The Dissertation Committee for Elizabeth Katherine Reid Certifies that this is the approved version of the following dissertation:

Ceramic Thin-Section Analysis and Early Postclassic to Middle Postclassic Discontinuity at Colha, Belize

Committee:

Fred Valdez, Jr., Supervisor

Darrell Creel

Martha Menchaca

Ann Scott

Lauren Sullivan

Ceramic Thin-Section Analysis and Early Postclassic to Middle Postclassic Discontinuity at Colha, Belize

by

Elizabeth Katherine Reid, B.S.; M.A.

Dissertation

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Doctor of Philosophy

The University of Texas at Austin

August 2012

Acknowledgements

I would first like to thank my advisor, Fred Valdez, Jr., for accepting me into the graduate program as his student. He has made so many opportunities possible, including field experience in Belize and funding from the University of Texas. He has shared his knowledge of Maya ceramics and provided guidance towards completing my degree.

Thank you to my wonderful committee members, Darrell Creel, Martha Menchaca, Lauren Sullivan, and Ann Scott, for their support, cooperation, encouragement, and suggestions. I truly appreciate all of their help. I would also like to thank Ann Scott for being such a good listener during the middle years of my doctoral experience.

Without Thomas Hester and Harry Shafer, co-directors of the Colha Project, my research would not have been possible. The many publications from the Colha Project form the foundation of my research. Sam Wilson was a great help during the admissions process, dissertation proposal, and early years at UT. Kay Sunahara, Greg Thompson, and Peter Eichhubl helped with petrography, thin-section preparation, and microscope use. Thank you so much to the Department of Archaeology, Belmopan, Belize for making these ceramics available for this dissertation.

For use of equipment, lab, and office space, I would like to thank Fred Valdez, Jr., of the Mesoamerican Archeological Research Laboratory, Darrell Creel of the Texas Archeological Research Laboratory, and Eric Potter of the Bureau of Economic Geology. The University of Texas Graduate School and the Dean of Liberal Arts provided a Recruitment Fellowship, and the University of Texas Institutional Support from the Dean of Liberal Arts also provided funds for equipment for this dissertation.

The University Co-operative Society, especially George Mitchell, has been a tremendous help throughout these years, with assistance ranging from employment to tuition reimbursement, as well as indirect assistance through their support of the Mesoamerican Graduate Student Association at the 2009 Maya Meetings. I would like to thank the accounting staff, especially James Kielty, Alison White, Linda Williams, for providing such a calm and postive work experience during my time in Austin.

Rolee Rios of the UT Anthropology Department, Diane Ruetz of the Texas Archeological Research Laboratory, and Bob Penman of the Office of Graduate Studies helped me get over various logistical and bureaucratic hurdles. I would like to thank the Anthropology Graduate Advisor, Chris Kirk, for his encouragement and cooperation. William Sederholm and Celeste Neathery assisted me in getting through the beginning of the program. I would also like to thank Ken Brown of the University of Houston; Robert Humphrey, Nancy Benco, and Alison Brooks of The George Washington University; and Harry Murphy for the opportunities and positive influence in my earlier Anthropology studies.

Thank you to everyone who provided food, shelter, and/or transportation, especially the Programme for Belize Archaeological Project and Fred Valdez, Jr..; my parents, Don and Joanna Reid; Robert Hrehor, Jr.; John Paladino and Rachel Zierzow; Sharon Hankins; and Elaine and David Schele. I am very fortunate to have such supportive people in my life.

In addition, I would like to thank my close friends, Alison Thorn, Ellen Mustachio, Stephen Steward, and Stephanie Boustany for their support. In addition to Sharon Hankins, Elaine Schele, and Ann Scott, I would like to thank my UT friends and classmates, Marisol Cortes-Rincon, Sandra Dias, Rissa Trachman, Virginia Walker, Anabella Coronado Ruiz, David Hyde, Skye Walker, and Grant Aylesworth, as well as my Belize field supervisors, Jon Lohse and Jon Hageman. Beth Goldberg of Integrity Center, my "life coach" during the last year of school, was a huge help towards finishing my degree.

Robert Hrehor, Jr., has been extremely helpful, through emotional support, financial assistance, and practical advice; I appreciate the support of all the Hrehor family. Many thanks to Donald Reid, Jr., Christopher Reid, Marianne and Terry Gildea, Andrew Manning, Grace Reid, and Donald Reid, Sr. for being great role models of academic achievement. All of these family members, as well as Joanna, Shannon, and Martha Reid have made my personal life as pleasant as possible during this time, and I am very fortunate to have such an amazing family. There are many other reasons to thank my fabulous parents, Donald and Joanna Reid, including various forms of financial support, their encouragement, patience, and confidence in my abilities.

Ceramic Thin-Section Analysis and Early Postclassic to Middle Postclassic Discontinuity at Colha, Belize

Elizabeth Katherine Reid, Ph.D.

The University of Texas at Austin, 2012

Supervisor: Fred Valdez, Jr.

Petrographic and Type:variety analyses of Colha ceramics are used to investigate changes in ceramic production technology and organization during the Early and Middle Postclassic. Postclassic sherds from Colha are grouped by petrofabric, surface treatment, and modes. This dissertation focuses on the petrofabric analysis of the ceramic sherds. The groupings are then compared to locally available raw materials. Changes in technological homogeneity, production specialization, and origin will be examined and related to the general economy of Postclassic Colha.

Table of Contents

List of Table xi

List of Figures xii

Chapter 1 Introduction 1

History of Investigations at Colha 2

The Site of Colha 3

Colha's Culture History 8

Postclassic Ceramics 11

Lithic Consumer Sites 16

Ceramic Exchange 18

Chapter 2 Sampling Methods 21

Chapter 3 Petrography Analysis 27

Petrography vs. Chemical Background 27

Making Thin-Sections 29

Qualitative Methods 29

Quantitative Methods 33

Chapter 4 Results: Qualitative and Quantitative Data 37

Identified Minerals 37

Assigned Groups 38

Clear Calcite Group 41

Chalky Calcite Group 44

Chalky/Quartz Group 47

Quartz Group 49
Matrix Group 52
Miscellaneous 54
Trends in Temper Classes..56
Summary..63
Chapter 5 Changes Through Time...64
Preclassic and Early Classic 64
Late Classic..65
Postclassic..66
Chapter 6 Specialization 69
Standardization 69
Fabric Groups vs. Context 79
Chapter 7 Soil and Minerals 82
Local Soils 82
Quartz in Local Soils 84
Carbonates in Local Soils 86
Comparison of Local Soils to Colha Postclassic Ceramics 86
Mineral Qualities 88
Calcite Grit vs. Volcanic Ash as Temper...88
Quartz Temper and High Matrix Paste 89
Limestone and Micrite as Temper 91
The Early-to-Middle Postclassic Change 92
Chapter 8 Models: Colha Ceramics within the Postclassic Maya Economy........95

Colha, Northern Belize, and Yucatan Connections 95

Trade, Warfare, and Chichen Itza 96

The Current Study..109

Chapter 9 Summary and Conclusions..111

Summary of Dissertation 111

Conclusions..114

References Cited 117

List of Tables

Table 1: Temper Groups by Suboperations 56

Table 2: Chalky Calcite Group Data...73

Table 3: Matrix and Clear Calcite Group Data 75

Table 4: Quartz Group and Miscellaneous Group Data.................................76

Table 5: Chalky/Quartz Group Data 77

Table 6: Data for Plate Forms 79

Table 7: Subsuites in Altun Ha Suite 84

List of Figures

Figure 1: Excavators from the 1989 Season..3

Figure 2: Archaeological Sites in Northern Belize...4

Figure 3: Site Plan of Colha 5

Figure 4: Colha and the Belize Chert-bearing zone 7

Figure 5: Lithic Assemblages of Colha 11

Figure 6: a, Payil Red; b-g, Zakpah Red; h, Centon Incised 14

Figure 7: Zakpah Red Rims..15

Figure 8: a-c, Zakpah Red; d, Payil Red 15

Figure 9: Culture Subareas 20

Figure 10: Operation 2001...22

Figure 11: Detail of the Monumental Center 23

Figure 12: Operation 2001 and Suboperations...24

Figure 13: Microscope...30

Figure 14: Auxiliary Illuminator 31

Figure 15: Effect of the Gypsum Plate...31

Figure 16: Clear Calcite and Chalky Calcite..40

Figure 17: Carbonate and Quartz 41

Figure 18: Components of the Clear Calcite Group..42

Figure 19: Clear Calcite Photo 43

Figure 20: Clear Calcite at 10x Magnification..43

Figure 21: Components of the Chalky Calcite Group.......................................45

Figure 22: Chalky Calcite Photo 45

Figure 23: Chalky Calcite at 10x, Poorly Sorted 46
Figure 24: Chalky Calcite at 10x, Well Sorted 46
Figure 25: Components of the Chalky/Quartz Group 48
Figure 26: Chalky/Quartz Photo 48
Figure 27: Chalky/Quartz at 10x 49
Figure 28: Components of the Quartz Group 50
Figure 29: Quartz Petrofabric Photo 51
Figure 30: Quartz Tempered Sherd at 10x 51
Figure 31: Components of the Matrix Group 52
Figure 32: Matrix Petrofabric Photo 53
Figure 33: Matrix Temper Class at 10x 54
Figure 34: Miscellaneous Petrofabric 55
Figure 35: Miscellaneous Tempered Sherd at 10x 56
Figure 36: Mineral Inclusions by Petrofabric Group 58
Figure 37: Mineral Inclusions by Time Period 59
Figure 38: Mineral Inclusions by Suboperation 60
Figure 39: Mineral Inclusions by Ceramic Type 61
Figure 40: Fabric by Time and Type 72
Figure 41: Tough vs. Strong 89
Figure 42: Zones 93
Figure 43: Lamanai Stela 9 97
Figure 44: Lineage Glyph of the Site of Lamanai 98
Figure 45: Reconstruction of Putun Sea-faring Canoe 99
Figure 46: Prehistoric Trade Routes of the Putun 100

Figure 47: Maya Sites......102
Figure 48: Toltec Architecture at Chichen Itza......103
Figure 49: Puuc Architecture at Chichen Itza......103
Figure 50: Mesoamerican Highlands......106

Chapter 1: Introduction

The purpose of this study is primarily to identify changes and/or similarities in ceramic paste from the Early Postclassic (AD 1000–1150) to the Middle Postclassic (AD 1150–1350) at the site of Colha in northern Belize. More specifically, the primary objectives are 1) to identify temper groups of Postclassic ceramics at Colha; 2) to compare these temper groups with Type:variety classes; and 3) to identify how these relationships between temper groups and Type:variety classes continue or change over time.

Secondary objectives for this study include the following: 1) to identify any changes in production technology through time, especially increasing standardization (homogeneity and simplification); 2) to identify any changes in production organization through time, especially the possibility of increasing centralization through time; 3) to assess the possibility that the pottery was made locally or imported, including suggestions regarding resource and production location; and 4) to compare findings to Sabloff and Rathje's model of increasing commercialization and the rise of the merchant class in the Postclassic (Rathje 1975; Sabloff and Rathje 1975). More generally, this study expands the temporal extent of ceramic petrographic research at Colha and contributes to the petrographic analysis of Maya and Mesoamerican ceramics.

This introductory chapter is organized in the following manner. First, "History of Investigations at Colha" provides a timeline of excavations at the site. Second, "The Site of Colha" is a description of the site, including its location; the layout of the site; and the environment, including water, topography, and natural chert resources making Colha a desirable location for settlement. Third, "Colha Culture History" is a description of the site's culture history, including changes in settlement, lithics, and ceramics. Fourth, "Colha's External Connections" discusses Colha's export of lithics and exchange of ceramics, based on evidence from other sites.

HISTORY OF INVESTIGATIONS AT COLHA

The site of Colha was first reported in 1973 as part of the British Museum-Cambridge University Corozal Project, which was led by Norman Hammond (Hammond 1973). Additional survey and testing during the 1975 season revealed extensive deposits of chert debitage and a long history of occupation (Hammond 1973; Wilk 1976).

After the findings at Colha were discussed at the 1976 Maya Lithic Conference, the Colha Project was founded for the purpose of long-term intensive investigation of the site. Under the direction of lithic technology experts Thomas Hester and Harry Shafer, the Colha Project conducted investigations during the 1970's, 80's, and 90's (Buttles 2002), which are detailed elsewhere. The original Type:variety analysis of the ceramics was conducted by Fred Valdez (Valdez 1987). Excavations were resumed in 2009 to investigate the Archaic and Preclassic components of the site (Buttles 2009).

Figure 1: Excavators from the 1989 Season (photo from Paul Hughbanks).

THE SITE OF COLHA

The archaeological site of Colha is located in the Rancho Creek area of Orange Walk District in northern Belize. Northern Belize is bordered on the south by the Belize River, on the north and west by the Rio Hondo, and by the Caribbean Sea on the east (Rice 1974 in Masson 1989). Colha and the rest of northern Belize are considered part of the central Maya Lowlands. The site is about 12 miles inland from the Caribbean Sea (Buttles 2002) and 47 miles north of Belize City (Figure 2). Colha is located at the intersection of Old Northern Highway and Rancho Creek. The site itself extends for more than 4 km along the Northern Highway and is at least 8 sq km (Valdez 1987:1).

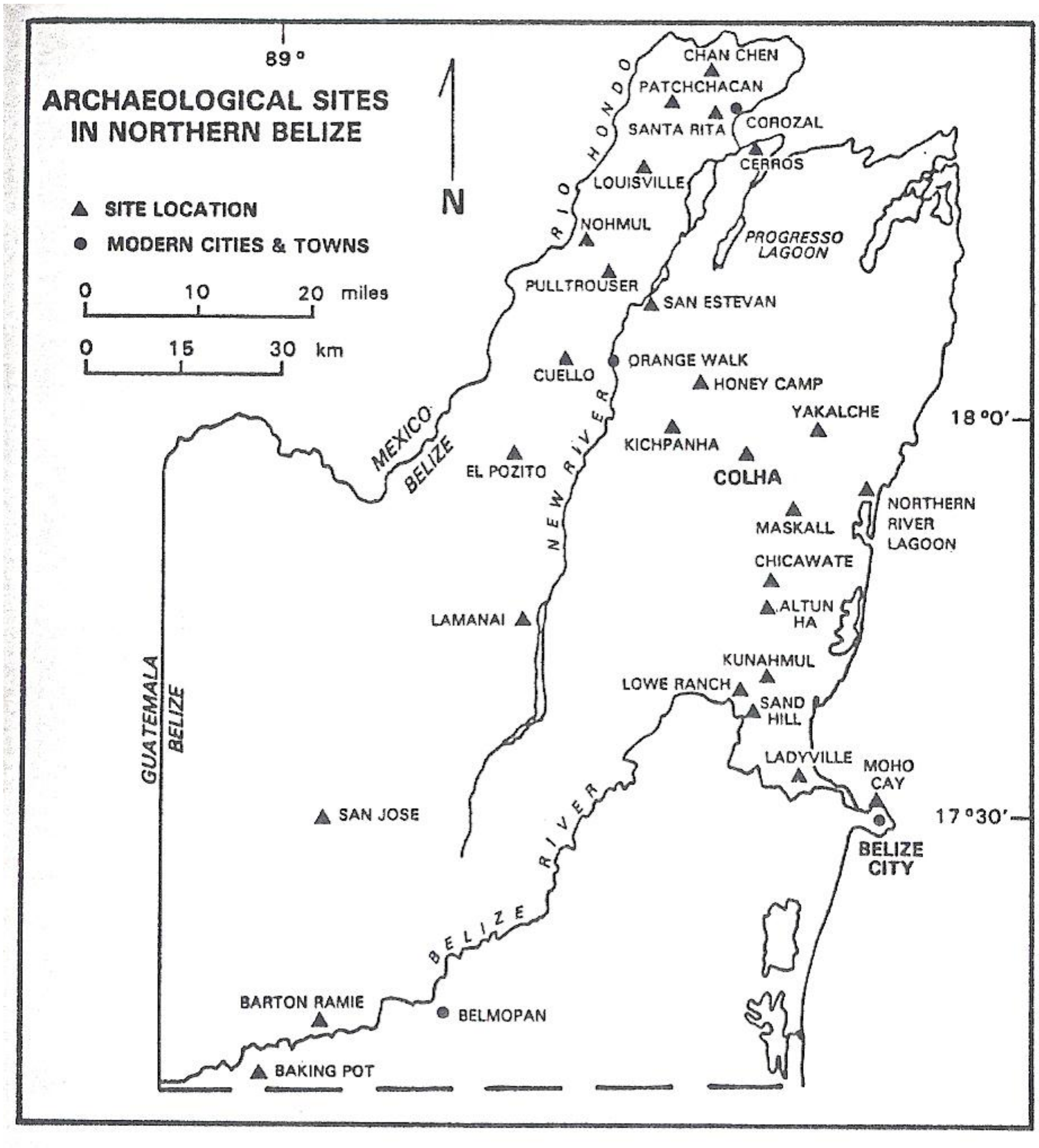

Figure 2: Archaeological Sites in Northern Belize (from Iceland and Goldbert 1999).

Today, the site is divided into quadrants by the crossing of the Rancho Creek flowing southwest to northeast and the Northern Highway running northwest to southeast (Figure 3). Most of the monumental construction is in the northern quadrant, and this is where the largest and most formal structural arrangements are, in Quadrant 2000. This is the area that was most densely populated. This trend includes the Postclassic, in which most of the habitation was in the northern quadrant of the site. To the west, east, and south are additional formal structures. The south quadrant is the area of greatest residential dispersion (Valdez 1987:5).

Figure 3: Site Plan of Colha (on file at MARL).

Rancho Creek, a perennial spring-fed creek, flows through the site into Cobweb Swamp, which borders Colha to the north and east (Valdez 1987:1). Cobweb Swamp drains to the southeast to Quashie Banner Creek, which connects to the Northern River, which empties into Northern River Lagoon on the east coast of Belize (Buttles 2002:63). In addition to the year-round source of fresh water supplied by Rancho Creek, Cobweb Swamp would have supplied aquatic fauna, as well as an avenue for transportation and trade.

The Colha area consists of undulating uplands, and the Colha ceremonial center is located on one of these higher areas. The undulating topography results in microenvironments and ecological diversity, such as fertile uplands, rivers, savannas, and forest. Colha's climate is characterized by wet and dry seasons, with most of the 1,500 mm of annual rainfall occurring between May and November (Masson 1989:10-13).

In addition to water and diverse microenvironments, Colha is also an attractive location for settlement, due to abundant high-quality chert. The site of Colha is located at the northern part of a chert-bearing zone (Figure 4). There are outcrops of chert throughout this zone, and chert from this area was especially desirable for making stone tools. Hester and Shafer state that the ancient Maya "utilized extensive outcrops of high quality chert – usually banded, and of various colors, including brown, gray, and tan" (Hester and Shafer 1989:2).

The northern Belize chert-bearing zone is at times referred to as CBZ. Colha is at the northern edge of the CBZ. Outside of this region, northern Belize lithic resources are of poor quality, including white and gray chalcedony, although there are some places like Kichpanha, 12 km north of Colha, where good quality chert has been identified (Hester and Shafer 1989:2). The site of Colha is well known for its extensive deposits of chert debitage (Hester and Hammond 1976), which indicate a high intensity of stone tool production, especially during the Late Preclassic and Late Classic periods. Along with its intensive lithic production, Colha is also known for its long occupational history extending from the Early Preceramic ca. 3400 BC (Iceland 1997) to the Middle Postclassic ca. AD 1350 (Valdez 1987).

Figure 4: Colha and the Belize Chert-bearing zone (from Masson 2989).

COLHA'S CULTURE HISTORY

The preceramic component at Colha, Cobweb Swamp, and other areas of the CBZ was identified through excavations, as well as lithic and pollen analysis. Radiocarbon dates from 3500 to 1900 BC are associated with "large-scale forest clearance, maize and manioc cultivation, the use of a distinctive Lowe-type dart point, and the production of large quantities of chert macroblades and smaller blades" (Hester et al. 1995). All these types of evidence are found at Colha-Cobweb Swamp, and in varying degrees at sites to the north of the CBZ near Pulltrouser Swamp.

A later Preceramic occupation dates from roughly 1500 BC to as late as 900 BC. This occupation is associated with large numbers of constricted unifaces, both within and just outside the CBZ. Production locations with all stages of manufacture of the constricted uniface have been found at Colha, as well as the Kelly site, at the southern end of the CBZ. There is evidence at these two sites of continued blade production, as well as the introduction of the small biface celt.

Pollen and soil evidence from Cobweb Swamp suggests that 1400-1000 BC may have been a time of large-scale deforestation and land modifications (Jones 1994). Microwear studies support the idea that the constricted unifaces were associated with widespread agricultural intensification (Hudler and Lohse 1994). The lithics of the preceramic time only generally overlap with the lithics of the Middle Preclassic. However, there is no clear chronological gap between the pre-ceramic occupation and the early Middle Preclassic occupation (Hester et al. 1995).

During the Middle Preclassic (1000-300 BC) Colha was a small village or hamlet, and there was significant chert utilization at the site, including formal tools for distribution beyond Colha (See "External Connections"). The Colha lithic sample exceeds that of any other Middle Preclassic Lowland site. The people of Colha made standardized tools, such as narrow oval biface celts, bifaces with wedge shaped bits, T-shaped adzes, and a burin on truncated blade technique for producing burin spall drills used in shell-bead making (Hester and Shafer 1989:2). Lithic production was likely a cottage level industry, with highly specialized forms, such as the T-shaped adze, exported to Middle Preclassic villages in northern Belize and possibly further (Hester and Shafer 1989:3)

Maximum expansion of the site of Colha occurred in the Late Preclassic (250 BC – AD 250) and Late Classic, with an estimated population of up to 5,000 people (Eaton 1980, 1982). These times of higher populations correlated with abundant chert workshops, settlement expansion, and attention to Colha's small ceremonial center (Hester and Shafer 1989:1-2).

Colha seems to have controlled lithic production during the Late Preclassic, as no other production sites are known for this time (Hester and Shafer 1989:2). During the Late Preclassic Colha dominated the production of stone tools, with over 35 large workshops, up to 450 sq m and up to 1.75 m thick, clustered in the central site core. Hundreds of thousands, or possibly millions, of tools were produced (Shafer and Hester 1983, 1986; Roemer 1984). Distinctive forms were produced in high volumes, including large oval bifaces, tranchet bit tools (adzes), and large stemmed macroblade points. These three forms, and to a lesser degree, eccentrics, were found at many other sites in various contexts. Colha workers made other forms too, but specialized in these, apparently for export (Hester and Shafer 1989:3).

During the Early Classic there is a hiatus in lithic workshop production. The Late Classic workshops are more numerous and are distributed across the site. Distinctive lithic products of this time period are general utility bifaces, smaller oval bifaces, continued tranchet technology, and eccentrics (especially smaller effigy-style eccentrics and multi-notched blades). During the Terminal Classic, workshops emphasized blade-making for the production of small-stemmed blade points (Hester and Shafer 1989:4)

In contrast to the Preclassic, during the Classic period, it is possible that Colha was under the control of the polity of Altun Ha, located about 21 km to the south. During the Late Classic there are several lithic workshops in the chert-bearing zone between Colha and Altun Ha. During the Late Classic lithic workshops also appear in the Peten and Rio Bec zones. Although Colha did not dominate production for the region during the Late Classic, there are some forms, such as the small stemmed blade points that were produced in large numbers at Colha during the Terminal Classic. In contrast, workshops to the south output only biface/celts (Hester and Shafer 1989:2).

Investigations have revealed that Colha was abandoned for about a 100-year period after the Classic period. Following this abandonment, the site was reoccupied in the Early Postclassic (AD 1000-1150). The Postclassic village was build over the earlier ceremonial center (Hester and Shafer 1989:4), but the new inhabitants were not likely related to the Classic period inhabitants. Evidence for a “new ethnic group” includes clear changes in settlement patterns, ceramics, lithics, and diet from the Terminal Classic to the Postclassic (Note that caution is needed when referring to ethnicity [Valdez, personal communication 2003]). During the Postclassic, Colha was once again used as a lithic production site (Shafer 1996:16).

Local chert continued to be used, as well as imported chalcedony, but lithic production was different than it had been in the Classic. For example, lithics were made at the household level, rather than at a lithic workshop separated from the residential area, and traditional products were replaced with new forms from outside the region, such as the Early Postclassic side-notched point, showing a strong influence from the northern Maya region. Variations from Early Postclassic to Middle Postclassic (AD 1150-1350) were less dramatic with an overall continuation of the same ceramic and lithic tradition, and products included lozenge-shaped points in the Middle Postclassic (Michaels 1994).

After the Middle Postclassic, Colha was again abandoned. It has been suggested that increasing warfare made the easily-manufactured arrow point the lithic of choice, so the specialized products of the Colha lithic industry were no longer in demand (Shafer 1996:16), a possible cause of abandonment. There is evidence, however, that the site was sometimes visited during the Late Postclassic, probably for ritual purposes.

POSTCLASSIC CERAMICS

This paper examines changes in type, as well as temper, from the Early Postclassic to the Middle Postclassic in order to draw inferences regarding technological homogeneity, production specialization, origin of the ceramics, and their relationship to the general economy of Postclassic Colha. The pottery of the Colha Postclassic was originally placed in the New Town Ceramics sphere. Within the New Town sphere, the pottery has been grouped into two complexes, Yalam and Canos (Valdez 1994:14-15).

The ceramics of the Early Postclassic are part of the Yalam Complex. These are significantly different from the ceramics of Late Classic Colha. They bear a strong resemblance to the ceramics of Lamanai, which reflect a Yucatecan influence. The assemblage is functionally complete, but there are significantly fewer forms than the assemblage of the Late Classic. In addition, the new ceramic forms (e.g., comales and grater bowls) indicate a change in food preparation, further supporting the idea that the Postclassic inhabitants of Colha were newcomers.

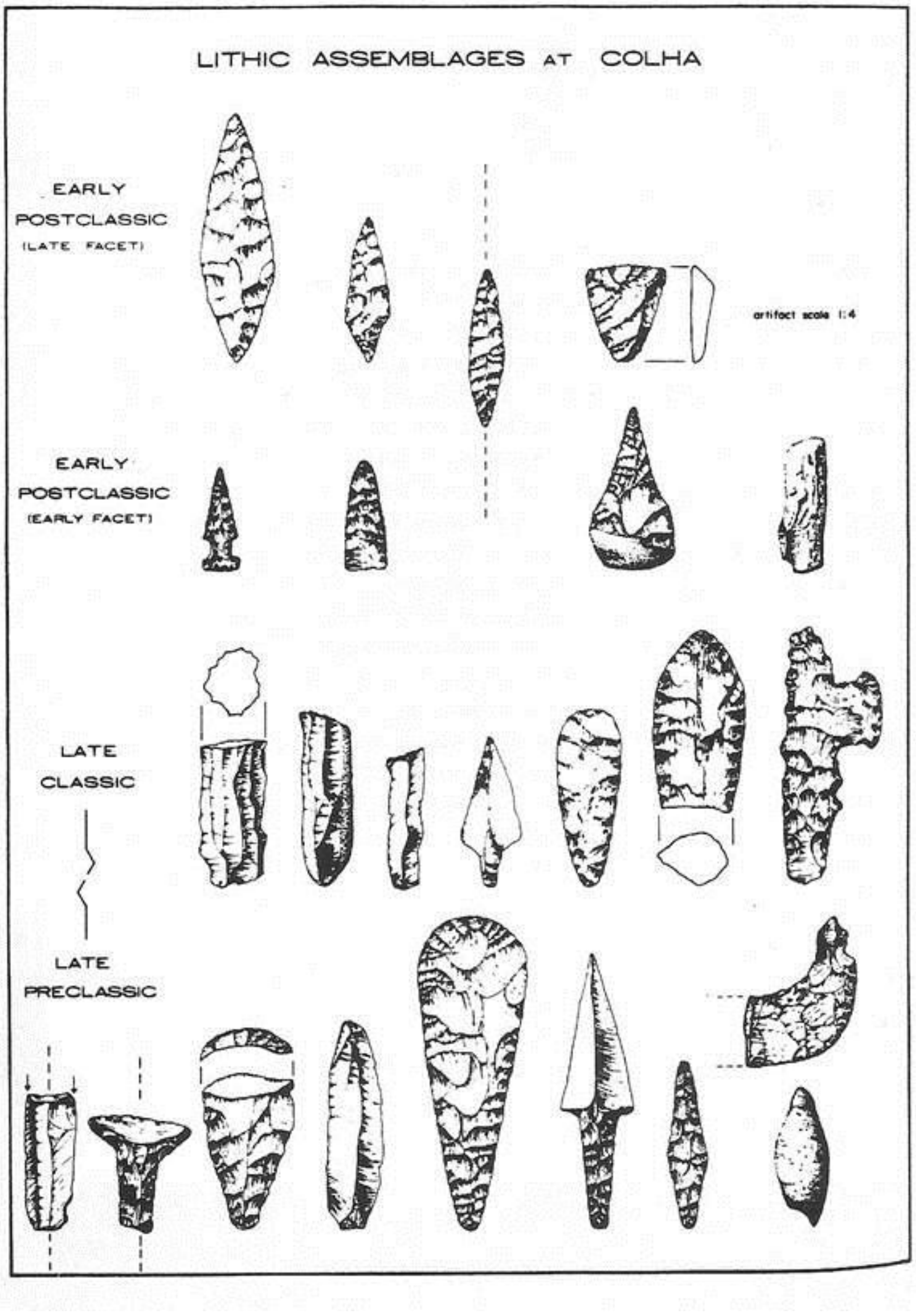

Figure 5: Lithic Assemblages of Colha (from Hester and Shafer 1984).

The Yalam Complex of Early Postclassic ceramics at Colha was initially assigned to the Augustine group, but was later re-assigned to the Zakpah group. The Augustine Red type was initially described at Barton Ramie (Gifford 1976). These ceramics have a hard, glossy reddish-orange slip. Forms include shallow, flat-bottomed bowl or dish forms, which have flaring sidewalls and hollow scroll or bulbous vessel supports (feet). This type also includes jars with short, outflaring necks (Valdez 1987:212-216).

The Zakpah ceramic group was initially described at Cerros. The Zakpah Orange-Red ceramics have a reddish orange slip on the interior and/or exterior. The forms include bowls, flanged dishes, and chalices. The pastes are a yellowish buff color on the surface and frequently have dark cores, some nearly completely black. Sand sized calcite particles give eroded paste surfaces a sandy texture (Walker 1990:81).

The Canos Complex of Middle Postclassic ceramics at Colha was initially assigned to the Paxcaman group, but later re-assigned to the Payil group. The Paxcaman Red ceramics were initially described at Barton Ramie (Gifford 1976). These ceramics have a uniform dark red (matte-like) slip, which is easily polished with minor rubbing. The forms are bowls or dishes with outflaring sides and jars with short to medium, outflaring necks. These have cylinder shaped vessel supports (Valdez 1987:224).

The Payil ceramic group was initially described at Tulum and Mayapan. The Payil Red ceramics have a medium red slip on the interior and exterior of the vessels. The forms include sag-bottomed bowls with flat-bottomed, hollow tripod feet containing three vents. The pastes are pink to gray on the surfaces, and pastes have a moderate amount of fine calcite inclusions (Walker 1990:86).

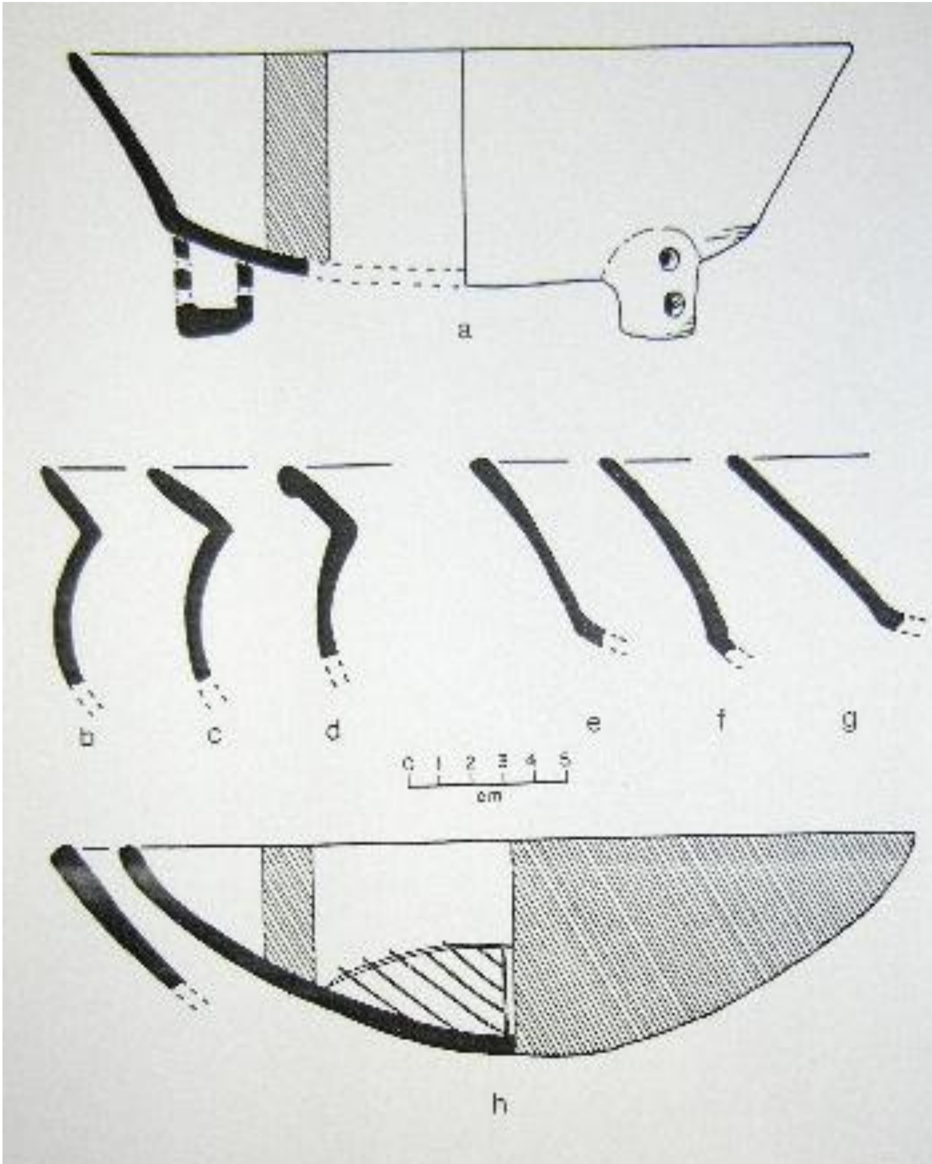

Figure 6: a, Payil Red; b-g, Zakpah Red; h, Centon Incised (Valdez 1987:213).

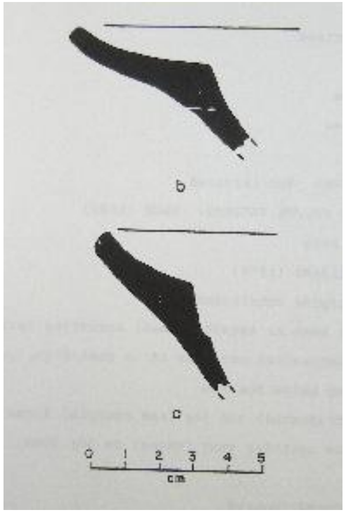

Figure 7: Zakpah Red Rims (Valdez 1987:215).

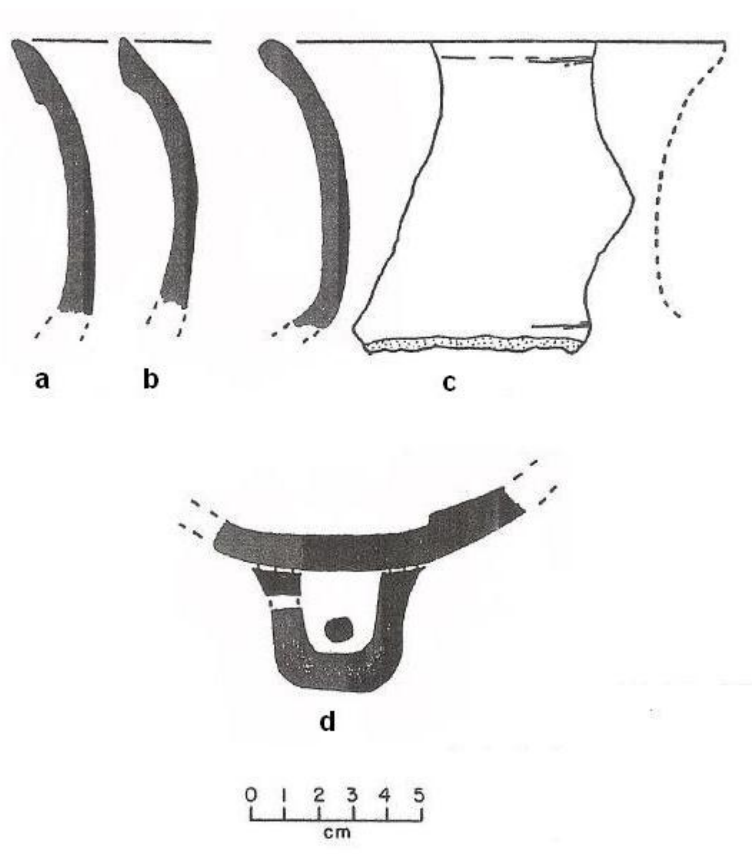

Figure 8: a-c, Zakpah Red; d, Payil Red (Valdez 1987:215).

There are four ceramic types at Colha that were found in both the Yalam Complex and the later Canos Complex. These types are currently identified as Maskal Unslipped, More Force Unslipped, Centon Incised, and Unnamed Unslipped Colander, although these types will be renamed in the future (Valdez, personal communication 2012). As the names imply, three of these types are unslipped. The Centon Incised (see Figure 6), however, is relevant to the present study. The Centon Incised ceramic group was initially described at Colha. The Centon Incised ceramics have an orange to red slip color, overlapping the color of Zakpah Red and Payil Red. The only form for this group is round, slightly incurving bowls with post-slip, post-fire incising on the interior bottom of the vessels in a geometric pattern. Dark cores are present in about 40 percent of the sherds, and pastes have five to 15 percent calcite inclusions (Valdez 1987).

The Canos is the last functionally complete ceramic complex at Colha. After the Middle Postclassic, the site was abandoned. During the Late Postclassic, some ceramics from the Ranas Complex were present, but these were only ritual objects, specifically Mayapan style unslipped effigy censers, of the Chen Mul Modeled type, mostly likely brought to the site during a ritual visitation (Valdez 1987:231). None of these were sampled for the current study.

LITHICS CONSUMER SITES

In addition to evidence of high lithic production at Colha, there is also archaeological evidence at other sites where Colha's lithic products were consumed. There are three basic trends in Colha lithic consumption. First, most of the lithics were distributed to other sites for utilitarian purposes. Second, eccentrics and many stemmed macroblades were distributed for ritual use and for elite tombs and caches. Third, the large-stemmed macroblade at times went to Maya centers further away (Hester and Shafer 1989:4).

The identification of Colha tools at other sites is based on Hester and Shafer's visual comparison of chert products with known characteristics of Belize CBZ material, such as distinctive banding and coloration, and Colha tool making technology (Hester and Shafer 1989:5). The Colha chert has honey colored stripes, which help identify tools at other sites that were made at Colha and distributed elsewhere (Shafer and Hester 1991).

Colha lithic consumer sites have been categorized as primary consumer sites and peripheral consumer sites. Primary consumer sites tend to be farming areas, communities, and centers in northern Belize and southern Quintana Roo. McAnany has suggested that these sites consumed utilitarian and at times non-utilitarian CBZ chert products. These products were likely traded through an interpolity exchange network. In this model, lithics were moved by small-scale interactions within a stable exchange network, with petty traders moving "a single line of goods over short distances" (McAnany 1986:269). This interpolity exchange network may have included "central marketplaces" at larger communities (McAnany 1986:269), such as Nohmul or San Estevan, with "barter as the circulation mechanism" (McAnany 1986:109).

In addition to Nohmul and San Estevan, notable primary consumer sites of northern Belize are Kichpanha, Kokeal at Pulltrouser Swamp, Cuello, Cerros, Santa Rita Corozal, Sarteneja, and El Pozito. In addition to Preclasssic CBZ products, Kichpanha and Santa Rita Corozal include Postclassic CBZ lithics among their collections (Hester and Shafer 1989:7-10). The central coast of Belize includes sites that could be considered either primary or peripheral consumer sites. One central Belize coastal site with heavy consumption of CBZ tools is Ambergris Cay, where lithics are "overwhelmingly of chert and Terminal Classic tool types from Colha" (Hester and Shafer 1989:11). At Moho Cay, likely a trading outlet (Healy et al. 1984) located at the mouth of the Belize River, both pristine materials, possibly intended for further exchange, and utilized CBZ products were found (Hester and Shafer 1989:11).

Peripheral sites include areas farther away, such as western, central, and southern Belize, as well as the Peten, where some commodities, especially the stemmed macroblades, were most likely exchanged through "professional traders – wealthy merchants … who were involved in moving merchandise over long distances" (McAnany 1986:269). Examples of peripheral sites in Belize are San Jose, Barton Ramie, Big Falls, and Ponce (Hester and Shafer 1989:12). More distance consumer sites in the Peten include El Mirador, Tikal, and possibly Macanche Island and Yaxha (Hester and Shafer 1989:13-14).

The evidence for Colha's high intensity of stone tool production and specialized chert tool workshops contrasts with the previously held belief that specialized craft production took place only in the larger centers, such as Tikal and Palenque (Shafer and Hester 1986:163). The extensive distribution of Colha lithic products supports the idea that Maya society was not just integrated vertically, but regionally as well (McAnany 1989:355-356; Gibson 1989:117).

Ceramic Exchange

Most of the Colha Postclassic ceramics are imitations of the Late Classic pottery from the northern Maya area, specifically from Quintana Roo (Figure 9) (Valdez 1994:14-15) and more generally from the Yucatan peninsula (Mock 1994:233). The Colha Postclassic pottery has the same form as the northern Maya Late Classic ceramics, but the Colha Postclassic pottery is red and orange, rather than buff and gray (Sharer 1994:698; Valdez, personal communication 2003). Similar imitations are found throughout northern Belize and the Peten. Comparison to vessels at the site of Lamanai in Belize shows pottery from the two sites to be "identical" (Valdez 1994:14; Pendergast 1981). Lamanai, however, differs from Colha and other northern Belize sites because there are no "abrupt discontinuities in ceramic tradition following the Classic collapse" (Mock 1994:233). Based on this ceramic continuity, as well as the high number of wares found in burial contexts, "Lamanai has been postulated as an interregional manufacturing center and probable source of Colha Postclassic ceramics" (Mock 1994:233; Valdez and Adams 1982:29).

The Colha Postclassic ceramics share significant typological ties with Tulum and Ichpaatun to the north in Mexico and with Lamanai to the west in Belize. The Zakpah Orange of the Early Postclassic (as defined at Colha) transitions into the Payil Red of the Colha Middle Postclassic (Valdez 1987). The chronological specifics are in need of correlation with the Lamanai sequence/terminology. The sequence of Zakpah and related types to the later Payil materials, however, remains a valid interpretation.

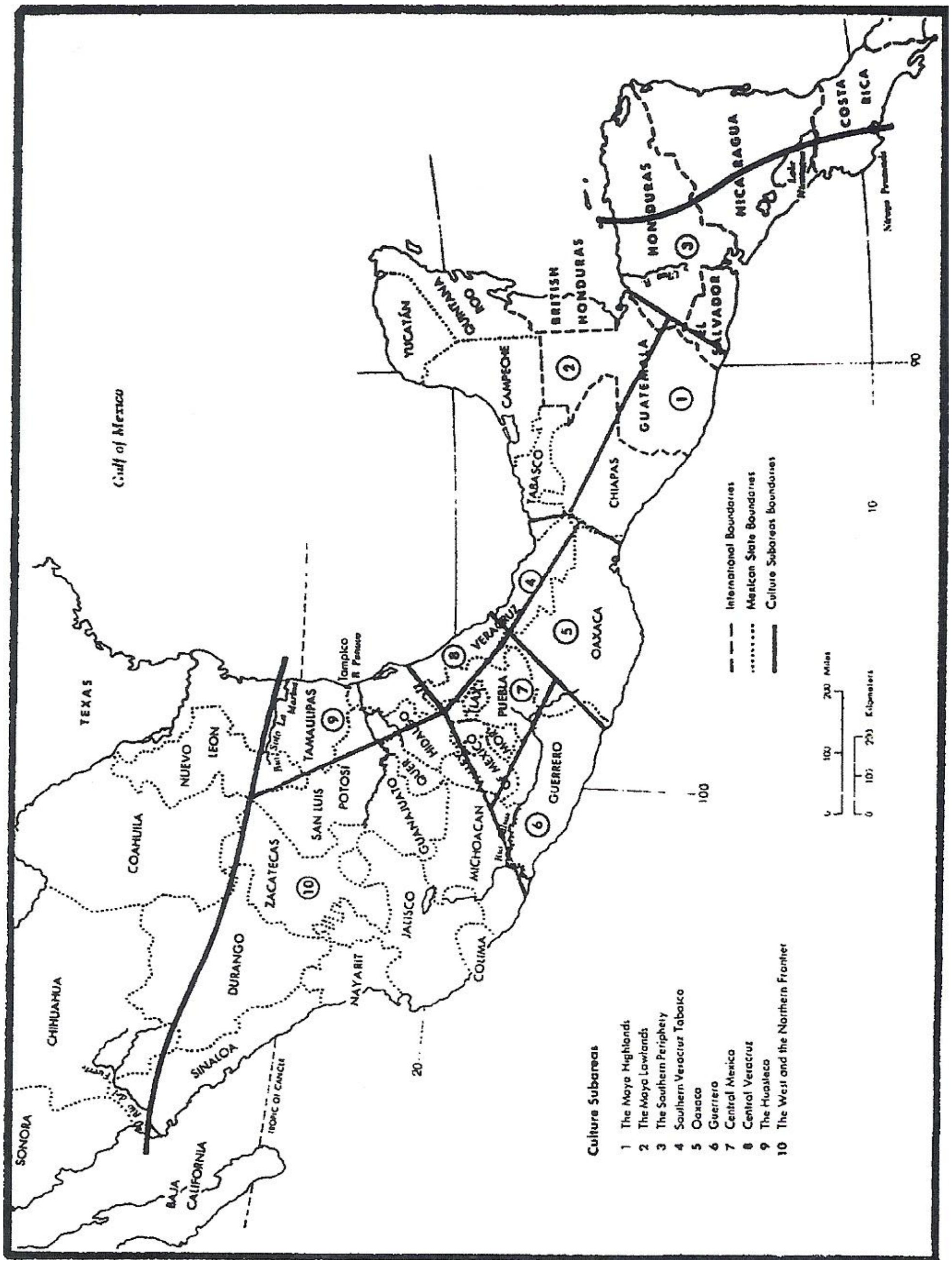

Figure 9: Culture Subareas.

Chapter 2: Sampling Methods

This chapter discusses how ceramics were chosen for the study. Operations with Postclassic occupation were identified. Postclassic red-slipped sherds were grouped by operation, suboperation, level, and type. These groups of sherds were then examined with a 10x magnifying loupe and subdivided based on the sherds' main visual components. From these subgroups samples were chosen for the study.

Postclassic ceramics were found at six Colha operations. Five of these (Operations 2001, 2003, 2010, 2032, and 2037; Figures 10 and 11) contained both Early Postclassic and Middle Postclassic sherds, while one operation (Operation 2040; Figure 10) contained only Middle Postclassic sherds.

For this study, small, plain, red-slipped rim sherds from Operation 2001 were examined. Reconstructable vessels, ceramic feet, and sherds with incising (that was visible on the rim sherd) were omitted. The remaining samples, 212 sherds, were grouped by context: Suboperations 1, 5, 11, or 12 (Figure 12); and Levels 1 to 3 or 4 to 6. Then they were assigned by visual appearance to the Early Postclassic (Zakpah), Middle Postclassic (Payil), or intermediate (Centon Incised), and they were also grouped by form: incurving, outcurving, or dishes. In cases where it was unclear whether the form was a dish, it was assigned to outcurving. For each type (in Operation 2001), several samples were examined with a hand lens, with 212 sherds being examined by 10x magnification. Use of the hand lens allows a large number of ceramics to be assigned to general temper classes (e.g., volcanic, quartz sand, limestone, shell). For this study, 10x classes were based on the presence or absence of white chalky temper, clear temper, and gray chalky temper. Once sherds were grouped into general temper classes, a smaller sample of 126 sherds was examined by the more sensitive technique of thin-section analysis (Bishop et al. 1982:281).

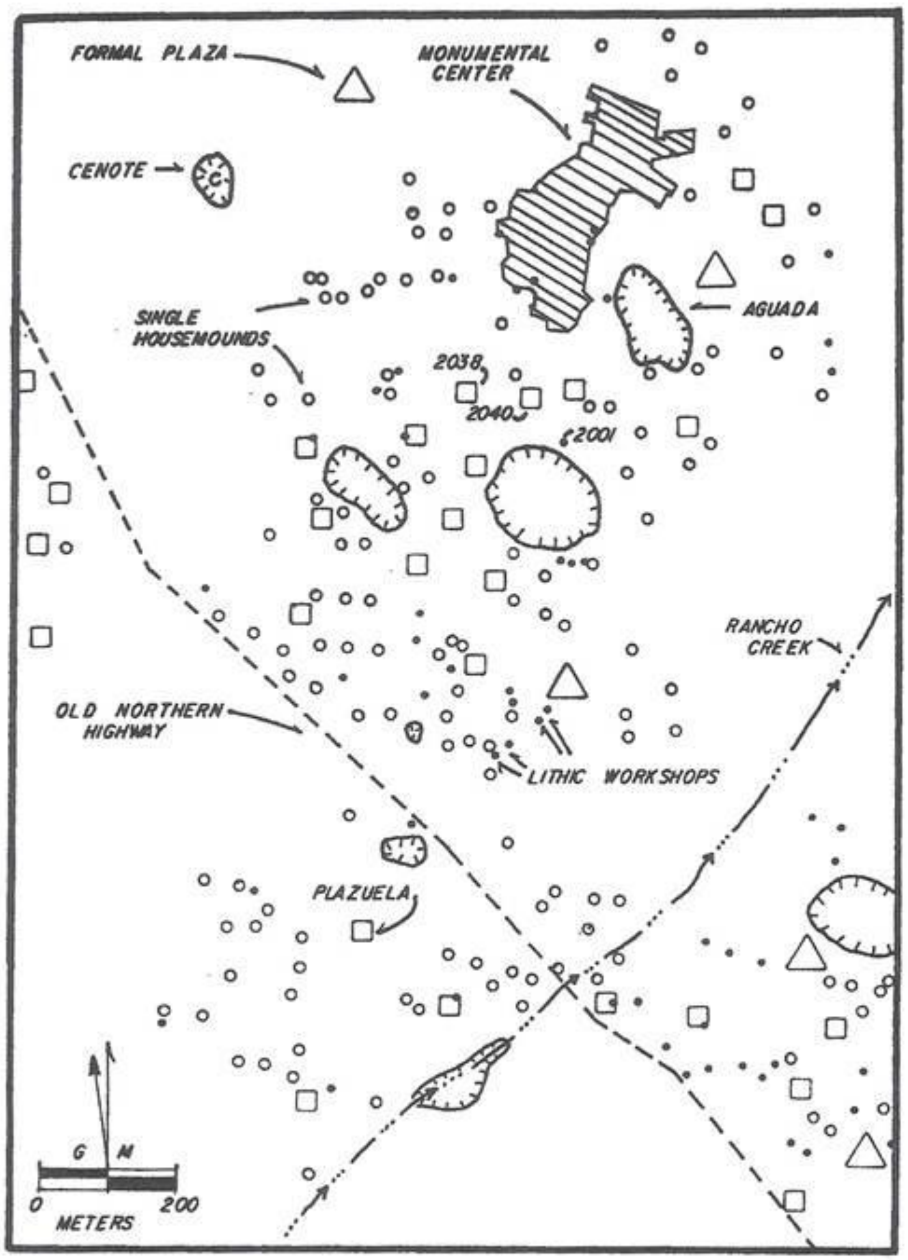

Figure 10: Operation 2001 (from Michaels 1987).

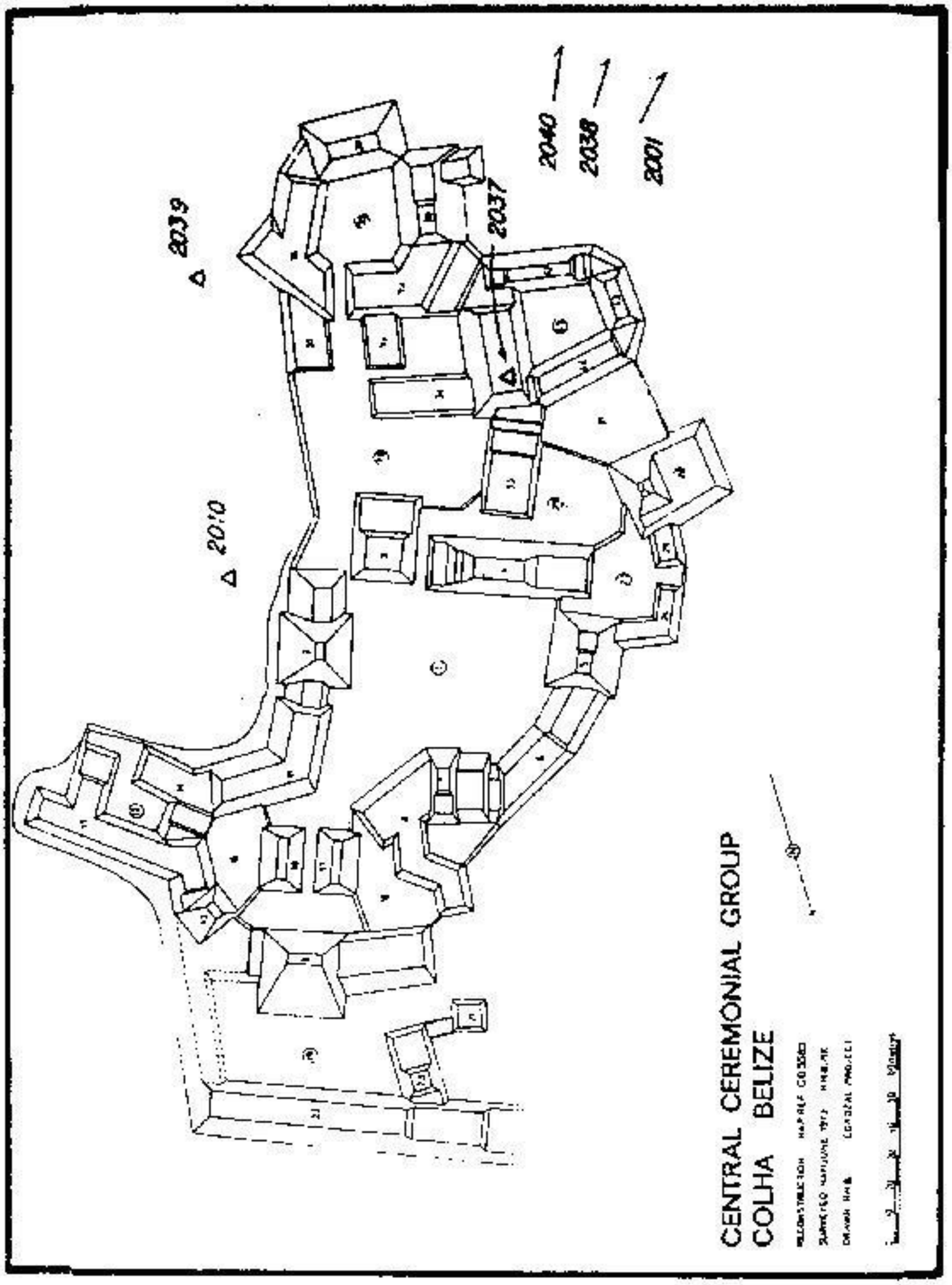

Figure 11: Detail of the Monumental Center (from Michaels 1987).

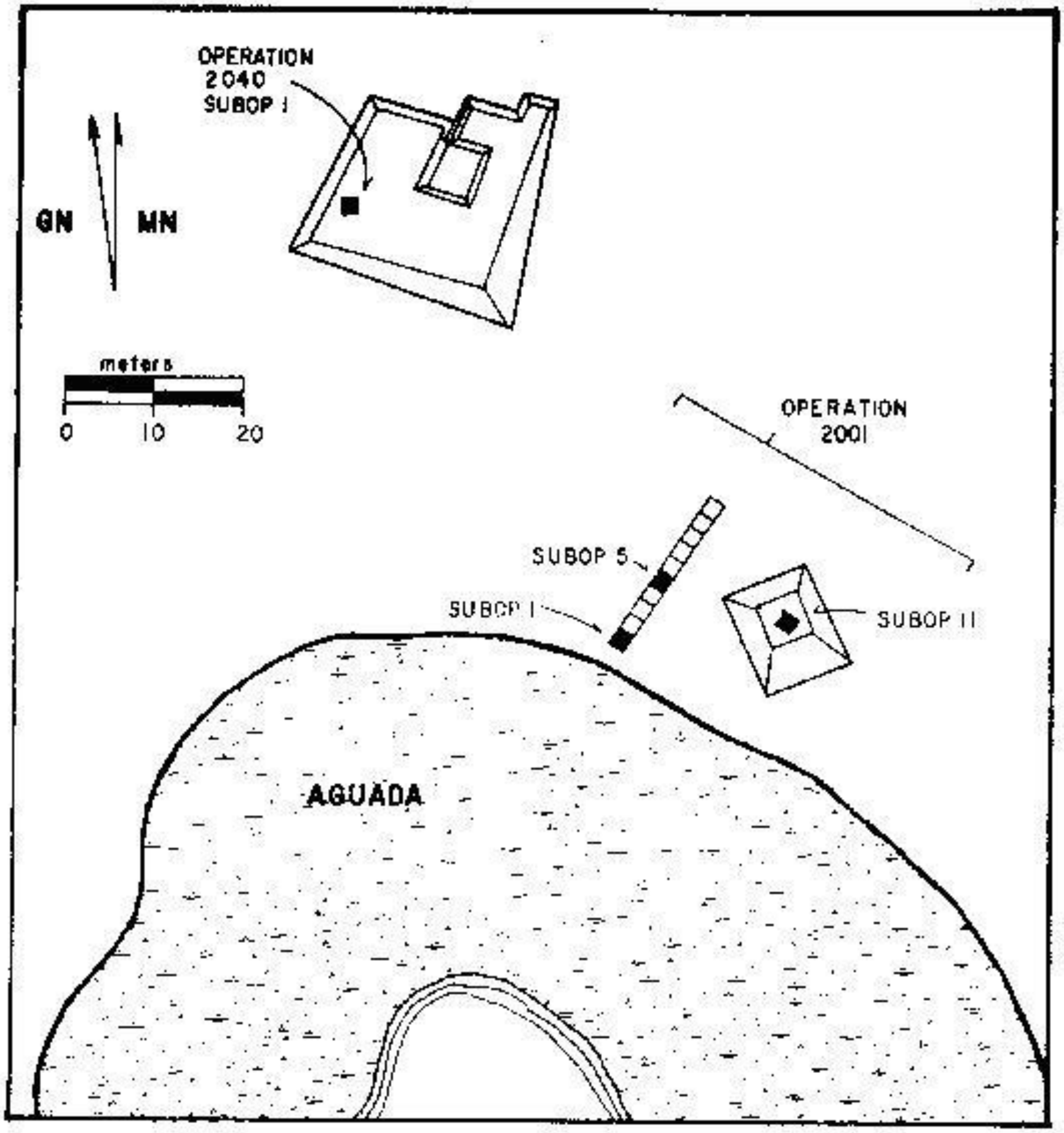

Figure 12: Operation 2001 and Suboperations (from Michaels 1987).

The current study includes Early and Middle Postclassic red slipped rim sherds from Operation 2001, Suboperations 1, 5, 11, and 12. Operation 2001 was an Early and

Middle Postclassic workshop area with an associated housemound. Suboperation 1 was a 2x2 m unit at the edge of the workshop downslope from the main workshop area. Suboperation 5 was a 2x2m unit in the main workshop area. Suboperation 11 was a 2x2 meter excavation sampling the residence midden of the housemound. Suboperation 12 was a 50x50cm excavation from the residence midden (Shafer 1979:34). The majority of the sherds come from Suboperations 5 and 11.

The Early and Middle Postclassic samples were expected to represent various types and proveniences. For the Early Postclassic, Zakpah Orange Red was sampled, as well as its related types (Valdez 1987; Walker 1990:80-82). For the Middle Postclassic, Payil Red and the related type Palmul Incised were sampled (Valdez 1987:224-225; Walker 1990:86-88). Early Postclassic forms included bowls, dishes, and a chalice. Middle Postclassic forms included bowls, dishes, and a jar. Tempers examined with the hand lens were categorized as white (usually micrite, which is microcrystalline calcite), clear (quartz and calcite grains), gray (also micrite), or combinations of these categories.

Wherever possible, three samples were taken from each temper class for each form within each time period for each suboperation for petrographic analysis. An initial estimate of sample size for Operation 2001 was 18 sherds, including 12 Early Postclassic samples (three sherds by four types by one operation), and six Middle Postclassic samples (three sherds by two types by one operation). In addition, if a certain ceramic type included more than one kind of petrofabric, then additional samples would be tested from that type, so that all petrofabrics within the type would be analyzed. The variety of petrofabrics was higher than anticipated, however, and the sample size reached 126 sherds using the sampling methods mentioned above. For this reason no additional operations were sampled. The 126 sherds were made into thin-sections and examined with a petrographic microscope in order to refine the groupings of sherds.

This sample provides an intensive look at a Postclassic lithics workshop and associated housemound. The benefit of this large sample from a small context is that the results suggest that variation is continuous, rather than results falling nicely into smaller groups. The sherds with a low percentage of temper do not separate clearly from the sherds with a high percentage of temper.

Given the destructive nature of petrographic analysis, however, no additional sherds or locations were sampled for this study. Perhaps comparing petrographic results to original 10x categories might allow sherds from other operations to be grouped by 10x inspection. It seems likely, however, that calcite and quartz will be difficult to distinguish at 10x.

This chapter explained sampling methods for this study. Postclassic sherds were identified, sorted, and examined with a 10x loupe. Based on provenience (suboperation and level) and visual examination, 126 red-slipped Postclassic sherds from Operation 2001 were chosen for petrography analysis. Petrographic methods are described in the next chapter.

Chapter 3: Petrography Methods

Petrographic analysis is a useful means for examining microscopic components of ceramics in order to infer information about production technology and organization of manufacture. The initial result of thin-section analysis is to get an estimate of the constituents in the sample, either as a percentage of volume or as a percentage of individual grains. This chapter explains the petrographic method for identifying microscopic components and compares this mineral-focused method to alternative chemical analyses. The procedure for making thin-sections is described. An explanation is provided regarding how components are identified and described, as well as how quantities of inclusions are estimated.

PETROGRAPHIC VERSUS CHEMICAL ANALYSIS

The purpose of the "Petrographic Method" is to examine raw material variability and production techniques. Previous geological/geographical studies examined the geological diversity of the Colha area (Angelini 1998; Iceland and Goldberg 1999; Wright et al. 1959).

> Pottery vessels will reflect the geological composition of the material, clay and temper that was used to produce them (Day et al. 1999; Mason 2003:271-272; Middleton et al. 1985). [In addition] specialised pottery production workshops are thought to create similar vessel forms with similar inclusion patterns, or recipes that reflect specialized craft production activities (Middleton et al. 1985). The identification of the mineralogy and granulometry can therefore aid in the identification of geological origins and production centres, as well as the delineation of distribution spheres (Sunahara et al. 2006:3).

Petrography was developed and applied in Mesoamerica by Anna O. Shepherd (1948, 1958, and 1967). It has been used in North American and Old World archaeology as well (Fargher 2007). More recent Mesoamerican research tends to emphasize chemical composition analyses, such as Inductively Coupled Plasma-Mass Spectrometry (ICP) and Instrumental Neutron Activation Analysis (INAA) instead (Fargher 2007:313). Some exceptions to this include Fargher (2007), Sunahara et al. (2006), and Howie et al. (2010).

Anna Shepard's study (1942) identified volcanic ash in ceramics found at lowland Maya sites. This finding was significant due to a lack of any known volcanic activity in the Maya lowlands. Shepard proposed three possible models: 1) a local ash source (possibly airborne ash) once existed but became exhausted or has not been located by scholars; 2) ash was imported (long distance trade); or 3) whole vessels were imported (long distance trade).

Regarding the advantages and disadvantages of petrography versus chemical analysis, petrography is more destructive. Chemical analysis is more expensive. Petrography is the logical precursor to chemical analysis. One should examine the microscopic components in order to understand the sub-microscopic chemicals. Petrographic analysis can give a better idea regarding how the ceramics were made, because it provides textural information, such as the size and shape of grains. "Petrographic thin section analysis is an effective means of understanding ceramic composition through the definition of petrofabrics. In turn, petrofabrics have proved a useful tool in tracing the distribution and possible movement and sources of ancient ceramics" (Sunahara et al. 2006:2). Chemical analysis makes sense for fine tuning results of petrographic analysis. For ceramics that look alike, chemical analysis can address questions of whether they were made from the same resources, where they came from, and where they were distributed.

One confounding issue is that during manufacturing the potter selects clays, cleans and blends the clays, adds temper, and fires the clay, all of which lead to variation between the clay source and the finished pot, so that similarities between pots may be due to the potter's methods, not the clay source. To a certain extent, this problem is less severe with petrographic than chemical characterization, because petrography takes into account some aspects of manufacturing behavior by considering texture, particle size and orientation, etc. (Bishop et al. 1982; Rice 1987).

MAKING THIN-SECTIONS

The thin-sections were prepared following steps specified by various sources (Angelini 1998; Orten et al. 1993; Velde and Druc 1999; Rice 1987; Greg Thompson, personal communication 2001; Kay Sunahara, personal communication 2003). Using a Hillquist trim saw, sherds were cut along the vertical plane, at right angles to the rim and base so that voids would be apparent. The exposed surface was sanded smooth with a Hillquist Thin Section Machine (thin section grinder). The prepared sherds were then impregnated with epoxy, mounted on petrographic slides, and ground to 0.03 mm thickness.

QUALITATIVE METHODS

Petrographic characterization is a technique borrowed from geology. With the polarizing microscope, transmitted plane-polarized or cross-polarized light passes through the thin-section. Thin-sections of pottery allow identification of different kinds of minerals, their abundance and associations, particle orientations, void size, shapes and locations, surface treatments (compaction or slipping), and alterations owing to firing (cracking) or postdepositional factors (recrystallization). Clay minerals are much smaller than non-clay grains, and identification of the clay minerals is usually not possible (Rice 1987; Velde and Druc 1999).

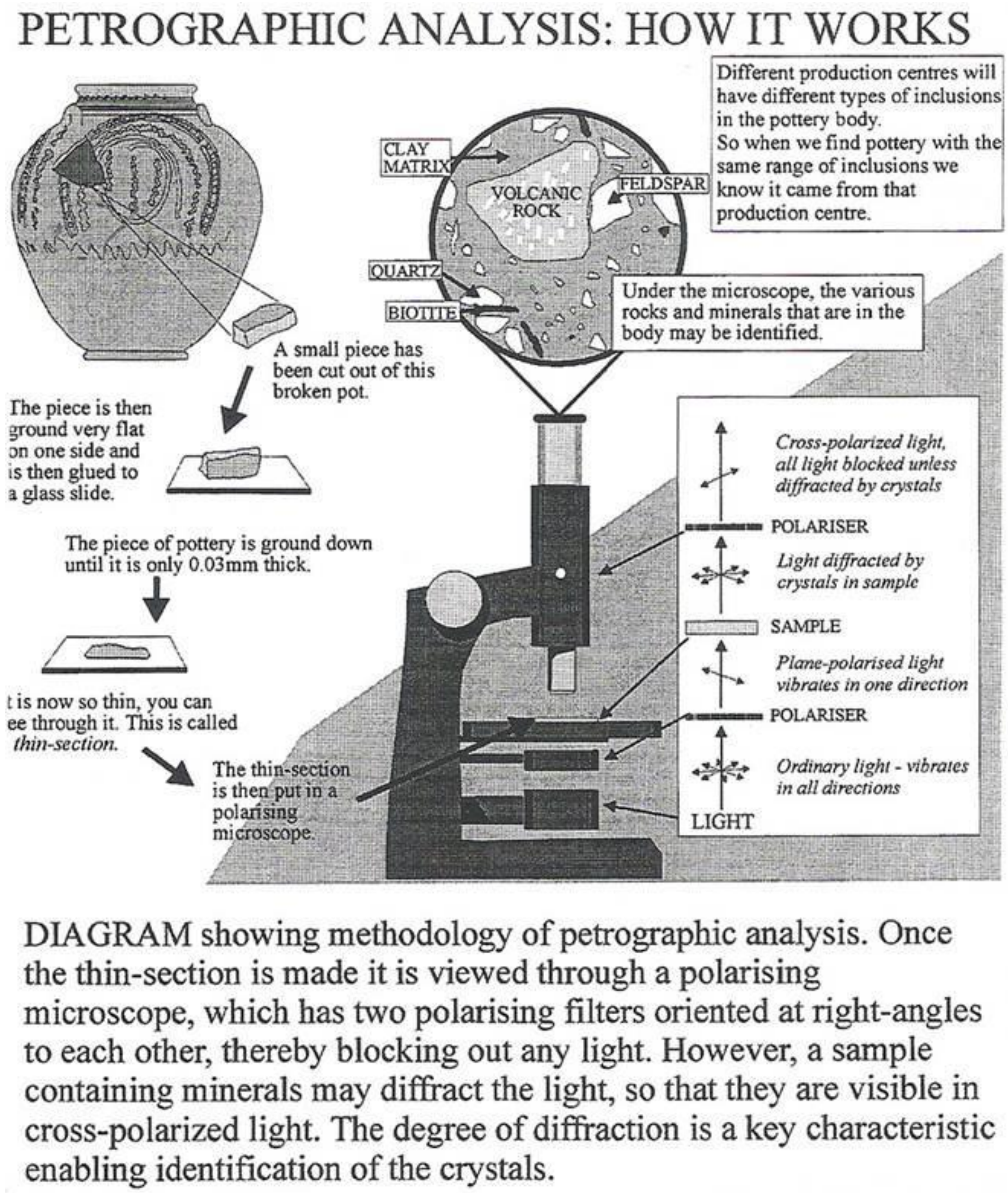

Figure 13: Microscope (from Mason 1994).

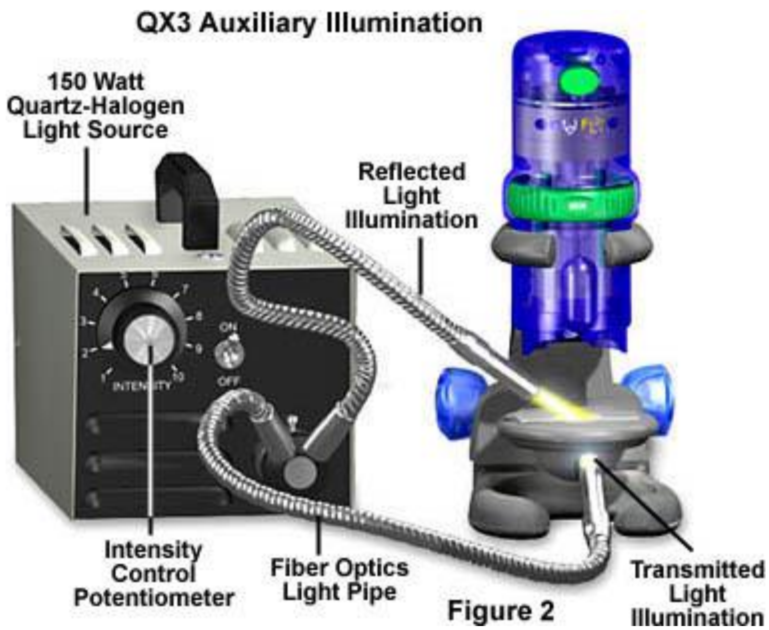

Figure 14: Auxiliary Illuminator; uses reflected light above the stage to observe opaques within the thin-section (from Davidson 2003).

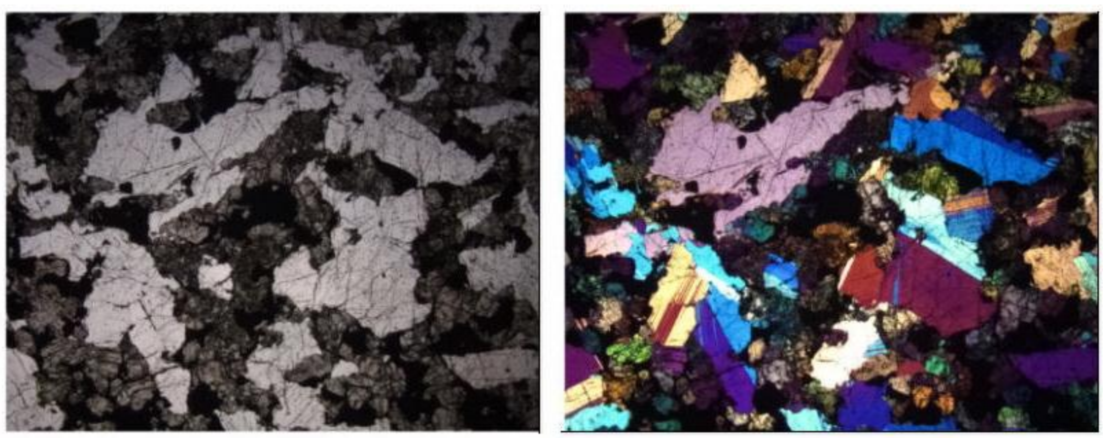

Figure 15: Effect of the Gypsum Plate: The gypsum plate, inserted in the microscopes accessory slot, intensifies the color of some minerals, while reducing the color saturation of other minerals, making them easier to differentiate. Shown here is plagioclase, which intensifies in color, like quartz; a, in cross-polarized light; b, in cross-polarized light with a gypsum plate (from Ocean Drilling Program Science Operator). In contrast, crystalline calcite remains very pale pastel to white in color.

Identifying the inclusions by mineralogy can help distinguish different sources of raw materials or distinguish one group of pots from another, although the origin of the minerals cannot be given with precision. The petrographic microscope can be used to identify minerals according to their optical properties, such as the shape of the grain, cleavage, and color of the mineral. Porosity and thermal changes in the minerals, such as quartz inversion, anisotropy of the matrix, and calcite decomposition, can be used to determine the temperature at which the pottery was fired (Rice 1987; Velde and Druc 1999).

For the Colha collection, types of inclusions were first identified. These included calcite, micrite (microcrystalline calcite), gray micrite, sparry calcite (intermediate between calcite and micrite), grog (broken pottery inclusions), quartz, chert (microcrystalline quartz), red/brown opaques, and black opaques. These minerals were identified by cleavage, (lack of) twinning, color, and extinction. I used Alizarin Red to stain the slides and confirm that the inclusions are calcite, rather than dolomite (Iceland 1997:962). Other minerals, such as feldspar and dolomite, were considered as possible inclusions, but none was found.

Grain shape focuses on sphericity and roundness. Sphericity is the closeness of the grain's outline to a circle. Sphericity is related to crystal shape, for example micas are elongated in thin section. Roundness is the smoothness of the grain, as opposed to angularity. In principle, the more a grain has been transported, the rounder it is, due to erosion. Grains can be categorized as angular, subangular, subrounded, and rounded. For example, rounded grains might be stream sands that have been eroded and transported; an irregular shaped is not eroded and probably comes from the original clay source (Velde and Druc 1999).

Size is usually measured as diameter. Estimates of grain size distribution involve estimating the relative amounts of different-sized grains. The size distribution of temper grains can be used to describe production method and to perhaps describe origins of different components. For example, inclusions that are small and evenly distributed are probably natural inclusions of the clay; a fine-grained matrix of clay and inclusions plus a second group of medium grains of rather constant size (bimodal temper-grain distribution), suggests temper was probably added; small and very large grains might indicate a segregation process by sorting, for example water washing, decantation, or levigation; highly irregular shape and great variety of sizes suggests grit (crushed rock). Irregularity of grain-size distribution from one portion of the sample to another or a "nebulous" aspect of the inclusions (fine-grained material around the temper grains) indicates that the paste was not well worked and not homogenized after extraction from the source (Velde and Druc 1999).

QUANTITATIVE METHODS

A central part of fabric characterization is percentage of inclusions, conducted by point counting or visual comparison, which involves estimating the density of inclusions. Percentage of inclusions can be given as a frequency, based on the number of grains, or by abundance, which is based on the surface area of grains (Rice 1987; Velde and Druc 1999). There are pros and cons to both visual comparison charts and to point counting. For this study visual comparison charts were used, primarily because it is faster, allowing more samples to be examined. The most widely used method of estimating percentage of inclusions is point counting (Middleton et al. 1985), although originally it was done by visual comparison, which involves estimating the density of inclusions by visual comparison with known or prepared standards (Rice 1987:379). The main advantage of visual comparison is that it can be conducted more quickly than other methods, allowing a larger quantity of samples to be examined.

Using the point count method thin-section constituents can be estimated from a series of observations made at fixed intervals, for example, every .5 mm or every 1mm, across the entire area of the thin section. The counting interval depends on several factors: texture (grain size), sampling theory, desired precision, and time available. The number of points per sample depends upon the area of the thin section and the counting interval selected (Stoltman 1989:148). Generally, 50 to 200 grains are measured (Middleton et al. 1985) although the probability of error decreases if 300 or more points are counted (Galehouse 1971). This procedure generally requires a polarizing microscope with a measuring eyepiece with a crosshair and a stage with an attachment that allows the thin section to be moved in fixed increments beneath the crosshair. At each stop of the stage, the mineral directly beneath the crosshair is identified (Stoltman 1989:148). An alternative is to project the image from the microscope onto a computer screen and count points from a superimposed grid or use a photographic image from the microscope with a superimposed grid (Angelini 1998).

A semi-automatic image analyzer can be used to make recording of petrographic features more accurate and more quantifiable. A digital camera attached to a petrographic microscope can be interfaced with imaging software that acquires the image from the camera. The captured image can then be viewed on the computer screen and manipulated by the software. The image can be enhanced to clarify specific features prior to measurement (Media Cybernetics 1999; Whitbread 1991).

Image analysis systems operate on differences in the gray-levels of a black and white image. However, petrographic inclusions may present a wide range of gray-levels because of interference colors which, in turn, depend upon inclusion composition, and inclusion orientation. Additionally, where composite inclusions are present, such as phenocrysts in a fragment of volcanic rock, it may be difficult to distinguish between the boundaries of the crystals and the boundary of the inclusion (Schafer and Teyssen 1987). For this reason, the researcher must be able to identify individual features and inclusions under the microscope, rather than relying on the image analyzer. Once identified, each type of feature or inclusion can be retouched in a specific shade of gray to eradicate the variation in gray-levels before measurement (Media Cybernetics 1999; Whitbread 1991). The software can then quantify the areas, shapes, and spatial relationships of a wide range of features, for example area, angle, perimeter, mean width, diameter, roundness, and volume of an equivalent sphere (Media Cybernetics 1999; Middleton et al. 1985). The collected data can be sorted, classified, and viewed numerically, statistically, or in graphic form (histogram or scattergram).

Petrographic analysis is a useful means for examining microscopic components of ceramics in order to infer information about production technology and organization of manufacture. The initial result of thin-section analysis is to get an estimate of the constituents in the sample, either as a percentage of volume or as a percentage of individual grains. This chapter explained the petrographic method for identifying microscopic components and compared this mineral-focused method to alternative chemical analyses. The procedure for making thin-sections was described. An explanation was provided regarding how components are identified and described, as well as how quantities of inclusions are estimated.

After comparing methods of compositional analysis, petrographic analysis by visual comparison charts was chosen for the current study. Mineral inclusions were identified, and information on their size, shape, and other qualitative measures were recorded. For the current study, percentage of inclusions was estimated by volume, based on the surface area of grains (Rice 1987; Velde and Druc 1999), using visual comparison with known or prepared standards (Matthew et al. 1997). The next chapter discusses the data collected using these methods.

Chapter 4: Results: Qualitative and Quantitative Data

Results of this study include both qualitative and quantitative data. Inclusions were identified by mineral type and percentage, and each sample was assigned to a group. This chapter discusses which minerals were identified, in what percentages these minerals were found, and what groups were formed based on these percentages.

IDENTIFIED MINERALS

The carbonates are the most abundant minerals found in the analyzed thin-sections. For this study the carbonate inclusions are categorized as chalky, micritic calcite; clear, crystalline calcite; and sparry calcite. In *Lowland Maya Pottery: the Place of Petrological Analysis*, Jones (1986:14) distinguishes between chalky calcite and crystalline calcite, and these textures differ both macroscopically and microscopically. Macroscopically, calcite groups were initially differentiated based on whether the calcite was primarily clear or primarily chalky when examined under a 10x loupe. For the finally groupings, the carbonates were differentiated based on how they appear microscopically with transmitted cross-polarized light.

The chalky calcite inclusions appear opaque white or gray with a 10x loupe. The majority of the chalky calcite in these samples is micrite, defined as “particles less than about 5 microns in size” (Society for Sedimentary Geology 2006) and ranging in color from subtransluscent light brown to opaque gray in transmitted, cross polarized light. Micrite is also known as microcrystalline calcite, and this term overlaps with the terms limestone mud and sascab (weathered limestone).

In contrast, crystalline calcite appears clear macroscopically and translucent in thin-section, ranging in color from white to very pale pastel. Volcanic ash can be mistaken for calcite macroscopically (Sunahara et al. 2006), but no volcanic ash was found in these samples. In addition, the staining of the samples with Alizarin Red stain indicated that none of the carbonates was dolomite (all carbonates turned pink when stained).

A third calcite texture, sparry calcite, was used in the present study to refer to "clear coarsely crystalline mosaic calcite crystals" (Society for Sedimentary Geology 2006). Sparry calcite was not found in significant quantities in the current study, with the exception of two sherds that are assigned to the Miscellaneous group.

Aside from the carbonates, quartz was the only abundant mineral inclusion. Quartz was primarily identified by undulatory extinction and low birefringence. Undulatory extinction is exhibited by different parts of the mineral changing from white to gray to black in a wavy pattern when the microscope stage is rotated with transmitted cross polarized light (Nesse 2000; see Figure 29 showing a quartz grain with areas of both light gray and dark gray). Low birefringence is exhibited by the mineral displaying various intense colors when the gypsum plate is inserted in the accessory slot of the microscope with transmitted cross polarized light (Nesse 2000; see Figure 15). The quartz component of the samples was almost entirely monocrystalline grains. Chert (microcrystalline quartz) was found in a few samples, but only in percentages of less than three percent.

ASSIGNED GROUPS

Groups were defined by the main mineral or minerals present in the ceramic paste. The first set of graphs (Figures 16 and 17) illustrates how the petrofabric groups were originally identified. Specifically, they were identified based on their percentages of clear, monocrystalline calcite; chalky, micritic calcite; and monocrystalline quartz.

Figure 16 emphasizes the differences in percentages of clear, monocrystalline calcite and chalky, micritic calcite. Figure 17 emphasizes differences in percentages of quartz.

The samples fall into five major groups, depending on which mineral component(s), if any, are dominant. These five categories are 1) Clear Calcite, 2) Chalky Calcite, 3) Chalky/Quartz, 4) Quartz, 5) Matrix, and 6) Miscellaneous (Figures 16, 17, and 37). In the descriptions that follow for each temper group, the name of the group is provided, as well as a general description, percentages of the main components, the number of samples in the group, the time period, form, and suboperations represented, any patterns in the group, and the original 10X category.

For each group a pie chart shows how much of each mineral type was present in the average sherd of each group (with the exception of the group of miscellaneous samples; Figures 18, 21, 25, 28, 31). These pie charts also include the average percentage of matrix, that portion of the ceramic paste where no inclusions are present; in general terms, this can be considered the clay portion of the ceramic paste. Shown also for each identified group is a photo of a representative thin-section in transmitted cross-polarized light at 10x magnification (Figures 19, 22, 26, 29, 32, 34), as well an image of the sherd with magnification by the 10x loupe prior to thin-sectioning (Figures 20, 23, 24, 27, 30, 33, 35).

For the purpose of analysis, the sherds were plotted on a new graph with quartz on the x-axis and calcite-minus-micrite (chalky calcite) on the y-axis (Figure 36). These axes allow the four major groups to clearly separate, making them easier to compare with other variables, such as time period (Figure 37), provenience (i.e., suboperation; Figure 38), and form (Figure 39).

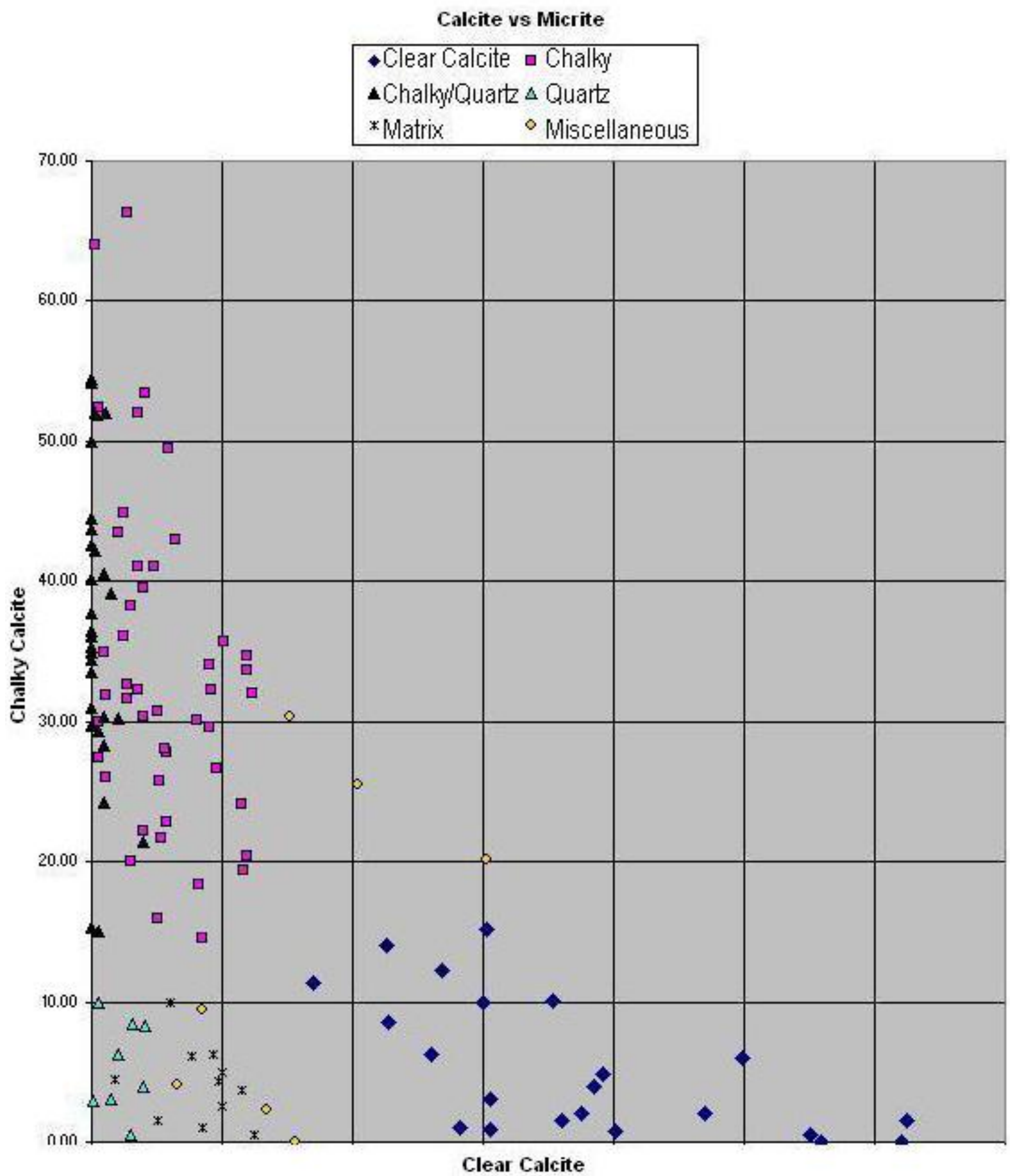

Figure 16: Clear Calcite and Chalky Calcite; all samples were plotted according to their percentages of clear calcite and chalky calcite. This group illustrates that some samples are high in clear calcite, some are high in chalky calcite, some are low in both, but few are high in both. The legend indicates the petrofabric groups into which samples were eventually assigned.

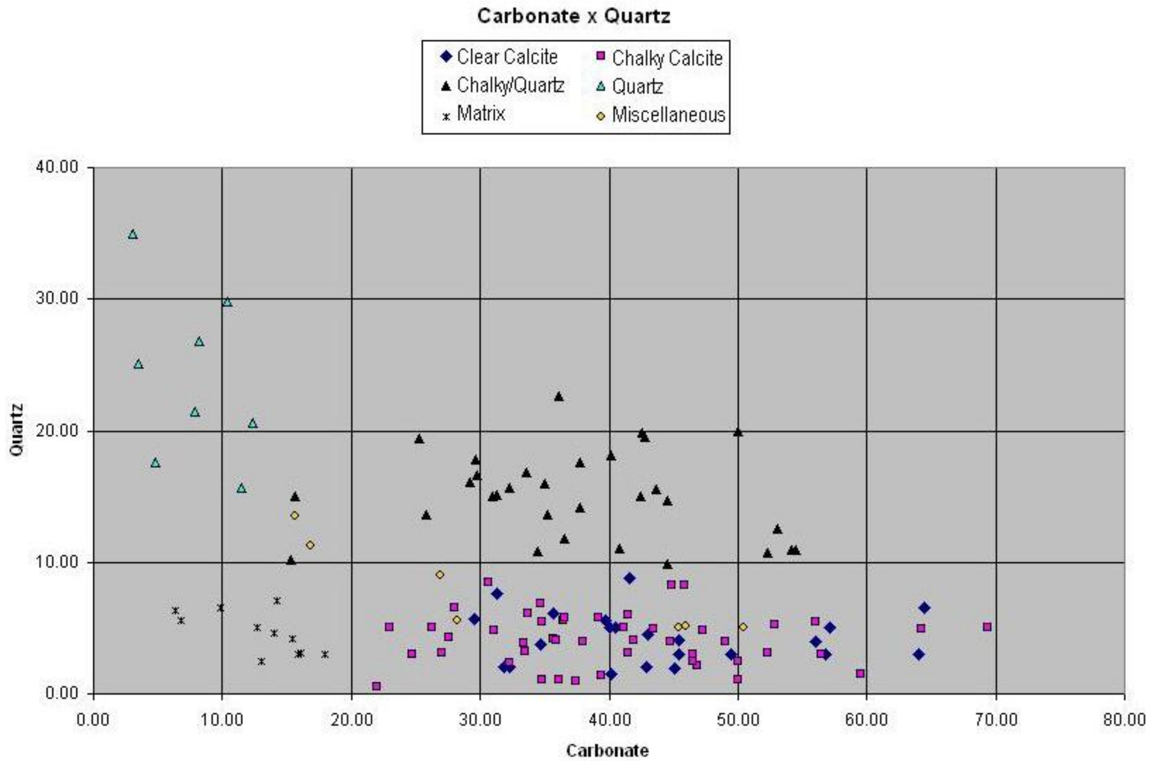

Figure 17: Carbonate and Quartz; all samples were plotted according to their percentages of total carbonates (clear and chalky calcite combined) and quartz. This graph helps to distinguish the Quartz Group from other low carbonate ceramics and helps to distinguish the Chalky/Quartz group from other high carbonate ceramics.

CLEAR CALCITE GROUP

The first group is the Clear Calcite Group (Figures 18 - 20). This group is defined by monocrystalline calcite inclusions making up more than 17 percent of the surface area of the thin section, micrite making up less than 16 percent, and quartz making up less than nine percent (Figures 16, 17). There are 22 samples in this group, including samples 5, 13, 15, 26, 34, 84, 96, 98, 99, 103, 115, 116, 117, 118, 119, 120, 123, 135, 138, 140, 142, and 145.

The calcite grains average 0.01 to 0.09 mm in size, with the largest sizes being 0.21 to 1.06 mm. With the exception of sample 84, which is classified as poorly sorted (but is possibly bimodal), the calcite in the samples is moderately to well sorted. This group includes jars, bowls, and plates from Suboperation’s 1, 5, and 11. The majority of these were initially in the visual category of “other”. Sample 13 is statistically at the edge of this group with only 17 percent clear calcite and as much as 11 percent micrite. Sample 45, however, having 13 percent clear calcite, two percent micrite, and 11 percent quartz, is grouped as high matrix, due to having a low percentage of inclusions overall.

The Clear Calcite Group does not overlap the Quartz and Chalky Calcite groups. The sherds with moderate micrite have little if any calcite grains. There is no chalky/clear group, and no clear/quartz group. This group is significant because almost all of these sherds come from the Middle Postclassic time period (Figure 37).

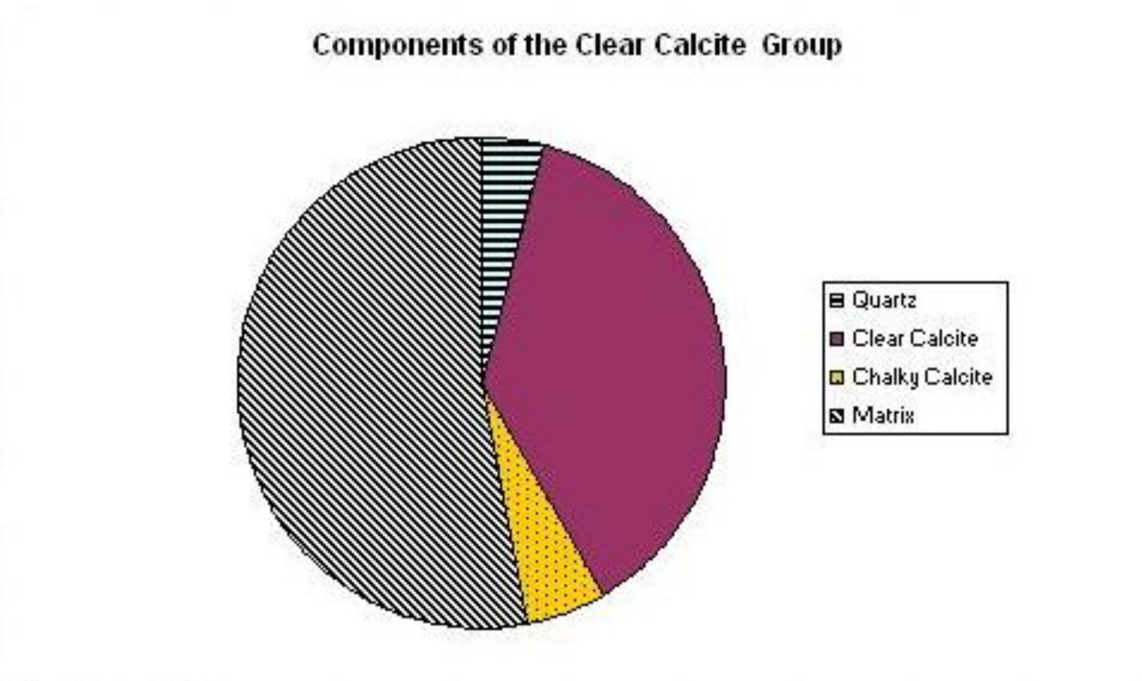

Figure 18: Components of the Clear Calcite Group.

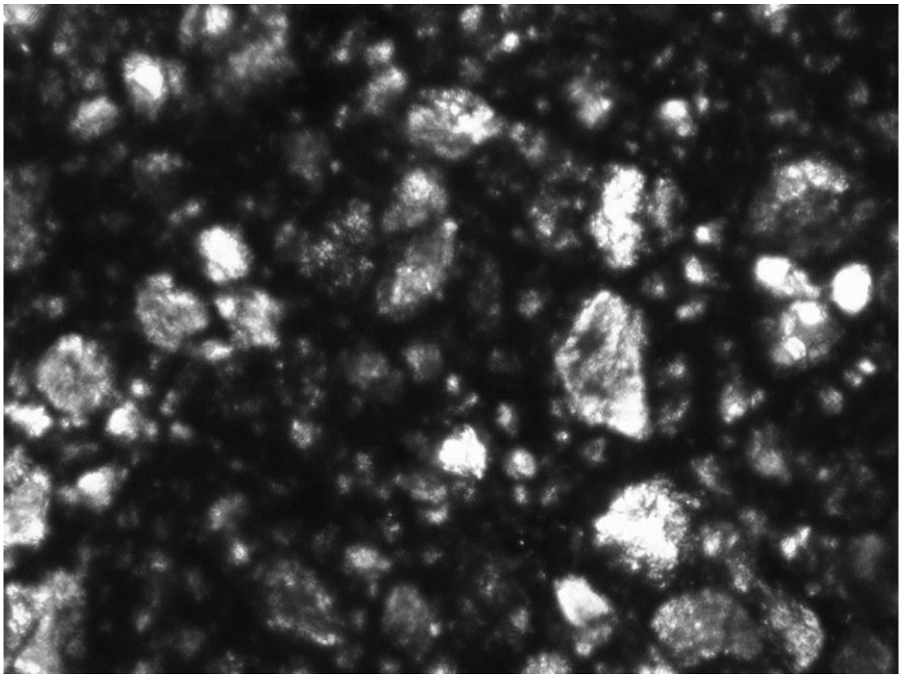

Figure 19: Clear Calcite Photo.

Figure 20: Clear Calcite at 10x Magnification (Sample 96).

CHALKY CALCITE GROUP

The second group is the Chalky Calcite Group (Figures 21-24). Micrite is defined as "microcrystalline calcite" (Iceland 1999:953). This group is defined by higher percentages of micrite with lower percentages of grains of monocrystalline calcite or quartz. Specifically, samples in this group contain 14 percent to 67 percent of micrite (including gray micrite), less than 13 percent calcite, and less than nine percent quartz (Figure 16, 17). This group includes the following 47 samples: 1, 2, 3, 11, 12, 17, 22, 23, 30, 31, 32, 38, 42, 43, 44, 52, 56, 61, 62, 72, 81, 83, 90, 91, 93, 94, 97, 101, 102, 104, 105, 106, 110, 111, 121, 122, 124, 126, 130, 132, 133, 137, 139, 141, 143, 144, and 146.

The micrite in these sherds has an average size ranging from submicroscopic to 0.32 mm, with the largest size between 0.026 and 2.50 mm. Sorting ranges from very poorly sorted to well sorted. No pattern is formed regarding time period (Figure 37), location (Figure 38), or type (Figure 39). This group covers a wide range of micrite percentages, with two sherds having over 60 percent of micrite. For this reason, it may be sensible to break this group into two to four groups (such as Moderate Micrite and High Micrite) to study differences and trends within the larger group. This group also includes some rhomb shapes. Most samples in this group were initially assigned to the visual category of "Lots of White".

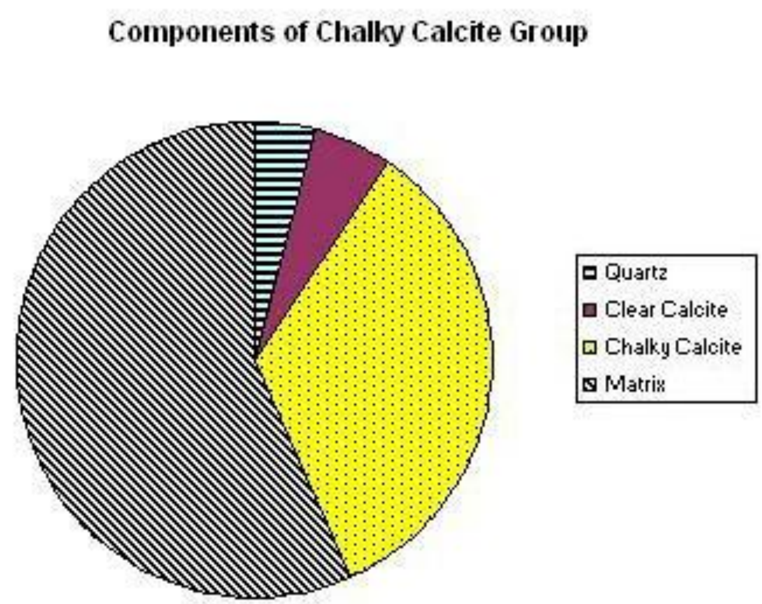

Figure 21: Components of the Chalky Calcite Group

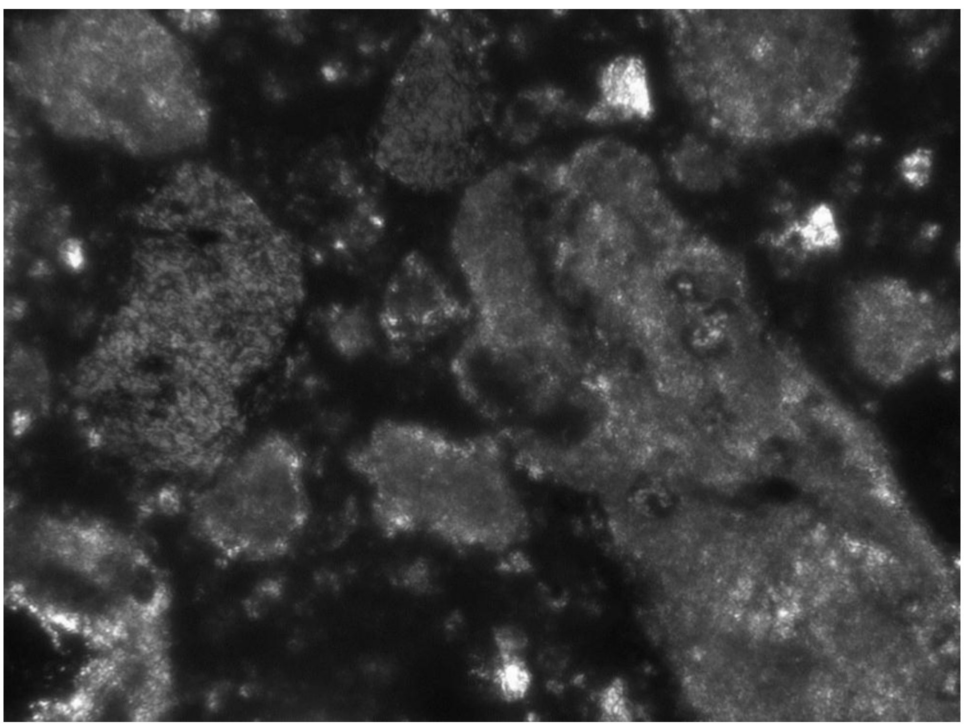

Figure 22: Chalky Calcite Photo.

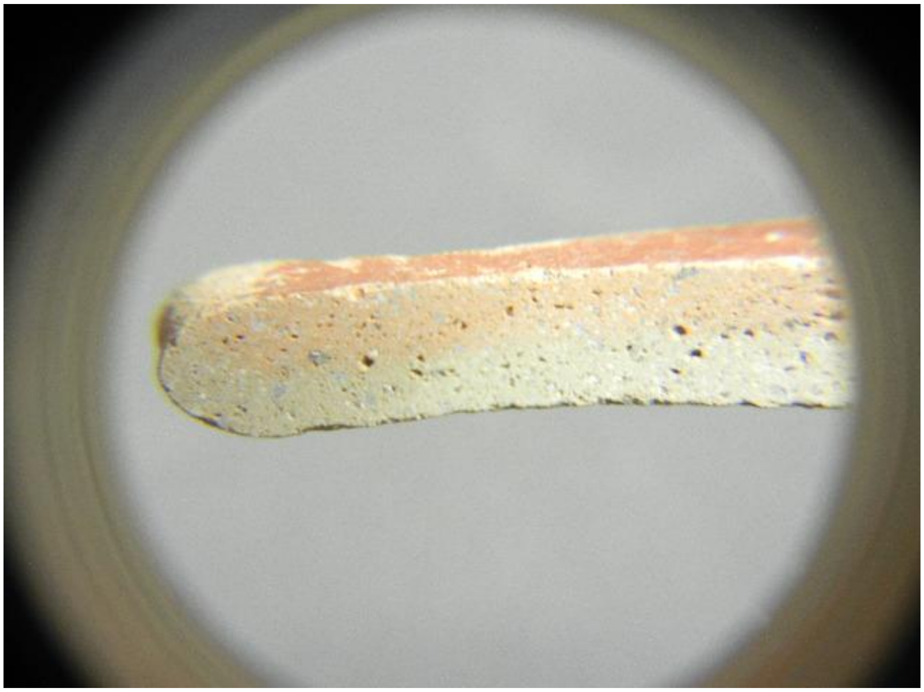

Figure 23: Chalky Calcite at 10x with Poorly Sorted Chalky Calcite (Sample 17).

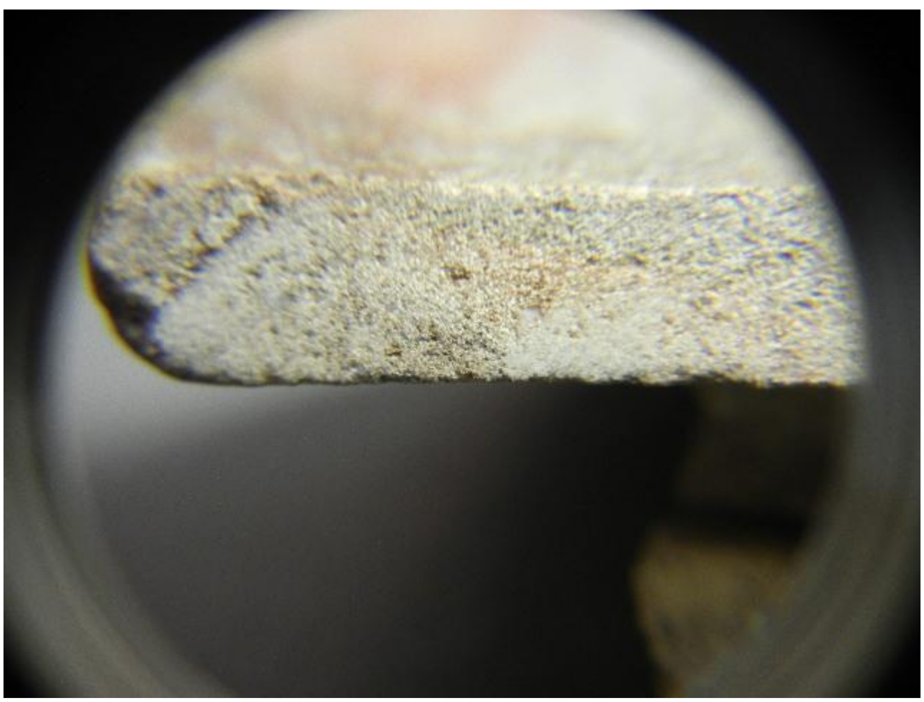

Figure 24: Chalky Calcite at 10x with Well Sorted Chalky Calcite (Sample 91).

CHALKY/QUARTZ GROUP

The third group is the Chalky/Quartz Group (Figures 25-27). This group is defined by 15 to 55 percent micrite, nine to 23 percent quartz, and less than four percent calcite (Figures 16 and 17). This group has 31 samples, including 18, 28, 29, 35, 36, 37, 39, 48, 49, 53, 55, 57, 58, 59, 63, 64, 65, 66, 67, 73, 74, 75, 76, 77, 78, 79, 80, 82, 128, 129, and 131. For micrite the average size ranges from 0.1 to 0.94 mm, and the maximum size ranges from 0.26 to 1.52 mm. For quartz the average size is 0.05 to 0.29 mm and the maximum size is 0.69 to 1.75 mm.

All but three of the sherds in this group were found in Suboperation 11, the residence midden (Figures 38). This group includes incurving bowls and outcurving jars, which are primarily from the Early Postclassic and intermediate Postclassic with only a few samples from the Middle Postclassic (Figure 39). For most samples the micrite is well sorted and the quartz is moderately or poorly sorted. Most sherds in this group were originally assigned to the visual category of "Clear Dominant".

At the center of this group is a subgroup of twelve samples in which the micrite is well sorted. Six of these 12 samples have rhomboid micrite. This group has a higher percentage of rhomboid micrite than any other group. Outliers, samples 18 and 39, have less micrite, and this micrite is not well sorted.

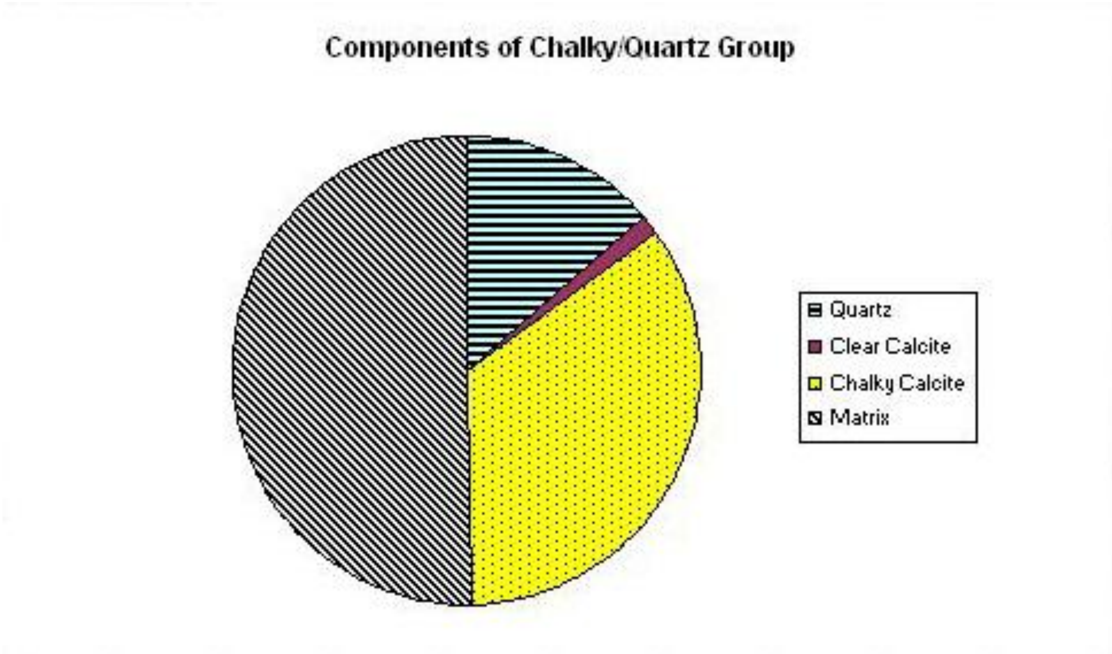

Figure 25: Components of the Chalky/Quartz Group.

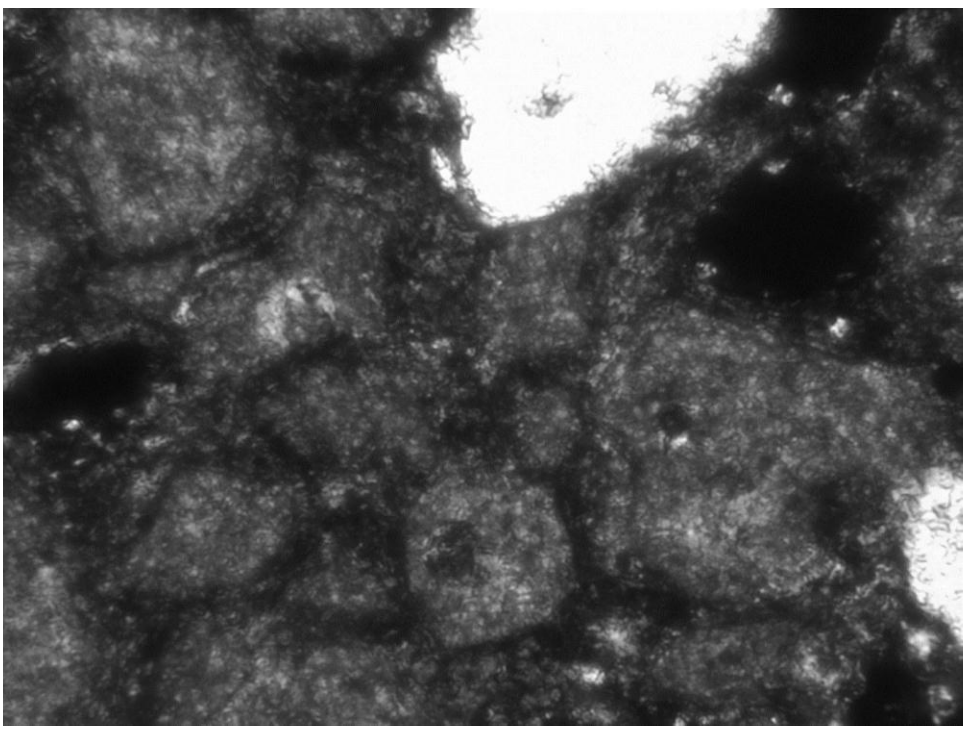

Figure 26: Chalky/Quartz Photo.

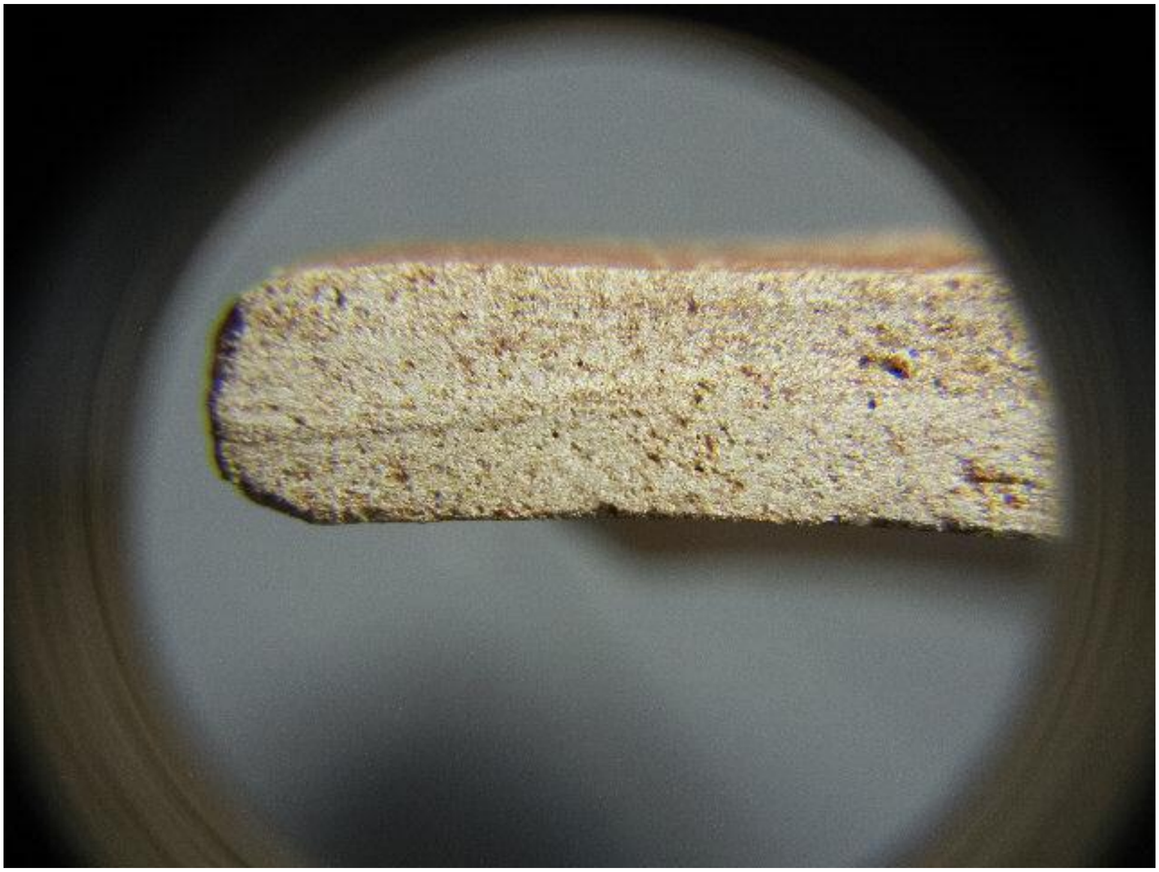

Figure 27: Chalky/Quartz at 10x (Sample 35).

QUARTZ GROUP

The fourth group is the Quartz Group (Figures 28-30). It is defined by a high percentage of quartz with low percentages of micrite and calcite. Specifically, quartz is between 15 and 35 percent, while micrite is below 10 percent, and calcite is below five percent (Figures 16, 17). The eight samples in this group include 24, 27, 40, 54, 68, 92, 107, and 125. The average size of quartz in these samples ranges from 0.08 to 0.16 mm, with the maximum size ranging from 0.83 to 1.29 mm. Sorting is moderate to poor. The Quartz Group, though small in number, overlaps all three time periods (Figure 37), all three forms (Figure 39), and most Suboperations (Suboperations 5, 11, and 12, but not

Suboperation 1; Figure 38). Most samples in this group were originally assigned to the visual category of “Clear Dominant”. It is worth noting that for all sherds with quartz over 15 percent, calcite and micrite are below 10 percent. In addition, this is the smallest group. This could have various implications ranging from quartz being more difficult to acquire, being less desirable, or used for very specific functions.

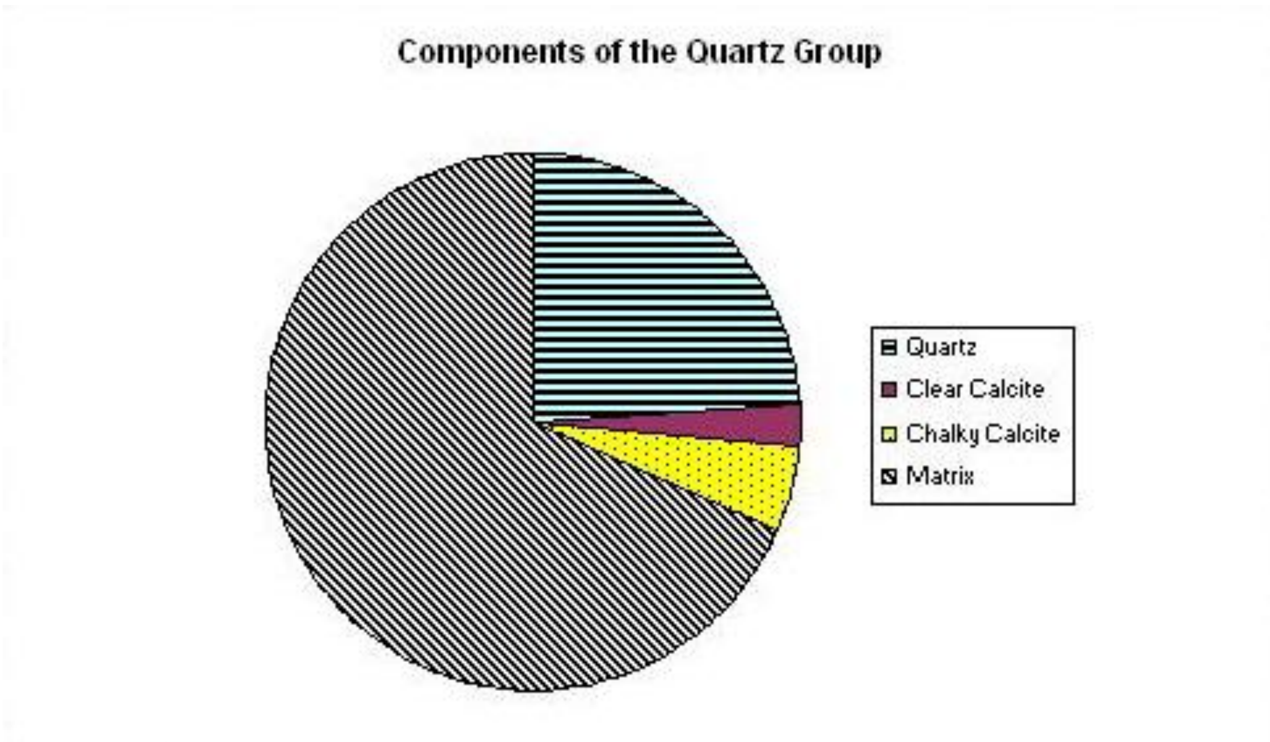

Figure 28: Components of the Quartz Group.

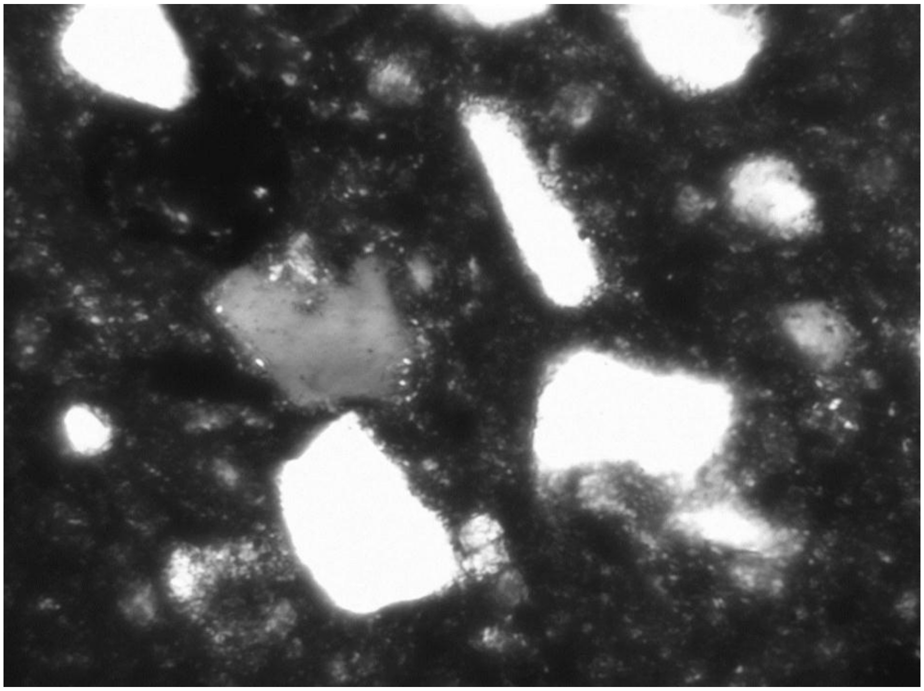

Figure 29: Quartz Petrofabric Photo.

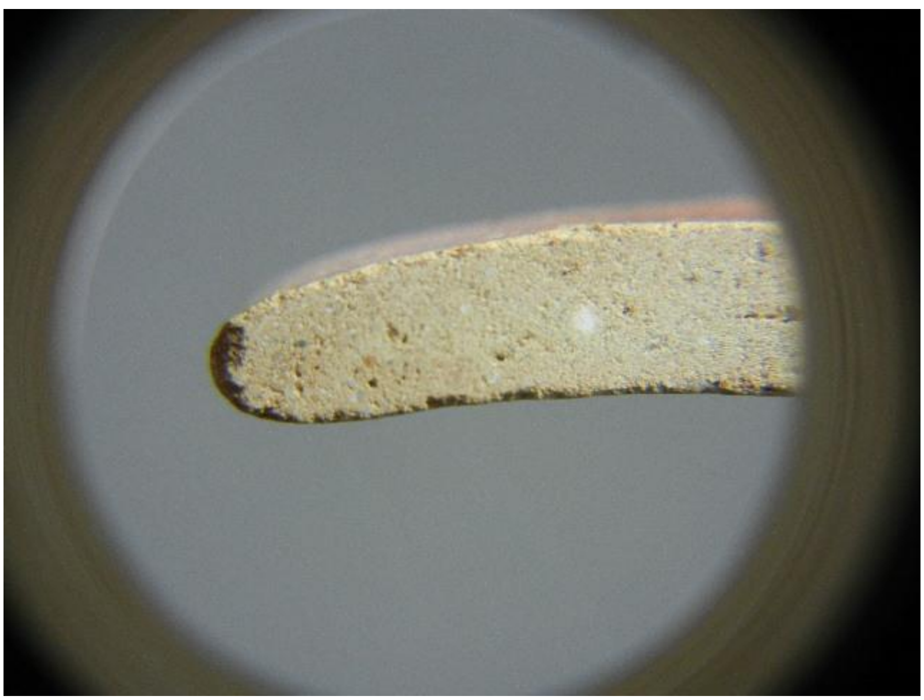

Figure 30: Quartz Tempered Sherd at 10x (Sample 107).

MATRIX GROUP

The fifth group is the Matrix group (Figures 31-33). This group is defined by a low percentage of all inclusions. The total inclusions are less than 22 percent, leaving the matrix at over 78 percent (Figures 16, 17). The 11 samples in this group are 7, 8, 33, 46, 47, 51, 95, 100, 108, 109, and 112.

The samples in this group have two to eight percent quartz, 0 to 10 percent micrite, and 0 to 12.5 percent calcite. Most samples in this group were originally assigned to the visual category of "Clear Dominant". Ceramics from this group were found in Early and Middle Postclassic contexts (Figure 37), in both Suboperations 5 and 11 (Figure 38), and representing incurving, outcurving, and plate forms (Figure 39).

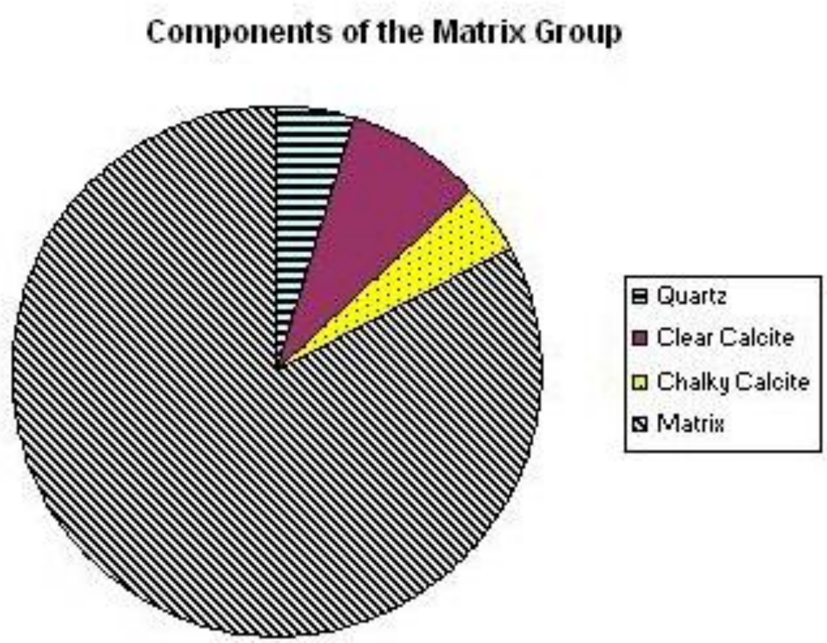

Figure 31: Components of the Matrix Group.

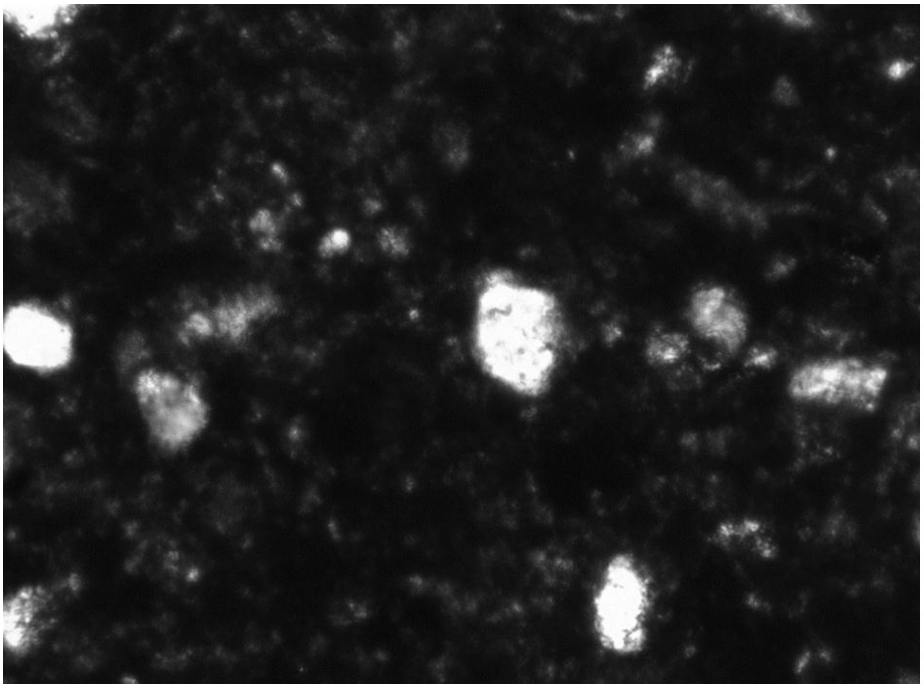

Figure 32: Matrix Petrofabric Photo.

Figure 33: Matrix Temper Class at 10x (Sample 112).

MISCELLANEOUS

The sixth group is Miscellaneous (Figures 34 and 35). This group includes the seven samples 45, 60, 69, 70, 71, 113, and 114, which do not fit well into any of the other groups (Figures 16, 17).

Samples 113 and 114 are characterized by higher than average percentage (8.98 and 17.63 percent) of sparry calcite (Figure 34), which has a texture intermediate between calcite and micritic calcite. These two samples were Middle Postclassic plates from Suboperation 5 and were originally assigned to the "other" visual category.

Samples 60, 70, and 71 include clear, monocrystalline calcite and chalky, micritic calcite together with a combination of over 15 percent calcite and over 16 percent micrite. These samples are Early and intermediate Postclassic outcurving ceramics from Suboperation 11. They were originally assigned to the "White Dominant" visual category.

Samples 45 and 69 include calcite and quartz together with a combination of 13 to 16 percent calcite and 11 to 14 percent quartz. These samples are Early and intermediate Postclassic outcurving ceramics from Suboperation 11. They were originally assigned to the "Clear Dominant" visual category.

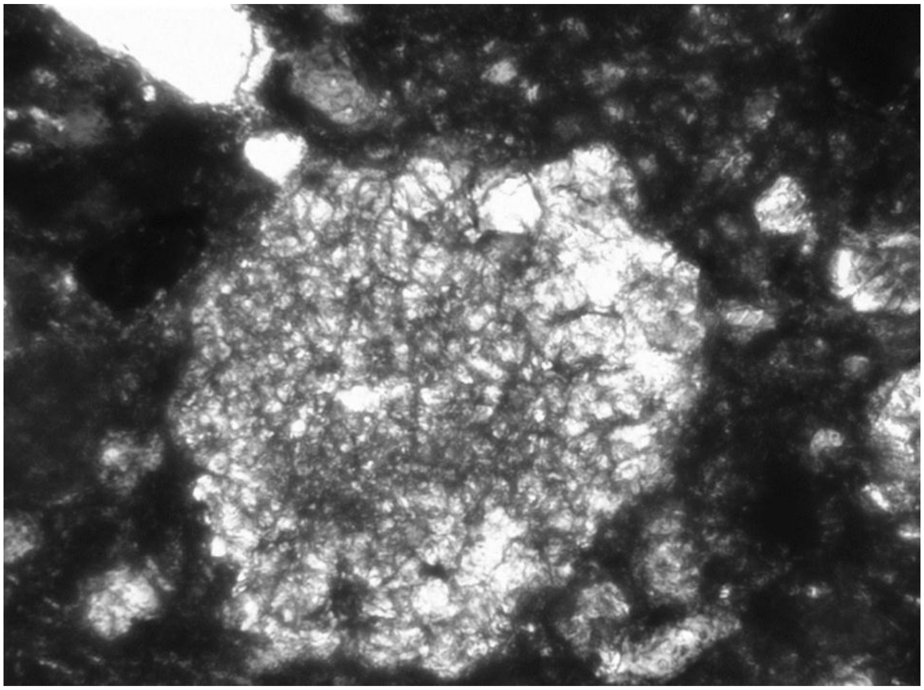

Figure 34: Miscellaneous Petrofabric (Sample 113).

Figure 35: Miscellaneous Tempered Sherd at 10x (Sample 113).

TRENDS IN TEMPER CLASSES

From the Early Postclassic to the Middle Postclassic there is both continuity and change in ceramic tempering (Table 1). With regard to continuity, for both the Early Postclassic and Middle Postclassic, the Chalky Group, Quartz Group, and Matrix Group ceramics were found in both the housemound (Suboperation 11) and workshop (Suboperation 5) contexts (Figures 36, 37, 39).

Temper Groups by Subops					
	Clear Calcite	Chalky/Quartz	Chalky Calcite	Quartz	Matrix
Early Postclassic		Subop 11	Subop 5 & 11	Subop 5 & 11	Subop 5 & 11
Middle Postclassic	Subop 5 & 11		Subop 5 & 11	Subop 5 & 11	Subop 5 & 11

Table 1: Temper Groups by Suboperations.

Regarding discontinuity, the Chalky/Quartz ceramics were consumed primarily in the Early and intermediate Postclassic in the household (Suboperation 11), with only three ceramics from this group found in a Middle Postclassic context (Figures 37 and 38). In addition to the lack of Chalky/Quartz samples in the Middle Postclassic, the main temporal change is the appearance of a new temper class, the Clear Calcite Group in the Middle Postclassic (Figures 37 and 38). In the Early Postclassic, no samples are high in crystalline calcite temper. However, this temper group is present in both suboperations in the Middle Postclassic. This change in temper, with both locations having Clear Calcite Group ceramics in the Middle Postclassic, compared with only the housemound having Chalky/Quartz Group ceramics in the Early Postclassic, could imply less differentiation between the house (Suboperation11) and the workshop (Suboperation5) in the Middle Postclassic. This change from Chalky/Quartz in the Early Postclassic to Clear Calcite in the Middle Postclassic may simply be a change from central Colha resources to Cobweb Swamp resources.

There is little correlation between fabric classes and ceramic types (Figure 39). For the most part, all ceramic forms are included in all temper classes. One exception is the intermediate period incurving forms, of which 11 out of 13 are composed of the Chalky/Quartz Group fabric, while the other two samples belong to the Chalky Calcite Group (Figure 39).

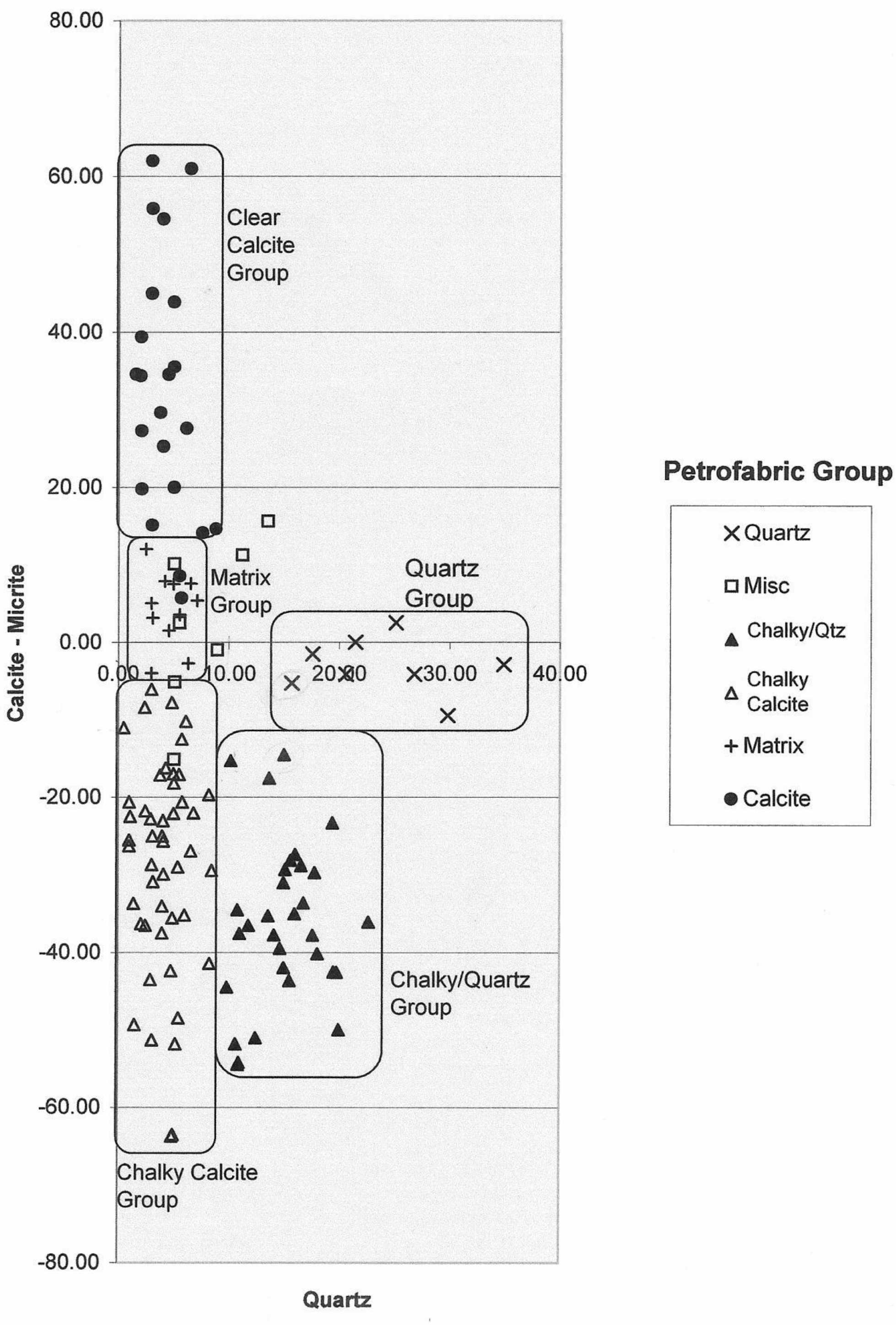

Figure 36: Mineral Inclusions by Petrofabric Group.

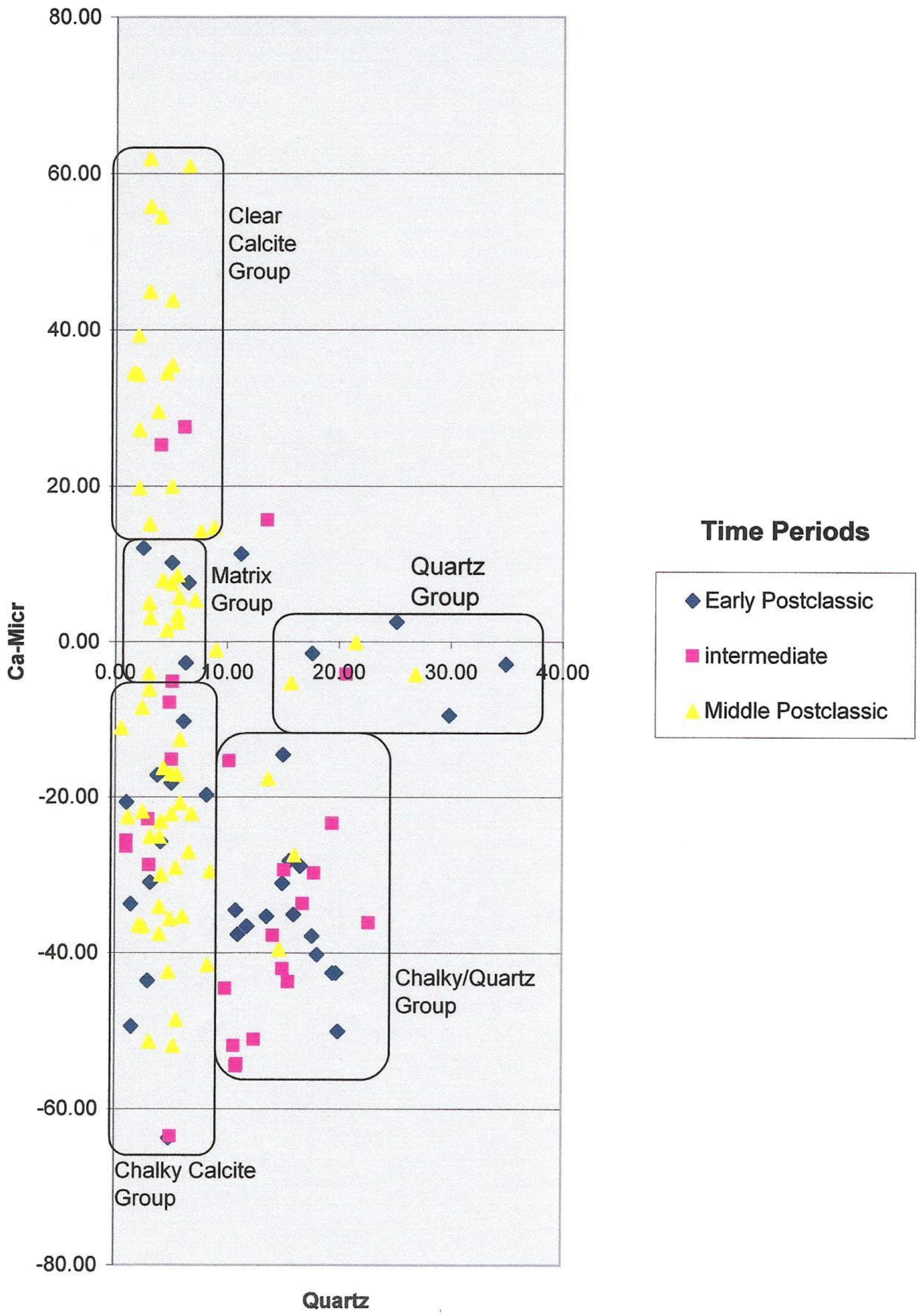

Figure 37: Mineral Inclusions by Time Period.

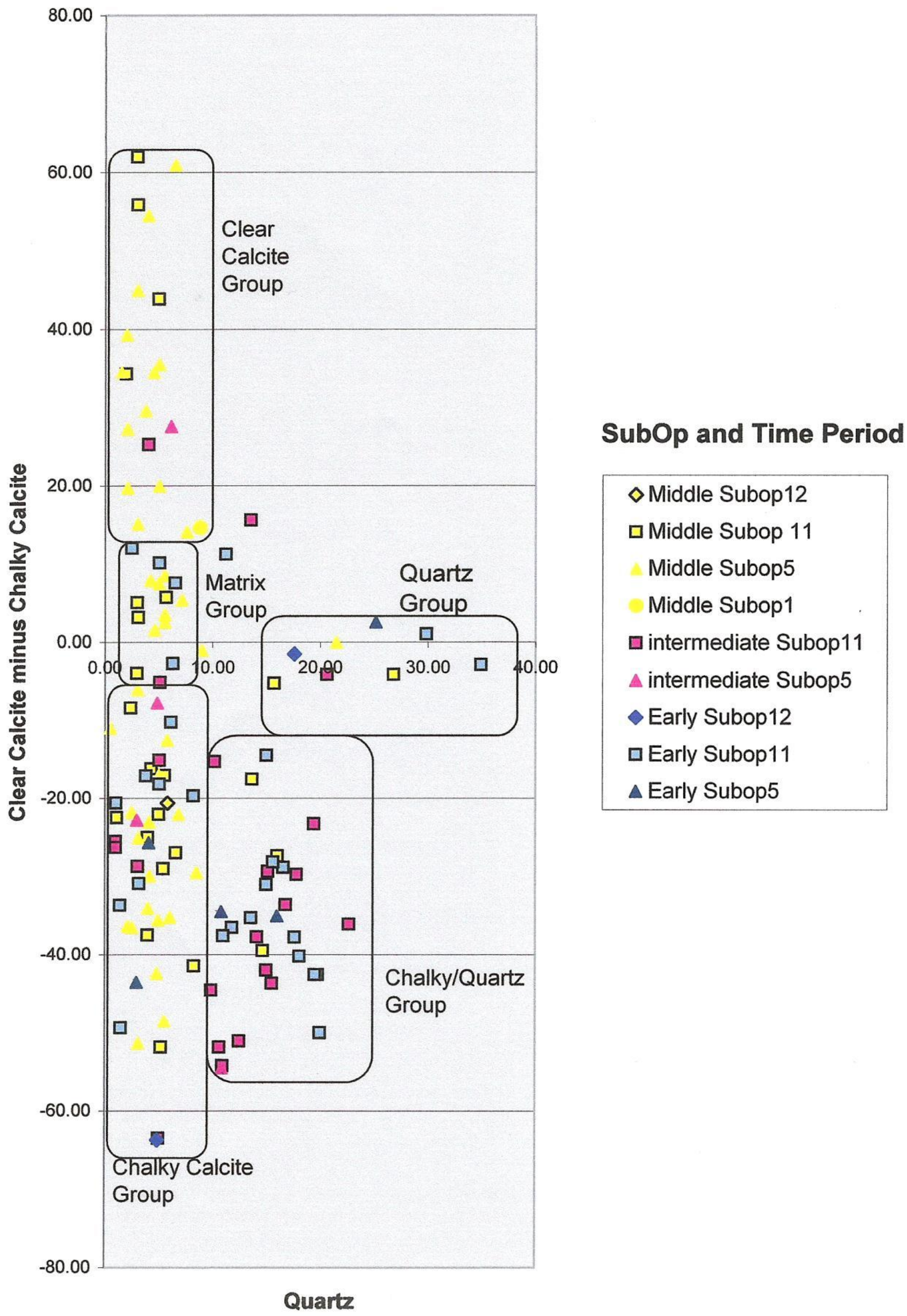

Figure 38: Mineral Inclusion by Suboperation.

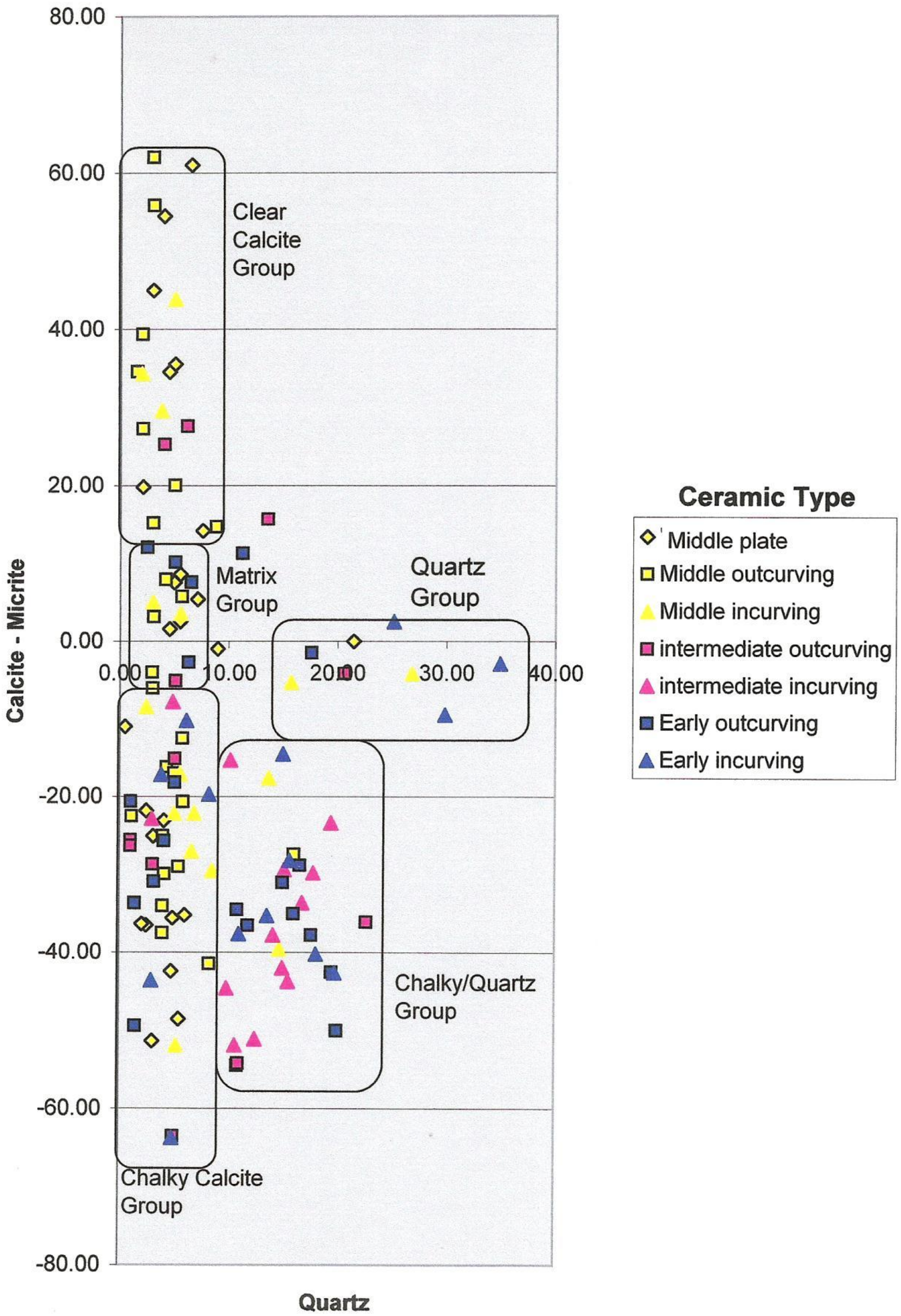

Figure 39: Mineral Inclusions by Ceramic Type.

The temper classes assigned in this study are consistent with findings at other sites within northern Belize. In the case of quartz, Jones (1986) states that quartz is rare in northern Belize, due to the limestone bedrock. She argues that quartz sand, eroded from the Maya Mountains, would be found along the Belize River, for example at Barton Ramie (Jones 1986:31). Not surprisingly, the Barton Ramie Augustine Group has been described as "calcite and scattered quartz" (Gifford 1976:291). Along these lines, Sunahara (2006) finds quartz in the ceramics of the Upper Belize River Valley sites, but these inclusions are found associated with volcanic ash, crystalline calcite, or feldspars and biotite (Sunahara 2006:93-110), rather than with chalky calcite. Wright et al. (1959) and King et al. (1992) found calcareous clays containing quartzose sand to be present in the Colha region. Howie states that quartz sand temper is present in Lamanai ceramics, and there is a source of "sandy non-calcareous clays … across the lagoon" from Lamanai (Howie 2007:13-14). In addition, Howie (2007:14) describes some tempers as sascab-quartz, which, depending on the percentage of quartz, could overlap Colha's Chalky/Quartz group (9-23 percent quartz) and/or Chalky Calcite group (less than 9 percent quartz).

At Cerros the Zakpah ceramic group of the Early Facet Kanan is described as "sand sized crystalline and non-crystalline calcite inclusions predominate" (Walker 1990:82). It seems likely these are related to Colha's Chalky temper group. The Payil group at Cerros was established at Tulum. It is defined by moderate amounts of fine calcite inclusions. Within the Clear Calcite temper group at Colha, all samples have very fine, well sorted inclusions. This seems consistent with the Payil group at Cerros and Tulum. In sum, it seems possible that Colha's Chalky group is consistent with the Zakpah group, and Colha's Clear Calcite group is consistent with the Payil group.

Summary

This chapter presented the results of the petrographic analysis, including assigning sherds to petrofabric groups, identifying trends within the groups, and comparing results with other sites. Distinguishing characteristics of each group were presented, specifically primary mineral or minerals present in each group. Graphs showed how much of each mineral type was present in the average sherd of each group (Figures 18, 21, 25, 28, 31). Photos were provided of thin-sections in transmitted, cross-polarized light (Figures 19, 22, 26, 29, 32, 34), as well as of sherds viewed through a 10x loupe (Figures 20, 23, 24, 27, 30, 33, 35). The petrofabric groups were then compared to time period, provenience, and type. The next chapter compares the results of the Colha Postclassic petrographic analysis with petrographic analyses of Preclassic and Classic studies, as well as soil and mineral studies.

Chapter 5: Changes Through Time

Previous petrographic studies of Colha ceramics have been conducted for early time periods. Reese-Taylor's (1991) study of Preclassic ceramics from Colha and Kichpanha finds ceramics to be primarily carbonate tempered. Iceland and Goldberg's (1999) study of Late-to-Terminal ceramics, also from Colha and Kichpanha, finds an increase in quartz tempering. Results of the Postclassic petrographic analysis will be compared to these earlier findings. This current study extends the temporal extent of petrographic studies at the site and compares findings across these time periods.

PRECLASSIC AND EARLY CLASSIC

Reese-Taylor (1991) describes the Preclassic samples from Colha and Kichpanha as having high percentages of fine calcite rhombs and very low percentages of quartz. Reese-Taylor's findings are consistent with Jones (1986:54-55), who finds Protoclassic specimens from northern Belize to be tempered with fine, dense calcite particles. Jones believes this type of tempering may represent an attempt to simulate volcanic ash-tempered fabrics in a region in which ash temper is not readily available. In Shepard's (1939) technological study of pottery from San Jose in the southwestern corner of the northern Belize region, crystalline calcite was found to be the most common temper in all periods represented, while quartz temper was rare.

The Early Classic ceramics of the Cobweb Complex developed directly out of the Terminal Preclassic Blossom Band Complex. There was little ceramic development during this time. Although the Cobweb Complex is functionally complete, few Early Classic deposits have been found at Colha, and these ceramics are not well represented at the site (Valdez 1987).

LATE CLASSIC

Petrographic analysis of Late-to-Terminal Colha ceramics has been conducted by Iceland and Goldberg (1999). Samples of Subin Red, Tinaja Red, Palmar Orange Polychrome, and Encanto Striated from the Masson Complex were examined. These samples were taken from several operations and areas of the site. An initial study of Late-to-Terminal Classic Subin Red sherds from Colha and Kichpanha indicates a predominance of quartz inclusions, as well as inter-site differences. Moreover, the extensive use of quartzitic clays in ceramics in northern Belize appears to represent a departure, distinctive to this region, from an earlier, widespread exploitation of fine calcareous clays. A second study of Orange Polychrome, Tinaja Red, and Encanto Striated sherds, also from the Late-to-Terminal Classic Masson Complex at Colha, further supports this pattern of using quartzitic clays for Late-to-Terminal Classic pottery at Colha (Iceland and Goldberg 1999:952). Comparisons with local clay samples suggest this new technology represents less selective use of available clay resources during this period.

Iceland and Goldberg (1999) find Subin Red and Orange Polychrome ceramics at Colha to be predominantly tempered with quartz. Tinaja Red, on the other hand, is predominantly tempered with fine calcite rhombs. Encanto Striated, the main unslipped type, varies more, but is mostly the new, quartz-tempered fabric. Micrite is present in Colha’s Late-to-Terminal sherds, but generally 11 percent or less. Two exceptions are one Subin Red sample and one Palmar Orange Polychrome plate with about 25 percent each of micrite and quartz (which would place them in the Chalky/Quartz category, as defined in the current study) (Iceland and Goldberg 1999).

Iceland and Goldberg (1999) conclude that Tinaja Red continues the carbonate-tempered tradition, while Subin Red and Palmar Orange Polychrome are predominantly quartz tempered, a new development in the Late-to-Terminal Classic northern Belize. It seems likely that the increase in quartz ceramics took place at the beginning of the Late-to-Terminal Classic, as this was a dynamic time period in many respects, although this is unclear without petrographic analysis from the intervening times. Results appear to support other lines of evidence indicating the formation of a Late-to-Terminal Classic political sphere extending from San Estevan in the north to the Northern River Lagoon site in the south (Valdez 1987). The Quartz temper at Late-to-Terminal Colha may reflect a northern Belize region tradition (Iceland and Goldberg 1999).

POSTCLASSIC

While there appears to be some overlap between Iceland and Goldberg's (1999) Late-to-Terminal groups and the Postclassic groups of this study, it is not a direct correlation. First, the samples in Late-to-Terminal quartz group have somewhat higher percentages of quartz (28-49 percent) than the samples in the current study's quartz group (15.71-34.93 percent), although this difference may be due to their using point-count and this study's using comparative charts. Their quartz group clearly makes up the majority of their sample (21 out of 25), where the current study's quartz group is one of the smallest groups (eight out of 126).

What initially seems absent from the Late-to-Terminal sample is the Clear Calcite group. They state "Carbonate inclusions include lumps of micrite (microcrystalline calcite), … fine rhomboid crystals, … and sparry calcite crystals" (Iceland and Goldberg 1999:953). It seems that their "sparry calcite crystals" correspond to the temper called Clear Calcite.

The Late-to-Terminal samples 1 (rhomb), 14 (rhomb), and 25 (rhomb) have carbonate percentages similar to the Postclassic Chalky Calcite or Clear Calcite groups. In these samples, their carbonates are all rhombs. None of the current study's crystalline calcite inclusions are rhombs, but some of the micrite inclusions are rhomboid. It is possible that their samples 1, 14, and 25 would fall into the Chalky Calcite group defined in the current study.

Regarding micrite, there appears to be a change in ceramic temper from the Late-to-Terminal Classic to the (Early and Middle) Postclassic. In the Late-to-Terminal Classic micrite is only used as a secondary inclusion. The Late-to-Terminal sample 23 falls directly into the Chalky/Quartz group (as far as percentages), but this is only one of 25 samples, in contrast to the Chalky/Quartz group making up one of the largest groups during the Early Postclassic. In addition, for both during the Early and Middle Postclassic, micrite (with little quartz) was also the main inclusion for the many ceramics of the Chalky Calcite group. One difficulty in comparing the Postclassic Chalky Calcite and Chalky/Quartz groups to the Late-to-Terminal findings is the question of how much micritic calcite was considered part of the matrix, rather than counted as inclusions. This discrepancy could explain why the micrite (chalky calcite) counts are found to be significantly higher in the Postclassic than in the Late-to-Terminal Classic.

None of the Late-to-Terminal samples match the Matrix (i.e., matrix >80 percent) group. The Late-to-Terminal study has one Palmar Orange Polychrome plate that would fit in either Chalky/Quartz or, more likely, the Miscellaneous group. Most importantly, none of their samples seem to fit well with the largest group, Chalky Calcite, with the possible exception of an overlapping fine rhomb group.

So it seems the use of micrite as a primary inclusion was new to the Postclassic, as was the Chalky/Quartz combination, with micrite being predominant. The use of Quartz was a continuation of a previous tradition (Palmar Orange Polychrome plates), and the re-introduction of Calcite (sparry) was a return to a previous tradition (some Encanto Striated jars). The Matrix category would also have been new to the Postclassic.

This chapter has summarized results from Reese-Taylor's 1991 study of Preclassic ceramics and Iceland and Goldberg's 1999 study of Late-to-Terminal Classic ceramics. Reese-Taylor reported that Preclassic ceramics were primarily tempered with fine crystalline carbonates, while Iceland and Goldberg reported Late-to-Terminal Classic ceramics showed an increase in the use of quartz temper. These findings contrast with the Postclassic results, which find the primary tempering material to be micritic calcite (called chalky calcite in this study). The Postclassic shows a decline in the use of quartz, and the Middle Postclassic shows the re-introduction of crystalline calcite as a significant temper. While this chapter examined changes through time, the next chapter will address the possibility of whether these changes are indicative of craft specialization.

Chapter 6: Specialization

Two of the goals of this dissertation are to identify any changes in production technology through time, especially increasing standardization (homogeneity and simplification); and to identify any changes in production organization through time, especially the possibility of increasing centralization. The only clear change, based on this study, is a change from Chalky/Quartz temper to monocrystalline calcite temper. This change does not necessarily reflect a change in specialization of production, but rather a change in resource procurement. The Colha Postclassic ceramic pastes are highly diverse and show little patterning in the size distribution of inclusions, which suggests a low intensity of production (Fargher 2007:326). With the exception of incurving vessels from the intermediate time periods, established styles were made with varied techniques. This suggests individual clay recipes and clay mines were used to produce similar styles. This chapter discusses standardization and further examines the possibility of standardization in the Colha Postclassic ceramic assemblage.

STANDARDIZATION

In studies of pottery production, the concepts of standardization and diversity have been used in efforts to understand specialization (Rice 1981, 1984; Toll 1981). In addressing specialized production, the premise is that a small number of skilled producers manufacturing pottery will adhere to a greater or lesser extent to principles of cost effectiveness, quality control, and mass production, leading to homogeneity or standardization of products (Rice 1987:203).

Standardization refers to a reduction of variability and has implications for production, distribution, and consumption. Standardization can be considered in terms of all aspects of the pottery manufacturing process, including resource selection, processing, forming, finishing, and firing as well as the organizational aspects (scale and mode). Highly standardized products imply that production is carried out either by individuals utilizing a limited range of materials and somewhat formalized mass production or by the use of molds. Standardization of production does not necessarily mean that only one kind of pottery is made and used in a community; it indicates, rather, that little heterogeneity in composition and appearance (form and style) is evident within each category of pottery (Rice 1987:202).

"The emergence of standardized types involve[s] a reduction in the number of forms and ceramic types, and in the amount of decoration" (Fargher 2007:317). This definition is consistent with the Valdez's (1987:212) findings that there are fewer types in the Early Postclassic, compared to the Late Classic. The Early Postclassic Yalam Complex (Zakpah group, formerly Augustine) "is a functionally complete complex though limited in the number of types represented" (Valdez 1987:212). The Middle Postclassic Canos Complex (Payil group, formerly Paxcaman) is also limited in types.

In addition to analyzing attributes of types, it is also useful to compare types with petrofabric groups (Figure 39 and Figure 40). For this study it was somewhat difficult to identify types, since no whole vessels were examined, and most of the samples were relatively small. Sherds were grouped according to incurving or outcurving, and in some cases outcurving sherds were classified as plates. Fabric groups were compared with form categories in order to infer the degrees of homogeneity and variability present in the production of types and to assess whether production technology (as inferred from fabric groups) is correlated with type or whether a single production technology is characteristic of all Colha ceramic production (Angelini 1998; Iceland and Goldberg 1999).

For the most part, the ceramics in this study do not show evidence of being standardized. There is little, if any, correlation between tempers and forms. Instead there appears to be significant variability, with each form being made with varied techniques.

The one clear exception is the intermediate Postclassic incurving vessels, which have the least variation in petrofabric, being made almost exclusively of Chalky/Quartz petrofabric (Figure 40). This correlation suggests that the makers of this ceramic type may have consistently used the same methods to produce this form of vessel.

The greatest variation is in the Early Postclassic outcurving vessels and Middle Postclassic plates. The Early Postclassic outcurving vessels include samples in the Quartz, Miscellaneous, Chalky/Quartz, Chalky Calcite, and Matrix Groups; and the Middle Postclassic plates include samples in the Quartz, Miscellaneous, Chalky Calcite, Matrix, and Clear Calcite Groups. In addition, there is no clear patterning in size distribution of inclusions, supporting the idea of low intensity of production. Based on the current study, it appears that different clay recipes and clay mines were used to produce the similar shapes.

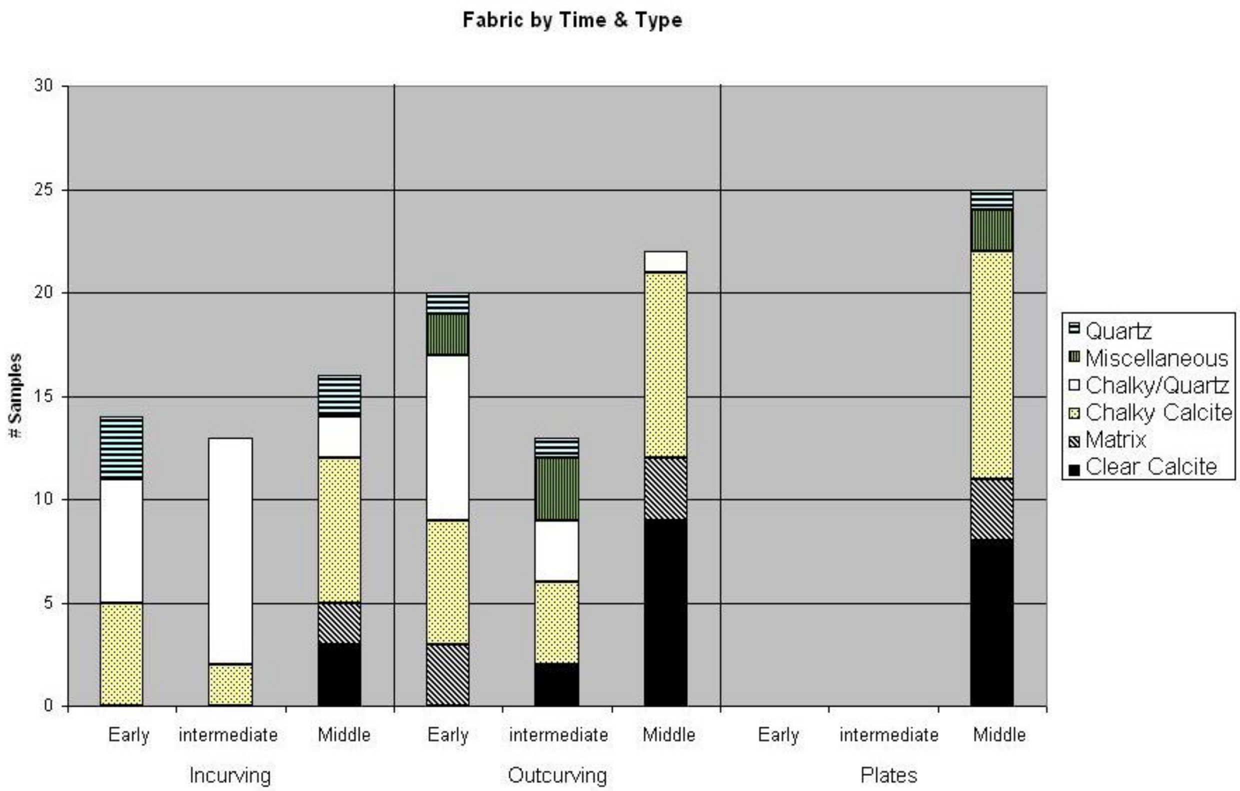

Figure 40: Fabric by Time and Form.

Variation within the petrofabric groups was also examined with the finding that there is high variability within fabric groups. For example, within the Chalky Calcite Group (Table 2), the percentage of the dominant inclusion, micritic calcite, ranges from 14.5 percent to 66.3 percent. Within the Clear Calcite Group (Table 3), the percentage of the dominant inclusion, calcite, ranges from 17.05 percent to 62.5 percent. Within the Quartz group (Table 4), the percentage of the dominant inclusion, quartz, ranges from 15.7 percent to 34.9 percent. Within the Chalky/Quartz Group (Table 5), the percentage of micrite ranges from 15.02 to 54.46, and the percentage of quartz ranges from 9.9 percent to 22.68 percent. Even where similar resources are used, i.e., within each petrofabric group, their relative percentages of inclusions are quite varied from one sample to the next.

sample#	Qtz Total	Micrite	calcite	sparry	grey micrite	micrite + gray = all micr	Carbonate	Ca minus all micr	Type	Time	SubOp	Descriptive	New Group
23	2.40	20.36	11.98	0.00	0.00	20.36	32.34	-8.38	incurving	MiddlePost	11	LotsWhite	MICRITE
3	8.29	43.52	2.07	0.26	0.00	43.52	45.85	-41.46	outcurving	MiddlePost	11	LotsWhite	MICRITE
122	2.50	42.50	6.50	0.50	0.50	43.00	50.00	-36.50	plate	MiddlePost	5	other	MICRITE
93	4.14	32.18	2.76	0.23	0.46	32.64	35.63	-29.89	outcurving	MiddlePost	5	LotsWhite	MICRITE
106	4.09	21.48	9.21	0.51	10.74	32.23	41.94	-23.02	plate	MiddlePost	5	LotsWhite	MICRITE
111	4.82	43.86	2.41	0.00	0.96	44.82	47.23	-42.41	plate	MiddlePost	5	LotsWhiteClear	MICRITE
102	6.82	26.25	5.77	1.05	1.57	27.82	34.65	-22.05	incurving	MiddlePost	5	WhiteDominant	MICRITE
121	5.50	51.50	3.50	0.50	0.50	52.00	56.00	-48.50	plate	MiddlePost	5	other	MICRITE
101	8.48	27.43	0.50	0.25	2.49	29.93	30.67	-29.43	incurving	MiddlePost	5	WhiteDominant	MICRITE
104	6.03	35.18	3.02	0.25	3.02	38.19	41.46	-35.18	plate	MiddlePost	5	LotsWhite	MICRITE
91	4.90	63.73	0.25	0.00	0.25	63.97	64.22	-63.73	incurving	EarlyPost	12	LotsWhiteClear	MICRITE
2	4.00	41.00	3.50	0.25	0.00	41.00	44.75	-37.50	outcurving	MiddlePost	11	LotsWhite	MICRITE
81	5.01	65.74	2.79	0.28	0.56	66.30	69.36	-63.51	outcurving	intermediate	11	LotsWhite	MICRITE
17	5.43	31.67	2.71	0.45	0.00	31.67	34.84	-28.96	outcurving	MiddlePost	11	GrayDominant	MICRITE
12	1.12	28.09	5.62	1.12	0.00	28.09	34.83	-22.47	outcurving	MiddlePost	11	WhiteDominant	MICRITE
31	6.59	27.47	0.55	0.00	0.00	27.47	28.02	-26.92	incurving	MiddlePost	11	White w/ Gray	MICRITE
11	4.32	21.62	5.41	0.54	0.00	21.62	27.57	-16.22	outcurving	MiddlePost	11	WhiteDominant	MICRITE
42	6.12	18.37	8.16	7.14	0.00	18.37	33.67	-10.20	incurving	EarlyPost	11	GrayDominant	MICRITE
90	5.82	23.81	8.99	0.53	5.82	29.63	39.15	-20.63	outcurving	MiddlePost	12	White w/ Gray	MICRITE
110	4.94	38.52	3.95	0.00	0.99	39.51	43.46	-35.56	plate	MiddlePost	5	LotsWhiteClear	MICRITE
97	2.11	39.47	4.74	1.05	1.58	41.05	46.84	-36.32	plate	MiddlePost	5	WhiteDominant	MICRITE
32	5.24	52.36	0.52	0.00	0.00	52.36	52.88	-51.83	incurving	MiddlePost	11	GrayDominant	MICRITE
124	0.50	5.00	5.00	1.00	11.00	16.00	22.00	-11.00	plate	MiddlePost	5	other	MICRITE
52	3.19	31.91	1.06	0.53	0.00	31.91	33.51	-30.85	outcurving	EarlyPost	11	GrayDominant	MICRITE
22	5.53	26.63	9.55	0.25	0.00	26.63	36.43	-17.09	incurving	MiddlePost	11	LotsWhite	MICRITE
43	1.52	53.16	4.05	2.03	0.25	53.42	59.49	-49.37	outcurving	EarlyPost	11	LotsWhite	MICRITE
44	1.44	36.06	2.40	0.96	0.00	36.06	39.42	-33.65	outcurving	EarlyPost	11	LotsWhite	MICRITE
126	2.97	49.50	5.94	0.99	0.00	49.50	56.44	-43.56	incurving	EarlyPost	5	WhiteOnly	MICRITE
94	3.02	12.08	8.46	1.81	2.42	14.50	24.77	-6.04	outcurving	MiddlePost	5	ClearDominant	MICRITE
1	4.00	34.00	9.00	6.00	0.00	34.00	49.00	-25.00	outcurving	MiddlePost	11	LotsWhite	MICRITE
38	3.81	22.86	5.71	4.76	0.00	22.86	33.33	-17.14	incurving	EarlyPost	11	ClearDominant	MICRITE
105	2.48	29.70	11.88	0.99	3.96	33.66	46.53	-21.78	plate	MiddlePost	5	LotsWhite	MICRITE
61	1.03	25.77	5.15	5.15	0.00	25.77	36.08	-20.62	outcurving	EarlyPost	11	other	MICRITE

Table 2: Chalky Calcite Group Data; Note that micrite and gray micrite are totaled in the seventh column, and the term micrite is used to indicate chalky calcite in Tables 2-6.

sample#	Qtz Total	Micrite	calcite	sparry	grey micrite	micrite + gray = all micr	Carbonate	Ca minus all micr	Type	Time	SubGp	Descriptive	New Group
62	5.05	20.20	4.04	0.00	2.02	22.22	26.26	-18.18	outcurving	EarlyPost	11	other	MICRITE
56	8.21	32.00	12.31	0.51	0.00	32.00	44.82	-19.69	incurving	EarlyPost	11	other	MICRITE
130	4.10	30.77	5.13	0.00	0.00	30.77	35.90	-25.64	outcurving	EarlyPost	5	White w/ Gray	MICRITE
72	1.02	35.71	10.20	4.08	0.00	35.71	50.00	-25.51	outcurving	intermediate	11	other	MICRITE
83	3.07	0.00	3.58	5.63	32.23	32.23	41.43	-28.64	outcurving	intermediate	11	ClearDominant	MICRITE
144	1.01	30.30	4.04	3.03	0.00	30.30	37.37	-26.26	outcurving	intermediate	11	other	MICRITE
132	2.97	34.65	11.88	0.00	0.00	34.65	46.53	-22.77	incurving	intermediate	5	other	MICRITE
133	4.85	19.42	11.65	0.00	0.00	19.42	31.07	-7.77	incurving	intermediate	5	other	MICRITE
143	3.11	51.81	0.52	0.00	0.00	51.81	52.33	-51.30	plate	MiddlePost	5	LotsWhite	MICRITE
141	3.13	26.04	1.04	0.00	0.00	26.04	27.08	-25.00	plate	MiddlePost	5	WhiteDominant	MICRITE
139	4.00	35.00	1.00	2.00	0.00	35.00	38.00	-34.00	outcurving	MiddlePost	5	other	MICRITE
137	5.77	24.04	11.54	0.96	0.00	24.04	36.54	-12.50	outcurving	MiddlePost	5	White w/ Gray	MICRITE
146	5.00	20.00	3.00	0.00	0.00	20.00	23.00	-17.00	outcurving	MiddlePost	5	WhiteDominant	MICRITE
30	5.02	30.12	8.03	3.01	0.00	30.12	41.16	-22.09	incurving	MiddlePost	11	White w/ Gray	MICRITE

Table 2: Chalky Calcite (continued).

New Group	Descriptive	SubOp	Time	Type	Ca minus all micr	Carbonate	micrite + grag = all micr	greg micrite	sparry	calcite	Micrite	Qtz Total	sample#
MATRIX	GrayDominant	11	EarlyPost	outcurving	-2.70	6.31	4.50	0.00	0.00	1.80	4.50	6.31	51
MATRIX	ClearDominant	11	EarlyPost	outcurving	7.54	9.80	1.01	0.00	0.25	8.54	1.01	6.53	46
MATRIX	ClearDominant	11	EarlyPost	outcurving	12.00	13.00	0.50	0.00	0.00	12.50	0.50	2.50	47
MATRIX	ClearDominant	5	MiddlePost	plate	7.48	12.72	2.49	2.49	0.25	9.98	0.00	4.99	108
MATRIX	ClearDominant	5	MiddlePost	plate	5.34	14.25	4.33	4.07	0.25	9.67	0.25	7.12	109
MATRIX	other	5	MiddlePost	plate	1.52	13.96	6.09	6.09	0.25	7.61	0.00	4.57	112
MATRIX	ClearDominant	11	MiddlePost	outcurving	-3.98	15.92	9.95	0.00	0.00	5.97	9.95	2.99	8
MATRIX	ClearDominant	11	MiddlePost	outcurving	3.11	16.06	6.22	0.00	0.52	9.33	6.22	3.11	7
MATRIX	ClearDominant	5	MiddlePost	outcurving	7.87	15.49	3.67	3.67	0.26	11.55	0.00	4.20	95
MATRIX	ClearDominant	5	MiddlePost	incurving	3.53	6.80	1.51	1.51	0.25	5.04	0.00	5.54	100
MATRIX	other	11	MiddlePost	incurving	5.00	18.00	5.00	0.00	3.00	10.00	5.00	3.00	33
CALCITE	other	5	MiddlePost	plate	61.00	64.50	1.50	1.50	0.50	62.50	0.00	6.50	116
CALCITE	GrayDominant	11	MiddlePost	outcurving	62.00	64.00	0.00	0.00	2.00	62.00	0.00	3.00	15
CALCITE	ClearDominant	11	MiddlePost	outcurving	55.84	56.85	0.00	0.00	1.02	55.84	0.00	3.05	5
CALCITE	other	5	MiddlePost	plate	54.50	56.00	0.50	0.00	0.50	55.00	0.50	4.00	119
CALCITE	other	11	MiddlePost	incurving	43.89	57.11	5.99	0.00	1.25	49.88	5.99	4.99	34
CALCITE	other	5	MiddlePost	plate	45.00	49.50	2.00	2.00	0.50	47.00	0.00	3.00	120
CALCITE	other	5	MiddlePost	outcurving	39.35	42.86	0.75	0.75	2.01	40.10	0.00	2.01	99
CALCITE	ClearDominant	11	MiddlePost	incurving	34.31	45.10	4.90	4.90	0.98	39.22	0.00	1.96	26
CALCITE	other	5	MiddlePost	plate	34.50	43.00	4.00	1.50	0.50	38.50	2.50	4.50	115
CALCITE	other	5	MiddlePost	plate	35.50	40.50	2.00	1.00	1.00	37.50	1.00	5.00	117
CALCITE	WhiteDominant	5	MiddlePost	outcurving	34.54	40.21	1.55	1.55	2.58	36.08	0.00	1.55	96
CALCITE	other	11	intermediate	outcurving	25.25	45.45	10.10	0.00	0.00	35.35	10.10	4.04	145
CALCITE	other	5	intermediate	outcurving	27.55	35.71	3.06	0.00	2.04	30.61	3.06	6.12	135
CALCITE	other	5	MiddlePost	incurving	29.58	34.74	0.94	0.94	3.29	30.52	0.00	3.76	103
CALCITE	WhiteDominant	5	MiddlePost	outcurving	15.15	45.45	15.15	0.00	0.00	30.30	15.15	3.03	138
CALCITE	other	5	MiddlePost	outcurving	20.00	40.00	10.00	0.00	0.00	30.00	10.00	5.00	140
CALCITE	other	5	MiddlePost	outcurving	27.25	31.88	1.03	1.03	2.57	28.28	0.00	2.06	98
CALCITE	other	1	MiddlePost	outcurving	14.67	41.56	12.22	3.91	2.44	26.89	8.31	8.80	84
CALCITE	ClearDominant	5	MiddlePost	plate	19.79	32.29	6.25	0.00	0.00	26.04	6.25	2.08	142
CALCITE	other	5	MiddlePost	plate	14.14	31.31	8.59	2.53	0.00	22.73	6.06	7.58	118
CALCITE	other	5	MiddlePost	plate	8.54	39.70	14.07	10.55	3.02	22.61	3.52	5.53	123
CALCITE	WhiteDominant	11	MiddlePost	outcurving	5.68	29.55	11.36	0.00	1.14	17.05	11.36	5.68	13

Table 3: Matrix and Clear Calcite Group Data.

sample#	Qtz Total	Micrite	calcite	sparry	grey micrite	micrite + gray = all micr	Carbonate	Ca minus all micr	Type	Time	SubOp	Descriptive	New Group
54	29.85	9.95	0.50	0.00	0.00	9.95	10.45	1.00	incurving	EarlyPost	11	ClearDominant	QUARTZ
92	17.59	0.00	1.51	0.25	3.02	3.02	4.77	-1.51	outcurving	EarlyPost	12	ClearDominant	QUARTZ
40	34.93	2.99	0.10	0.00	0.00	2.99	3.09	-2.89	incurving	EarlyPost	11	ClearDominant	QUARTZ
125	25.13	0.00	3.02	0.00	0.50	0.50	3.52	2.51	incurving	EarlyPost	5	ClearDominant	QUARTZ
68	20.62	0.00	4.12	0.00	8.25	8.25	12.37	-4.12	outcurving	intermediate	11	ClearDominant	QUARTZ
107	21.47	0.56	3.95	0.00	3.39	3.95	7.91	0.00	plate	MiddlePost	5	ClearDominant	QUARTZ
27	15.71	8.38	3.14	0.00	0.00	8.38	11.52	-5.24	incurving	MiddlePost	11	ClearDominant	QUARTZ
24	26.80	6.19	2.06	0.00	0.00	6.19	8.25	-4.12	incurving	MiddlePost	11	ClearDominant	QUARTZ
45	11.24	2.25	13.48	1.12	0.00	2.25	16.85	11.24	outcurving	EarlyPost	11	ClearDominant	MISC
69	13.54	0.00	15.63	0.00	0.00	0.00	15.63	15.63	outcurving	intermediate	11	ClearDominant	MISC
60	5.05	0.00	30.30	0.00	20.20	20.20	50.51	10.10	outcurving	EarlyPost	11	White w/ Gray	MISC
70	5.10	10.20	20.41	0.00	15.31	25.51	45.92	-5.10	outcurving	intermediate	11	White w/ Gray	MISC
71	5.05	30.30	15.15	0.00	0.00	30.30	45.45	-15.15	outcurving	intermediate	11	White w/ Gray	MISC
113	8.98	1.00	8.48	8.98	8.48	9.48	26.93	-1.00	plate	MiddlePost	5	other	MISC
114	5.54	1.51	6.55	17.63	2.52	4.03	28.21	2.52	plate	MiddlePost	5	other	MISC

Table 4: Quartz Group and Miscellaneous Group Data.

sample#	Qtz Total	Micrite	calcite	sparry	grey micrite	micrite + gray = all micr	Carbonate	Ca minus all micr	Type	Time	SubOp	Descriptive	New Group
58	20.00	50.00	0.00	0.00	0.00	50.00	50.00	-50.00	outcurving	EarlyPost	11	LotsWhiteClear	MicrQtz
55	19.80	7.92	0.00	0.00	34.65	42.57	42.57	-42.57	incurving	EarlyPost	11	LotsWhiteClear	MicrQtz
59	11.85	36.53	0.00	0.00	0.00	36.53	36.53	-36.53	outcurving	EarlyPost	11	LotsWhiteClear	MicrQtz
57	15.00	1.00	0.00	0.00	30.00	31.00	31.00	-31.00	outcurving	EarlyPost	11	ClearDominant	MicrQtz
63	16.59	0.00	0.49	0.00	29.27	29.27	29.76	-28.78	outcurving	EarlyPost	11	other	MicrQtz
53	15.63	4.17	2.08	0.00	26.04	30.21	32.29	-28.13	incurving	EarlyPost	11	ClearDominant	MicrQtz
48	19.53	42.56	0.00	0.25	0.00	42.56	42.81	-42.56	outcurving	EarlyPost	11	LotsWhiteClear	MicrQtz
49	17.63	37.78	0.00	0.00	0.00	37.78	37.78	-37.78	outcurving	EarlyPost	11	LotsWhiteClear	MicrQtz
37	11.03	39.10	1.50	0.25	0.00	39.10	40.85	-37.59	incurving	EarlyPost	11	LotsWhite	MicrQtz
36	18.09	40.20	0.00	0.00	0.00	40.20	40.20	-40.20	incurving	EarlyPost	11	LotsWhite	MicrQtz
129	16.00	35.00	0.00	0.00	0.00	35.00	35.00	-35.00	outcurving	EarlyPost	5	LotsWhiteClear	MicrQtz
128	10.84	34.48	0.00	0.00	0.00	34.48	34.48	-34.48	outcurving	EarlyPost	5	LotsWhiteClear	MicrQtz
35	13.60	35.26	0.00	0.00	0.00	35.26	35.26	-35.26	incurving	EarlyPost	11	LotsWhite	MicrQtz
39	15.02	15.02	0.50	0.10	0.00	15.02	15.62	-14.51	incurving	EarlyPost	11	ClearDominant	MicrQtz
78	15.02	31.91	0.23	0.00	10.32	42.23	42.47	-42.00	incurving	intermediate	11	LotsWhiteClear	MicrQtz
80	10.68	51.04	0.26	0.00	1.04	52.08	52.34	-51.82	incurving	intermediate	11	other	MicrQtz
131	10.89	54.46	0.00	0.00	0.00	54.46	54.46	-54.46	outcurving	intermediate	5	LotsWhiteClear	MicrQtz
82	10.97	0.00	0.00	0.00	54.19	54.19	54.19	-54.19	outcurving	intermediate	11	ClearDominant	MicrQtz
67	22.68	0.00	0.00	0.00	36.08	36.08	36.08	-36.08	outcurving	intermediate	11	LotsWhite	MicrQtz
79	16.80	31.50	0.00	0.00	2.10	33.60	33.60	-33.60	incurving	intermediate	11	other	MicrQtz
77	15.53	43.69	0.00	0.00	0.00	43.69	43.69	-43.69	incurving	intermediate	11	LotsWhiteClear	MicrQtz
76	17.82	29.70	0.00	0.00	0.00	29.70	29.70	-29.70	incurving	intermediate	11	LotsWhiteClear	MicrQtz
73	19.42	24.27	0.97	0.00	0.00	24.27	25.24	-23.30	incurving	intermediate	11	ClearDominant	MicrQtz
66	12.50	0.00	1.04	0.00	52.08	52.08	53.13	-51.04	incurving	intermediate	11	other	MicrQtz
64	9.90	0.00	0.00	0.00	44.55	44.55	44.55	-44.55	incurving	intermediate	11	GrayDominant	MicrQtz
65	14.15	0.00	0.00	0.00	37.74	37.74	37.74	-37.74	incurving	intermediate	11	GrayDominant	MicrQtz
74	15.15	0.00	1.01	0.00	30.30	30.30	31.31	-29.29	incurving	intermediate	11	ClearDominant	MicrQtz
75	10.20	15.31	0.00	0.00	0.00	15.31	15.31	-15.31	incurving	intermediate	11	ClearDominant	MicrQtz
29	14.68	40.51	1.01	3.04	0.00	40.51	44.56	-39.49	incurving	MiddlePost	11	LotsWhiteClear	MicrQtz
28	13.67	21.48	3.91	0.49	0.00	21.48	25.88	-17.58	incurving	MiddlePost	11	LotsWhiteClear	MicrQtz
18	16.04	28.30	0.94	0.00	0.00	28.30	29.25	-27.36	outcurving	MiddlePost	11	GrayDominant	MicrQtz

Table 5: Chalky/Quartz Group Data.

One petrofabric group with signs of standardization is the Clear Calcite Group. These ceramics have fine crystalline inclusions that are described in other studies, at both Colha (Reese-Taylor 1991) and other Belize sites, such as the Upper Belize Valley (Sunahara 2003) and Cerros in northern Belize (Walker 1990). This petrofabric group, however, includes both incurving and outcurving vessels.

FABRIC GROUPS VS CONTEXT

Fabric groups were compared to context in order to assess whether differences in ceramic production technology and ceramic consumption are correlated. Depositional context may signal the social value of an artifact, which aids in identifying the means by which it was exchanged (Knapp and Cherry 1994:146). For example, artifacts occurring in a limited range of archaeological contexts (e.g. burials) provide evidence for gift exchange (Knapp and Cherry 1994:147). On the other hand, when there is widespread distribution of the artifact in households, and access to an artifact type is not restricted to high-status households or elite centers, it suggests that access to the artifact may have been determined by market exchange and not by status or kinship affiliation (West 2002).

In addition to the suggested standardization of intermediate incurving vessels, the Chalky/Quartz Group is significant for another reason. There is a correlation of Chalky/Quartz Group with Suboperation 11 (and multiple types) in the Early Postclassic, and this may suggest a correlation to household use specifically. In contrast, all the plate forms were found in the Middle Postclassic context in Suboperation 5 (Table 6), the workshop. This correlation could imply a function related to the lithic workshop. These plates, however, belong to all five of the Middle Postclassic petrofabric groups, suggesting that manufacture was not standardized.

sample#	Qtz Total	Micrite	calcite	sparry	greg micrite	micrite + greg = all micr	Carbonate	Ca minus all micr	Type	Time	SubOp	Descriptive	New Group
122	2.50	42.50	6.50	0.50	0.50	43.00	50.00	-36.50	plate	MiddlePost	5	other	MICRITE
106	4.09	21.48	9.21	0.51	10.74	32.23	41.94	-23.02	plate	MiddlePost	5	LotsWhite	MICRITE
111	4.82	43.86	2.41	0.00	0.96	44.82	47.23	-42.41	plate	MiddlePost	5	LotsWhiteClear	MICRITE
121	5.50	51.50	3.50	0.50	0.50	52.00	56.00	-48.50	plate	MiddlePost	5	other	MICRITE
104	6.03	35.18	3.02	0.25	3.02	38.19	41.46	-35.18	plate	MiddlePost	5	LotsWhite	MICRITE
110	4.94	38.52	3.95	0.00	0.99	39.51	43.46	-35.56	plate	MiddlePost	5	LotsWhiteClear	MICRITE
97	2.11	39.47	4.74	1.05	1.58	41.05	46.84	-36.32	plate	MiddlePost	5	WhiteDominant	MICRITE
124	0.50	5.00	5.00	1.00	11.00	16.00	22.00	-11.00	plate	MiddlePost	5	other	MICRITE
105	2.48	29.70	11.88	0.99	3.96	33.66	46.53	-21.78	plate	MiddlePost	5	LotsWhite	MICRITE
143	3.11	51.81	0.52	0.00	0.00	51.81	52.33	-51.30	plate	MiddlePost	5	LotsWhite	MICRITE
141	3.13	26.04	1.04	0.00	0.00	26.04	27.08	-25.00	plate	MiddlePost	5	WhiteDominant	MICRITE
107	21.47	0.56	3.95	0.00	3.39	3.95	7.91	0.00	plate	MiddlePost	5	ClearDominant	QUARTZ
113	8.98	1.00	8.48	8.98	8.48	9.48	26.93	-1.00	plate	MiddlePost	5	other	MISC
114	5.54	1.51	6.55	17.63	2.52	4.03	28.21	2.52	plate	MiddlePost	5	other	MISC
108	4.99	0.00	9.98	0.25	2.49	2.49	12.72	7.48	plate	MiddlePost	5	ClearDominant	MATRIX
109	7.12	0.25	9.67	0.25	4.07	4.33	14.25	5.34	plate	MiddlePost	5	ClearDominant	MATRIX
112	4.57	0.00	7.61	0.25	6.09	6.09	13.96	1.52	plate	MiddlePost	5	other	MATRIX
116	6.50	0.00	62.50	0.50	1.50	1.50	64.50	61.00	plate	MiddlePost	5	other	CALCITE
119	4.00	0.50	55.00	0.50	0.00	0.50	56.00	54.50	plate	MiddlePost	5	other	CALCITE
120	3.00	0.00	47.00	0.50	2.00	2.00	49.50	45.00	plate	MiddlePost	5	other	CALCITE
115	4.50	2.50	38.50	0.50	1.50	4.00	43.00	34.50	plate	MiddlePost	5	other	CALCITE
117	5.00	1.00	37.50	1.00	1.00	2.00	40.50	35.50	plate	MiddlePost	5	other	CALCITE
142	2.08	6.25	26.04	0.00	0.00	6.25	32.29	19.79	plate	MiddlePost	5	ClearDominant	CALCITE
118	7.58	6.06	22.73	0.00	2.53	8.59	31.31	14.14	plate	MiddlePost	5	other	CALCITE
123	5.53	3.52	22.61	3.02	10.55	14.07	39.70	8.54	plate	MiddlePost	5	other	CALCITE

Table 6: Data for Plate Forms.

This chapter has examined criteria for determining specialization and compared these to the petrofabric groups in this study. In general, the ceramics show much variation within petrofabric groups and within types, with a few exceptions. In addition to the question of whether the ceramics were manufactured through specialized production, there is the question of whether they were produced locally or imported. Soil studies to help address this question are discussed in the next chapter.

Chapter 7: Soil and Minerals

One factor in assessing the production location of ceramics is to address whether the ceramics could have been made of local materials. A comparison of ceramic tempers with locally available resources can indicate whether local production was likely. Towards the goal of assessing whether the Colha ceramics were made locally or imported, their petrographic compositions were compared with raw materials, such as local clay resources and possible sources of temper. For provenience studies of coarse-textured and tempered pottery, petrographic analysis (as opposed to chemical analysis) is sometimes sufficient to determine the region of resource procurement and hence manufacture (Peacock 1970; Shepard 1942, 1965), because mineral inclusions may be distributed enough that a particular geological location can be identified. Findings from the thin-section analysis of Colha sherds were compared with soils that have been previously collected and analyzed (Angelini 1998; Iceland 1997; Iceland and Goldberg 1999:957-8; King et al. 1992; and Wright et al. 1959). The results of these analyses are summarized in the "Local Soils" section below. In addition, qualities of the relevant mineral inclusions, specifically quartz and carbonates, will be discussed. Finally, possible reasons for the change in temper from Chalky/Quartz in the Early Postclassic to Clear Calcite in the Middle Postclassic will be suggested.

LOCAL SOILS

A number of previous petrographic analyses are relevant to the current project, including Angelini (1998) and Iceland and Goldberg (1999). Both Angelini (1998) and Iceland and Goldberg (1999) collected and analyzed raw materials local to Colha. Angelini collected and analyzed 143 clay samples, primarily from the K'axob area, but also "from fields, aguadas, and streams near the sites of Colha, Cuello, Nohmul, San Estevan, Lamanai, and Altun Ha" (Angelini 1998:75, 119, Appendix A and B). Forty-four rock samples were also collected (Angelini 1998:75, 123, Appendix C).

Iceland and Goldberg (1999) collected samples from the soil profiles of two adjacent 2x2m units that are part of a series of off-mound units excavated to bedrock in the southeastern quadrant of Colha (Op. 4046). From these samples, they made and analyzed 15 thin sections (Iceland 1997, Iceland and Goldberg 1999). They also relied on Alcala-Herrera et al.'s (1994) analysis of a core taken from Cobweb Swamp, adjacent to the Colha site (Iceland and Goldberg 1999).

Both Angelini's (1998) and Iceland and Goldberg's (1999) studies rely on data collected by King et al. (1992), a land resource assessment of northern Belize, which is a refinement of the work of the Wright et al. (1959) geological survey of Belize. King et al. (1992) is an extensive soil and land use survey of the northern Belize area, which revealed a number of different soil types in the Colha region. Angelini includes a map of where she and King et al. (1992) took samples and what types of soils were found (Angelini 1998:74-85). The principal soil types and summary descriptions are presented in Iceland and Goldberg (1999). Furthermore, Baillie et al. (1993) is a revision of King et al. (1992) The Colha ceramics are consistent with Colha soils, meaning the pottery could have been produced locally.

While much of the Maya lowlands contains sources of calcite, micritic calcite, and quartz, there are no known natural sources of volcanic ash in the region. Some sites, such as Lamanai have found ceramics with volcanic ash as an inclusion and concluded that these ceramics are likely imported. This would perhaps be the most obvious inclusion for identifying vessels that were likely imported. For the current study, no volcanic ash was identified in any samples (Sunahara 2006).

Quartz in Local Soils

Iceland and Goldberg's (1999) study involved examining 15 thin-sections using point counting. "While samples taken from just above marl bedrock were found to contain relatively low proportions of quartz (0-8 percent), all higher levels contained substantially higher amounts, frequently over 30 percent" (Iceland and Goldberg 1999:956). Quartz grain sizes in these soils range up to 2 mm, similar to the largest particles found in the Late-to-Terminal Classic pottery, and larger than the particles found in the Colha Postclassic sample. These findings indicate the presence of at least one readily available source of quartz-rich soil. This source also includes hematite concretions, micritic marl, and chert.

All the soil types found in the Colha and Kichpanha area by the King et al. (1992) survey are generally calcareous with varying amounts of quartz. In addition the soil in the immediate surroundings of Colha, specifically the soils examined in the Iceland and Goldberg study (1999), fall into the Jobo Subsuite, BH and BJ, which "is noteworthy for its siliceous character and the occurrence of iron and manganese concretions" (Iceland and Goldberg 1999:957). This subsuite is part of the Altun Ha Suite.

Baillie et al. (1993) describes the soils of the Altun Ha Suite as "derived from the flinty siliceous Late Tertiary limestones of northern Belize District and small areas in neighbouring parts of Orange Walk and Corozal Districts. They are divided into two subsuites" (Table 7).

Subsuite	Distinctive features and environment	Detailed description (LRA report)*	Profile descriptions and analyses (LRA report)*
Jobo	Dark greyish or brownish loams and clays with or without flintstones, over grey and brown stony clay, over hard flinty limestone	NB 1992	OZ 22, OZ 25 OZ 49, OZ 55 OZ 56, OZ 57 OZ 58 (NB 1992)
Rockstone	Greyish or brownish stony sandy loam or loamy sand over grey very stony sandy loam or sandy clay over flinty limestone	NB 1992	OZ 89 (NB 1992)

* LRA report: NB 1992 = King *et al.*, 1992

Table 7: Subsuites in Altun Ha Suite (from Baillie et al. 1993).

Baillie et al. (1993) describe the Jobo Subsuite in more detail, as follows:

Jobo Subsuite (Cambisol, Luvisol; Eutropept, Udalf) is the more extensive and important. It is morphologically variable with fine earth textures from loam to clay, and colours from gray through brown to reddish brown. Consistent features are an increase in clay content with depth and the presence of flints. The flints may be concentrated, on the surface or as a subsoil stoneline, or may be scattered throughout the profile. A common position is as a stone line overlying the limestone. This is usually fairly shallow, between 50 and 100 cm. It differs from most other limestones in northern Belize in being microcrystalline and hard, fracturing to give hard planar or subconchoidal faces. It tends to form a thick carapace of hard rock over the slightly weathered material beneath. The competence of this carapace gives rise to the 'pitted plain' appearance of this landscape, with numerous small solution holes and hollows, surrounded by rims of hard intact rock.

As in the other limestone soils, there is a tendency to deeper and slightly imperfectly drained profiles on the margins of larger swamps and in other accumulation sites. These deeper soils have pale coloured lower horizons

> with moderate blocky structures and weak or moderate mottling, but gypsum is rare (Baillie et al. 1993).

In sum, these soil studies mentioned in this section indicate that plenty of quartz is available in Colha area, especially in the immediate surroundings of Colha. More importantly, this locally available quartz indicates that quartz tempered ceramics could have been made locally and supports the possibility that ceramics tempered with quartz and chalky calcite could have been made locally.

Carbonates in Local Soils

Regarding the carbonate component of the ceramics, the components of both Clear Calcite and Chalky Calcite Groups are consistent with the soils of Colha and surrounding areas. Micrite is quite abundant in the local Colha soils (Iceland and Goldberg 1999). The fine clear calcite may be weathered from marble, however, fine euhedral calcite crystals make up to 80 percent of the carbonate layers from a core taken from Cobweb Swamp, likely to have resulted from in situ precipitation (Alcala-Herrera et al. 1994). In addition to the presence of chalky calcite and clear calcite, the sparry calcite found in small percentages in the current study is consistent with the local geology (Iceland and Goldberg 1999).

Comparison of Local Soils to Colha Postclassic Ceramics

Based on Reese-Taylor (1991), Iceland and Goldberg (1999), and Alcala-Herrera et al.'s (1994) findings, it is entirely possible that all ceramics in the current study were made from resources at Colha or the surrounding area. It is possible that all ceramics were made locally, based on available local resources, i.e. quartz, calcite, and micrite. The fine rhombs are consistent with Preclassic ceramics. The quartz inclusions are consistent with Late Terminal ceramics. There are also calcite ceramics consumed in the Late Terminal Classic.

Soil studies have similar constituents as the quartz-tempered pottery, including frequent coarse micritic inclusions, ferruginous concretions and chert fragments in a calcareous clay matrix. Wright et al. (1959) and King et al. (1992) also found "calcareous clays containing quartzose sands characteristic of soils in the Colha region, there is little doubt that the coarse natural clays used in the production of this quartz-tempered pottery received minimal processing before they were worked into often elegantly and elaborately decorated vessels" (Iceland and Goldberg 1999:964).

"It seems likely these quartzitic clays were more easily accessed, perhaps ubiquitous at the site, than the finer non-quartzitic clays, possibly of more limited distribution, exploited during earlier times" (Iceland and Goldberg 1999:964). In other words, it is possible that fine rhombs characterize the Preclassic and quartz characterizes the Late-to-Terminal Classic (no, Subin Red has quartz, but Tinaja Red has fine rhombs). These tempers, however, are also present in ceramics from other sites, such as Lamanai (at least the fine rhombs are). Therefore, they might be made in many places or imported from elsewhere, despite being possible to make at Colha. It is interesting to note that Iceland and Goldberg (1999) considers quartz use a Late-to-Terminal northern Belize characteristic, and it is used in the Early Postclassic, but not the Middle Postclassic. This may suggest that the idea of a northern Belize sphere still applied to Colha during the Early Postclassic, but by the Middle Postclassic, Colha economy ties had expanded, consistent with Masson's (2002a) idea of a more interregional economy.

Mineral Qualities

This section discusses some of the mineral terms and mineral qualities that are relevant to this dissertation. Shoval et al.'s (1993) study of carbonate tempers provide insight into the suitability of these material, based on archaeological evidence and experimental archaeometry. Tite et al.'s (2001) experimental archaeology, along with the concepts of strength, toughness, and thermal shock resistance, provide insight into the effect of different percentages of temper, especially quartz. Archaeology and ethnographic evidence show calcite grit to be a desirable temper and provide insight into the benefit of crystalline calcite. Possible explanations for Colha's switch from Chalky/Quartz temper to Clear Calcite temper are discussed below.

Calcite Grit vs. Volcanic Ash as Temper

Archaeological and ethnographic evidence provide insight into the benefit of crystalline calcite and show calcite grit to be a desirable temper. Arnold (1971), in his ethnographic study of Maya potters at Ticul, in Yucatan, finds that they use a temper called *hi'*, a form of sparry calcite, exclusively for pottery used for cooking. Arnold was told that potters mine this tempering material as rock in a nearby natural cave. Pottery made with one type of *hi'*, in particular, "is said to be harder, resists heat better, doesn't crack or break easily, and lasts longer" (Arnold 1971).

Clay bonds better with irregular shaped temper (for example, better with volcanic ash than with sand), which improves strength. Research finds angular inclusions to be better than rounded inclusions, due to the angular inclusions bonding better to the clay. It has even been suggested that fine rhombs or monocrystalline calcite was used as a replacement for volcanic ash (Jones 1986). Volcanic ash seems to be the most desirable inclusion (Jones 1986; Arnold 1971), based on who used it when, as well as physical properties.

Volcanic ash has a low level of thermal expansion when compared to quartz or calcium oxides. The quality of low level of thermal expansion results in less stress during the heating and cooling of the ceramic. As a result, volcanic ash tempered ceramics have a better resistance to thermal stress. This resistance to thermal stress is especially useful for cooking vessels. Since access to specific temper sources affects what temper can be chosen by the potter (Arnold 1971), calcite grit may be a desirable alternative in areas where volcano ash is not available.

Quartz Temper vs. High Matrix Paste

Tite et al.'s (2001) experimental archaeology, along with the concepts of strength, toughness, and thermal shock resistance, provide insight into the effect of different percentages of temper, especially quartz.

In materials analysis, the qualities of toughness and strength have specific meanings. Toughness is the quality of being able to withstand impact, like rubber (which is not strong, but weak). Strength is the quality of being able to support a lot of static weight, like glass (which is not tough, but brittle). A material that is intermediate between these two is oak (Figure 41).

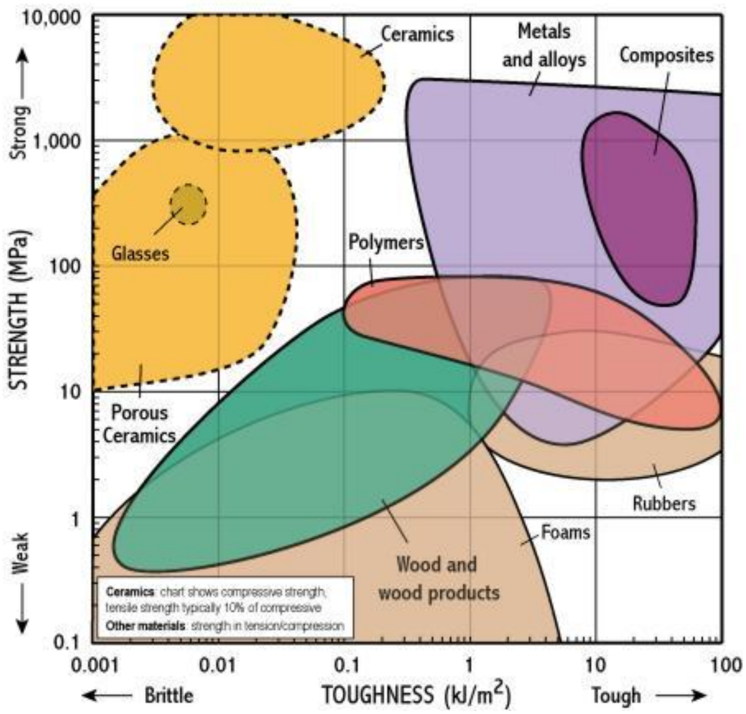

Figure 41: Tough vs. Strong (from Materials Group).

Tite et al. (2001) examined the effect of varying amounts of quartz temper and varying firing temperatures. Their study supports the hypothesis that to produce pottery with high strength requires high firing temperatures and low temper concentrations. Conversely, to produce pottery with high toughness and thermal shock resistance requires low firing temperatures and high temper concentrations, with platy or fibrous temper being most effective. There is no convincing published evidence that strength and toughness requirements were a significant factor in determining the technological choices (clay type, temper type and concentration, and firing temperature) in the production of pottery used as containers for transport and storage. In contrast, the routine use of high temper concentrations and low firing temperatures in the production of cooking pots suggests that the requirement for high thermal shock resistance is a factor that influences technological choice (Shoval et al. 2006).

These archaeometric studies are relevant to different temper choices observed at Postclassic Colha. Once crystalline calcite was re-introduced to the Colha ceramic assemblage in the Middle Postclassic, the household of Operation 2001 abandoned the micrite-and-quartz temper (Chalky/Quartz Group) in favor of crystalline calcite tempered (Clear Calcite Group) ceramics. This apparent preference for crystalline calcite temper raises the question of why consumers continued to choose some quartz tempered ceramics. It seems that, like many tempers, quartz adds strength to the pottery, making it an acceptable temper for vessels not used for cooking. In addition quartz does not cause spalling, and it helps resist cracking, although not necessarily better than crystalline calcite.

It would seem that Shoval et al.'s (2006) analysis of ceramics with low percentages of temper would be relevant to the current study's Matrix Group. Colha's Matrix Group ceramics, however, are generally not well fired, and so are not comparable to Shoval et al.'s (2006) low tempered, high-fired ceramics that exhibit high strength.

Limestone and Micrite as Temper

Shoval et al.'s (1993) study of carbonate tempers provide insight into the suitability of these materials, based on archaeological evidence and experimental archaeometry. The qualities of limestone and micrite are relevant to this dissertation because the temper group called Chalky Calcite includes a range of carbonate inclusions from poor quality calcite grains to micrite to limestone mud. Shoval et al. (1993) have addressed the issue of the quality of limestone versus monocrystalline calcite tempers. Limestone and monocrystalline calcite tempers (grains) are abundant in ancient pottery.

Shoval et al. (1993) note that in pottery from the Canaan area the limestone is common in Iron Age storage and tableware vessels, while monocrystalline calcite is present in cooking pots. He notes that sources of limestone are much more widespread in that area than monocrystalline calcite, and potters often used limestone as temper when manufacturing pottery, but usually not for manufacturing cooking pots. While defects appear frequently around limestone tempers, they do not appear around monocrystalline calcite ones. Shoval et al. (1993) examine the reason for this difference. For their study raw materials of carbonate tempers in a clay matrix were fired, and

> the decarbonation process was followed by quantitative IR thermospectrometry. The results indicate that the monocrystalline calcite tempers prevent formation of defects in the cooking pots during firing or during use. The reasons for this are higher thermostability at elevated temperatures, lower intensity of decarbonation, and retention of grain shape, as compared to limestone tempers (Shoval et al. 1993:263).

THE EARLY-TO-MIDDLE POSTCLASSIC CHANGE

This section explores possible explanations for Colha's change in ceramic consumption from Chalky/Quartz temper in the Early Postclassic to Clear Calcite temper in the Middle Postclassic. Generally, these reasons are related to resources, population, and trade.

First, it is possible that a new, more desirable resource was discovered, possibly as close as Cobweb Swamp. Studies regarding the desirability of different tempers were discussed above. It seems that the quality of the tempers are inversely related to their availability, with micritic carbonates (Chalky Group) being the most readily available and least desirable, followed by quartz, crystalline calcite, and finally volcanic ash, which seems to be the most desirable but unavailable. In any case, monocrystalline calcite, including fine rhombs, is generally (Arnold 1971) considered better tempering material for cooking wares than quartz. For this reason, if calcite had been available for tempering cooking vessels, it is reasonable that potters would have taken advantage of this resource.

Second, an increase in population may have been a factor. Based on the current study, there is an increase in the total number of ceramics found at Colha in the Middle Postclassic, suggesting an increase in ceramic consumption and possibly an increase in population. If living near the workshop is considered desirable, population may cluster there initially, but then spread out. With the population spreading out, for example near Cobweb Swamp, some people may be closer to a new resource, which could then be used as temper in the Middle Postclassic.

Related to population, immigration could have been a factor in this change in ceramic temper. An initial wave of immigration likely led to the Early Postclassic reinhabitation of the site. Immigrants would have brought ceramics with them, as well as specific knowledge of ceramic production technology; they may have continued to import ceramics from their place of origin and/or continued to make ceramics by their traditional method. Over time, however, they may have eventually turned to using local resources and new manufacturing methods. Another possibility is that a new technology may have been brought by a smaller group of immigrants arriving in the Middle Postclassic and bringing new ideas.

A third possible factor is trade. As the Postclassic lithic industry became better established, it is likely that Colha increasingly exported lithic products in exchange for imported ceramics. This increase in trade could have led to a change from locally produced ceramics to imported ceramics. Along these lines, Colha may have been importing ceramics in the Early Postclassic, but simply had a change in trade partners in the Middle Postclassic, for example a change from Lamanai to eastern Yucatan.

In this chapter soil studies of the Colha area and northern Belize were summarized. Quartz and micrite ("chalky calcite") were found to have been readily available. Crystalline calcite was found at Cobweb Swamp, and it would be consistent with the general geology of the Colha area. Based on geological, ethnographic, and archaeological studies, volcanic ash temper seems to be especially desirable, but volcanic ash was found in neither the soil studies nor in the local ceramics. Crystalline calcite seems desirable as well, followed by quartz and the "chalky calcite", such as micrite and limestone. Some possible explanations for the change from Chalky/Quartz in the Early Postclassic to Clear Calcite in the Middle Postclassic are suggested. A possible general explanation is that quartz and chalky calcite were available locally and used together for tempering Early Postclassic ceramics. During the Middle Postclassic crystalline calcite tempered ceramics became available and replaced the less desirable chalky calcite with quartz temper.

Chapter 8: Models: Colha Ceramics within the Postclassic Maya Economy

The findings of this study will be examined within the context of models proposed by Fred Valdez, Jr., William Rathje, and Robert Carneiro. Northern Belize, interpreted as a subregion of the Maya (Masson 1989; Valdez 1987; Walker 1990), has shown intraregional similarities as early as the Preclassic. Ceramic evidence linking Colha within the northern Belize region, as well as outside ties, will be discussed.

COLHA, NORTHERN BELIZE, AND YUCATAN CONNECTIONS

At Colha in the Late Preclassic stone tools were made and distributed primarily in northern Belize, except for ritual stone tools, which were distributed more widely, including parts of Mexico and Peten, Guatemala. In the Late-to-Terminal Classic, Colha's dominance of regional lithic production declined. However, the number and distribution of lithic workshops increased at this time. This decentralization of lithic production seems to parallel the increased variety of polychrome pottery production. This coincides with the Masson Complex, especially Palmar Orange Polychrome, which was found throughout the northern Belize area (Valdez 1987). Together this lithic and ceramic pattern may represent a consolidated political sphere. Most of the Colha Postclassic ceramics are imitations of the Late Classic pottery from the northern Maya area, specifically from Quintana Roo (Valdez 1994:14-15) and more generally from the Yucatan peninsula (Mock 1994). The Colha Postclassic pottery has the same form as the northern Maya Late Classic ceramics, but the Colha Postclassic pottery is red and orange, rather than buff and gray (Sharer 1994:698; Fred Valdez, personal communication, 2003). Similar imitations are found throughout northern Belize and Peten. Comparison to vessels at the site of Lamanai in Belize shows pottery from the two sites to be "identical" (Valdez 1994:14; Pendergast 1981). Lamanai, however, differs from Colha and other northern Belize sites because there are no

> abrupt discontinuities in ceramic tradition following the Classic collapse. Due to the ceramic continuity and the great numbers of wares in burial contexts, Lamanai has been postulated as an interregional manufacturing center and probably source of Colha Postclassic ceramics (Mock 1994:233; Valdez and Adams 1982:29).

The Colha Postclassic ceramics share significant typological ties with Tulum and Ichpaatun to the north in Mexico and especially with Lamanai to the west in Belize.

TRADE, WARFARE, AND CHICHEN ITZA

Three models proposed by William Rathje (1972, 1975, 1983) in regard to Maya political economy have proven useful and enduring. First, in the core-buffer model (Rathje 1972; Rathje et al. 1978), the development of the core Peten centers is associated with exchange with the resource-rich areas of the coastal and highland buffer zones. Second, along with Sabloff, Rathje (Sabloff and Rathje 1975; Rathje and Sabloff 1973; Rathje 1975; Rathje et al. 1978) proposed the mercantile model to explain the developments of the Postclassic with an emphasis on maritime trade, bulk transactions, and long-distance exchange. Third, Rathje (1983) called for analysis of household economies, as they formed the basic unit of production, exchange, and consumption within the regional economy (Masson 2002a). In addition to Rathje's models, Robert Carneiro's (1970) "Theory of the Origin of the State" provides a complementary model of the rise of Chichen Itza as a state based on warfare and a circumscribed environment. These models provide a framework for interpreting the findings of the current study.

Rathje proposed the core-buffer model (Rathje 1972; Rathje et al. 1978) for the Maya Classic period. This model states that the politically powerful Peten core sites

(Figure 42) obtained resources from peripheral Maya “buffer” sites. The peripheral areas were diverse in resources and the elite of the core area were consumers. Under this model, there were local polity leaders (Masson 2002a, 2002b), for example Lamanai in northern Belize (Figures 43 and 44).

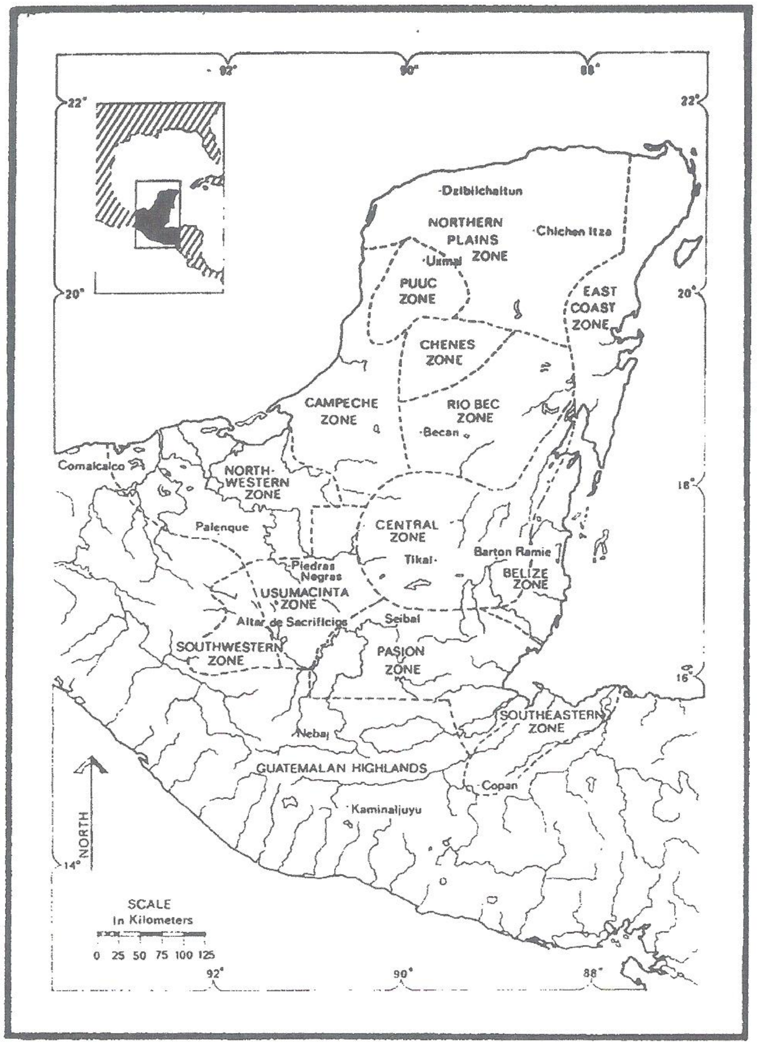

Figure 42 Zones; The core area of the core-buffer model corresponds to the Central Zone, as well as to the uplands of the Usumacinta and Pasion Zones; the Belize Zone was one of the buffer areas (from Michaels 1987, adapted from Culbert 1973).

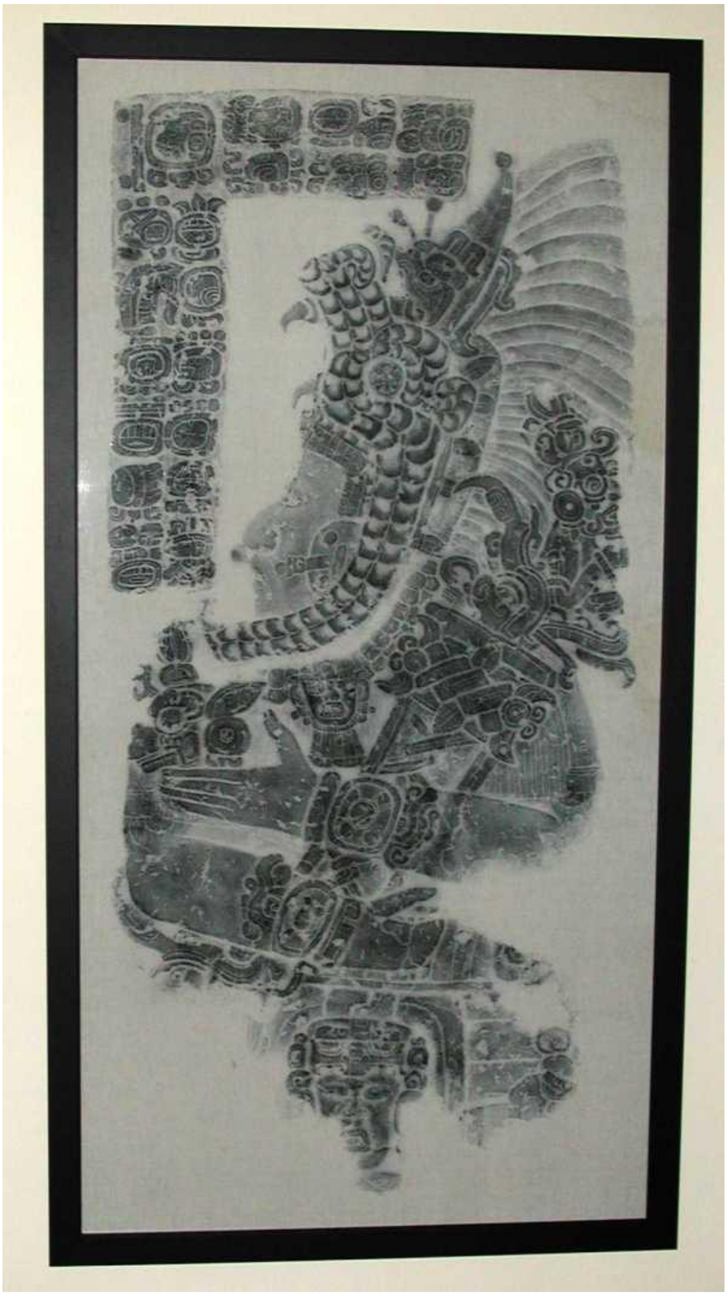

Figure 43: Lamanai Stela 9 with Lineage Glyph in Position E2 (far right, second row; Stan Loten rubbing from McKenzie 1998).

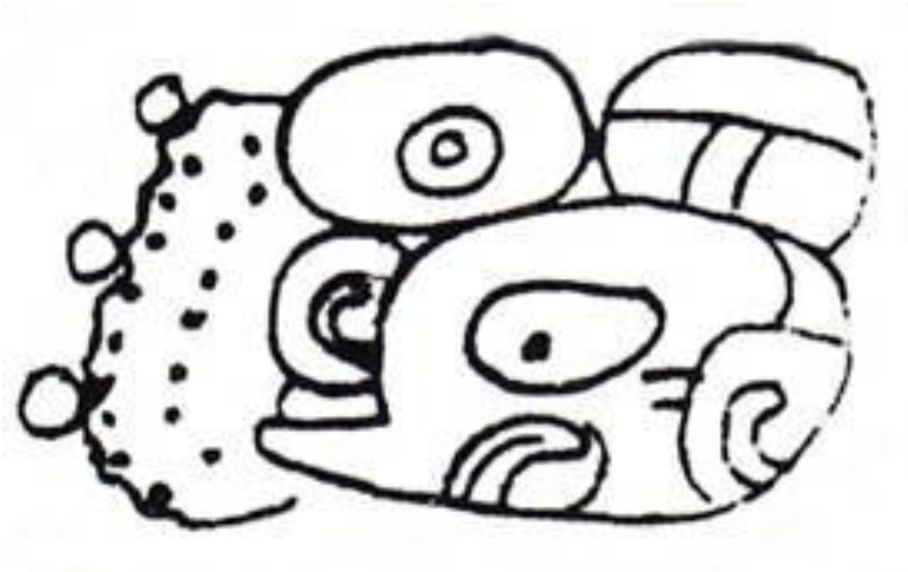

Figure 44: Lineage Glyph of the Site of Lamanai (Michael Closs 1988).

During the Classic period the Putun Maya were a group of merchants and warriors based in the southwestern periphery of the Maya area, along the Gulf Coast of Tabasco. They were Mexicanized Maya, heavily influenced by central Mexico, and characterized by militarism and commercialism. The Putun were traders in the Lowlands, especially along rivers by canoe (Sharer 1994).

The Putun were focused on taking over trade routes. They took over the sites Altar de Sacrificios and Seibal in the Petexbatun region. Whether Putun invasions caused instability in the Terminal Classic or the existing instability invited invasions, the fall of the Classic Maya sites corresponded with the rise of the Putun Maya (Sharer 1994).

Regardless, the fall of Peten sites allowed the Putun Maya to take advantage of the new coastal trade route. The Putun became less interested in the central Maya area and more interested in the Yucatan coast (Sharer 1994).

More importantly, in the Late Classic the Putun began using much larger canoes that allowed them to circumnavigate the Yucatan Peninsula, making trade through the Peten unnecessary (Sharer 1994). This change in focus to northern Yucatan, away from the central Lowlands, is likely related to the collapse of the core area, and the collapse of the core would have also caused instability for buffer areas, like northern Belize (Sharer 1994:356, 382-383).

Figure 45: Reconstruction of Putun Sea-faring Canoe (Richard Thorton).

Colha came to a violent end (Valdez 1987) at the end of the Classic period. After 100 years of abandonment, the site was re-inhabited to produce lithics (Michaels 1994) for the new mercantile demand. As the new trade routes became established, the producer communities of northern Belize were resettled, likely by Yucatecan people or groups connected to them, such as Lamanai. The low population of the Colha Postclassic may suggest residents being there only to take advantage of the chert production opportunity (Michaels 1994).

The sites of northern Belize and Quintana Roo were well positioned for this maritime trade. Products that may have been produced for exchange at other northern Belize sites are textiles, cacao, honey, salt, hides, wood, bark, and shell products. Exchanged exotic goods included beads, greenstone adzes, obsidian, and basaltic or granite metates (Masson 2002b:9,12,14; Masson 2002a:359).

Figure 46: Prehistoric Trade Routes of the Putun (Chontal) (from Douglas Peck).

The Putun's first strategic foothold was Isla Cerritas, an island port off the northern Yucatan coast. The evidence of trade on the island, including many piers and much pottery, suggests Isla Cerritas was a Chichen Itza port. The Putun later founded Chichen Itza around AD 850 in north central Yucatan, south of Isla Cerritas, and they also took over many other sites, including the Puuc sites in western Yucatan and the trading site of Coba in northeastern Yucatan (Figure 47). They are credited with the Toltec architecture at Chichen Itza (Figure 48), which contrasts with the traditional Puuc style architecture of the site (Figure 49). The Putun then expanded their influence by trade, marriage alliances, and especially military conquest to control most of the northern Lowlands during the Early Postclassic. Aggression in the Postclassic had led to consolidation, rather than independent sites, such as the Puuc area, Coba, and other sites, like Dzibilchaltun. The Putun were not popular with the native population, with native sources saying, "There were no more lucky days for us" (The Book of Chilam Balam; Sharer 1994).

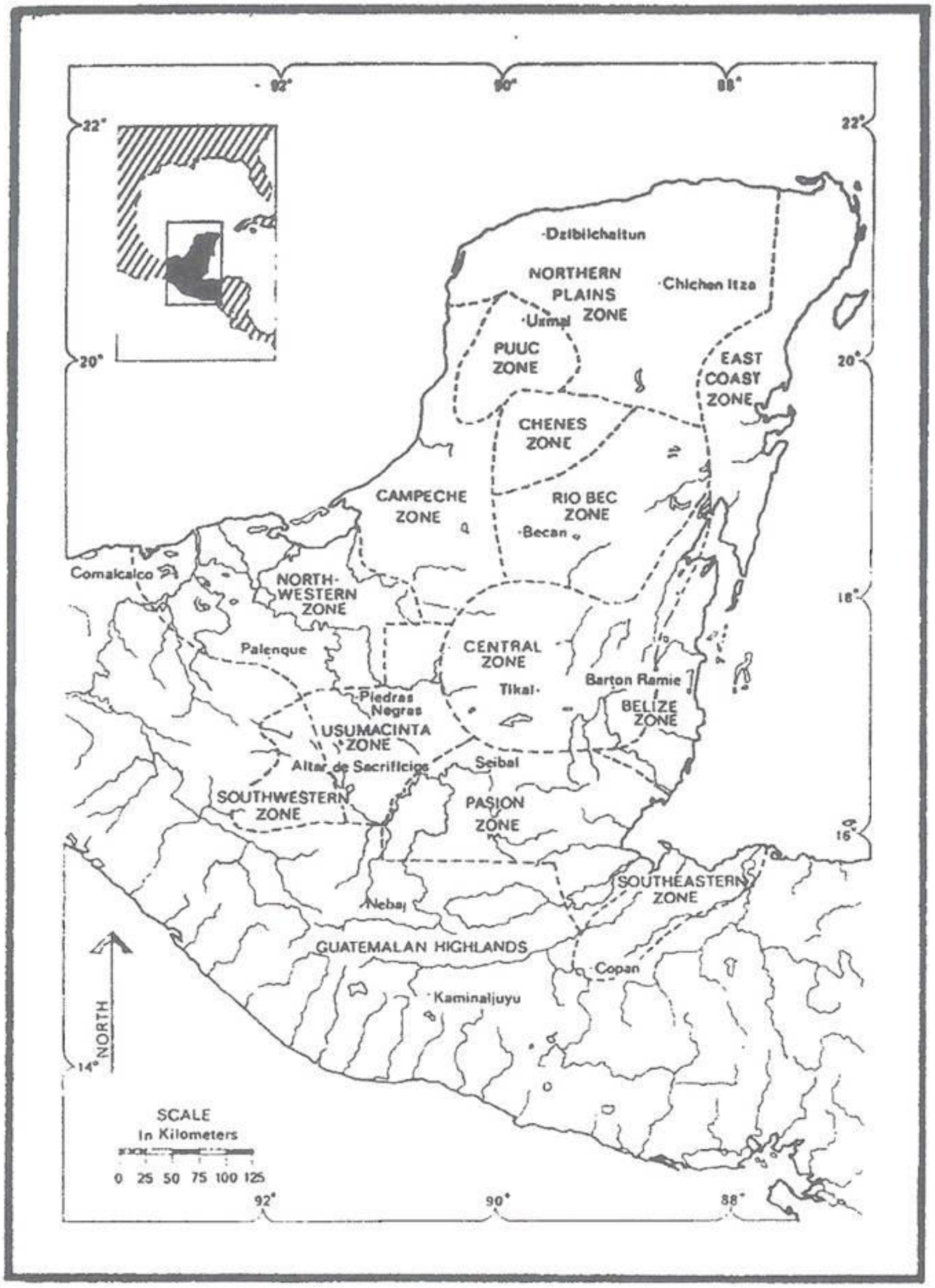

Figure 47: Maya Sites; Sites include Chichen Itza, Coba, Dzibilchaltun, and Puuc sites, such as Uxmal, Kabah, and Edzna (From Michaels 1987, adapted from Hammond 1982).

Figure 48: Toltec Architecture at Chichen Itza (from Barbezat; photo from Visions of America/Joe Sohm/Getty Images).

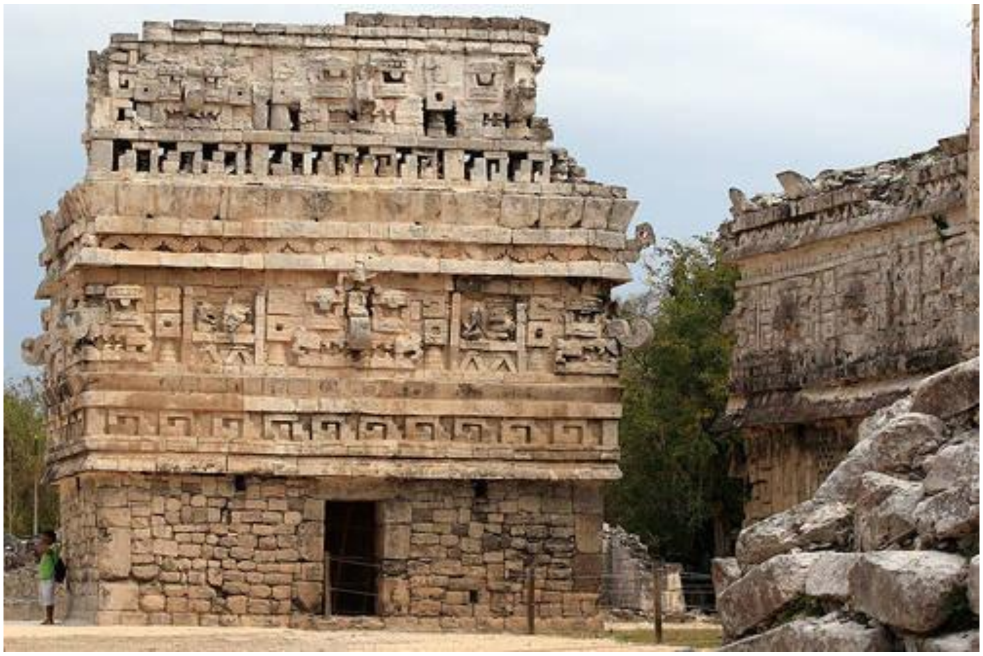

Figure 49: Puuc Architecture at Chichen Itza (from Barbezat; photo from Alaskan Dude, Flickr user).

In Sabloff and Rathje's model (Rathje 1975; Sabloff and Rathje 1975) "the Postclassic period was characterized by growing commercialization and the rise of the merchant class" (West 2002:175). Their model was partly based on the perception that ceramics "became standardized, simplified, and mass produced" (West 2002:175) in the Postclassic. This model is supported by ceramic compositional studies for northern Yucatan (Rands et al. 1982; Kepecs 1996; Kepecs et al. 1994; Smyth et al. 1995; Shepard 1964). Relying on these studies of ceramic production and distribution, West concludes that the strong state model (Martin and Grube 2000; Chase and Chase 1996) applies to Chichen Itza and the Early (and Middle) Postclassic Maya, but not to other times. In other words, she sees the Terminal Classic/Early (and Middle) Postclassic period as a restructuring of the northern lowland economy in which ceramic production became centralized and possibly administered by the rulers of Chichen Itza (West 2002).

The state is generally defined as a highly culturally complex, stratified society. States are assumed to have centralized governments that can codify and enforce laws, collect taxes and tribute, and draft soldiers. In addition to being larger in population and territory than other societal forms, states encompass a diversity of settlement sizes, such as villages, towns, and sometimes cities. States are characterized by full-time craftsmen and other specialists and a powerful, integrated national economy, often with market systems (Wenke and Olszewski 2007).

Relying on examples from all over the world, Carneiro's "Theory of the Origin of the State" (1970) argues that the rise of the state always result from warfare, in combination with environmental circumscription, resource concentration, and/or social circumscription. Circumscription can be an environmentally attractive area of land surrounded by a less desirable area, either because the less desirable area is not arable (environmental circumscription) or because the attractive area is especially abundant in resources (resource concentration). The circumscription can also be social, in that surrounding areas are already inhabited, and thus the circumscribed areas are restricted.

While Carneiro applied this theory to the Classic Maya states, it is perhaps even more applicable to the Postclassic. Warfare, drought, or any number of factors had made the central area less attractive (Me-bar and Valdez 2004). The Putun conquered not only the coast of the Yucatan Peninsula and northern Yucatan itself, but related warrior merchants had entered the southern lowlands, expanding from the Gulf Coast, up the Usumacinta River, conquering Seibal and Altar de Sacrificios along the Pasion in the Terminal Classic, and occupying and establishing several sites in the highland. The Usumacinta and Montagua Rivers were likely trade routes for the Putun Maya. The site of Quirigua on the Rio Motagua (Figure 50) showed links to the Putun of Yucatan. Still other groups had taken over the southern area, the Pacific highlands. To the east and west of the Maya area the Putun also controlled trade to Central Mexico and to Panama (Sharer 1994:427).

In sum, conquered peoples had nowhere to flee. As peoples were conquered, administrators were needed to collect tribute, organize workers, and integrate the people, and this job generally falls on those who have distinguished themselves in war, in this case the Putun. These warriors/administrators become the upper class, while the conquered become the lower classes. Those made landless by the war will gravitate to cities, where they can make a living as specialists, "exchanging their labor or their wares for part of the economic surplus exacted from village farmers by the ruling class and spent by members of that class to raise their standard of living" (Carneiro 1970:736).

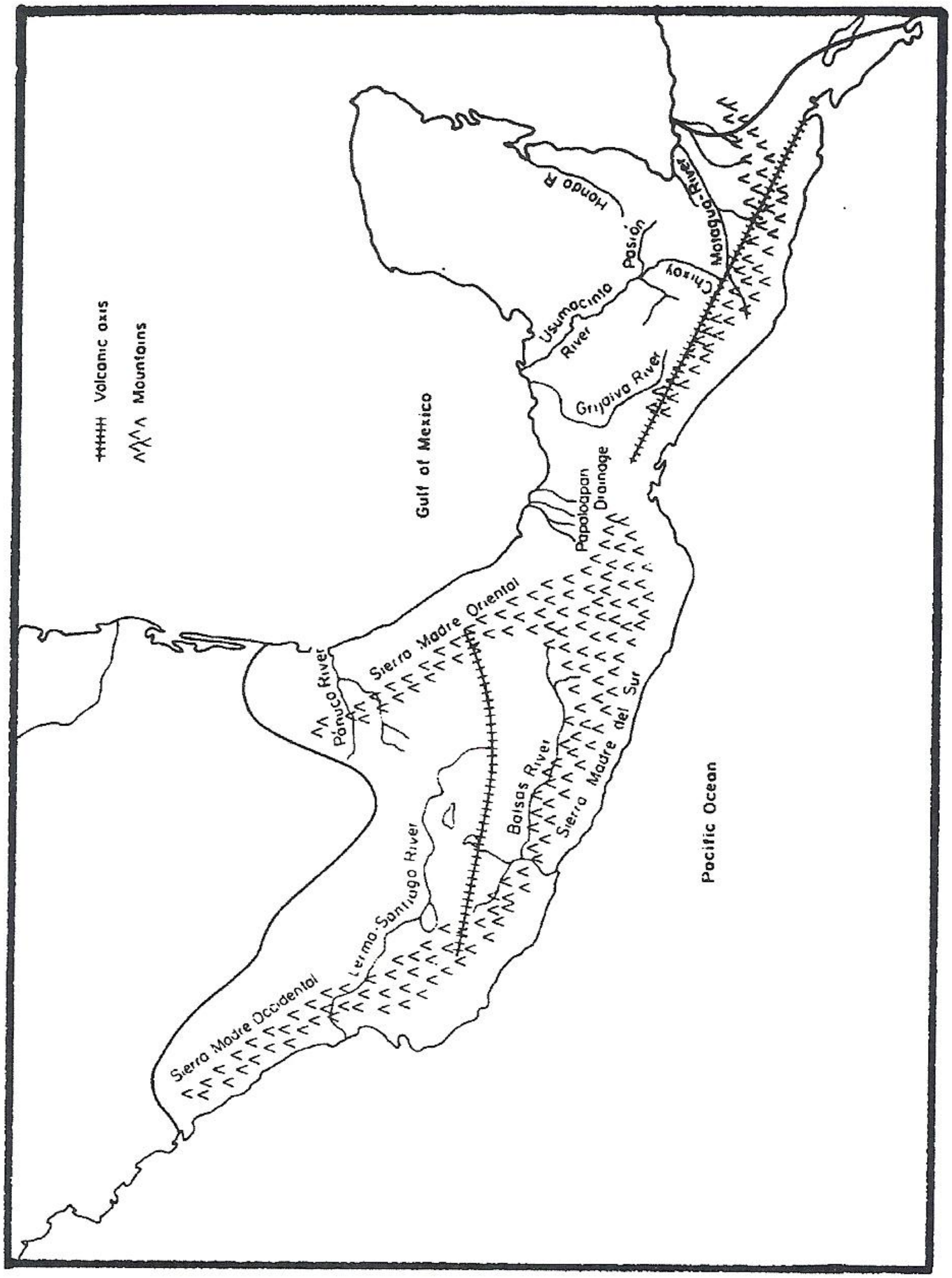

Figure 50: Mesoamerican Highlands; showing the Pacific Highlands, Motagua and Pasion Rivers, all areas of Putun occupation.

There is evidence that the lowlands were socially circumscribed, since a second wave of Putun Maya had gained control of the Usumacinta and Montagua rivers, which together span the base of the Yucatan Peninsula. In addition, the Putun associated with Chichen Itza seemed to have taken over Quirigua along the lower Montagua river, which emptied into the Caribbean Sea to the east. A secondary wave of Putun had taken over much of the highlands in the upper drainage basins of these rivers and their tributaries (Sharer 1994:427).

Chichen Itza's domination over a wide region facilitated widespread interregional exchange that made intensified workshop output and increased specialization profitable. Kepecs's (Kepecs 1996; Kepecs el al. 1994) work suggests a change to standardized, mass production of ceramics during Chichen Itza's domination in the Early (and Middle) Postclassic. This change in the economic structure suggests greater political centralization and interregional integration of ceramic production, in contrast to the Classic period when ceramic production does not seem to be important to the political economy (West 2002:182-185).

This idea of a strong state, however, is combined with the idea of egalitarian producers and consumers (Masson 2002a:337-338). Sabloff and Rathje (1975) argue that Postclassic elites were less interested in the construction of monumental architecture, in comparison to their Classic period counterparts. Instead, they were more concerned with the development of trade, which lead to increased opportunities for social mobility and the rise of the mercantile class. Along these lines, Postclassic markets led to greater distribution of resources, including goods and profits, and traditionally elite luxury goods being consumed in non-elite utilitarian contexts (Sabloff and Rathje 1975; Rathje 1975). One example of more egalitarian consumption is the increase of obsidian in non-elite context for utilitarian purposes, including at Colha (Masson 2002b; Michaels 1994; Walker 1990). Evidence of fewer differences in exchange items obtained by elite and commoners suggests the existence of open markets, where local and distant products were available for purchase. It seems, that while Chichen Itza controlled the trade, it did not control the producers outside of northern Yucatan very tightly (Masson 2002a, 2002b).

In AD 1221 Chichen Itza was defeated, and Mayapan became the dominant power in northern Yucatan (Sharer 1994). During these times of turmoil and competition, war led to the increased demand for darts and small points. These tools could be easily made and did not require large pieces of high quality chert (Shafer 1996). Perhaps for this reason, the rise of Mayapan corresponds with the end of residential occupation at Colha. The site of Colha continued to be visited for ritual purposes in the Late Postclassic, however, as suggested by the presence of Mayapan style censors (Valdez 1994).

THE CURRENT STUDY

This chapter has discussed northern Belize as a subregion of the Maya political economy. The Classic period has been discussed in terms of Rathje's core-buffer model, and the Postclassic has been discussed in terms of his mercantilism model. In addition, the rise of Chichen Itza was discussed as an example of Carneiro's theory of the rise of the state.

The last topic remaining for this chapter is Rathje's model of the household as the basic unit of study. As noted previously, the ceramics in this study come from a single housemound and associated lithic workshop. It has been noted that the Clear Calcite Group of ceramics likely has regional ties to northern Belize and eastern Yucatan. The

Chalky Calcite Group and Chalky/Quartz Group could have been made locally and/or could have ties to Lamanai. The Quartz Group seems to be a local trend continuing from the Late-to-Terminal Classic. Finally, the Matrix Group and Miscellaneous Group add to the variation found within this single household.

Chapter 9: Summary and Conclusions

SUMMARY OF DISSERTATION

This dissertation used petrographic analysis to examine Postclassic ceramics from the Maya site of Colha. The first chapter gave an overview of Colha research and culture history. Additionally, regional exchange was discussed in terms of the similarities between Colha's lithic and ceramic assemblages in comparison to other sites, especially sites in northern Belize. The second chapter discussed the sampling of Postclassic red-slipped sherds from Suboperation 2001, a lithic workshop and associated housemound at the site of Colha. The sherds were grouped by provenience, form, and visual inspection of temper. From these groups, samples were selected for petrofabric analysis. The third chapter discussed the petrographic method of characterizing ceramics, including the method of using visual comparison charts.

The petrographic analysis resulted in the identification of five petrofabric groups, which are defined in chapter four. Chalky Calcite is composed primarily of carbonates that appear chalky white or gray by visual inspection. These inclusions could also be termed sascab, micrite, or white carbonate. Chalky/Quartz is composed primarily of chalky calcite, along with a moderate amount of quartz. The Quartz Group consists of quartz grains as its main inclusion. The Clear Calcite Group includes primarily monocrystalline calcite as temper, which corresponds with the Payil ceramic group. The Matrix Group is characterized as being low in total percentage of inclusions. The Miscellaneous Group is composed of samples that do not fit well into the other groups, for example, sherds with significant amounts of both chalky calcite and crystalline calcite.

Chapter four also discusses trends within the data. For the most part, there is a high degree of variability within the ceramic groups and little correlation between petrofabrics and ceramic types. There are, however, some noticeable patterns. First, the Chalky/Quartz Group is strongly correlated with Suboperation 11 (the housemound) and with the Early Postclassic and intermediate time periods. Second, while the Chalky/Quartz group contains various forms from the Early and intermediate Postclassic time periods, almost all the incurving vessels of the intermediate time period fall within this petrofabric group. Third, the Clear Calcite Group contains only Middle and intermediate period samples, but unlike the Chalky/Quartz Group, the Clear Calcite Group is abundant in both the housemound and lithic workshop suboperations. Fourth, there is continuity also, with the Chalky Calcite ceramics being abundant in both the Early and Middle Postclassic, as well as the Quartz and Matrix groups being present in both facets.

Chapter five discusses continuity and change through time on a larger scale. The results of the current study were compared with petrographic analyses of previous time periods. Comparison to earlier studies suggests that the Quartz Group is a tradition continuing from the Late-to-Terminal Classic, and the Clear Calcite Group may be the re-introduction of a Late Preclassic technology or trade partner. The Chalky Calcite Group, arguably the most easily made from readily available materials, may be a new petrofabric for this time period, the Postclassic.

In chapter six, the possibility of specialized production was examined. The number of Postclassic ceramic types is reduced in comparison to the types of the Late Classic (Valdez 1987), and this could suggest centralized production. Within the types themselves, however, there is significant variety in petrofabric, with the exception of the intermediate incurving bowls mentioned above. The temporal change from the Chalky/Quartz Group to Clear Calcite Group seems to be more a change in resource procurement or possibly a change in trading partners, rather than an increase in specialization.

In chapter seven soil and mineral studies were reviewed. Comparison to soil studies suggests that all the petrofabric groups of the Postclassic could have been made from resources local to Colha and the immediate surroundings, with evidence for quartz and micrite (chalky calcite) being the most apparent. Although the ceramics could have been made locally, they bear a strong resemblance visually to the ceramics of other northern Belize sites, as well as eastern Yucatan. This is especially clear in the case of the Chalky/Quartz group related to Lamanai and the Clear Calcite group related to Cerrros and eastern Yucatan. Mineral studies are reviewed to suggest reasons potters and consumers might prefer some tempers over others. Mineral studies suggest that the Chalky Group petrofabric was likely the lowest in quality, while the Clear Calcite Group was likely the highest in quality.

Chapter eight discusses this study's finding within the framework of various models, including northern Belize as a cultural region; the core-buffer model of the Classic period; the mercantile model of the Postclassic period; the rise of Chichen Itza as the result of coercion and environmental circumscription; and the household as the basic unit of regional exchange. Colha's abandonment and reoccupation, its ceramic similarities to northern Belize and Quintana Roo, and the presence of these regional styles of ceramics at the household level are consistent with these models.

CONCLUSIONS

The purpose of this study was primarily to identify changes and/or similarities in ceramic paste from the Early Postclassic (AD 1000–1150) to the Middle Postclassic (AD 1150–1350) at the site of Colha in northern Belize. More specifically, the primary objectives were 1) to identify temper groups of Postclassic ceramics at Colha; 2) to compare these temper groups with Type:variety classes; and 3) to identify how these relationships between temper groups and Type:variety classes continue or change over time. Secondary objectives for this study were 1) to identify any changes in production technology through time, especially regarding standardization; 2) to identify any changes in production organization, especially regarding centralization; 3) to assess the possibility that the pottery was made locally or imported; and 4) to compare findings to Sabloff and Rathje's model of commercialization and the rise of the merchant class (Rathje 1975; Sabloff and Rathje 1975). Each of these objectives is addressed below.

Temper groups of Postclassic ceramics at Colha were identified. These groups include Clear Calcite, characterized by moderate to high amounts of monocrystalline calcite; Chalky Calcite, characterized by moderate to high amounts of micritic calcite; Chalky/Quartz, characterized by moderate to high amounts of micritic calcite with moderate amounts of quartz; Quartz, characterized by moderate to high amounts of quartz; and Matrix, characterized by a low percentage of inclusions.

These temper groups were compared to Type:variety classes. There was almost no correlation between forms and tempers. Most ceramic forms corresponded with three or more petrofabric groups. The one exception is the intermediate Postclassic incurving vessels, which were composed almost exclusively of Chalky/Quartz temper. These intermediate Postclassic incurving ceramics are most likely the Centon Incised type.

Whether relationships between temper groups and Type:variety classes continue or change over time was examined. As mentioned there is little correlation between form and temper. There is, however, a change in temper over time from the Early Postclassic Zakpah to the Middle Postclassic Payil Groups. The Zakpah ceramics were made primarily of the Chalky Calcite and the Chalky/Quartz pastes, as well as a few samples being made from the Matrix Group paste and a few from the Quartz Group paste. The Payil ceramics were made primarily of the Chalky Calcite and Clear Calcite and Matrix pastes, as well as a few from the Quartz Group paste. In other words, the Chalky/Quartz paste is characteristic of the Early Postclassic Zakpah ceramics and the Clear Calcite paste is characteristic of the Middle Postclassic Payil ceramics.

Changes in production technology through time, especially regarding standardization through time were identified. Standardization of production is reflected in homogeneity of appearance and composition within each category of pottery. The ceramics in this study do not show signs of increasing standardization. Only the intermediate Postclassic incurving vessels (Centon Incised) were consistently made with the same petrofabric (Chalky/Quartz), and this type overlaps both the Early and Middle Postclassic.

Changes in production organization through time, especially the possibility of increasing centralization through time were examined. Increased centralization of production would be reflected in a decline in the number of compositional groups and a decline in the quantities of ungrouped pastes. In contrast, dispersed production would be reflected in higher compositional diversity. Neither of these changes occurred, which suggests that centralization neither increased nor decreased from the Early Postclassic to the Middle Postclassic.

The possibility that the pottery was made locally or imported was assessed, including suggestions regarding resource and production location. All the ceramics in this study could have been made locally, with the Quartz, Chalky Calcite, and Chalky/Quartz Groups being the most similar to natural local resources, and Clear Calcite being consistent with Cobweb Swamp resources. Nevertheless, the fact that similar ceramics with similar pastes were found at Lamanai and Cerros suggests that these types of ceramics may have been part of a larger Postclassic exchange system. There is no evidence to suggest that Colha was producing ceramics for export. Instead, the strong evidence of lithic export implies other products, possibly ceramics, would have been imported. Tentatively, the Chalky/Quartz ceramics may have been produced at Lamanai, and the Clear Calcite ceramics were likely produced at some other, currently unidentified location.

Findings were compared to various models, including Sabloff and Rathje's model of increasing commercialization and the rise of the merchant class in the Postclassic (Rathje 1975; Sabloff and Rathje 1975). Colha petrographic groups were found to overlap descriptions of ceramic temper at Lamanai and Cerros, which are also visually similar to ceramics from Quintana Roo. These similarities fit Rathje's model of mercantilism in the Postclassic. In addition, findings were consistent with Rathje's core-buffer model for the Classic period, Rathje's emphasis on household economies, Me-Bar and Valdez's model of Relative Attractiveness, and Carneiro's model of the origin of the state. In these ways, the petrographic analysis of Colha Postclassic ceramics contributes to a clearer picture of Colha culture history, northern Belize political economy, and the Maya Postclassic period in general.

References Cited

Adams, R. E. W. and F. Valdez, Jr.

1980 The Ceramic Sequence of Colha, Belize: 1979 and 1980 Seasons. In *The Colha Project Second Season, 1980 Interim Report*, edited by T.R. Hester, J.D. Eaton, and H.J. Shafer with illustrations by K. Bareiss, pp. 15-40. Center for Archaeological Research, The University of Texas at San Antonio and Centro Studi e Ricerche Ligabue, Venezia, San Antonio, Texas 1980.

Alcala-Herrera, J.A., J.S. Jacob, M.L. Mchain Castillo, and R.W. Neck

1994 Holocene Palaeosalinity in a Maya Wetland, Belize, Inferred from the Microfaunal Assemblage. *Quaternary Research* 41:121-130

Angelini, M.L.

1998 *The Potter's Craft: A Study of Formative Maya Ceramic Technology at K'axob Belize*. Unpublished Ph.D. Dissertation. Department of Anthropology, Boston University, Boston.

Alcala-Herrera, J.A., J.S. Jacob, M.L. Mchain Castillo, and R.W. Neck

1994 Holocene Palaeosalinity in a Maya Wetland, Belize, Inferred from the Microfaunal Assemblage. *Quaternary Research* 41:121-130.

Arnold, D.E.

1971 Ethnomineralogy of Ticul, Yucatan Potters: Etics and Emics. *American Antiquity* 36(1):20-40.

Baillie, I.C., A.C.S. Wright, M.A. Holder, E.A. FitzPatrick

1993 *Revised Classifications of the Soils of Belize*. NRI Bulletin Series 59. Natural Resources Institute, Chatham, UK. http://www.greenstone.org/greenstone3/nzdl;jsessionid=08426020AFACE171F7881E54797F22BF?a=d&c=hdl&d=HASHaa250f8d90a80dea58551b&dt=hierarchy&p.a=b&p.s=ClassifierBrowse. Retrieved August 9, 2012.

Barbezat, S.

n.d. Chichen Itza Photo Gallery. About.com Mexico Travelsite. http://gomexico.about.com/od/ancientsites/ig/Chichen-Itza-Photos/ Retrieved August 10, 2012.

Bishop, R. L., R. L. Rands, and G. R. Holley

1982 Ceramic Compositional Analysis in Archaeological Perspective. In *Advances in Archaeological Method and Theory*, Vol 5, edited by M.B. Shiffer, pp. 279-330. Academic Press, New York.

Buttles, P. J.

2002 *Material and Meaning: A Contextual Examination of Select Portable Material Culture from Colha, Belize*. Unpublished Ph.D. dissertation, Department of Anthropology, University of Texas, Austin.

2009 Pre-Maya and Early Maya in Northern Belize: Investigations at Colha, 2009. In *Programme for Belize Archaeological Project: Summary Report of the 2009 Investigations*, edited by F. Valdez, Jr, pp. 107-108. The University of Texas at Austin.

Carneiro, R.L.

1970 A Theory of the Origin of the State. *Science* 169(3947):733-738.

Chase, A.F. and D.Z. Chase

1996 More than King and Kin: Centralized Political Organization Among the Late Classic Maya. *Current Anthropology* 37:803-810.

Closs, M.P.

1988 *The Hieroglyphic Text of Stela 9, Lamanai, Belize*. Research Reports on Ancient Maya Writing 21. Center for Maya Research, Washington, DC. http://www.mesoweb.com/bearc/cmr/21.html. Retrieved April 8, 2012.

Culbert, T.P.

1973 Introduction: A Prologue to Classic Maya Culture and the Problem of It's Collapse. *The Classic Maya Collapse*, edited by T.P. Culbert, pp. 3-19. University of New Mexico Press, Albuquerque.

Davidson, M.W.

2003 Enhanced Brightfield Microscopy. *Molecular Expressions*. Florida State University. http://micro.magnet.fsu.edu/optics/intelplay/qx3brightfield.html. Last updated August 1, 2003. Retrieved April 3, 2012.

Day, P., E. Kiriatzi, A. Tsolakidou, and V. Kilioglo

1999 Group Therapy in Krete: A comparison Between Analysis by NAA and Thin Section Petrography of Early Minoan Pottery. *Journal of Archaeological Science* 26:1025-1036.

Eaton, J.D.

1980 Architecture and Settlement at Colha. In *The Colha Project, Second Season, 1980 Interim Report*, edited by T.R. Hester, J.D. Eaton, and H.J. Shafer, pp. 41-50. Center for Archaeological Research, University of Texas at San Antonio and Centro Studi e Ricerche Ligabue, Venezia..

1982 Colha: An Overview of Architecture and Settlement. In *The Colha Project, Second Season, 1980 Interim Report*, edited by T. R. Hester, H.J. Shafer, and J.D. Eaton, pp. 11-20. Center for Archaeological Research, University of Texas at San Antonio; and Centro Studi e Ricerche Ligabue, Venzia.

Fargher, L.F.

2007 A Microscopic View of Ceramic Production: An Analysis of Thin-Sections from Monte Alban. *Latin American Antiquity* 18:313-332.

Fox, J.W.

1987 *Maya Postclassic State Formation: Segmentary Lineage Migration in Advancing Fontiers.* (New Studies in Archaeology) Cambridge University Press, Cambridge, England.

Galehouse, J.S.

1971 Point Counting. In *Procedures in Sedimentary Petrology*, edited by R.E. Carver, pp. 385-407. Wiley-Interscience, New York.

Gibson, E. C.

1989 The Organization of Late Preclassic Maya Lithic Economy in the Eastern Maya Lowlands. In *Prehistoric Maya Economies of Belize*, edited by P. A. McAnnany and B.L. Isaac, pp. 115-138. (Research in Economic Anthropology, Suppl. 4) JAI Press, Greenwich.

Gifford, J.C.

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

Hammond, N.

1973 *British Museum-Cambridge University Corozal Project 1973*. Interim Report, Cambridge, England.

Hester, T.R. and N. Hammond

1976 *Maya Lithic Studies: Papers from the 1976 Belize Field Symposium.* Center for Archaeological Research, The University of Texas at San Antonio, Special Report 4.

Hester, T.R., H.B. Iceland, D.B. Hudler, and H.J. Shafer

1995 *The Colha Preceramic Project: A Status Report*. Texas Papers on Latin America. Paper No. 95-03.

Hester, T.R. and H.J. Shafer

1984 Exploitation of Chert Resources by the Ancient Maya of Northern Belize, Central America. In *World Archaeology* 16:157-173.

1989 The Ancient Maya Craft Community at Colha, Belize, and Its External Relationships. Paper presented at the 54th Annual Meeting of the Society for American Archaeology, Atlanta, GA.

Howie, L.

2007 *Provenance, Style and Technology: Integrated Approaches to Ceramic Production and Exchange During the Classic to Postclassic Transition.* Paper presented at the 72st Annual Meeting of the Society for American Archaeology, Austin.

Howie, L., C.D. White, F.J. Longstaffe

2010 Potographies and Biographies: The Role of Food in Ritual and Identity as Seen Through Life Histories of Selected Maya Pots and People. In *Pre-Columbian Foodways: Interdisciplinary Approaches to Food, Culture, and Markets in Ancient Mesoamerica*, edited by J.E. Staller and M.D. Carrasco., pp. 369-398 Springer, New York.

Hudler, D.B. and J. Lohse

1994 *Replication and Microscopy: Determining the Function of Unifacial Chert Tools from Belize*. Unpublished draft report, The University of Texas at Austin.

Iceland, H.B.

1997 *The Preceramic Origins of the Maya: The Results of the Colha Preceramic Project in Northern Belize*. Unpublished Ph.D. dissertation. The University of Texas at Austin.

Iceland, H.B. and P. Goldberg

1999 Late-Terminal Classic Maya Pottery in Northern Belize: A Petrographic Analysis of Sherd Samples from Colha and Kichpanha. *Journal of Archaeological Science* 26:951-966.

Jones, J.G.

1994 Pollen Evidence for Early Settlement and Agriculture in Northern Belize. *Palynology* 18:205-211.

Jones, L.D.

1986 *Lowland Maya Pottery: The Place of Petrological Analysis*. BAR International Series 288. Archaeopress, Oxford.

Kepecs, S.

1996 Native Yucatan and Spanish Influence: The Archaeology and History of Chikinchel. *Journal of Archaeological Method and Theory* 4:307-327.

Kepecs, S., G. Feinman, and S. Boucher

1994 Chichen Itza and Its Hinterland: A World-Systems Perspective. *Ancient Mesoamerica* 5:141-158.

King, R.B., I.C. Baillie, T.M.B. Abell, J.R. Dunsmore, D.A. Gray, J.H. Pratt, H.R. Versey, A.C.W. Wright, and S.A. Zisman

1992 *Land Resource Assessment of Northern Belize*. Vols 1 and 2. Bulletin 43. Natural Resources Institute, Kent, U.K.

Knapp, A.B. and J.F. Cherry

1994 *Provenience Studies and Bronze Age Cyprus: Production, Exchange, and Politico-Economic Change*. Monographs in World Archaeology 21. Prehistory Press, Madison, WI.

Lopez Varela, S.L.

1989 *Analisis y Clasificacion de la ceramica de un Sitio Maya del Clasico: Yaxchilan, Mexico*. BAR International Series 535. Archaeopress, Oxford.

Martin, S. and N. Grube

2000 *The Chronicles of Maya Kings and Queens*. Thames and Hudson, London.

Mason, R.B.

1994 *Islamic Glazed Pottery: 700-1250*. Unpublished Ph.D. Dissertation, Wolfson College, Oxford University.

2003 Petrography of Pottery from Kirman. *Iran* XLI: 271-8.

Masson, M.A.

1989 *Lithic Production Changes in Late Classic Maya Workshops at Colha, Belize: A Study of Debitage Variation*. Unpublished M.A. thesis. Department of Anthropology, Florida State University.

2002a Community Economy and the Mercantile Transformation of Postclassic Northeastern Belize. In *Ancient Maya Political Economies*, edited by M.A Masson and D.A. Freidel, pp.335-364. AltaMira Press, Walnut Creek, CA.

2002b Introduction. In *Ancient Maya Political Economies*, edited by M.A Masson and D.A. Freidel, pp.1-30. AltaMira Press, Walnut Creek, CA.

Materials Group

n.d. *Strength-Toughness*. Engineering Department, University of Cambridge: http://www-materials.eng.cam.ac.uk/mpsite/interactive_charts/strength-toughness/IEChart.html. Retrieved August 4, 2012.

Matthew, A. J., A. J. Woods, and C. Oliver

1997 Spots Before the Eyes: New Comparison Charts for Visual Percentage Estimation in Archaeological Material. In *Recent Developments in Ceramic Petrology*, edited by A.P. Middleton and I.C. Freestone, pp. 369-388. British Museum Occasional Papers 81. British Museum, London.

McAnany, P.A.

1986 *Lithic Technology and Exchange Among Wetland Farmers of the Eastern Maya Lowlands*. Doctoral dissertation, University of New Mexico, Albuquerque.

1989 Economic Foundations of Prehistoric Maya Society: Paradigms and Concepts. In *Prehistoric Maya Economies of Belize*, edited by P.A. McAnany and B.L. Isaac, pp. 347-372. (Research in Economic Anthropology, Suppl. 4) JAI Press, Greenwich.

1995 *Living with the Ancestors*. University of Texas Press, Austin.

McKenzie, B

1998 *Lamanai: Stela 9*. http://www.mayaruins.com/lamanai/stela9_rubbing.html. Last updated June 15, 1998. Retrieved April 8, 2012.

Me-bar, Y. and Valdez F. Jr

2004 Recovery Time after a Disaster and the Ancient Maya. *Journal of Archaeological Science* 31:1311-1324.

Media Cybernetics

1999 Image-Pro Plus version 4.1 for Windows: Start-Up Guide. Media Cybernetics, Silver Springs.

Michaels, G.H.

1987 *A Description and Analysis of Early Postclassic Lithic Technology at Colha, Belize*. MA thesis, Department of Anthropology, Texas A&M University.

1994 The Early Postclassic at Colha, Belize: A Summary Overview and Directions for Future Research. In *Continuing Archeology at Colha, Belize*, edited by T.R. Hester, H.J. Shafer, and J.D. Easton, pp. 129-135. Studies in Archeology 16. Texas Archeological Research Laboratory, University of Texas at Austin.

Middleton, A.P., I.C. Freestone, and M.N. Leese

1985 Textural Analysis of Ceramic Thin Sections: Evaluation of Grain Sampling Procedures. *Archaeometry* 27(1):64-74.

Mock, S.B.

1994 Yucatecan Presence in Northern Belize as Seen in the Postclassic Ceramics of Colha. In *Continuing Archaeology at Colha, Belize,* edited by T.R. Hester, H.J. Shafer, and J.D. Eaton, pp. 233-243. Studies in Archeology 16. Texas Archeological Research, University of Texas at Austin.

1998 Monkey Business at Northern River Lagoon: A Coastal-Inland Interaction Sphere in Northern Belize. *Ancient Mesoamerica* 8(2), 165-184.

Nesse, W.D.

2000 *Introduction to Mineralogy*. Oxford University Press, New York.

Ocean Drilling Program Science Operator

2007 "Figure F28 Photomicrograph showing large resorbed plagioclase grain that is optically discontinuous" In ODP Final Technical Report

Orten, C., P. Tyers and A. Vince

1993 *Pottery in Archaeology*. Cambridge University Press, Cambridge.

Peacock, D.P.S.

1970 The Scientific Analysis of Ancient Ceramics: A Review. *World Archaeology* 1(3):375-89.

Peck, D.T.

2002 *The Little Known Scientific Accomplishments of the Seafaring Chontal Maya from Northern Yucatan*. New World Explorers, Incorporated, Bradenton: http://www.newworldexplorersinc.org/MayaSeafarers.pdf. Retrieved August 8, 2012.

Pendergast, D.M.

1981 Lamanai, Belize: Summary of Excavation Results, 1974-1980. *Journal of Field Archaeology* 8:29-53.

Rands, R.L., R.L. Bishop, and J.A. Sabloff

1982 Maya Fine Paste Ceramics: An Archaeological Perspective. In *Excavations at Seibal No. 2: Analyses of Fine Paste Ceramics*, edited by J.A. Sabloff, pp. 315-338. Memoirs of the Peabody Museum of Archaeology and Ethnology, Vol 15, No. 2, Harvard University, Cambridge, MA.

Rathje, W.L.

1972 Praise the Gods and Pass the Metates: A Hypothesis of the Development of Lowland Rainforest Civilizations in Mesoamerica. In *Contemporary Archaeology: A Guide to Theory and Contributions*, edited by M.P. Leone, pp. 365-392. Southern Illinois University Press, Carbondale.

1975 The Last Tango in Mayapan: A Tentative Trajectory of Production-Distribution Systems. In *Ancient Civilization and Trade*, edited by J.A. Sabloff and C.C. Lamberg-Karlovsky, pp. 409-448. University of New Mexico Press, Albuquerque

1983 To the Salt of the Earth: Some Comments on Household Archaeology Among the Maya. In *Prehistoric Settlement Patterns: Essays in Honor of Gordon R. Willey*, edited by E.Z. Vogt and R.M. Leventhal, pp23-34. Albuquerque: University of New Mexico Press.

Rathje, W.L., D.A. Gregory, and F.M. Wiseman

1978 Trade Models and Archaeological Problems: Classic Maya Examples. In *Mesoamerican Communication Routes and Cultural Contacts*, edited by T.A. Lee and C. Navarrete, pp.147-176. New World Archaeological Foundation, Brigham Young University, Provo, UT

Rathje W.L., and J.A. Sabloff

1973 Ancient Maya Commercial Systems: A Research Design for the Island of Cozumel, Mexico. *World Archaeology* 5:221-231.

Reese-Taylor, K.

1991 Late Preclassic Ceramic Production in Northern Belize. Unpublished manuscript.

Rice, P.M.

1981 Evolution of Specialized Pottery Production: A Trial Model. *Current Anthropology* 22(3):219-40.

1984 *Ceramic Diversity: Implications for Production and Use*. Paper presented at the 49th Annual Meeting of the Society for American Archaeology, Portland, Oregon.

1987 *Pottery Analysis: A Sourcebook*. University of Chicago Press, Chicago.

Roemer, E.

1984 *A Late Classic Maya Lithic Workshop at Colha, Belize*. Unpublished M.A. thesis, Texas A & M University, College Station.

Sabloff, J.A., and W.L. Rathje

1975 The Rise of a Maya Merchant Class. *Scientific American* 233:72-82

Scarborough, V.L.

1985 Late Preclassic Northern Belize: Context and Interpretation. In *Status , Structure and Stratifications: Current Archaeological Reconstructions,* edited by M. Thompson, M.T. Garcia, and F.J. Kense, pp. 331-344. Archaeological Association of the University of Calgary.

Schafer, A. and Teyssen, T.

1987 Size, Shape and Orientation of Grains in Sands and Sandstones – Image Analysis Applied to Rock Thin Sections. *Sedimentary Geology* 52:251-271.

Shafer, H.J.

1979 A Technological Study of Two Maya Lithic Workshops at Colha, Belize. In *The Colha Project, 1979: A Collection of Interim Papers*, edited by T.R. Hester, pp.28-78. Center for Archaeological Research, University of Texas at San Antonio.

1996 *Colha, A Community of Craft Specialists in the Maya Lowlands: Postclassic*. Report submitted to The University of Texas at Austin and Texas Engineering Experiment Station, National Endowment for the Humanities Grant #RK-20211-95.

Shafer, H.J. and T.R. Hester

1983 Ancient Maya Chert Workshops in Northern Belize, Central America. *American Antiquity* 48:519-543.

1986 Maya Stone Tool Craft Specialization and Production at Colha, Belize: Reply to Mallory. *American Antiquity* 51(1):158-166.

1991 Lithic Craft Specialization and Product Distribution at the Maya Site of Colha, Belize. *World Archaeology* 23:79-97.

Sharer, R.J.

1994 *The Ancient Maya*. Fifth Edition. Stanford University Press, Stanford.

Shepard, A.O.

1939 Technological Notes on the Pottery of San Jose. In *Excavations at San Jose, British Honduras*, edited by J.E. Thompson, pp. 251-277. Carnegie Institution, Washington, D.C., publication 506.

1942 Classification of Painted Wares. In *Late Ceramic Horizons at Benque Viejo British Honduras*, by J.E.S. Thompson. Carnegie Institution of Washington Publication 528, Washington, DC.

1948 *Plumbate Pottery: A Mesoamerican Tradeware*. Carnegie Institution of Washington, Washington, D.C.

1958 Ceramic Technology. *Year Book* 57:451-454.

1964 Ceramic Development of the Lowland and Highland Maya. In *35th International Congress of the Americanists.* Vol 1, pp. 518-520. Mexico, D.F.

1965 Rio Grande Glaze-Paint Pottery: A Test of Petrographic Analysis. In *Ceramics and Man*, edited by F.R. Matson, pp. 62-87. Aldine, Chicago.

1967 Preliminary Notes on the Paste Composition of Monte Alban Pottery. In *La Ceramica de Monte Alban*, by A. Caso, I. Bernal, and J.R. Acosta, pp. 476-484. Instituto Nacional de Anthropologia e Historia, Mexico.

Shoval, S., P. Beck, and E. Yadin

2006 The Ceramic Technology Used in the Manufacture of Iron Age Pottery from Galilee. In *Geomaterials in Cultural Heritage*, edited by M. Maggetti and B. Messiga, pp. 101-117. Geological Society, London, Special Publication, 257.

Shoval, S., M. Gaft, P. Beck, and Y. Kirsh

1993 The Thermal Behavior of Limestone and Monocrystalline Calcite Temper During Firing and Their Use in Ancient Vessels. *Journal of Thermal Analysis*, 40, pp. 263-273.

Smyth, M.P., D.D. Christopher, H. Neff, and M.D. Glascock

1995 The Origin of Puuc Slate Ware: New Data from Sayil, Yucatan, Mexico. *Ancient Mesoamerica* 6:119-134.

Society for Sedimentary Geology

2006 *Carbonate Classification*. SEPM STRATA: http://www.sepmstrata.org/page.aspx?&pageid=89&4. Last updated April 6, 2012. Retrieved 22 March 2012.

Stoltman, J.B.

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

Sunahara, K, J. Chartrand, P. Healy, and J. Awe

2003 *Ancient Maya Ceramic Economy in the Belize River Valley Region: Petrographic Analyses*. Unpublished dissertation. Department of Anthropology, McMaster University, Hamilton, Ontario.

2006 *Petrographic Analysis of Cunil Phase Ancient Maya Pottery from Western Belize*. Paper presented at the 71st Annual Meeting of the Society for American Archaeology, San Juan, Puerto Rico.

Thornton, R.

2011 *Was There an Ancient Lost Civilization in Cuba?* Patrimundia INDI-UNI: http://www.archeolog-home.com/pages/content/was-there-an-ancient-lost-civilization-in-cuba-part-2.html. Retrieved August 4, 2012.

Tite, M., V. Kilikoglou, and G. Vekinis

2001 Strength, Toughness, and Thermal Shock Resistance of Ancient Ceramics, and Their Influence on Technological Choice. *Archaeometry* 43:301-324.

Toll, H.W.

1981 Ceramic Comparisons Concerning Redistribution in Chaco Canyon, New Mexico. In *Production and Distribution: A Ceramic Viewpoint*, ed. H. Howard and E. Morris, 83-122. BAR International Series 120. Archaeopress, Oxford.

Valdez, F., Jr.

1987 *The Prehistoric Ceramics of Colha, Northern Belize*. Unpublished dissertation. Department of Anthropology, Harvard University, Cambridge.

1994 The Colha Ceramic Complexes. In *Continuing Archeology at Colha, Belize*, edited by T.R. Hester, H.J. Shafer, and J.D. Eaton, pp. 9-16. Studies in Archeology 16. Texas Archeological Research Laboratory, University of Texas at Austin.

Valdez, F., Jr., and R.E.W. Adams

1982 The Ceramics of Colha after Three Field Seasons: 1979-1981. In *Archaeology at Colha, Belize: The 1981 Interim Report*, edited by T.R. Hester, H.J. Shafer, and J.D. Eaton, pp. 21-30. Center for Archaeological Research, The University of Texas at San Antonio and Centro Studi e Ricerche Ligabue, Venezia. San Antonio.

Velde, B. and I.C. Druc

1999 *Archaeological Ceramic Materials: Origin and Utilization*. Natural Science in Archaeology, series edited by B. Herrmann and G. A. Wagner. Springer, New York.

Walker, D.S.

1990 *Cerros Revisited: Ceramic Indicators of Terminal Classic and Postclassic Settlement and Pilgrimage in Northern Belize*. Unpublished dissertation. Southern Methodist University.

Wenke, R.J. and D.I. Olszewski

2007 *Patterns in Prehistory: Humankind's First Three Million Years*. Fifth Edition. Oxford University Press, New York.

West, G.

2002 Ceramic Exchange in the Late Classic and Postclassic Maya Lowlands: A Diachronic Approach. In *Ancient Maya Political Economies*, edited by M.A Masson and D.A. Freidel, pp.140-196. AltaMira Press, Walnut Creek, CA.

Whitebread, I.K.

1991 Image and Data Processing in Ceramic Petrology. In *Recent Developments in Ceramic Petrology*, edited by A. Middleton and I. Freestone, pp. 369-388. British Museum Occasional Papers 81. British Museum, London.

Wilk, R.

1976 Work in Progress at Colha, Belize, 1976. In *Maya Lithic Studies: Papers from the 1976 Field Symposium*, edited by T.R. Hester and N. Hammond, pp. 35-40. Center for Archaeological Research, University of Texas at San Antonio.

Wright, A.C.S., D.H. Romney, R.J. Arbuckle and V.E. Vial

1959 *Land in British Honduras*. Colonial Research Publications 24. British Honduras Land Use Survey, London.