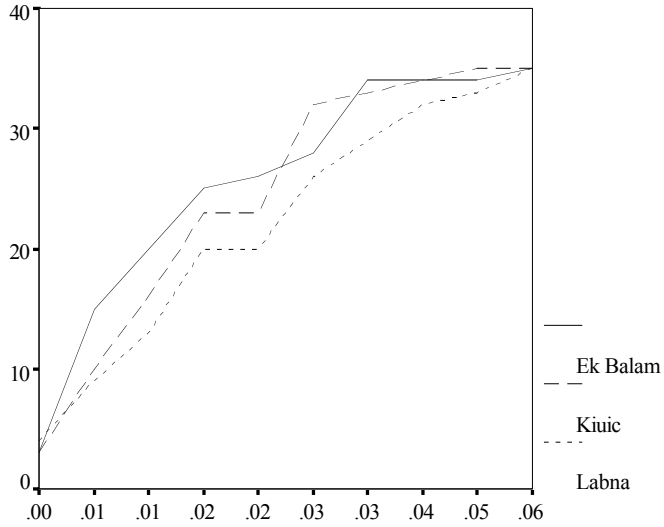
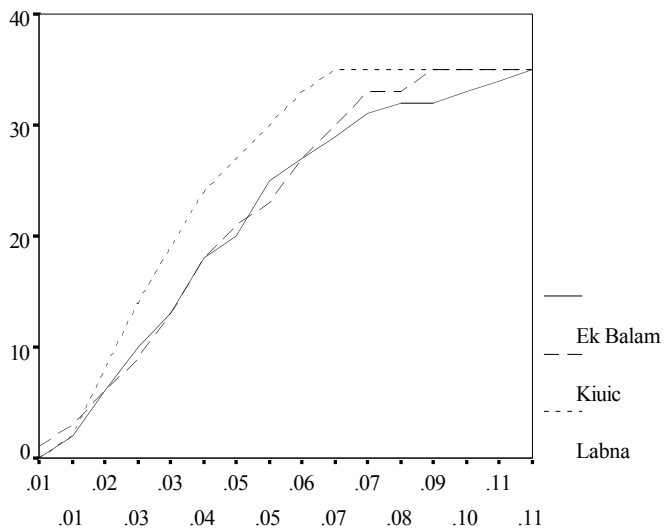


Table 6.5. Kolmogorov-Smirnov results for combined angular voids and carbonates

	K-S Z-score ^a	Significance
Ek Balam - Kiuic	0.359	1.000
Ek Balam - Labná	0.837	0.486
Labná - Kiuic	0.837	0.486

a. For 95% confidence level $Z=1.36$; for 99.9%, $Z=1.95$

Figure 6.11. Cumulative frequency of combined proportions of angular voids and angular carbonates in total count



Carbonates

Crystalline carbonates (calcite and dolomite) were commonly encountered in the sherds, but in small amounts. Means of total counts centered between 1.9 and 2.8%, while the mean proportions of crystalline carbonates with respect to total aplastics ranged from 10.9 to 12.5% (Table 6.6; Figure 6.12). In all three sites, there were sherds in which crystalline carbonates were not present in amounts large enough to be detected in the sample. In terms of the proportions of crystalline carbonate in the total count, Labná's sherds contain a higher percentage overall, and show more variability than sherds from Ek Balam or Kiuic. None of the differences between the samples are significant at the 95% confidence level (Table 6.7; Figure 6.13). Considering the proportions of crystalline carbonates to total aplastics demonstrates that Kiuic and Ek Balam have similar dispersions and means (Table 6.6; Figure 6.14). Labná demonstrates a similar mean, but lower dispersion within the data. None of the differences between sherds from different sites are significant (Table 6.7; Figure 6.15). The overall patterning in the crystalline carbonates, then, does not readily distinguish between these sites.

Table 6.6. Proportions of crystalline carbonates

Site ^a		min.	1 st quartile	mean	median	3 rd quartile	max.	st. dev.
Ek Balam	<i>P</i> total	0.00	0.0067	0.0187	0.0133	0.0200	0.10	0.0185
	<i>P</i> aplastics	0.00	0.0588	0.1203	0.1071	0.1667	0.43	0.0910
Kiuic	<i>P</i> total	0.00	0.0067	0.0200	0.0133	0.0267	0.08	0.0187
	<i>P</i> aplastics	0.00	0.0333	0.1088	0.1000	0.1600	0.32	0.0886
Labná	<i>P</i> total	0.00	0.0133	0.0278	0.0267	0.0400	0.08	0.0180
	<i>P</i> aplastics	0.00	0.0811	0.1252	0.1020	0.1522	0.48	0.0844

a. n=35 in all cases

Figure 6.12. Proportion of crystalline carbonates in total count

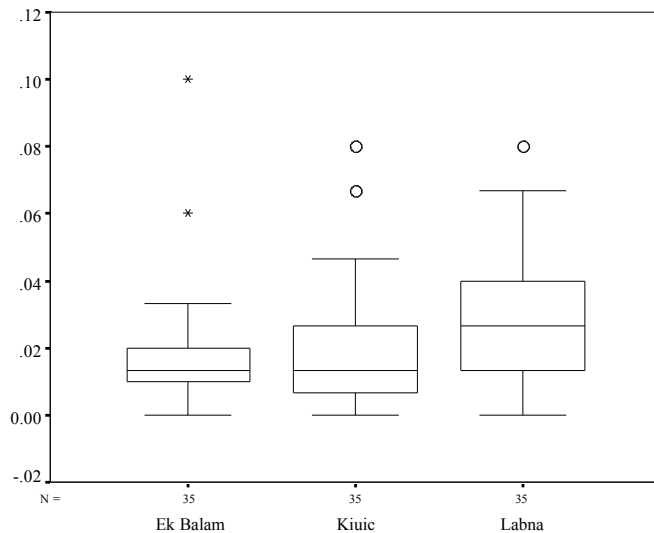


Table 6.7. Kolmogorov-Smirnov results for crystalline carbonates

		K-S Z-score ^a	significance
Ek Balam - Kiuic	<i>P</i> total	0.478	0.976
	<i>P</i> aplastics	0.717	0.683
Ek Balam - Labná	<i>P</i> total	1.315	0.063
	<i>P</i> aplastics	0.478	0.976
Labná - Kiuic	<i>P</i> total	0.956	0.320
	<i>P</i> aplastics	0.956	0.320

a. For 95% confidence level $Z=1.36$; for 99.9%, $Z=1.95$

Figure 6.13. Cumulative frequency of proportions of crystalline carbonates in total counts

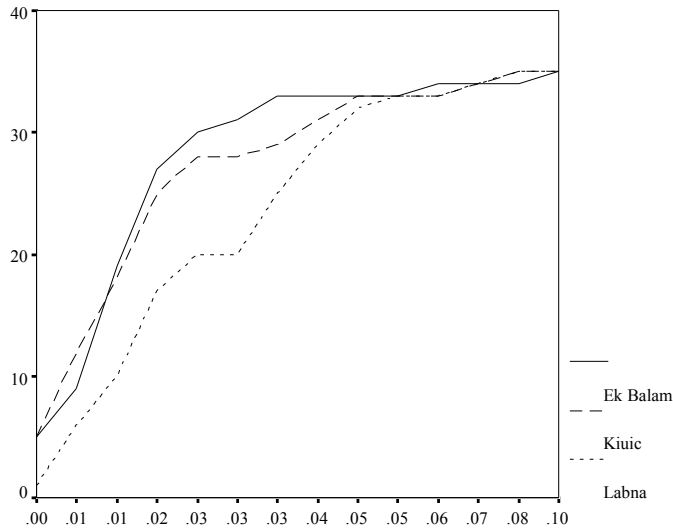


Figure 6.14. Proportion of crystalline carbonates in total aplastics

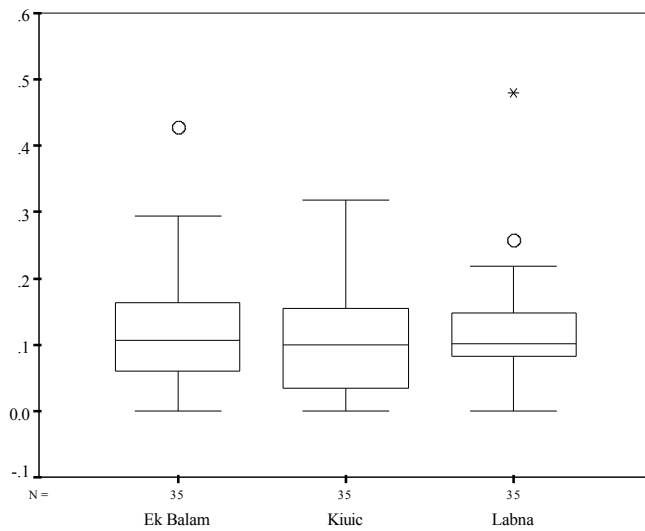
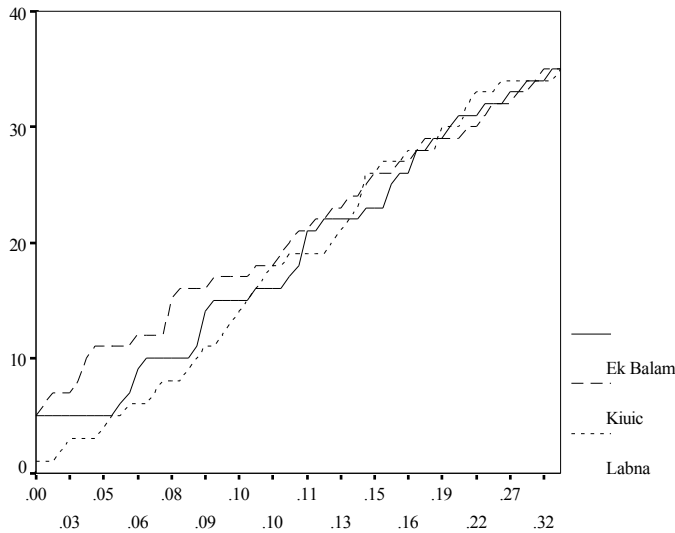


Figure 6.15. Cumulative frequency of proportions of crystalline carbonates in total aplastics



In addition to crystalline carbonates, partially calcined carbonates were also encountered in a few sherds. As calcium carbonate, CaCO_3 , is heated in the presence of oxygen, it decomposes into calcium oxide (CaO), or lime, and carbon dioxide. Lime attracts water molecules, and readily re-hydrates to portlandite, $\text{Ca}(\text{OH})_2$. Portlandite lacks a crystalline structure, and appears as a gray cloudy constituent. The cloudy areas observed in the thin sections are often surrounded with, and sometimes contain, microcrystalline carbonates that scintillate as the thin section is rotated under crossed polarized light. These features are argued to indicate that the gray areas were originally larger pieces of crystalline carbonates that decompose during vessel firing. Distributions of partially calcined carbonates are fairly similar when considering either total proportions or proportions of aplastics. Labná sherds had higher overall counts of partially calcined carbonates (Table 6.8; Figures 6.16, 6.17). They were significantly different from Kiuic's sherds in overall counts (Table 6.9; Figures 6.18, 6.19). Kiuic and Ek Balam shared more similar mean values, but Ek Balam's sherds contained more partially calcined carbonates overall. Ek Balam and Labná have similar distributions for proportions of partially calcined carbonate, but Labná's sherds have higher proportions overall. The differences, however, are insignificant at the 95% confidence level. Kiuic's distribution falls completely within Ek Balam's and there is no significant difference between these sherds. However, there is a significant difference between Labná sherds and Kiuic's sherds in the amount of partially calcined carbonate for proportions of total counts and proportion of aplastics.

Table 6.8. Proportions of partially calcined carbonates

Site ^a		min.	1 st quartile	mean	median	3 rd quartile	max.	st. dev.
Ek Balam	<i>P</i> total	0.00	0.0000	0.0234	0.0067	0.0333	0.15	0.0357
	<i>P</i> aplastics	0.00	0.0000	0.1372	0.0556	0.2353	0.72	0.1842
Kiuic	<i>P</i> total	0.00	0.0000	0.0135	0.0067	0.0133	0.09	0.0204
	<i>P</i> aplastics	0.00	0.0000	0.0731	0.0345	0.1316	0.39	0.1015
Labná	<i>P</i> total	0.00	0.0067	0.0444	0.0267	0.0667	0.20	0.0525
	<i>P</i> aplastics	0.00	0.0455	0.1768	0.1053	0.2381	0.73	0.1872

a. n=35 in all cases

Figure 6.16. Proportions of partially calcined carbonates in total counts

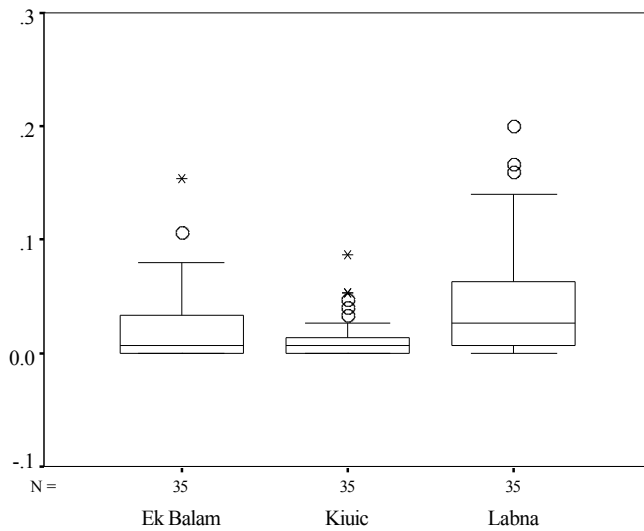


Figure 6.17. Proportions of partially calcined carbonates in total aplastics

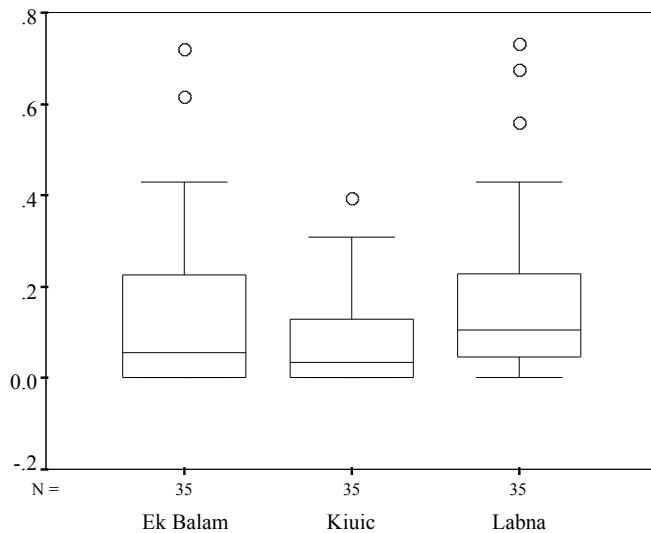


Table 6.9. Kolmogorov-Smirnov results for partially calcined carbonates

		K-S Z-score ^a	significance
Ek Balam - Kiuic	<i>P</i> total	0.598	0.867
	<i>P</i> aplastics	0.956	0.320
Ek Balam - Labná	<i>P</i> total	1.195	0.115
	<i>P</i> aplastics	1.076	0.197
Labná - Kiuic	<i>P</i> total	1.434	0.033
	<i>P</i> aplastics	1.554	0.016

a. For 95% confidence level $Z=1.36$; for 99.9%, $Z=1.95$

Figure 6.18. Cumulative frequency of proportions of partially calcined carbonates in total counts

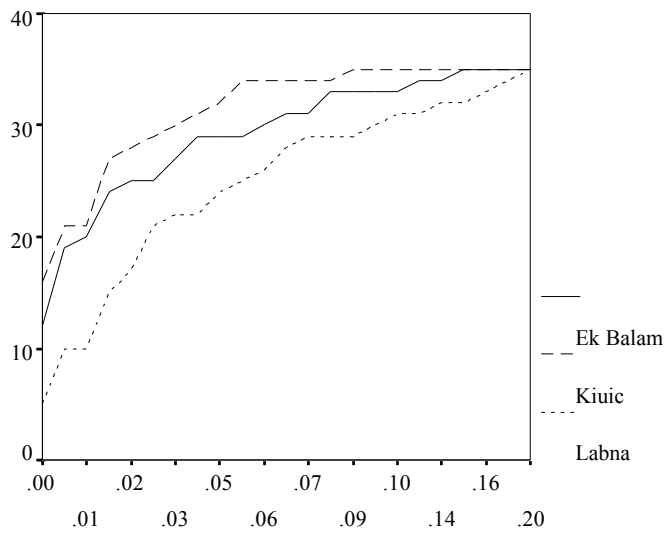
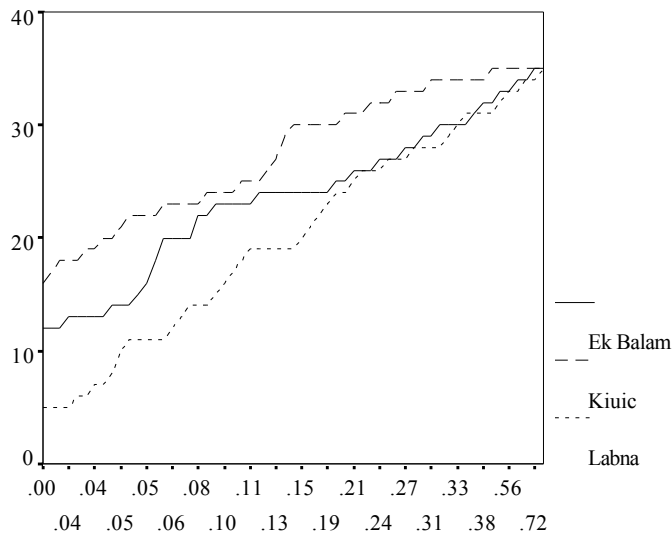


Figure 6.19. Cumulative frequency of proportions of partially calcined carbonates in total aplastics



The presence of carbonates in these sherds is to be expected given the overall homogeneity of the peninsula's karstic limestone geography. Yet, the amounts of carbonates in these ceramics are surprisingly low given the ubiquity of limestone. Combining the means for both crystalline and partially calcined carbonates yielded maximum means of 7.2% of total counts, and 30.2% of aplastic counts (both for Labná). There are two possibilities that can explain the low occurrence of carbonates in the clays. First, if *sak lu'um* is used as a temper, as indicated by ethnomineralogical studies (see Chapter 5), then the low carbonate content in these samples is not as surprising.

Another factor that could contribute to the low occurrence of crystalline calcite relates to its conversion to lime. The process discussed above whereby calcite decomposes to lime requires heat. Between 650-900°C, calcite begins to decompose. Open firing of pottery can achieve such temperatures, but rarely reaches 1000°C, the point at which CaO will not rehydrate (Rice 1987c:98, 156-157). If crystalline carbonates are replaced by partially calcined carbonates, and eventually lime, as temperature increases during firing, then partially calcined carbonates and crystalline carbonates should demonstrate an inverse relationship. In other words, as temperature rise from 650°C to 900°C, the proportion of crystalline carbonates should decrease as the proportion of partially calcined carbonate increases. This relationship is not demonstrated when considering the proportions of total counts and total aplastics for each site individually and all sites together (Table 6.10; Figures 6.20, 6.21). Each of the correlations is weak, and all are slightly positive. This is suggestive of a range of firing temperatures that was at once variable and low enough to ensure that all of the carbonate materials were not converted to CaO.

Table 6.10. Correlations between crystalline carbonates and partially calcined carbonates

Site		<i>r</i>	sig.
Ek Balam	<i>P</i> total	0.362	0.016
	<i>P</i> aplastics	0.298	0.041
Kiuic	<i>P</i> total	0.176	0.156
	<i>P</i> aplastics	0.197	0.129
Labná	<i>P</i> total	0.128	0.233
	<i>P</i> aplastics	0.003	0.492
All Sites	<i>P</i> total	0.248	0.005
	<i>P</i> aplastics	0.173	0.039

Figure 6.20. Relationships of crystalline carbonates to partially calcined carbonates in proportions of total counts

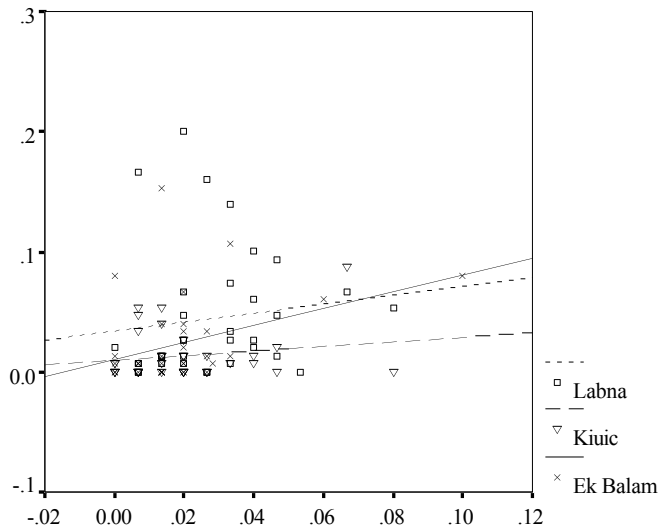
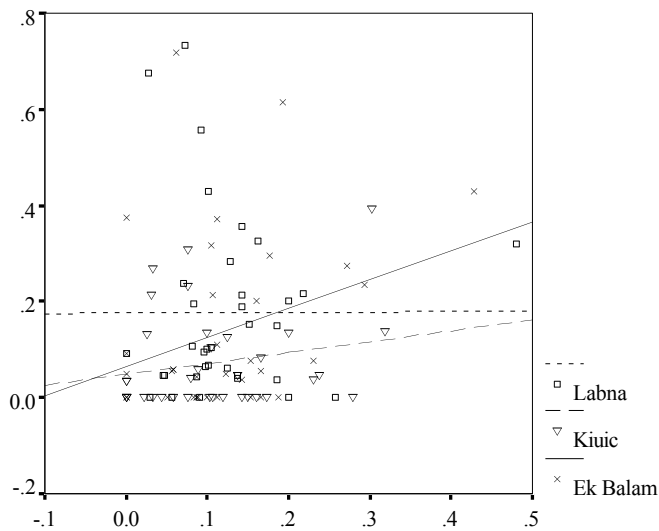


Figure 6.21. Relationships of crystalline carbonates to partially calcined carbonates in proportions of total counts



Despite the limitations in accurately recovering carbonates in this analysis (discussed above), carbonates do not seem to be a major constituent of the aplastics within the ceramic matrix of the sherds examined here. From the review of the ethnographic literature, it is not clear to what extent crystalline carbonates may be included within the clay deposits utilized by ancient Maya potters. Modern accounts (Arnold 1971; Schultz 1971; Arnold et al. 2000) indicate that potting clays are mined a few meters below ground surface from deposits that are interbedded with limestones. These deposits are well defined at the bottom, but have breccia transition zones of variable thickness towards the top (Schultz et al. 1971:138). From this evidence, it is not easy to say what portion of the carbonates seen in these ceramics were added as temper and which portion occurred naturally in the clays. In fact, these low proportions suggest that ancient Maya

pottery may have removed carbonates while preparing the raw clays for potting. Proportions of total carbonates ranged between 0.0% and 22%, with means ranging from 3.4% and 7.2% (Table 6.11; Figure 6.22). The difference in carbonate proportions between Labná and Kiuic's ceramics presents the only significant difference in terms of the total count between the samples (Table 6.12; Figure 6.23). Proportions of carbonate contribution to total aplastics showed tremendous range, from 0.0% to 86% (Table 6.11; Figure 6.24). Again, differences were only significant for comparisons between Labná and Kiuic's sherds (Table 6.12; Figure 6.25). The ways in which these data reflect difference in firing regimes is not clear, and it is not possible to say whether Labná's ceramics were fired at a higher or lower temperature than Ek Balam's and Kiuic's.

Table 6.11. Proportions of total carbonates

Site ^a		min.	1 st quartile	Mean	median	3 rd quartile	max.	st. dev.
Ek Balam	<i>P</i> total	0.00	0.0133	0.0422	0.0267	0.0533	0.18	0.0458
	<i>P</i> aplastics	0.00	0.0909	0.2576	0.1707	0.3750	0.86	0.2284
Kiuic	<i>P</i> total	0.00	0.0067	0.0335	0.0267	0.0467	0.15	0.0299
	<i>P</i> aplastics	0.00	0.0588	0.1818	0.1579	0.2692	0.70	0.1473
Labná	<i>P</i> total	0.01	0.0267	0.0722	0.0600	0.1067	0.22	0.0576
	<i>P</i> aplastics	0.03	0.1695	0.3020	0.2222	0.4103	0.80	0.2057

a. n=35 in all cases

Figure 6.22. Proportions of total carbonates in total counts

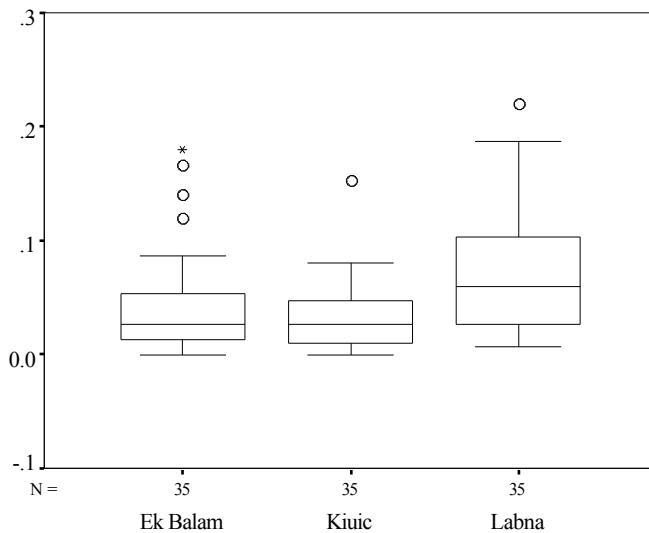


Table 6.12. Kolmogorov-Smirnov results for total carbonates

		K-S Z-score ^a	Significance
Ek Balam - Kiuic	<i>P</i> total	0.598	0.867
	<i>P</i> aplastics	0.837	0.486
Ek Balam - Labná	<i>P</i> total	1.315	0.063
	<i>P</i> aplastics	1.076	0.197
Labná - Kiuic	<i>P</i> total	1.554	0.016
	<i>P</i> aplastics	1.434	0.033

a. For 95% confidence level $Z=1.36$; for 99.9%, $Z=1.95$

Figure 6.23. Cumulative frequency of proportions of total carbonates in total counts

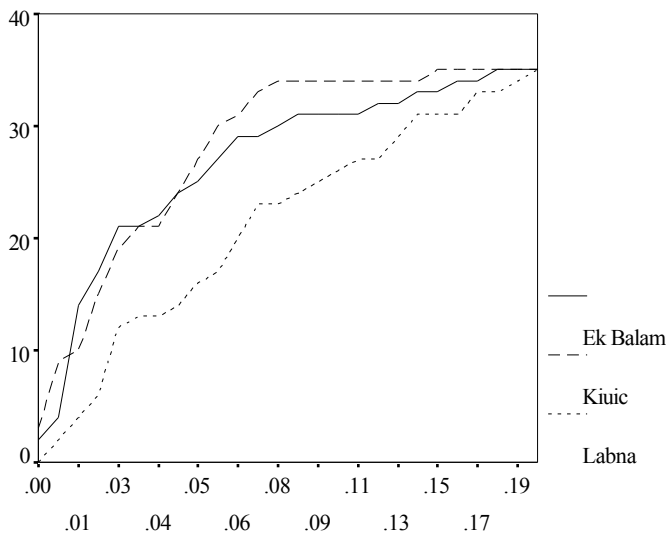


Figure 6.24. Proportions of total carbonates in total aplastics

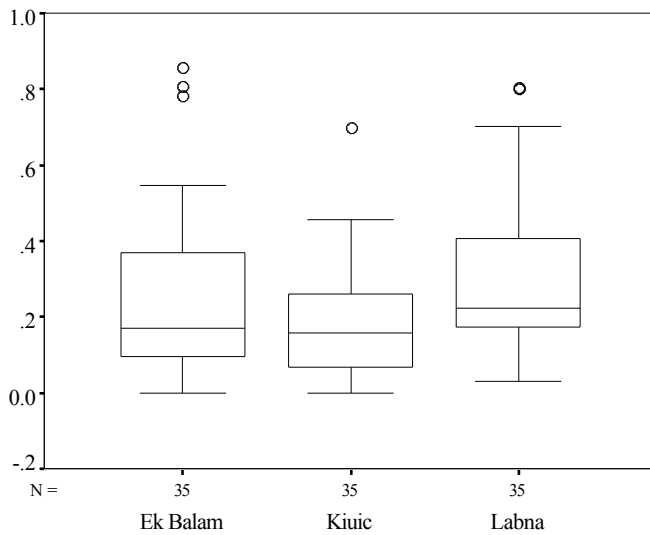
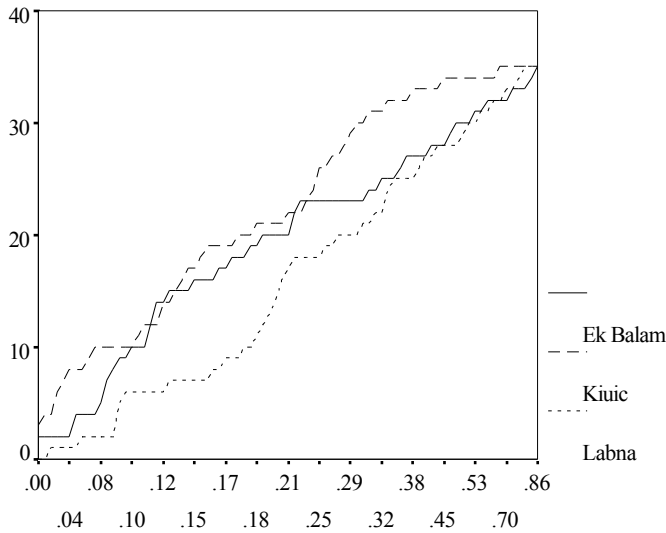


Figure 6.25. Cumulative frequency of proportions of total carbonates in total aplastics



Although it was noted that differences in preparation technique had an impact on the counts of angular voids and angular carbonates, this has little effect on this study for two reasons. First, when the total proportions of carbonates are combined with the total counts for angular voids, the differences in the ceramics disappear, and each population exhibits fairly similar distributions (Table 6.13; Figure 6.26). Because the angular voids most likely represent angular carbonates that were removed during preparation, combining these with the total carbonates provides a better approximation of the true proportion of carbonates in these ceramics. The differences in the distributions are not significant (Table 6.14; Figure 6.27). The overall distribution in carbonates, then suggests a relatively homogenous distribution within the Muna Slate wares examine here, and, all things being equal, would not serve to distinguish between groups of ceramics. Secondly, the counts of the other constituents in these ceramics are independent of the proportions of voids and carbonates, and the differences indicated in these categories are still valid.

Table 6.13. Proportions of combined angular voids and total carbonates

Site ^a		min.	1 st quartile	mean	median	3 rd quartile	max.	st. dev.
Ek Balam	<i>P</i> total	0.01	0.0333	0.0756	0.0533	0.1133	0.23	0.0548
Kiuic	<i>P</i> total	0.01	0.0400	0.0669	0.0667	0.0867	0.17	0.0341
Labná	<i>P</i> total	0.02	0.0467	0.0901	0.0733	0.1200	0.24	0.0566

a. n=35 in all cases

Figure 6.26. Distribution of combined angular voids and total carbonates

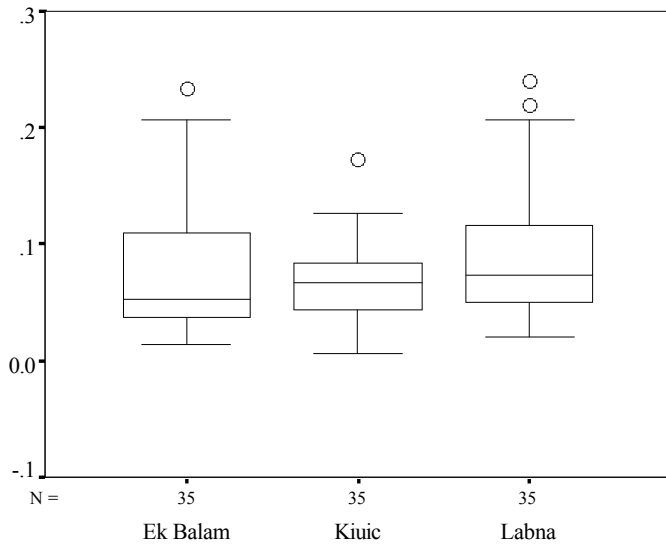
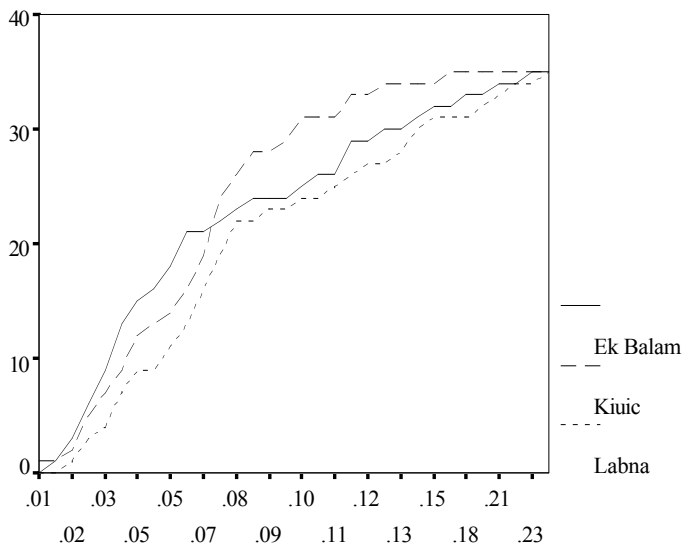


Table 6.14. Kolmogorov-Smirnov results for combined angular voids and total carbonates

		K-S Z-score ^a	Significance
Ek Balam - Kiuic	<i>P</i> total	0.717	0.683
Ek Balam - Labná	<i>P</i> total	0.956	0.320
Labná - Kiuic	<i>P</i> total	0.837	0.486

a. For 95% confidence level $Z=1.36$; for 99.9%, $Z=1.95$

Figure 6.27. Cumulative frequency of proportions of combined angular voids and total carbonates



Rare Constituents

Occasionally during the analysis, uncommon minerals were encountered. Out of all of the points collected for all of the sherds, only five rare constituents were counted. These included one grain of chlorite, two grains of a pyroxene (probably diopside), one grain of quartz, and one grain of an unidentified mineral showing red and green interference colors. Although other rare constituent minerals were noted, these did not fall within the point counting transect. Though these rare mineral inclusions do not form major classes of inclusions, their presence is interesting. As was discussed in the section on volcanic glass, accessory minerals have been used to try to characterize different deposits of ash. In this respect, it is interesting that all of the rare constituent minerals were counted in ceramics from Ek Balam and Kiuic. Yet, Labná ceramics were not without rare constituent minerals; they were simply not observed at any sampled point. Because Kiuic and Ek Balam have higher occurrences of volcanic glass temper, it is possible these minerals were introduced along with the ash. On the other hand, they may have been natural inclusions in the clay beds. The exact explanation remains unclear.

Hematite

Lumps of hematite are a common natural inclusion in the iron rich soils and clays of the northern Yucatan. However, their specific concentration in deposits of raw clays could be a potential means of distinguishing ceramic samples from one another. In total counts and in proportion of aplastics, hematite levels are lower in Ek Balam sherds than they are in the two Puuc sites (Table 6.15; Figures 6.28, 6.29). This difference is significant at a 95% confidence level (Table 6.16; Figures 6.30, 6.31). Because Ek Balam is so far away from the other two sites, it is probable that the differences apparent in both hematite and natural clay lump inclusions may be related to broad differences in the regional geology of the northern Plains and the Puuc Hills. In this aspect, Muna Slate wares from Ek Balam serve as a control set with which to examine the differences in the Muna Slate wares from the Puuc sites.

Table 6.15. Proportions of hematite

Site ^a		min.	1 st quartile	Mean	median	3 rd quartile	max.	st. dev.
Ek Balam	<i>P</i> total	0.00	0.0067	0.0112	0.0067	0.0200	0.03	0.0091
	<i>P</i> aplastics	0.00	0.0294	0.0816	0.0769	0.1071	0.29	0.0768
Kiuic	<i>P</i> total	0.00	0.0133	0.0229	0.0200	0.0333	0.05	0.0149
	<i>P</i> aplastics	0.00	0.0612	0.1335	0.1034	0.2174	0.47	0.1039
Labná	<i>P</i> total	0.00	0.0133	0.0189	0.0200	0.0267	0.05	0.0122
	<i>P</i> aplastics	0.00	0.0541	0.0827	0.0816	0.1154	0.18	0.0488

a. n=35 in all cases

Figure 6.28. Proportion of hematite in total counts

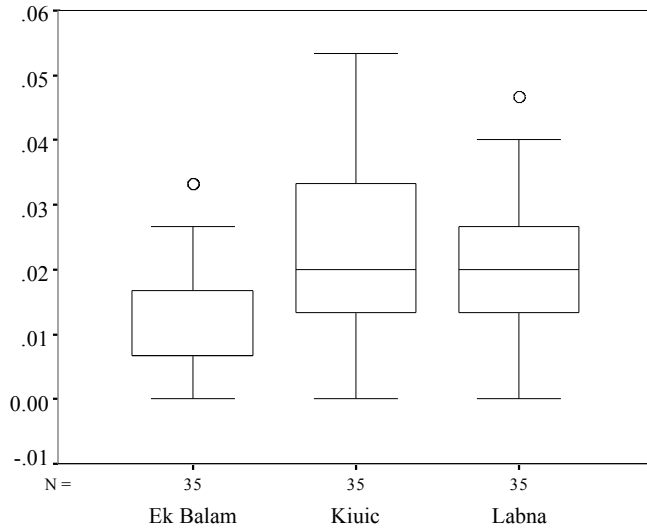


Figure 6.29. Proportion of hematite in total aplastics

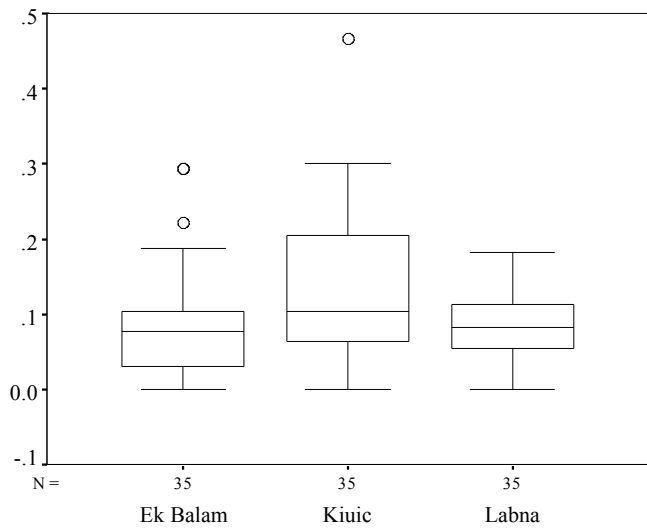


Table 6.16. Kolmogorov-Smirnov results for hematite

		K-S Z-score ^a	Significance
Ek Balam - Kiuic	<i>P</i> total	1.434	0.033
	<i>P</i> aplastics	1.195	0.115
Ek Balam - Labná	<i>P</i> total	1.315	0.063
	<i>P</i> aplastics	0.837	0.486
Labná - Kiuic	<i>P</i> total	0.717	0.683
	<i>P</i> aplastics	1.315	0.063

a. For 95% confidence level $Z=1.36$; for 99.9%, $Z=1.95$

Figure 6.30. Cumulative frequency of proportion of hematite in total counts

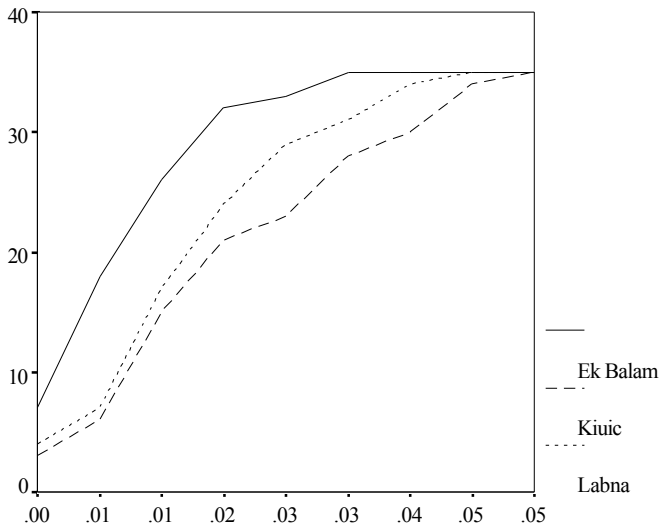
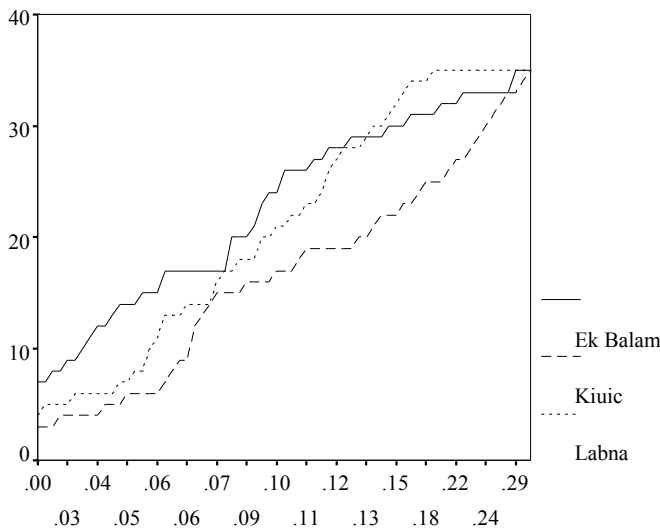


Figure 6.31. Cumulative frequency of proportion of hematite in total counts



Clay Inclusions

Overall trends in the data indicate that Labná ceramics have higher proportions of clay inclusions than do Kiuic and Ek Balam with respect to total counts (Table 6.17; Figures 6.32, 6.33). However, the differences between the Kiuic and Labná samples are not statistically significant (Table 6.18; Figures 6.34, 6.35). For proportions of total counts and proportions of aplastic inclusions, Ek Balam's sample differ at a statistically significant level from both Kiuic's and Labná's counts. Labná's ceramics display higher proportions of clay inclusions than the ceramics from Ek Balam and Kiuic, but Kiuic and Labná exhibit similar patterning in terms of

total counts and counts of aplastic inclusions. Again, difference between Kiuic and Labná are not statistically significant, while Ek Balam is significantly different from both of these sites above a 95% confidence level.

Table 6.17. Proportions of total clay inclusions

Site ^a		min.	1 st quartile	mean	median	3 rd quartile	max.	st. dev.
Ek Balam	<i>P</i> total	0.00	0.0267	0.0560	0.0533	0.0733	0.15	0.0377
	<i>P</i> aplastics	0.00	0.2353	0.3441	0.3500	0.4783	0.85	0.1961
Kiuic	<i>P</i> total	0.01	0.0533	0.1055	0.1000	0.1400	0.26	0.0662
	<i>P</i> aplastics	0.05	0.3600	0.5176	0.5600	0.6667	0.91	0.2149
Labná	<i>P</i> total	0.01	0.0800	0.1230	0.1133	0.1600	0.29	0.0687
	<i>P</i> aplastics	0.04	0.3953	0.5324	0.5897	0.6818	0.82	0.2008

a. n=35 in all cases

Figure 6.32. Proportions of total clay inclusions in total counts

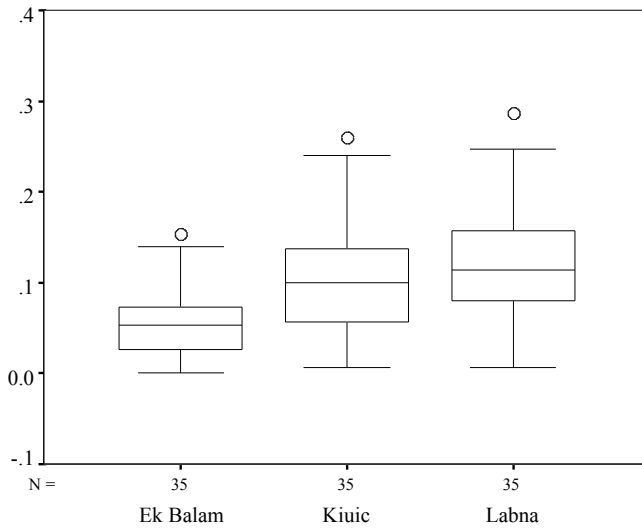


Figure 6.33. Proportions of total clay inclusions in total aplastics

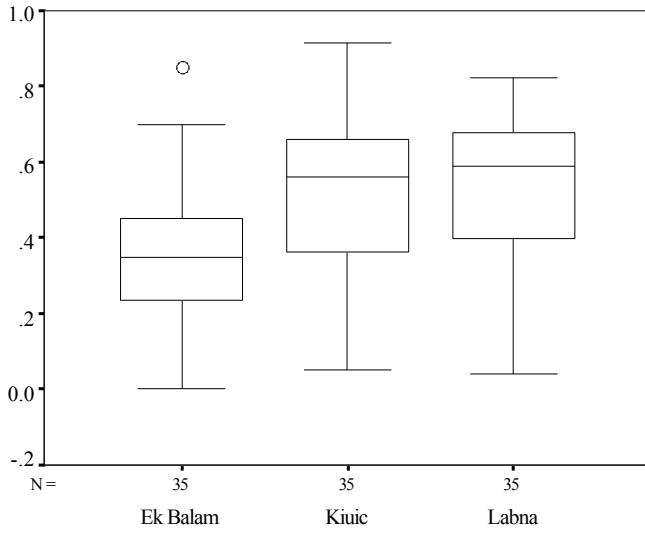


Table 6.18. Kolmogorov-Smirnov results for total clay inclusions

		K-S Z-score ^a	Significance
Ek Balam - Kiuic	<i>P</i> total	1.793	0.003
	<i>P</i> aplastics	1.793	0.003
Ek Balam - Labná	<i>P</i> total	2.271	0.000
	<i>P</i> aplastics	2.032	0.001
Labná - Kiuic	<i>P</i> total	0.837	0.486
	<i>P</i> aplastics	0.598	0.867

a. For 95% confidence level $Z=1.36$; for 99.9%, $Z=1.95$

Figure 6.34. Cumulative frequency of proportions of total clay inclusions in total counts

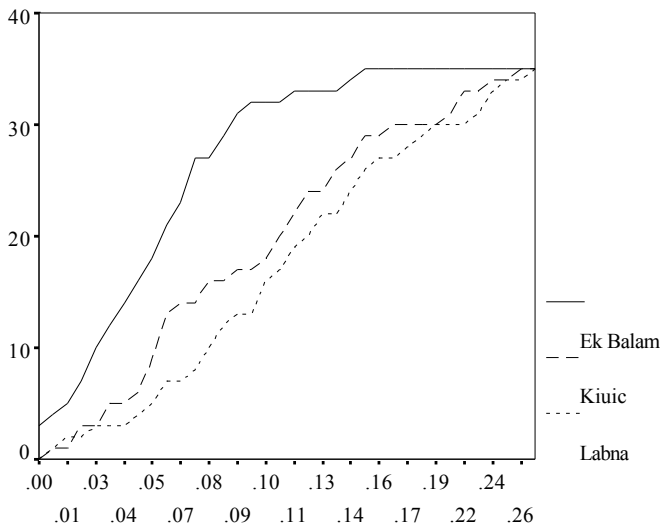
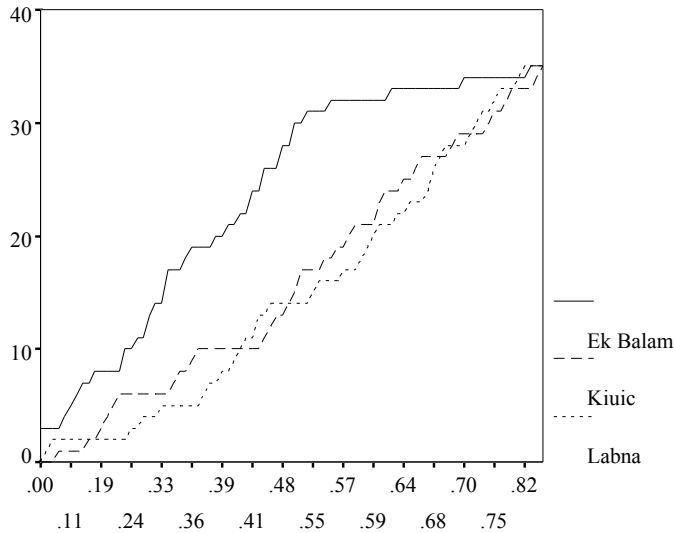


Figure 6.35. Cumulative frequency of proportions of total clay inclusions in total counts



By far, clay inclusions comprise the most diverse category of aplastic encountered in this study. These inclusions ranged from simple lumps of clay to highly complex inclusions containing carbonates, volcanic glass, hematite, and other clay lumps. In one instance from Labná, one angular clay inclusion not only contained volcanic ash, but a sintered layer of slip was also visible along one side. This begs the question whether clay inclusions seen in these all of these ceramics are natural or if they constitute temper (i.e. purposeful inclusions). Sherd tempers, or grogs, are known for Maya ceramics. Jones (1986:20-22) finds that grog temper use is a predominantly Preclassic behavior, and is replaced by the widespread adoption of ash temper. Shepard (1964b:518) also noted the presence of sherd temper in Maya ceramics, noting that they were distinguishable by color, texture, the presence of other inclusions within them, and by their irregular shape. In her analyses of northern Yucatan ceramics, she distinguished between sherd temper and clay lump temper (Shepard 1958:452). With respect to Shepard's paste inclusion categories, Smith (1971:269) states:

Clay lump... or lumpy untempered paste is found principally in Puuc Slate Ware at both Uxmal and Kabah... The clay base [(the matrix)] is dense, almost waxy looking, and contains medium to fine rounded particles of clay which are generally reddish or brown and darker in color than the clay but equally dense and fine.... In relative quantity, clay lumps range from sparse to abundant.

Clay inclusions encountered in ceramics in the present study conform to descriptions for both sherd temper and clay inclusions. Except for the one ash-tempered example mentioned above, clay inclusions conformed to the oxidation state of the matrix around them, but appeared as denser, finer, darker, patches.

To some extent, trying to distinguish between the two involves making a judgment about the behavior of the potters. While Shepard (1958; 1964b) and Jones (1986) both provide examples of grog temper, there are too many sub-angular and rounded clay inclusions to argue

conclusively for the presence of grog temper in the samples examined here. It is also important to note that the distribution of clay inclusions for each of these sites seems to be inversely related to the amount of volcanic glass. Both sherd temper and ash make excellent tempers because of their angularity and their similar or lower coefficients of thermal expansion relative to the clay matrix (Shepard 1980:29, ; Rice 1987c:72). The differences in the distributions of clay inclusions and ash may reflect a choice made by potters between equally suitable tempers.

An equally convincing case can be made that the amount of ash found in Muna Slate wares (see below) reflects a decision based on the potter's perception of the qualities of the raw clay that contained natural clay lump inclusions. In this scenario, the decision for the potter would not have been the ratio of grog to ash required to make the clay ready for potting, but the amount of ash that the clay body requires to become suitable for pottery production. A related possibility is that the clay inclusions are tangentially related to potters' behaviors. Clay masses typically undergo some form of preparation before they are ready for potting. Crushing and grinding of dry clays facilitates the removal of unwanted inclusions by sieving or through removal by hand. Levigation may also be utilized to remove undesired inclusions. After these preparatory steps, clay masses are kneaded either to thoroughly distribute water throughout the clay mass, to evenly distribute tempers, or both. All of these actions may lead to the formation of small clay lumps that would be introduced into the clay mass without the knowledge of the potter. As in the case above, the potter would simply work clays and tempers together until the desired consistency was reached.

Although each of these scenarios present possible explanations for the presence of clay lumps in the Muna Slate wares examined here, the reasons for their presence cannot be determined. However, the differences in their distributions in the samples of ceramics examined in this research serves as a discriminating characteristic of these slatewares. Significant differences ceramics from Kiuic and Labná are compared.

Volcanic Glass (Ash)

Volcanic glass was ubiquitous in the sherds sampled, and it represents the only aplastic constituent that may securely be considered 'temper'. In increasing abundance of volcanic glass, the sites are ordered Labná, Kiuic, Ek Balam (Table 6.19; Figures 6.36, 6.37). The same pattern holds for volcanic glass as a proportion of total aplastics. Labná has the lowest mean and narrowest dispersion for volcanic glass. Kiuic is intermediate, and Ek Balam shows the largest proportions and the greatest dispersion of those proportions. Most importantly, the differences in the proportions of volcanic glass for each site are significant in several instances (Table 6.20; Figures 6.38, 6.39). At a 95% confidence level, the differences between the sites are close to significant for ash as a proportion of total counts. However, the difference between Labná and Ek Balam surpasses this confidence level (and by quite a wide margin). Considering the contribution of volcanic glass to total aplastics, the differences are significant between all sites.

Table 6.19. Proportions of volcanic glass

Site ^a		min.	1 st quartile	mean	median	3 rd quartile	max.	st. dev.
Ek Balam	<i>P</i> total	0.00	0.0200	0.0435	0.0467	0.0600	0.11	0.0278
	<i>P</i> aplastics	0.00	0.1481	0.3145	0.3333	0.5000	0.67	0.2054
Kiuic	<i>P</i> total	0.00	0.0067	0.0276	0.0200	0.0467	0.08	0.0243
	<i>P</i> aplastics	0.00	0.0333	0.1637	0.1364	0.2400	0.52	0.1539
Labná	<i>P</i> total	0.00	0.0000	0.0147	0.0067	0.0200	0.06	0.0172
	<i>P</i> aplastics	0.00	0.0000	0.0830	0.0392	0.1364	0.44	0.1064

a. n=35 in all cases

Figure 6.36. Proportions of volcanic glass in total counts

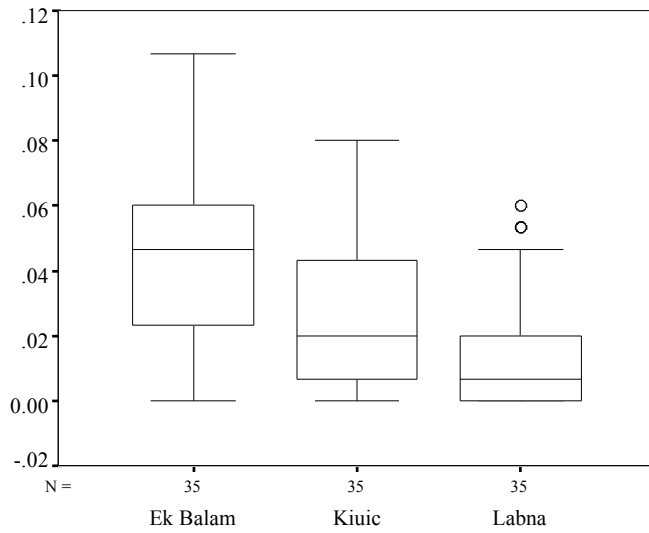


Figure 6.37. Proportions of volcanic glass in total aplastics

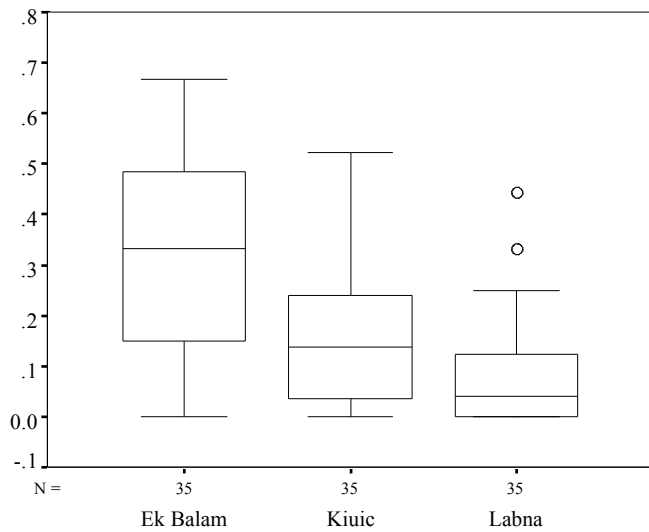


Table 6.20. Kolmogorov-Smirnov results for volcanic glass

		K-S Z-score ^a	Significance
Ek Balam - Kiuic	<i>P</i> total	1.315	0.063
	<i>P</i> aplastics	1.793	0.003
Ek Balam - Labná	<i>P</i> total	2.271	0.000
	<i>P</i> aplastics	2.510	0.000
Labná - Kiuic	<i>P</i> total	1.195	0.115
	<i>P</i> aplastics	1.434	0.033

a. For 95% confidence level $Z=1.36$; for 99.9%, $Z=1.95$

Figure 6.38. Cumulative frequency of proportions of volcanic glass in total counts

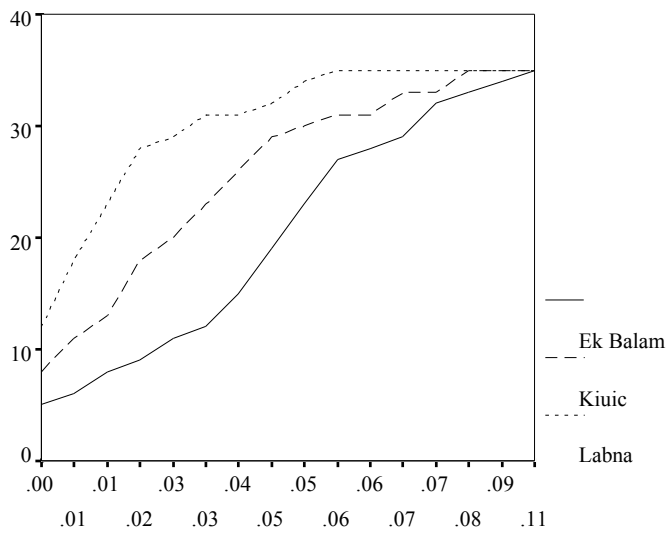
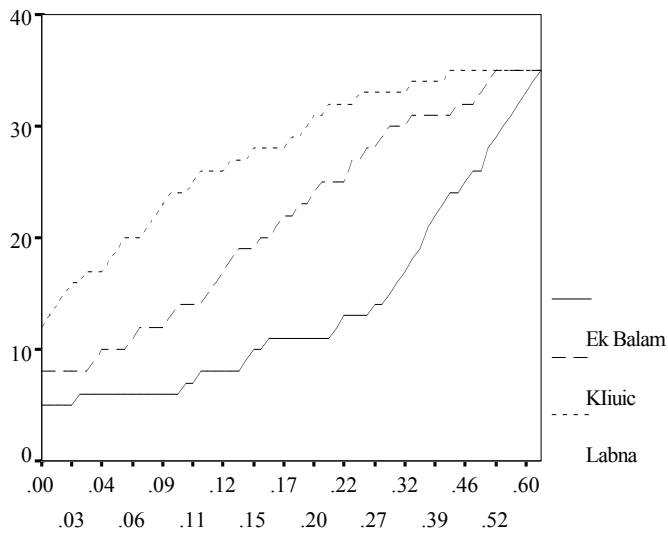


Figure 6.39. Cumulative frequency of proportions of volcanic glass in total aplastics



By far, this is the single most important class of aplastics considered in this study given their apparent origin outside of the Yucatan peninsula. Shepard noted the presence of volcanic glass in ceramics ranging from Central America through the greater Southwest (1980:378), and specifically as a constituent in Puuc Slate Wares (1958:452). Isphording's (1973) studies of the geology of Yucatan revealed that its clay deposits are definitely not of volcanic origin. On this basis, and from analyses of other clays in the Yucatan, Isphording and Wilson (1974) suggested that Shepard (and others) had mistakenly identified palygorskite, a lath-structure clay similar to attapulgite (mentioned above), as volcanic ash. Their study, however, was based on clay samples, and not on pottery; and their suggestion that volcanic ash not be used to describe ceramic inclusions is misguided (Jones 1986:40). Simmons and Brem (1979) surveyed sherds from the northern Yucatan, demonstrating the presence of ash in sherds from several sites. Importantly, they provide evidence that the Maya Mountains in Belize are not the origin of the ash utilized in northern Yucatan ceramics. Although they are limited by a small sample size (nine sherds), they synthesize their data with other evidence to suggest that the source of ash for both Dzibilchaltun (in the northwestern coastal plain) and Chichén Itzá was the same. This ash differed from ash used to temper ceramics from Cobá and Yaxuná (Simmons and Brem 1979:88). So, not only were different ash sources utilized, but also ash was imported from outside the peninsula.

The issue, then, is deducing the origin of the volcanic glass. Simmons and Brem (1979:89) link Proto-Classic and Early Classic period sources for ash with the sources of obsidian exchanged in the Lowlands, specifically the El Chayal source in the Guatemalan Highlands and the Ixtepeque source in El Salvador. However, they believe that the number of sources must increase during the Late and Terminal Classic period. Arnold (1985:59) points out that the nearest source of ash to the northern Lowlands is more than 700 km away, in highland Guatemala. He suggests that this distance is too far outside of the predictive range of his model, and proposes that undiscovered deposits of wind-blown ash exist in the northern Lowlands. Isphording counters, however, that deposits of windblown ash covering the Yucatan peninsula are unlikely. Given the modern prevailing wind patterns, only an eruption in the Antilles could have deposited ash in the northern parts of the peninsula. While there are deposits of volcanic materials in the Gulf of Mexico, Isphording argues that these do not reach the northern Yucatan peninsula. Although an argument for or against the presence of ash in the Yucatan peninsula based on the projection of modern wind patterns in to the past is somewhat tenuous, the lack of ash deposits in the northern Lowlands still remains. Jones (1986:41) supports a highland derivation for volcanic ash, but is unsure of the mechanisms of its transport. Ford and Glicken (1987) suggest on the basis of their petrographic analysis of southern and central Lowland ceramics, that ash tempering begins predominantly in the Late Classic period. Based on their estimates, the central Lowlands would have consumed 800,000 kg of ash per year for vessels using 20% ash temper. Further, their results suggest that the geology of Central American volcanoes provide a close approximation of the range of accessory minerals the accessory minerals that occur in central Lowland ceramics.

This last point, and the data used to support it are important. Ash is composed of volcanic glass, sometimes accompanied by other minerals, and forms when magma is ejected from volcanoes (Klein and Hurlbut 1993:568). A basic distinction among ash types is between those that contain accessory minerals and those that do not (Shepard 1980:378-381). Crystal ash often contains the minerals hornblende, pyroxene, mica, and olivine, and Shepard (1980:379) notes that these crystal ashes are common among Central American deposits. These are the same

criteria used by Ford and Glicken (1987) to suggest a Central American origin of the ash in central Lowland ceramics. These accessory minerals did not occur in association with ash in the sherds examined here, suggesting the possibility of a different source of ash. Shepard (1980:379) describes volcanic glass that originated from crushed pumice:

If the bubbles [formed while the lava cooled] are fairly coarse and closely packed, plates will be formed from their sides and multiflanged pieces from their junctures. Thin sections of paste tempered with such a material show a very characteristic texture in which lunar, forked, and Y-shaped fragments of glass are prominent.

This statement characterizes the vitric ash in the sherds from Kiuic, Labná, and Ek Balam well. A similar pattern may also occur when pumice vesicles launched through the air during eruption events cool more rapidly than the gas contained within. The trapped hot gasses cause the pumice vesicles to shatter before reaching the ground. While the research presented here cannot pinpoint the location of ash sources, it does suggest a different source of ash used by potters in the northern Lowlands. Shepard noted similar differences between ash in the ceramics from Uaxactun compared with those from the Puuc (1964a:251; cited in Smith 1971:269):

Petrographic analysis of volcanic ash-tempered sherds from Uaxactun reveals several significant facts. First, many different varieties of ash were used. In this respect there is a great contrast between the volcanic ash temper of Uaxactun and that of Yucatan, which is remarkably uniform in character whether it comes from Puuc sites or Chichén Itzá.

The presence of volcanic glass in Muna Slate ware sherds (as well as others) from various sites in the Yucatan peninsula, when considered in light of its proposed exogenous origin, suggest that volcanic ash was an important trade item. Shepard's quote presents an interesting possibility for models of trade. If the ash from Chichén Itzá ceramics and the ash from Puuc ceramics are remarkably uniform, this may imply that potters across the northern Lowlands were utilizing the same trade networks to procure volcanic glass. Assuming that volcanic ash is not found in Yucatan, then the intermediate amounts of ash in Kiuic's sherds present several interesting possibilities concerning access to the trade networks that distributed ash in the northern Lowlands. On the one hand, it may suggest that potters at each site organized the importation of ash for slatewares, and that the amount of ash in the Muna Slate wares represents the potters' conscious efforts to import and utilize a desired tempering material. As noted above, clay inclusions vary inversely with the amount of volcanic glass found in the ceramics, and the possibility exists that these clay lumps were added as grog temper. Thus, it is possible that potters with better access to volcanic glass chose this tempering agent over grog. On the other hand, it is entirely possible that potters' access to ash was balanced against the working properties of the raw clays with which they worked. If the clay inclusions were incorporated in to the ceramic matrix unintentionally, then the amount of volcanic glass may represent the potters' addition of an exotic tempering material that may have been expensive to procure in as sparing a manner as possible. The answer to this question remains enigmatic.

Though the different amounts of volcanic ash are possibly explained by different factors, the fact remains that this class of inclusion distinguishes the ceramics from each of the sites examined here. This supports the interpretation that Muna Slate wares were produced in multiple locations with imported ash. Additionally, volcanic ash was not encountered in the point counts

for 5-12% of the sherds from each of the sites. This finding offers additional support for the conclusion that Muna Slate wares were manufactured at several locations. It appears that some slatewares contain ash and some do not (see also Varela T. and LeClaire 1999), again suggesting the presence of multiple production locations with differential access to imported ash.

Summary

The thin section point count reveals significant differences in the various inclusions within the ceramic body. The proportions of matrix, total aplastics, and voids are somewhat related, and suggest some level of similarity exists among these ceramics. This is not surprising given that the ceramics are all Muna Slate wares, and are products of a similar technological tradition. This ceramic technology, though showing important regional trends, demonstrates a fairly high degree of similarity over a wide area. Although there is overlap between the distributions of all of the constituents of the ceramic fabric examined in this research, the differences point towards multiple production location for Muna Slate wares. The differences observed in these groups may relate to variations within the specific clay resources that Maya potters at each of their respective sites utilized in the production of Muna Slate wares. Potters supplying Kiuic, Ek Balam, and Labná with Muna Slate wares all shared a technological tradition that provided them with ideas of what these ceramics should look like and how to produce these types of pots. Yet, the data presented here suggest that each production unit probably utilized natural resources that were particular to the regions near to their sites. Consequently, each community of potters reconciled the production technology with the specific constraints presented by the raw materials available to them. At times, the differences may be indicative of broad regional patterning in the geology of the region. Matrix counts indicated more similarity between Kiuic and Labná than between these sites and Ek Balam, possibly signaling an important difference in the raw clays used to make these pots. The different distributions of ash in these slatewares may additionally suggest that economic factors related to access to trade routes may have also impacted pottery production in the northern Lowlands.

CHAPTER 7: MUNA SLATE WARES AND THE LATE AND TERMINAL CLASSIC MAYA

The research presented here stemmed from studies of Puuc Slate Ware production at Sayil (Smyth and Dore 1994; Smyth et al. 1995). In those studies, the researchers argued for the existence of ceramic production loci adjacent to one of Sayil's major architectural groups, the Mirador Complex. Some of the architecture associated with the El Mirador group was previously interpreted as a market. The researchers based their argument for a ceramic production area on the presence of an extensive area to the west of the Mirador Complex which produced burned earth and large amounts of burned and deformed ceramics interpreted wasters. In the area next to the Mirador Complex, "ceramics manufacturing appears to have been a large-scale activity organized within a barrio that was strategically positioned to serve consumers at Sayil and throughout the Puuc Hills region" (Smyth and Dore 1994:50-51). Several of the vessel fragments recovered were from jars and bowls. The researchers point out that jars and bowls may be stacked easily for transport over long distances. The existence of a production location specializing in the production of vessels that are easily stacked for long-distance transport lead the researchers to suggest that these data imply "economic organization geared, in part, for export," and "that Puuc Slate jars were not only in demand locally but were significant trade items themselves and perhaps even served as containers for special commodities traveling long distances" (Smyth et al. 1995:132).

Although these studies established a baseline of compositional data through NAA the sampling strategy used to select samples for testing did not include ceramics from outside of Sayil. Thus, the presence and extent of any Puuc Slate Ware distribution network based at Sayil remained untested. Further, the suggestion that a single site was a major producer of a major class of utilitarian ware stood in contrast to previous research on Maya ceramic production that suggested that Maya centers are net consumers of ceramics rather than net producers. Further, the argument that Sayil contained a production location geared towards export to the Puuc region or further has implications for our understanding of Maya craft production, and the way that craft production is used in constructing models of Maya polity.

The research presented here aimed to provide some test of the presence and extent of an exclusive distributional network for Puuc Slate Wares based at Sayil. To test these, Muna Slate wares from three sites, Kiuic, Labná, and Ek Balam, were selected for petrographic thin section analysis. Research on the geology of the northern Yucatan peninsula demonstrates a fair degree of regional homogeneity, and an analytical technique was sought to explore variation within a single sample, among samples from a particular site, and among samples from different sites. Point counting of petrographic thin sections was chosen to pursue the questions posed above because it provides a sensitive technique for exploring variation in the individual constituents in a ceramic body. At the same time, this technique provided data that lend themselves to statistical description and testing.

Conclusion

The issue of Muna Slate ware production and distribution was addressed through a framework of ceramic ecology. Because this framework highlights both the natural and social contexts of pottery production, distribution, and consumption, it provides an ideal framework within which to address the place of ceramic wares and ceramic producers in society. In the second, third, and fourth chapters, ethnological, ethnographic, and economic studies and models

of ceramic production and specialization, models of the economics of culture-historical contexts, and empirical data from studies of archaeological ceramic manufacture and distribution were presented as a basis for the preliminary evaluation of the hypothesis that Muna Slate wares were centrally produced and distributed from Sayil. It was argued that this hypothesis was at odds with theoretical expectations and comparative data in all of these areas that suggest that utilitarian ceramic manufacture should be a local industry. This suggestion is supported in terms of economic rationality of supply and demand, of our conceptualization of the political economy of subsistence goods (i.e. independent production and staple finance economies), in terms of the arguably fluid political dynamics of the Late and Terminal Classic period, and by the empirical data gathered in studies of Lowland Maya ceramics.

The hypothesis of centralized production and distribution of Muna Slate wares was tested through point-counting petrographic thin sections. In this research, it was hypothesized that ceramics that were produced in separate production locations should be more heterogeneous than ceramics produced in a single location. In essence, it was thought that the range of variation exhibited by the samples of ceramics from a single site should exhibit a significant statistical difference from ceramics from other sites. The results of the research presented here indicate that the three samples of ceramics differ from one another in statistically significant ways within several of the categories of inclusions. From this, it is possible to say that neither Sayil, nor any other site, was the sole supplier of Muna Slate wares to Kiuic, Labná, and Ek Balam. This does not rule out the possibility that Muna Slate wares produced in and around Sayil, Kiuic, or Labná. The degree of overlap exhibited in the distributions of the individual constituent of the ceramics examined in this study makes it impossible to rule out the occasional exchange of vessels between sites. Yet, the patterning in these data support the work of Bey et al. (1992) who define at least two subspheres – an eastern and a western – in the broader Cehpech tradition. Further, it can be said with certainty that the results of the research presented here indicate that inferences about the scale and intensity of ceramic production at Sayil should be re-examined.

Suggestions for Future Research

The suggestion that Muna Slate wares were centrally produced and distributed gets at the heart of ongoing debates about the nature of Maya polity. Recently this debate has been characterized as one between ‘centralists’ and ‘decentralists’ (see Fox et al. 1996). It is hoped that the research presented here represents the kind of efforts that will ultimately draw out the range of variation present in Maya polity. While narrowly, this research has been about compositional variation in Muna Slate wares from three sites, it holds implications for understanding social and political dynamics for the Late and Terminal Classic periods.

The centralist/decentralist debate is primarily concerned with modeling political economy, or the “analysis of social relations based on unequal access to wealth and power” (Roseberry 1989:44). The argument presented for Sayil (Smyth and Dore 1994; Smyth et al. 1995) would suggest that elites at that site gained some of their power from the control of a subsistence (i.e. utilitarian) good, and would have thus acted as managers and beneficiaries of a staple finance economy (Brumfiel and Earle 1987). One very important aspect of staple finance economies is that they directly impact households. Because households are the basic productive and consumptive units in society (Wilk and Ashmore 1988; Santley and Hirth 1993), staple finance economies would have had a great deal of impact on the potential for households to provision their basic needs. On the one hand, centralizing the production of a high-demand

commodity creates job security for producers and ensures that benefits will accrue to those who control distribution. This situation would support the development or proliferation of specialized production in other goods and services, but at the expense of household autonomy in production. In this respect, staple finance economies may serve to weaken overall household economic stability, especially if the good in question could be (and Muna Slate wares were) produced in multiple locations. This provides little incentive for dependent households to participate in such economic relationships.

This argument was advanced over the course of Chapters 2 and 3, but here, special emphasis is placed on households for two reasons. The concept of household has shifted from social group to activity group over the course of its application in archaeology (Alexander 1999), but the fact remains that households are composed of people. These people were men and women, grandparents, and children. They were producers and consumers, and, through the course of these activities, they made and re-made society. While the archaeological record is usually limited in the quality and quantity of information that it provides on individuals, these individuals should not be forgotten. This is especially relevant to archaeological studies of production, for crafts and labor are often gendered. If men were primarily agricultural producers, were women the producers of ceramics? More broadly, what then of lithic production? Or textiles? Though the answers to these questions are obscured by time, they should not be forgotten.

Finally, the household, as an analytical unit, is poised to become a renewed focus of interest due to recent work by Hirth (1998) who addresses issues of household consumption through a “distributional approach.” As Masson (2002:5) states, “[d]istribution studies of local, regional, and distant resources in household consumption contexts represent a valuable tool for evaluating material dependencies that reflect market exchange.” This is also true at a general level of consumption, regardless of the specific form of distribution used to move goods from producers to consumers. While exotic goods such as obsidian and imported ceramics, have received the majority of archaeological attention, a shift towards the inclusion of the more mundane items in household consumption is a logical and important consideration in analyses. Both in core areas and in their peripheries understanding patterns in consumption at the household level will provide a rich source of data on which to model ancient political economies. For ongoing work in the Puuc Region (as well as other regions), household consumption presents an avenue of exploration that will aid in increasing our views of ways in which households articulated with one another at the local and regional levels. These connections and interactions are what constitute society. As Ball (1993:254) suggests, ceramic consumption is best approximated at the complex and sphere levels of the type-variety system. The work presented in this research provides some initial indications that compositional patterning may be used to distinguish between ceramic assemblages from a given site for a given type of ceramic. The next step should be to broaden the scope of research in terms of the number of ceramic types considered as well as the number and type of household consumption contexts. Although broad patterns in the variation within the Cehpech sphere of ceramics have been identified, there are undoubtedly more dimensions of variability that ultimately reflect on the ways that households integrated with one another to form communities and polities during the prehistory of the ancient Maya.

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2002 *The Fall of the Ancient Maya: Solving the Mystery of the Maya Collapse*. London, Thames and Hudson.

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CURRICULUM VITA

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Education

B.S. Sociology-Anthropology, Anthropology concentration. Millsaps College, Jackson MS.
1997. Degree awarded *cum laude* with departmental Honors in Anthropology.

Honors Thesis: *A Modal Analysis of Muna Slatewares from Ek Balam*

Field Experience

2000-present

- Ceramic Analyst and Lab Manager, Proyecto Arqueológico “Labná-Kiuic”, Yucatán, México

1997

- Ceramic Analyst, Proyecto Arqueológico Ek Balam, Yucatán, México
- Field Assistant, testing of a 19th Century kitchen, Brandon, MS

1996

- Student Participant, Southern Utah University Field School, Hurricane, UT

Teaching Experience

2002

- Teaching Assistant, University of Kentucky, Introduction to Physical Anthropology (ANT 230), Dr. Augusto Oyuela-Caycedo
- Teaching Assistant, University of Kentucky, Ceramic Analysis (ANT 651), Dr. Christopher A. Pool
- Teaching Assistant, University of Kentucky, Advanced Archaeological Method and Theory (ANT 541), Dr. George Crothers

2001

- Teaching Assistant, University of Kentucky. Native North Americans (ANT 221), Dr. Richard Jefferies
- Teaching Assistant, University of Kentucky. Cultural Diversity in the Modern World (ANT 160), Dr. Monica Udvardy

- 2000
- Teaching Assistant, University of Kentucky. Native North Americans (ANT 220), Dr. Richard Jefferies
- 1997
- Teaching Assistant, Millsaps College. Quantitative Social Research Methods (SocAnth 2110), Dr. Carolee Larsen
- 1996
- Teaching Assistant, Millsaps College. Qualitative Social Research Methods (SocAnth 2100), Dr. Carolee Larsen

Technical Publications

- 2002
Resumen de la Cerámica 2001: Aspectos de investigación y cerámica. In *Investigaciones Arqueológicas en las Ruinas de Kiuic y la Zona Labná-Kiuic, Distrito de Bolonchen, Yucatan, Mexico*, Temporada de campo 2001 Informe técnico al Consejo de Arqueología del Instituto Nacional de Antropología e Historia, Mayo, 2002
- 2001
C. M. Gunn and George J. Bey, III. Analisis Preliminar de la Ceramica de Kiuic. In *Investigaciones Arqueológicas en las Ruinas de Kiuic y la Zona Labná-Kiuic, Distrito de Bolonchen, Yucatan, Mexico*, temporada 2000. Submitted to INAH-CRY, May 2001.

Presentations at Professional Meetings

- 2002
Petrographic and Chemical Perspectives on the Production and Distribution of Muna Slate Ware: Preliminary Findings. Presented at 51st meeting of the Southeastern Section of the Geological Society of America, Lexington, Kentucky.
- 1996
The Internet and Anomie. Alabama Mississippi Sociological Association

Public Presentations

- 2002
Pots and People: Anthropological Experiences in the Ceramics Lab of the Labná-Kiuic Regional Archaeological Project. Millsaps Anthropology Club, Millsaps College, Jackson Mississippi
- 1998
Crocodiles, Birds, and Bats: The Haffenreffer Museum of Anthropology Collection of Costa Rican Ceramics. Haffenreffer Museum of Anthropology, Brown University.

Work Presented at Professional Meetings

- 1997
Ek Balam Muna Slate Ware Project: A Preliminary Report. Presented at the 96th Annual Meeting of the American Anthropological Association. George J Bey, III, Tim Ward,

Stan Galicki, Christopher M. Gunn, Reid Bruce, and An Nyguen.

Fellowships and Grants

2001

Graduate Student Support Grant, University of Kentucky, \$300

1999-2000

Kentucky Opportunity Fellowship, University of Kentucky, \$12,000

Organizational Participation

2000-2001

Treasurer, Anthropology Graduate Student Association, University of Kentucky.

Professional Organization Membership

Society for American Archaeology

Honor Society Membership

Phi Eta Sigma (undergraduate Sociology Honorary)

Public Outreach

2001, 2002

Science Fair Judge, Lexington Traditional Magnet School.

Work Experience

1997-1999

Database Coordinator, Haffenreffer Museum of Anthropology, Brown University