2018

A CERAMIC ANALYSIS OF TWO TERMINAL CLASSIC MAYA SITES: EXAMINING ECONOMIC TIES THROUGH POTTERY

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A CERAMIC ANALYSIS OF TWO TERMINAL CLASSIC MAYA SITES:

EXAMINING ECONOMIC TIES THROUGH POTTERY.

By

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Bachelor of Arts, University of Central Florida, Orlando, FL 2014

Thesis

presented in partial fulfillment of the requirements
for the degree of

Master of Arts
in Anthropology

The University of Montana
Missoula, MT

December 2018

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ABSTRACT

Johannesen, Kara, M.A., December 2018 Anthropology

Chairperson: Dr. John Douglas

The objective of this thesis is to examine the relationship between two Maya sites, Cahal Pech and Xunantunich, during Terminal Classic (780-950 CE) through ceramic variability. Until recently the Terminal Classic (TC) was often misunderstood as a time of the "Maya collapse." The TC period is now understood as a complex time with shifting political tides possibly due to environmental pressures. New evidence from a TC deposit at Cahal Pech known as "south of H-1" shows an abundance of a specific decorated ware known as Mount Maloney Black (MMB), a type more closely associated with the neighboring site of Xunantunich. With the close proximity between the two sites (roughly 10 km) and given that Xunantunich was a politically influential civic center during this time, one might postulate that the MMB at Cahal Pech may indicate an influx from Xunantunich due to political or economic control over the site. However, the rim forms at Cahal Pech reflect that of an earlier style of MMB. This fact may indicate an emulation of the style by the residents of Cahal Pech, suggesting multiple production sites, or an early abandonment of Cahal Pech. This thesis uses the combined strategies of microphotography through the use of a portable digital microscope as well as thin section petrographic analysis to examine MMB pottery sherds from both Cahal Pech and Xunantunich to determine if they came from the same source. These approaches to ceramic analysis allow us to compare the mineral composition of the sherds from each site and to gather information about the 'recipes' used to make the MMB. From the data that were collected and analyzed, I suggest that there is some statistical significance between the mineral inclusions used in the MMB between the sites. Other lines of evidence such as texture, quantity of minerals, and thickness of sherds indicate possibly more than one production site. Comparing the MMB sherds found at Plaza H of Cahal Pech to Terminal Classic MMB at Xunantunich possibly sheds light on the interactions between these two sites and give a broader understanding of regional activities during the Terminal Classic.

ACKNOWLEDGMENTS

I would first like to thank my committee, for this research would not have been possible without their knowledge, guidance, and support throughout this process. Thank you to Dr. John Douglas for all the hard work and time you dedicated to helping me make this dream become a reality. This has been a long journey and you have helped me through the whole process. I am truly grateful for opportunities and guidance you gave me. To Dr. Jaime Awe, thank you so much for sharing your immense knowledge of the Maya world with me, and for all of the opportunities and experiences I was able to have in Belize. To Dr. Julie Baldwin, thank you for sharing your knowledge of geosciences with me, and your patience in teaching me how to use a petrographic microscope; I sincerely appreciate your guidance in helping me understand the thin section slides and for your perspective on this topic.

I would like to thank the Toelle-Bekken Family Fund, for through this funding petrographic analysis of pottery sherds was made possible. I would also like to thank the Belize Valley Archaeological Reconnaissance Project (BVAR), and all those who work for BVAR, for allowing me to stay with and work alongside BVAR students during my summer research.

Thank you to my friends and family for continuing to support and believe in me. To my biggest support system, mom, dad, and Chelsea, thank you so much. When I felt overwhelmed at times you were there for encouragement to keep me going. Mom, when things got challenging I was often reminded me of those "ten little words" you taught me as a child to never give up. Finally, thank you to all the students at UM and NAU who helped bounce ideas around with me and give me different points of insight during my thesis research.

Table of Contents

List of Tables

List of figures

Chapter 1 - Introduction

Brief Overview

Ceramics are one of the most useful and diagnostic cultural remains for the study of complex societies by archaeologists. The combination of their durability in the archaeological record and their stylistic markers have made ceramics one of the most studied artifacts (Quinn 2013). Ceramics can signify a time or place, cultural identity, and even offer insight into daily activities. The association between people, pottery, and activities can be examined by looking at the ceramic's life histories, from the manufacturing to disposal, as well as the performance characteristics of the ceramics. The manufacturing of pottery is a time-consuming process, which requires the procurement of clay, processing, forming, drying and firing of the vessel (Skibo 2015). Even the most basic, expediently made vessels still require effort; highly time-consuming pottery often involve a degree of craft specialization (Skibo 2015). Pottery is also extremely important because it is required for everyday needs such as cooking, eating, and storage. Pottery is used for everything from the sacred to the profane, often playing a role in communication and ritual (Skibo 2013). The performance characteristics selected during the manufacturing process of ceramics reflect both the utilitarian as well as the social and symbolic functions the vessel would be used for. Even utilitarian, everyday vessels can reflect a broader community identity. The embodied tendencies of a group of people is often enforced by the perceived world around them, and therefore even the most basic everyday items tend to inform us of a broader community identity (Bourdieu 1977). It is this basic notion that allows archaeologists to examine ceramics and gather information about a community as a whole.

For several millennium the peoples of the upper Belize Valley created pottery and other types of ceramics utilizing local clays and mineral additives. The long temporal duration of pottery traditions in this area has allowed for relatively precise categorization of pottery into groups and phases based on modal and stylistic attributes, therefore making on-site identification of pottery type/age possible (Masson and Rosenswig 2005; Aimers 2002). Regions with long ceramic traditions provide an opportunity to study the continuity or discontinuity in pottery, reflecting cultural phases and group identities (Ercole et al. 2017).

Prior to the Late Classic (LC), pottery types in upper Belize Valley sites appear nearly indistinguishable from center to center (LeCount 2011). This pattern may indicate that before the LC, the polities in this region were highly interactive, or that sociopolitical identities was not of great importance (McAnany 2001). Therefore, the increase in stylistic zones around the LC may be the result of changing economic or political spheres (Rice 1976). Late and Terminal Classic style zones coincide with periods of interpolity competition, and reflects the desire for group identity tied to these polities (Masson 2001).

Works such as Thompson (1942) and Gifford (1976) laid the groundwork for Maya ceramic studies in the Belize Valley by providing a ceramic chronology in order to identify phase and geographic distribution of ceramics based on a type-variety system. Based on the ceramic phases from Gifford (1976) work at Barton Ramie, the ceramic phase addressed in this thesis is mainly that of the Spanish Lookout Phase.

Table 1.1. Major Lowland Maya Periods adjusted from Gifford 1976 and Kirkpatrick 1973.

Major Periods	Date	Barton Raime
POST-CLASSIC	1000	New Town
C	900	
L	800	
A	700	Spanish Lookout
S	600	Tiger Run
S	500	
I	400	
C	300	Hermitage
P	200	
R	100 A.D	Mount Hope
E	100 B.C.E	
C	200	
L	300	Barton Creek
A	400	
S	500	
S	600	Jenny Creek
I		
C		

Common Spanish Lookout (LC to TC) ceramic types include Belize Red, Mount Maloney Black, Platon Punctuated Incised, Cayo Unslipped, and Benque Viejo Polychrome, to name a few (Gifford 1976). As previously mentioned, this thesis focuses on one of these types of pottery, Mount Maloney Black, as a means of addressing questions related to the economic and political interconnectedness between Cahal Pech and Xunantunich during the TC.

Center	LAT	LONG
Cahal Pech	17.146023	-89.073975
Xunantunich	17.090055	-89.141611

Figure 1.1. Map of upper Belize Valley.

As illustrated in Figure 1.1, both major and minor centers co-existed in time and space in the Upper Belize River Valley. Regional goods found throughout the Upper Belize Valley display the networks of trade common among these civic centers. Given the proximity of Cahal Pech to Xunantunich, similar material culture, including pottery groups, is observed in TC deposits at each site. However, Xunantunich and Cahal Pech existed as independent polities, and the percentages of these goods varies from site to site.

Many of the sites in the upper Belize Valley seem to have been affected by environmental stress during the TC, however, how each center responded to these conditions varies by site (Demarest et al. 2004). Between the end of the LC and into the TC, both Cahal Pech and Xunantunich appear to undergo a shift in sociopolitical status. Xunantunich appears to gain prominence around the end of the Late Classic and into the

TC, marked by monumental construction projects and new alliances with centers outside of the upper Belize Valley (Leventhal 2010). The 2016 discovery of panels from a hieroglyphic stairway from Caracol found at Xunantunich Structure A9, provide strong evidence for Xunantunich's ties with Naranjo towards the end of the LC, and gives insight into the strengthening of Xunantunich's sociopolitical and economic spheres (Helmke & Awe 2016a, b). In contrast, Cahal Pech seems to decrease in size and power at the end of the Late Classic and into the Terminal Classic period, resulting with the abandonment of many buildings and a contraction of the remaining population towards Plaza H (Douglas and Brown 2014). Furthermore, changes in construction technique and burial practice also suggests a reorganization of political structure at Cahal Pech during the TC.

Following the discovery of an elaborate TC burial in Plaza H at Cahal Pech in 2006, the University of Montana (UM), under the auspices of the Belize Valley Archaeological Reconnaissance Project (BVAR), has conducted field schools focusing on TC deposits in Plaza H since 2011. In addition to the elite tomb found in Plaza H, several special deposits were discovered, including what appears to be a "termination deposit" containing a dense deposit of pottery sherds, often larger than typical, along with other special items. Among this pottery is a large percentage of MMB, comprising nearly 30% of the decorated wares.

Although MMB is found regionally, the high percentage in the special deposit south of H-1 is not typical for Cahal Pech. This raised questions of interactions between the sites during the TC. What, for example, led to the significant presence and increase of MB pottery at Cahal Pech at this time? Could this be the result of changing economic ties during the TC? Since Xunantunich appears to have gained political power during the LC to TC, is it possible that the influx of MMB in Plaza H was the result of Xunantunich's growing economic and sociopolitical influence over a waning Cahal Pech? Alternatively, because certain stylistic differences are apparent in the MMB assemblage at Plaza H, is it possible that there were multiple centers of production of this TC ceramic type? If in fact there were multiple production zones, then differences in the "recipe" of the pottery might be observed. Fortunately, MMB ware has been well studied, providing a solid basis of expected observable qualities for Late and Terminal Classic wares. As previously mentioned, the MMB found in Plaza H reflects an earlier style which will be explained below, based on LeCount's (1996) temporal variants of MMB by lip angle. In order to further understand the variation between the samples, a brief outline of the "typical" characterizations of MMB are also provided below.

Mount Maloney Black Characteristics

The type-variety system of ceramic classification has been criticized by some and many have suggested that further refinement would prove beneficial (Smith 1979; Rice 1976). Nonetheless, it is still widely accepted by Maya archaeologists as a method for organizing large quantities of ceramics into groups, and for providing temporal information and places of manufacture. In the type-variety classification, pottery wares are defined by paste composition and slip attributes (Rice 1979). In the upper Belize Valley, "stylistic zones" are often interpreted by quantity of wares commonly associated with sites.

Mount Maloney Black (MMB) ware is one such ceramic type named after the site it is most associated with. Mount Maloney was one of the first names given to

Xunantunich, and therefore based on the large quantity of black wares at Xunantunich, the type-ware was called Mount Maloney Black (LeCount 2010). Comprising between 38-46 percent of Late and Terminal Classic assemblages at Xunantunich, MMB is the most abundant ware regardless of social status, being found in nearly all contexts and distributed throughout the site and its hinterlands (LeCount 2010). LeCount (1996) refines the type-variety of MMB by including other diagnostic features in addition to temper and slip. By measuring the frequency of ceramic attributes from stratified deposits, LeCount (1996) was able to observe small shifts in ceramic modes through time. LeCount (1996) suggests that based on lip orientation, MMB bowls are temporally distinct, with minor changes in orientation between LC and TC. The orientation of the lip from vertical to horizontal occurs gradually from the Late to Terminal Classic (LeCount et.al, 2002). Therefore, MMB bowls are temporally diagnostic, allowing archaeologists to conduct a microseriation of the ware. This seriation sequence (see Figs. 1.2 to 1.4) is divided into Late Classic I (600-670), Late Classic II (A.D. 670-790), and Terminal Classic (A.D.790-1000) (LeCount 1996, 1999).

Figure 1.2. Late Classic I (LC-I) rim.

Figure 1.3. Late Classic II (LC-II) rim.

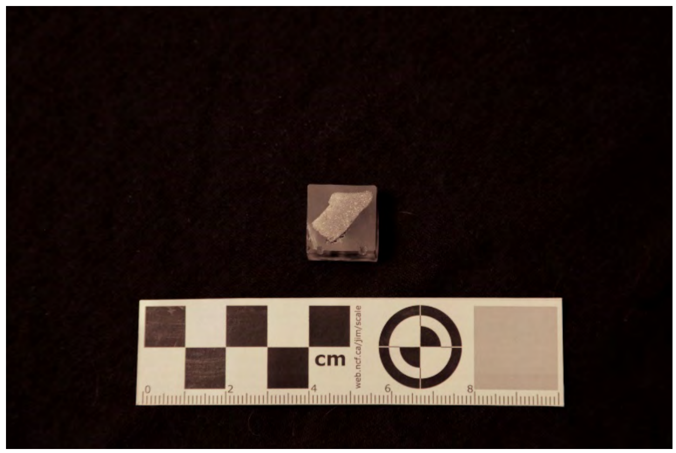

Figure 1.4. TC rim in epoxy.

University of Montana excavations at Cahal Pech during the 2015 and 2016 field seasons noted a divergence from the seriation pattern recorded at Xunantunich. Foremost, the lip orientation of MMB sherds found in TC deposits Cahal Pech reflected mainly that of LC-I and LC-II. Furthermore, the frequency of MMB pottery in the TC deposits in Plaza H reflected an atypical pattern when compared with other TC deposits in the Cahal Pech site core. In assemblages at Cahal Pech, red wares such as Belize Red are typically the most common of the decorated wares (LeCount 2010; Audet 2006; Douglas and Brown 2015). In special deposits found in Plaza H, however, roughly 30 percent of the decorated wares were MMB (Douglas and Brown 2015).

It is this atypical distribution of MMB pottery in Plaza H that prompted further research of this anomaly, and which forms the basis of this thesis. To compare the MMB at Cahal Pech with that of Xunantunich, additional factors beyond slip color and lip orientation needed to be addressed. During the 2016 field season, ceramics from units at Plaza H containing large volumes of sherds were systematically organized first by ware, then by type. The MMB rims were subsequently analyzed using the LeCount rim chart and recorded accordingly. These assemblages would later be used for paste analysis and additional thin-section petrographic analysis. In the following sections, this analysis is described first by examining the context in greater detail, which is followed by sampling considerations and then by a description of the methodology.

Chapter 2 - Context and Sampling Strategies

To better understand the relationship between the MMB at Xunantunich and Cahal Pech (Plaza H), samples were taken from each site and several methods of analysis were applied to all of the samples. In addition, two other assemblages from the larger Cahal Pech polity were also analyzed to determine if any similarities or differences between Cahal Pech and Xunantunich were part of a larger pattern or unique. The first of these comes from, deposits that were recovered at the base of Str. A1 and A2 in Plaza A at the Cahal Pech ceremonial center. The second sample was recovered from the Zopilote Group, a large ceremonial complex located just south of the Cahal Pech acropolis.

Cahal Pech, Plaza H

The Cahal Pech acropolis is situated about 900 ft. above sea level, on a large hill overlooking the Macal River. This location provides a 360-degree view of the surrounding area, and would have provided the site with a defensible setting during its occupancy. Beginning in the 1950s and continuing through present day, investigations at Cahal Pech have served to establish that the center encompassed an area as large as ten square kilometers (Awe 2013). Excavations have also revealed that Cahal Pech was continuously occupied from the end of the Early Preclassic to the Terminal Classic (with a possible hiatus after the Late Classic) (Awe 1992; Douglas et al. 2015). Recent efforts have focused on the plazas related to the late phases of the site, particularly Plaza H and Plaza A.

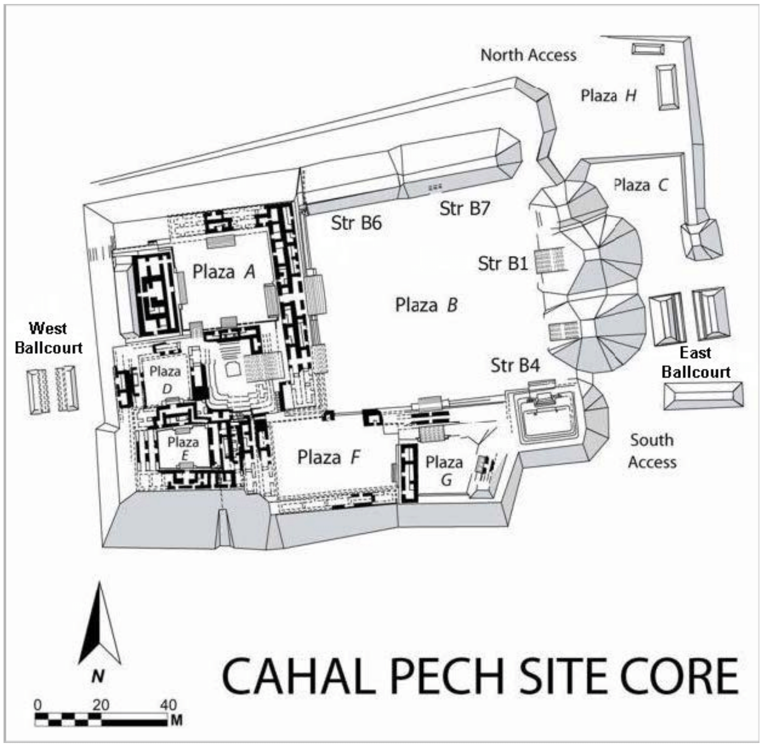

Figure 2.1. Cahal Pech site map. From: Douglas and Brown 2016.

Plaza H is located in the northeast corner of the site core of Cahal Pech, north of Plaza C, and east of Plaza B. Prior to the discovery of an elaborate TC tomb found during the 2006 excavations, Plaza H was previously unmarked on older maps (Douglas and Brown 2013). The unearthing of this burial raised questions of the occupational history of Cahal Pech and the activities that took place in Plaza H during the TC. As previously mentioned, UM, in conjunction with BVAR, began winter session field excavations in 2011 to address the nature of TC occupation in Plaza H.

The 2016 field season focused on the south side of the H-1 structure. Previous excavations south of the southern wall of H-1 uncovered dense sherd deposits lying on the plaza floor (Douglas & Brown 2017). In 2016 one of the objectives was to further investigate the area along the southern wall of H-1 in order to identify the extent of this dense sherd deposit (Douglas & Brown 2017). While excavations along the south side of

H-1 continued, I began sorting the sherds from units 34, 35, and 49 based on slip, paste, and form into their type-variety designations (MMB, Belize Red, Benque Viejo Polychrome, etc.). Gathering this information allowed for precise determination of the percentage each decorated ware represented among the total assemblage. This preliminary analysis found a significant amount of MMB sherds in these deposits, contrary to other Plaza H deposits in which only occasional sherds are found. Of the identifiable MMB rim sherds, the majority were that of LC II, with some LC-I and few TC styles (Table 2.1). The MMB sherds make up over 30% of the decorated wares from these units.

Table 2.1. Example of preliminary findings of high quantity of MMB.

EU	Level	Type	Style	Count	Weight	% of total bag count	% of total weight	Mt. Maloney Form		Mt. Maloney Rim Seriation	
35	3	Dec Body	Ash Temper Red	38	404 g	36.20%	37.20%	Bowl:	16		
35	3	Dec Body	Calcite Red	28	145 g	26.70%	13.30%	Jar:	16		
35	3	Dec Body	Mt. Maloney Black	38	378 g	36.20%	35%	Rim:	0		
35	3	Dec Body	Cayo Unslipped Striated	1	160 g	1%	14.70%	Unknown:	6		
35	3	Dec Other	Ash Temper Red	1	7 g	50%	54%				
			Mt. Maloney Black	1	6 g	50%	46%	Rim/other	1		
35	3	Dec Base	Ash Temper Red	4	111 g	80%	79.90%				
35	3	Dec Base	Calite Red	1	28 g	20%	20.10%				
35	3	Dec Rim	Ash Temper Red	7	209 g	36.80%	32%	Bowl:	6	LC I:	1
35	3	Dec Rim	Calcite Red	5	119 g	26.40%	18.20%	Jar:	1	LC II:	4
35	3	Dec Rim	Mt. Maloney Black	7	326 g	36.80%	49.80%			TC:	1
35	2	Dec Body	Ash Temper Red	22	356 g	25.30%	23.20%	Bowl:	24		
35	2	Dec Body	Calcite Red	29	290 g	33.30%	19%	Jar:	3		
35	2	Dec Body	Mt. Maloney Black	36	886 g	41.40%	57.80%	Unknown:	9		
35	2	Dec Rim	Ash Temper Red	6	368 g	21.40%	33.80%	Bowl:	9	LC I:	2
35	2	Dec Rim	Calcite Red	12	388 g	42.90%	35.60%	Jar:	1	LC II:	6
35	2	Dec Rim	Mt. Maloney Black	10	333 g	35.70%	30.60%			TC:	1

Additionally, the south side of H-1 contains other special deposits, including a dense debitage deposit, and a variety of stone, bone, and shell artifacts (Douglas and Brown 2016). The position of the artifacts along the plaza floor, as opposed to occurring in small amounts layer by layer may indicate a single event. This is a pattern typically associated with Maya “termination deposits” (Stanton et al. 2008; Dussol 2017) or other ritual activity. Termination rituals typically include broken pottery, bone, and other artifacts, as well as intentional destruction of architectural features at the time of abandonment (Stanton et al. 2008; Dussol 2017). The characteristics associated with termination rituals is evident in units south of H-1. Therefore, the MMB found in the special deposits south of H-1 could be from the abandonment of Plaza H and potentially Cahal Pech entirely. Why then towards the end of the occupational history of Cahal Pech does a large quantity of MMB appear in the archaeological record? Addressing this may possibly help in our understanding of the larger scope of the activities which took place in the Upper Belize Valley during the TC.

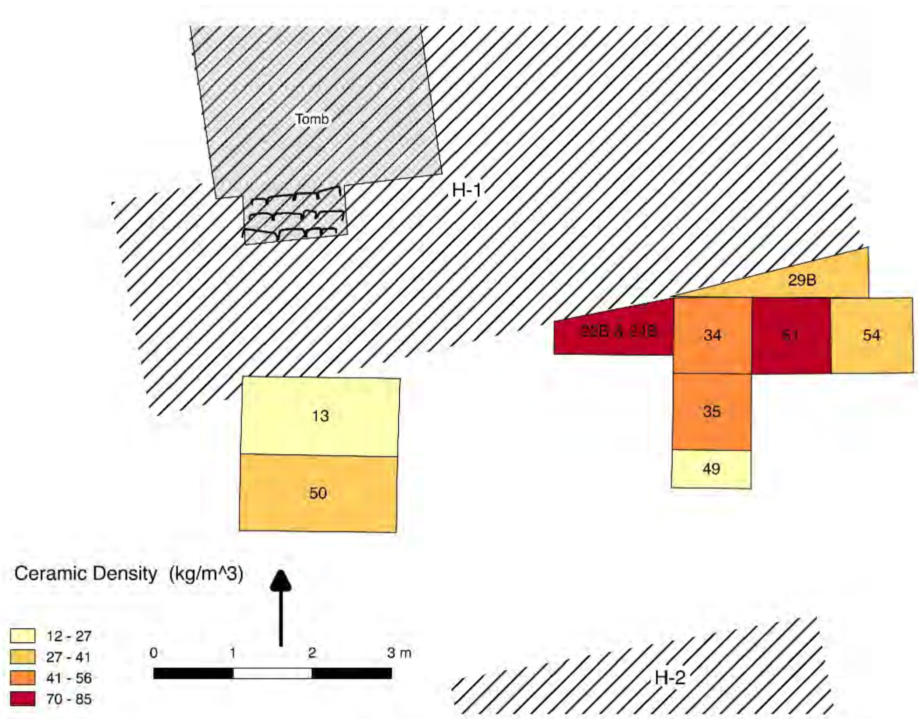

Figure 2.2. Ceramic densities from units south of H-1. From: Douglas and Brown 2017.

In the summer of 2016, sherds from units 13, 22B/24B, 34, 35, 50, and 51 were collected for microphotography. These units were selected for analysis as they are from the special deposit south of H-1 and contained containing large volumes of ceramics. A total of 185 sherds were processed for microphotography and for further analysis.

Xunantunich

Positioned on a hill above the Mopan River, Xunantunich is an architecturally impressive site, with the Castillo towering over the grounds below. Compared to Cahal Pech, the occupational history of Xunantunich is fairly short. In fact, most of the monumental architecture seen today was built over a ~150-year period (LeCount & Yaeger 2010; LeCount et al. 2002). Architectural evidence suggests Xunantunich grew to its maximum size sometime around the Late Classic (LeCount & Yaeger 2010). During the Terminal Classic, Xunantunich continued to erect carved monuments, displaying their late and affluent political stature (LeCount & Yaeger 2010).

Figure 2.3. Map of Xunantunich site core.

To compare the ceramics from Xunantunich with those from Cahal Pech, we acquired TC samples of MMB that were recovered at the former site by the BVAR

Project. Specifically, we used pottery recovered from unit A-3-1 in Structure A-3, the central pyramid of the Eastern Triadic Shrine at Xunantunich. In the summer of 2015, excavations took place on structure A-3 with the objectives of investigating any similarities in architecture or possible ritual usage with that of Structure B-1 at Cahal Pech (Santasilia & Tilden 2016). Previous excavations of Structure B-1 at Cahal Pech revealed 13 burials and three caches, supporting the claim that some eastern triadic shrines, or “E-Group” structures, are of religious or ritual importance related to ancestor veneration (Santasilia & Tilden 2016; Awe et al. 2017b). Additionally, at the summit of B-1, a TC intrusive burial was uncovered along with Spanish Lookout phase ceramics (Awe et al. 2017b). The special deposit in B-1 indicated the burial was placed there sometime after the site had fallen into disrepair, reinforcing the TC depositional patterns at Cahal Pech (Awe et al. 2017b).

The Xunantunich Str. A-3-1 TC deposit is situated just south of the building’s stair side outset (Santasilia & Tilden 2016). Given that BVAR’s objectives were to examine any possible correlations between Structure A-3 at Xunantunich with that of B-1 at Cahal Pech, samples from this unit were selected for comparison to the chosen samples from Cahal Pech. Furthermore, knowing that the MMB in Plaza H was probably from a termination ritual, and that the sherds from Xunantunich A-3-1 may have been used in ritual activity made for a more meaningful and interesting comparison.

Samples from unit A-3-1 level 2 were taken to the lab located at Cahal Pech to be sorted and prepped for analysis. A total of 108 MMB sherds from unit A-3-1 level 2 were chosen for microphotography. Of the identifiable rims, the majority were LC-II and TC styles, paralleling what one would expect from a TC deposit at Xunantunich. Therefore, these, as well as body pieces identified by the distinct black slip, were chosen for this research.

A1/A2 CHP

Additional evidence for Terminal Classic activities at Cahal Pech were recovered by Awe and his colleagues (2017a) in Plaza A, particularly along the flanks of the palaces and alleyways in this elite courtyard. An intrusive burial found in Structure A3 was also determined to be a child, approximately seven to nine years of age, containing grave goods associated with the TC (Awe et al. 2017a). The intrusive burial was cut into a bench in the central room of Structure A3, then filled with dirt but never resealed. This, along with the relative date of the grave goods, including Spanish Lookout phase ceramics, all suggested the burial occurred during the Terminal Classic (Awe et al. 2017a).

The sherds that were selected for analysis from Plaza A come from the A1/A2 Alley. Heavy rainfall in January of 2014 caused damage to structure A-1, revealing TC deposits (Kollias 2015). For this reason, the A1/A2 alley was selected for excavation with the objectives of fully exposing the TC deposit (Kollias 2015). Excavations from 2002-2003 revealed numerous ritual deposits associated with the TC (Kollias 2015). Ceramic materials constituted approximately 95% of the artifacts uncovered in the A1/A2 Alley (Kollias 2015). The ceramic types from A1/A2 consisted of Belize Red, Platon Punctuated Incised, Cayo Unslipped, Mount Maloney Black, and other types typical of Terminal Classic deposits (Gifford 1976; Kollias 2015).

Samples from A1/A2 were chosen to compare to the Plaza H samples for a broader context of TC deposits within the site core of Cahal Pech. A total of 21 sherds were used for microphotography. The sherds came from units 1B East, 1C East, 1B West, and 1C West. Unfortunately, no rim pieces were found in this assemblage, limiting the scope of comparison. However, based on the context of the sherds coming from TC deposits, and the distinctive MMB slip, these sherds were still useful in providing information about MMB paste found in multiple areas of Cahal Pech.

Zopilote

The final area chosen for comparison of MMB sherds was from the Zopilote Group. The Zopilote Group is located approximately 0.75 km south of the Cahal Pech site core (Awe and Brisbin 1993; Ebert and Fox 2016). Zopilote consists of two primary temple structures, and contains two vaulted tombs, likely of elite status (Awe 2013; Ebert and Fox 2016). Construction phases, ceramics, and one carved monument indicate that Zopilote was used from the Middle Preclassic through the Terminal Classic (Ebert and Fox 2016). The temple platforms at Zopilote suggest that this area may have held ritual significance. Furthermore, the elite burials and presence of a carved stela suggest that rituals conducted at Zopilote were likely related to ancestor worship.

In 2015 Structure 2 at Zopilote was re-excavated, revealing a large Terminal Classic deposit containing Spanish Lookout phase ceramics (Ebert and Fox 2016). Additional excavations in 2016 sought to determine the extent of this terminal deposit (Fox and Awe 2017). The evidence collected suggests that Zopilote was continually visited as a site of ancestor reverence during the TC (Fox and Awe 2017). The presence of several Late Classic burials found at Zopilote adds to the importance of the Zopilote

Group to the people living at Cahal Pech, who continued to use the site as a ceremonial center into the Terminal Classic (Fox 2018) when the site was in decline.

Since Zopilote is a terminus group of Cahal Pech, the samples chosen from the TC deposits at Zopilote provided yet another context of Terminal Classic MMB at Cahal Pech. Sherds provided by Steven Fox in the summer of 2016 were chosen for microphotography. Identification of MMB in these deposits was most challenging as the slip had been worn on many of the sherds. Consequently, only 38 of the best-preserved sherds from Zopilote were selected for our analysis. The entire sample came from Structure 3, level 2, a TC deposit.

Summary

In an effort to determine the TC relationship between the Belize Valley sites of Cahal Pech and Xunantunich, this thesis was designed to study and compare MBB ceramics at two centers. To conduct the analysis, I selected pottery samples from Plaza H at Cahal Pech, Structure A-3 at Xunantunich, the A1/A2 Alley at Cahal Pech, and Structure 3 at Zopilote. Although the main objectives of this thesis are to compare the MMB from Plaza H with those from Xunantunich, the additional samples from two other locations at Cahal Pech helps broaden the cultural context of the ceramics, and allowed us to conduct a more comprehensive study of the assemblage. The context of each of these assemblages was also taken into account and specifically chosen to address other objectives of the project. In order to ascertain the political and economic relationship between Cahal Pech and Xunantunich during the TC, samples of Mount Maloney pottery were selected for ceramic analysis for the following purposes: A) to determine whether or not there were multiple areas of production for MMB pottery, or B) to determine whether the MMB pottery discovered in Plaza H was imported from Xunantunich, possibly due to

Xunantunich gaining economic control over a weaken Cahal Pech. The samples that were chosen from each assemblage would be examined beyond the parameters of form, slip and rim shape. The following section details how the sherds were analyzed through the use of both a portable digital microscope, and through a petrographic microscope for analysis of the pottery's mineral and additive qualities.

Chapter 3 – Methodology

This chapter presents the methodology applied to the study of MMB ceramics from Cahal Pech and Xunantunich. The two main methods of analysis used in this study are 1) qualitative and quantitative analysis through the use of a portable digital microscope and point count system, and 2) thin-section petrographic analysis with the use of a petrographic microscope. These methods were used to examine the compositional characteristics of MMB sherds at both Cahal Pech and Xunantunich. Determining the compositional characteristics of the sherds provided a means of addressing questions surrounding areas of production as well as variation within the MMB paste.

Pottery consists of two main components: clay matrix and inclusions (Worrell 1975). Inclusions can be either naturally occurring or deliberately added to the clay by the potter. The deliberately added inclusions are called temper (Braekmans and Degryse 2017, Druc 2015). These intentionally added non-plastic inclusions can enhance the workability of the clay and strengthen the body of the final product (Peterson 2009). The temper of a sherd and the percentage of temper to clay matrix can yield information regarding the "recipe" of the ceramic. There are multiple approaches to finding the recipe of a sherd. This thesis uses a multifaceted approach to the analysis of MMB, and in the following sections I will explain how these approaches were employed and how using multiple approaches can be beneficial when conducting ceramic research.

Portable Digital Microscope

The use of a portable digital microscope for ceramic studies is becoming an increasingly popular tool for field archaeologists because it allows for on-site analysis of ceramic sherds with moderate magnification (Druc 2015). It can also help researchers narrow down their sample size, selecting which sherds to export for further analysis such as thin section petrography, slip analysis, and other techniques. The introduction of the binocular microscope for ceramic analysis has been credited to Anna Shepard (1964), and Frederick Matson (1970) who were some of the first to suggest its usefulness for paste descriptions. Typically, without the use of a microscope, only limited descriptive qualities can be assigned to sherds, such as their color, sherd/rim size, and feel (sandy, coarse, etc.). With the additional use of a portable digital microscope it is possible to take photos of sherds which can subsequently be examined for defining details of the ceramic's paste, and provide more information on ceramic technology. Portable digital microscopes are useful in identifying features in ceramic sherds such as texture, color, presence or absence of firing core, mineral and non-mineral inclusions, angularity of grains, how sorted inclusions are, degree of porosity, and percentage of inclusions to clay matrix. These features can therefore be interpreted to give a more comprehensive idea about the potter's recipe for each ceramic vessel. When done systematically, similarities and differences within and between groups can be observed.

When trying to answer questions concerning a specific pottery type occurring at multiple sites, it is important to keep in mind the context of the sites. Given that these two sites are on two different drainages, the Mopan and Macal, there may be some observable differences in the mineralogy of the sherds. This study addresses mineral inclusions within the sherds as well as looks at the overall recipes and techniques that went into the pottery making process.

Over a four-week period in the summer of 2016, each of the selected samples were prepped, photographed with the digital microscope, and recorded in detail. This was done at the on-site lab located at Cahal Pech. Photos were taken at 30x magnification using a digital microscope (Dino-lite Pro AM4113T). This microscope attaches to a computer via USB cable, and the images were uploaded directly to a laptop.

Each sherd first had to be prepared before going under the microscope. This process consisted of taking pliers and breaking off a chip of the sherd to expose the paste. Each sherd was subsequently mounted under the microscope, and stabilized as much as possible with the use of putty. One drawback of using pliers to break off a chip of the ceramic sherd is that it does not always produce a flat, smooth surface, and sometimes even creates unintentional post depositional cracks or holes. Mounting the sherds under the microscope was the best way to get as much of the sherd in the photo as possible, however, as some sherds were larger than others, or oddly shaped, it was not always possible to get the same-sized, focused images. Upon further review, some of the images of the sherds could not be used for subsequent analysis, however, there were enough quality images to make for a thorough analysis.

Figure 3.1. Xunantunich photo#8. Example of surface breakage due to pliers.

Through the use of the computer program JMicrovision, the photographed images were then measured based on a set of variables useful in answering the proposed research questions. Using this program allowed for calibration of images to 30x magnification, the same magnification that the photos were taken at. For the quantitative portion of the image analysis, point counting was done with the minimum of 100 random grid points with the goal of quantifying the paste composition. One hundred random grid points has been suggested as a good minimum amount when doing point counting research (Stolman 1989). The following categories were measured (1) matrix (2) mineral inclusions (3) non-calcite rock fragment (4) grog (5) void, and (6) other. Although the categories began much more specific to mineral type, it was quickly noticeable that it was difficult to differentiate between certain minerals such as quartz and calcite under 30x reflective magnification and therefore the minerals were grouped together to identify percentage of matrix to overall mineral count. Furthermore, it was difficult to make out very fine minerals which led to high percentages of clay matrix. This quickly led to a biased count and therefore the categories were narrowed down.

Figure 3.2. CHP-69 example of very fine inclusions.

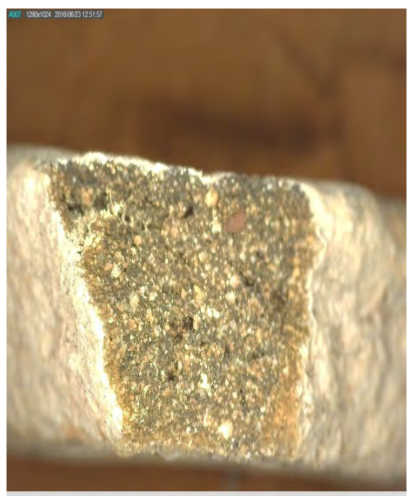

Figure 3.3. CHP-169 example of slightly out of focus image.

The descriptive portion of the point count analysis consisted more so of recording the potter's technique rather than the constituent components. The recorded descriptive categories consist of shape of inclusions, color/description, and texture. Shape of inclusions was subdivided into seven categories ranging from round to angular. This gave insight into added crushed minerals vs naturally occurring minerals. Color of matrix was measured in order to observe firing temperatures and variation. There were seven categories for color since there was a wide variety, ranging anywhere from solid brown or grey, to sherds with varying degrees of oxidized cores. Texture was measured on a scale of very fine to very coarse; however, it was judged purely on an observational base, not calibrated to any standardized scale such as Udden-Wentworth or ISO scales (Druc 2015).

Initial review from the point count data appeared to have a high variability between all of the collections. The four selected assemblages all contained a large quantity of inclusions compared to matrix, and the descriptive portions were varied at each sampling location. Furthermore, the lack of ability to differentiate between minerals within the sherds led to a limited ability for comparing and contrasting the ceramic recipes between sites. More precise identification of mineral type, and size needed to be conducted in order to perform any statistical analysis between the sites. Therefore, samples were selected for export to the United States for thin section petrographic analysis. As these samples were also going to be used for slip analysis, the sherds that were chosen were samples that preserved the most slip covering the surface. The tables below show the units and quantity of selected samples for export from both Plaza H and Structure A3.

Table 3.1. List of CHP MMB sherds exported to the U.S.

EU	Level	Quantity
22B/24B	3	4
34	3	5
34	4	7
35	2	4
35	3	10
50	2	3
50	3	5
51	3	3

Table 3.2 List of Xunantunich MMB sherds exported to the U.S.

Xunan EU	Level	Quantity
A-3-1	2	14
A-3-1	2	5
A-3-1	2	3
A-3-1	2	2

Thin Section Petrography

As mentioned in the previous section, carrying out a full paste analysis on the documented sherds proved to be more challenging than anticipated through microphotography and point counting alone. The main concern was that individual mineral type could not be identified reliably, which could lead to biased results or missing key variability between the samples. Thin section petrographic analysis has been argued to be one of the most advantageous approaches to ceramic paste analysis (Ciliberto and Giuseppe 2000; Rice 1996; Stoltman 1989, Stoltman et al. 2008; Whitbread 1989, 1996).

In the late nineteenth century, English scientist Henry Clifton Sorby demonstrated how thin section petrography was useful as a method for studying rocks (Humphries 1992, Peterson 2009, Quinn 2013). This technique for studying rocks was soon after applied to the identification of minerals in ceramics (Quinn 2013). Early works such as Ferdinand Fouque's use of thin section for identifying volcanic inclusions in prehistoric Thean pottery, and Gustav Nordenskiold's 1893 petrographic study of sherds from Mesa Verde, pioneered the development of ceramic petrography (Quinn 2013). Although this method proved to be useful in the identification of ceramic pastes in the late 19th Century, it would not be until the mid to late 20th Century with works by archaeologists such as Anna Shepard (1942, 1964), and David Peacock (1968) that ceramic petrography would finally be recognized as a scientific approach to archaeological studies (Quinn 2013).

There are two characteristics that differentiate petrographic microscopes from regular microscopes, and that is the use of polarized light and the rotating stage on which the thin sections sit (Nesse 2013). Thin sections are samples which have been cut thin enough for the polarized light to pass through and show the optical properties of the minerals within the sample (Nesse 2013). Ceramic thin sections are usually prepared as a vertical cross-section of the ceramic sherd (Whitbread 2017). Thin sections can be studied under two different light conditions; plane polarized light (PPL) and crossed polarized (XPL) (Nesse 2013). These light conditions are produced by filters arranged at 90-degree angles and provide different identification tools for the study for minerals in thin sections. Paste recipe identification is possible using a petrographic microscope by identifying mineral type, occurrence, size, shape, and arrangement.

Fifty-six of the 65 exported sherds were chosen and shipped to National Petrographic Services, Inc. where they were cut to 27x44 mm slides. Since the material was porous and delicate, each of the samples was impregnated with epoxy resin and grinded in oil. Fortunately, all of the 56 samples were successfully made into thin section slides. Of these thin section slides, 33 were from Cahal Pech, and 23 from Xunantunich. The slides were examined using both PPL and XPL.

As one of the main objectives in the thin section petrographic analysis was to identify mineral type, it is important understand how to read the thin sections under the petrographic microscope. There are three main groups of minerals determined by the way light is or is not transmitted through their crystal structure (Braekmans and Degryse 2017). These are opaque, isotropic, and anisotropic (Nesse 2013). Opaque minerals are those that do not transmit light in any direction, isotropic minerals transmit light the same in all directions, and anisotropic minerals display light differently depending on the rotation angle (Nesse 2013). The thin section samples used for this thesis focus mainly on the identifiable anisotropic minerals.

When placed between crossed polarizers, anisotropic minerals may display "interference colors" (Nesse 2013). Anisotropic minerals transmit light following different wave lengths, causing a difference in velocity in how light passes through a mineral depending on direction (Braekmans and Degryse 2017). Using the rotating stage on the petrographic microscope, anisotropic minerals will go "extinct" once every 90 degrees (Nesse 2013). The colors produced under the crossed polarizers are the interference colors and these are measured by their degree of birefringence.

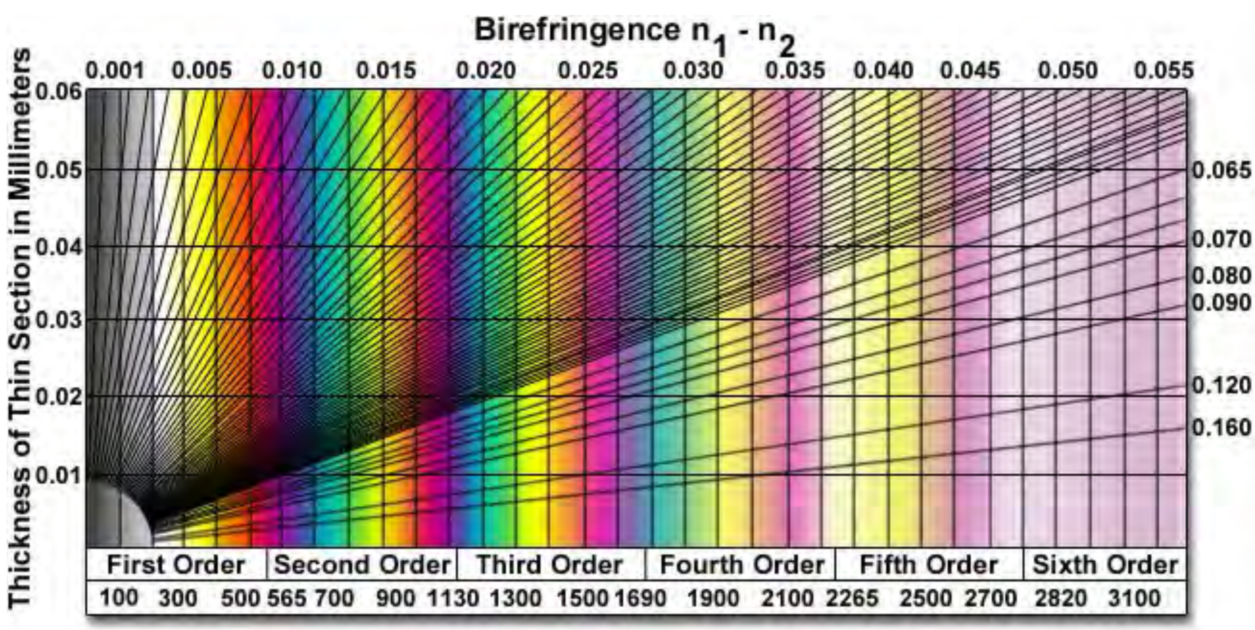

Figure 3.4. Michel Levy Chart used in petrography to identify mineral types; lowest order to left (Goeke 2011).

The colors are classified according to their order. First order appearing more greyish, and the higher the order the more pastel the colors appear. Preliminary thin section analysis indicated that the MMB samples consisted of mainly carbonate inclusions. In addition, quartz and other additives were observed.

It is important to keep in mind that ceramic thin section samples can somewhat differ from geological samples, which may make it challenging to identify all mineral inclusions (Allen 2017). Furthermore, carbonates may appear similar and could present a diagnostic error for someone with an untrained eye. Even with that in mind, and based on previous ceramic works on MMB, I am confident that the majority of the carbonates are calcite.

PPL allowed for some mineral characteristics to be identified such as color and cleavage. However, most minerals were difficult to distinguish using PPL. Looking at the slides using XPL made mineral identification based on interference colors much easier.

Although data from the digital microscope focused heavily on qualitative analysis, the thin-section analysis focuses more on the quantitative. Certain qualities such as color and firing core were not measured using the petrographic microscope as thin sections are translucent and all the slides appeared relatively the same under the plane polarized light and the crossed polarizers. Instead, more measurable variables were examined such as mineral type, frequency of occurrence, and inclusion size.

Preliminary analysis indicated similar inclusion types between sites as expected, however, several slight variations between the groups may indicate different production sites. The samples from Cahal Pech at first glance seemed to have larger quartz inclusions present. Interestingly, several of the samples from Xunantunich present a mineral not found in the Cahal Pech samples. This mineral is a magnesium rich carbonate, most likely dolomite. The dolomite appears brighter than pastel calcite under

XPL. The presence of a magnesium carbonate being found only in the Xunantunich samples may indicate multiple production sites occurring simultaneously in the Belize Valley. This information will be further explained in the following sections.

Under the petrographic microscope only partial amounts of the slide could be viewed at once. In order to view the entire sherd for point counting and line measurements, two to three photos had to be taken of each slide and complied together. Using the program Image Composite Editor (ICE), each slide was stitched together to form one image. Some of the slides matched up seamlessly, whereas others were not able to match up. For this reason, the ten best ICE slides from Cahal Pech and the ten best from Xunantunich were selected for point counting and line length measurements.

Figure 3.5. Example of a good stitch MBV034.

Figure 3.6. Microphotograph panorama with inadequate photo joins.

According to Stolman (1989), at least 100 non-void points should be the minimum number of point counts per sherd. This method was followed as it was not always clear which voids were holes cut in the preparation of the thin section and which ones were from the production process. Some of the holes caused in the preparation of the thin sections were very large and obvious, whereas others appear to be long, thin lines, much like the voids found in MMB. Therefore, using the JMicrovision program, approximately 100-200 points were collected on each selected sample until 100 non-void points was reached. Similarly, to the point count analysis conducted from images taken with the digital microscope, each point was selected using a random grid, and was assigned a category.

In summary, the two main methods used for ceramic analysis in this thesis research were the use of a portable digital microscope, and thin section petrography. Each of these methods provided slightly different data sets to be analyzed. The portable digital microscope provided strong qualitative data, but it was difficult to identify mineral types. In contrast, the use of thin section petrography allowed for a more detailed examination of the temper through the optical properties of the non-plastic inclusions. The combined approach provides a more holistic view of the assemblages, as one photograph, or one thin-section, may not yield enough information alone, but together can provide valuable understanding for ceramic paste analysis.

Chapter 4 – Analysis

Microphotography Quantitative Approach

As discussed in the methods section, there were two ways in which the sherds were analyzed using the portable digital microscope. The first approach quantified the mineral additives to clay matrix, and the other documenting the descriptive qualities of the sherds such as color, size of inclusions, and angularity. The quantitative averages for the four contexts are described in Table 4.1.

Site	Matrix	Calcite	Other Rock Fgmt	Void	Oxide	Other
Plaza H	81%	17%	0.3%	0.4%	1%	0.3%
Xunan	75%	23%	0%	1%	1%	0%
A1/A2	80.4%	18%	0.4%	0.4%	0.6%	0.2%
ZPL	81%	17%	1%	0%	1%	0%

Table 4.1. Point count data of recipe from microphoto analysis.

While the numbers appear moderately similar, with the majority of the point count data showing high amounts of clay matrix, the consistency of these ratios of inclusions to matrix was variable among the sites. Although these numbers reflect the averages of each assemblage, there was some variability within the groups. For example, CHP contains an average of 0.3% rock fragments for the total assemblage, while image CHP-007 contains 7% non-calcite rock fragment. While both Plaza H and Xunantunich assemblages are mainly made up of matrix, the samples from Xunantunich contain slightly more calcite. The abundance of calcite in the Xunantunich sherds is also documented in the thin section analysis in which higher percentages of calcite appears in the thin sections from Xunantunich.

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Microphototgraphy Descriptive Portion

The second portion of point count analysis with the images from the PDM was describing attributes of the sherds which may have resulted from the manufacturing process. This was done in order to group ceramics with similar characteristics if possible, in order to see if there was any variation within each paste group. Doing so provided an opportunity for moving beyond the percentage of inclusion to temper, but also the manufacturing and firing process of the sherds.

Table 4.2. Most common qualitative category found based on site.

Site	Shape of Inclusion	Color/description	Texture
Plaza H	Round to subround	Brown with some oxidized core	Fine
Xunantunich	Round	Grey	Medium
A1A2	Round	Varying degrees of orange and brown	Fine
ZPL	Round	Brown and half oxidized	Very fine

As shown in table 4.2, and further documented in the appendices, sherds from Xunantunich tend to be coarser. This quality can sometimes be selected to make vessels more porous. The coarser inclusions in the Xunantunich samples also attests to the thickness observed in the dimensions of the sherds. The oxidization occurring in the Cahal Pech samples may be the result of uneven heating temperatures or having high heat added quickly.

Thin-section slides

The most common ways to measure quantitative characteristics within ceramic thin sections often deals with size, proportion and abundance of inclusions. Comparing the data which were measurable from the microscopic photos to that of the thin section slides allowed for the categories of non-plastic mineral inclusions to be more precise. Based on the preliminary observations under the petrographic microscope the point counting list of minerals and inclusions was narrowed down to those which were able to be identified based on birefringence and cleavage.

The categories were as follows: (1) matrix, (2) calcite, (3) quartz, (4), grog, and (5) other.

The matrix of the images can be seen as the "background" of the images. It is the dark, opaque, clay-like base which can be distinguished between the intentionally added temper. Any time a point would land on clay or any inclusion too small and round to be considered deliberately added, that point was counted as matrix. Calcite was identifiable by its extreme birefringence. Pastel pinks and green colors, along with a notable distinct change to extinction with rotation made calcite easily identifiable. Cleavage and twinning were also indications of calcite inclusions. Quartz, conversely, is among the first order minerals, exhibiting grey, white, black, and sometimes yellow interference colors. Quartz was identified by its low birefringence and lack of cleavage. Grog was identifiable by dark brown to black round inclusions which did not have a point of extinction when rotated. The final category, labelled as other, was included for any minerals/additives which did not fall under the first four categories. One other mineral was noted as occurring only in the Xunantunich samples. This was a limestone carbonate, most likely dolomite. Many of the limestone additives in the upper Belize Valley will appear similar under XPL, however, the Dolomite exhibited in the slides was recognizable by its vibrancy compared to the pastels of the calcite.

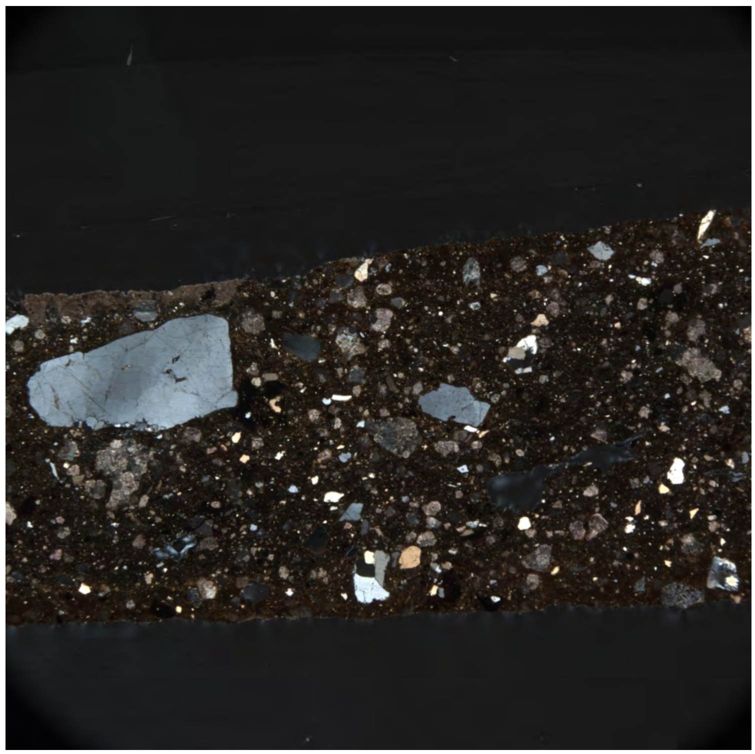

Figure 4.1. Slide #MB V005. Example of large quartz inclusions at CHP.

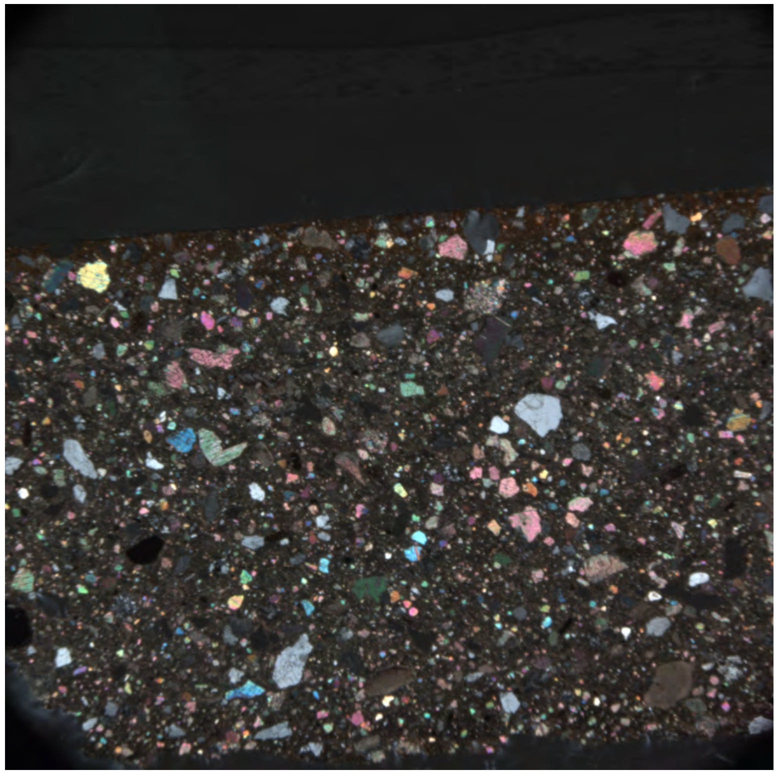

Figure 4.2. Slide #MBV047. Example of possible dolomite in Xunantunich.

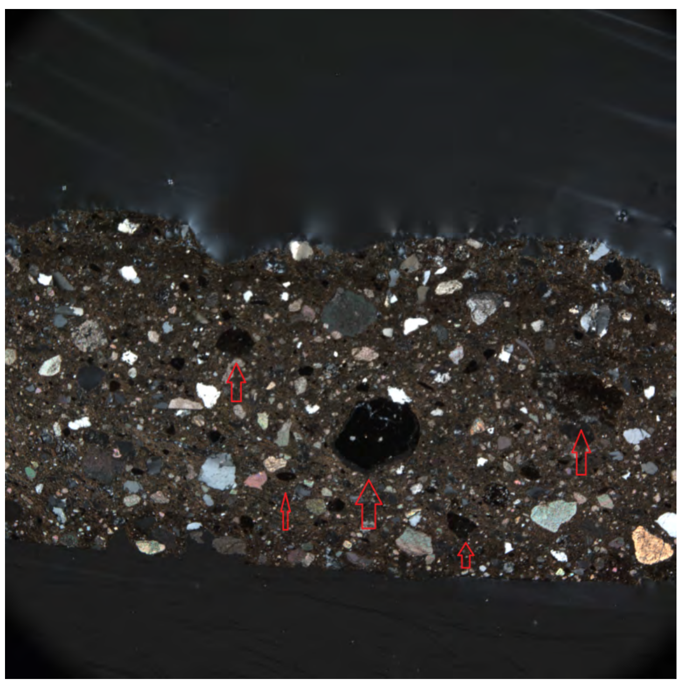

Figure 4.3. Slide #MBV 0061 Large grog inclusions.

The petrographic analysis was completed on ten sherds from Plaza H at Cahal Pech and ten sherds from the Xunantunich A-3-1 structure. The table below shows the averages for group A (Cahal Pech) and group B (Xunantunich). There are differences, but based on percentages alone it is impossible to say if the two assemblages were statistically significant. Some outliers such as MBV001 had higher quartz percentages and five of the ten samples from Xunantunich contain a small amount of dolomite.

Table 4.3. Thin section point count averages

	Matrix	Calcite	Quartz	Grog	Other
A	57%	36%	5%	2%	0%
B	52%	42%	1%	3%	2%

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Were the larger quartz inclusions found at Cahal Pech, or the dolomite found in the Xunantunich samples enough to show any statistical significance? In order to address this question several approaches were taken to look at the strength of the differences between the two samples Statistical significance was calculated by performing a t-test for each of the inclusion types. The second approach was to look at percentage of inclusions larger than .50 mm in both the ten Cahal Pech samples as well as the ten Xunantunich samples for a textural analysis.

Thin Section Statistical Analysis

In order to understand the relationship between the samples it was important to find the means, proportions, and variance between the two assemblages. Although finding the mean was important, it only provides a limited amount of information, and for the statistical portion of this thesis the distribution and variance within the sample population needed to be found. In order to see whether the sample groups were statistically significant, a student's t-test was performed on each of the thin section point count categories. In statistics a t-test is used to test the null hypothesis that there is no statistically significant difference between two samples.

An unpaired t-test assumes that the two populations (Cahal Pech and Xunantunich), have the same variances, and therefore the same standard deviation. T-test provide a t-value which is the ratio of the difference between group means to the variability of groups. A large t-value indicates different groups, whereas a small t-value means the groups are similar. For each t-value there is a corresponding p-value, which is the probability that the pattern of data in a sample could be produced by random sampling of the same underlying population (Devore and Burk 2012). For this set of data, a p-value of 0.05 was used as the standard to determine if the assumption that the underlying populations were the same (no statistical significance), and the associated critical values based on degrees of freedom was analyzed. The results below were calculated through the use of graphpad.com calculator.

Table 4.4. T-test for each category of thin-section point count.

Category	**P-value**	**Significance**
Matrix	0.0753	Not Quite Significant
Calcite	0.0461	Statistically Significant
Quartz	0.0056	Very Statistically Significant
Grog	0.3582	Not Statistically Significant
Other	0.0356	Statistically Significant

Running the t-test on the categories individually helped break down the data and showed that when compared to one another there were some differences among site recipes. The above table shows the P-values and corresponding significance from the t-test that were performed. In the appendices to this thesis, the statistical analysis performed is given so as to display how these results were gathered. From the above table we can see that several categories when compared varied by site. The most notable of these is the abundance of quartz in the Cahal Pech samples and lack thereof in the Xunantunich samples which made the results very statistically significant. The mean, standard deviation, and SEM for the quartz categories shows the high variance.

Table 4.5. Descriptive statistics for quartz inclusions in the two samples

Group	Cahal Pech	Xunantunich
Mean	5.00	0.70
SD	4.24	0.82
SEM	1.34	0.26
N	10	10

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The differences in quartz abundance yielded the strongest results for difference among the recipes for the two samples, however, several of the other inclusions also proved to be statistically significant. As with the microphotography point count, the Xunantunich samples also had more calcite inclusions which yielded a statistically significant result. Furthermore, the presence of dolomite in the Xunantunich samples was enough to make the category of other statistically significant between sites. Although at first glance the temper recipes seem highly variable both between and within sample groups, when the t-test were performed it showed there the two samples displayed differences that are not due to chance.

Textural Analysis

The second study of data was related to the size of aplastic inclusions, known as grain-size analysis. This involved collecting the longest dimensions of inclusions that were randomly selected from each of the thin-section slides used in the point count data. The objectives of quantifying the grain-size was to determine intentionality of mineral inclusions in order to see if there was any differentiation between site recipes. Temper larger than 0.50 mm can typically be reflective of intentional human actions (Rice 1987). This is due to potters selecting more coarse temper for pottery function. Larger inclusions can be added to make vessels more porous, a trait particularly useful for water storage (Rice 2009).

The lengths for each sample population was measured on a scale of 0 to 3 mm. For the same ten ICE thin section slide images used in the point count analysis from Cahal Pech and from Xunantunich, the ten largest grain inclusions were measured, totaling 100 grain inclusion measurements for each site. This was done by visually selecting the inclusions which appeared to be largest as they would most likely be the ones intentionally added. The inclusions were selected based on length and not mineral type. From there a histogram of line length was made for each site. This was to put the data set into ranges, set at specific intervals (bin), starting at 0 and increasing by 0.1 mm, ending at 3 mm since there were no inclusions larger than that. Once the bin was set, the frequencies in which the grain size occurred from each sample was measured.

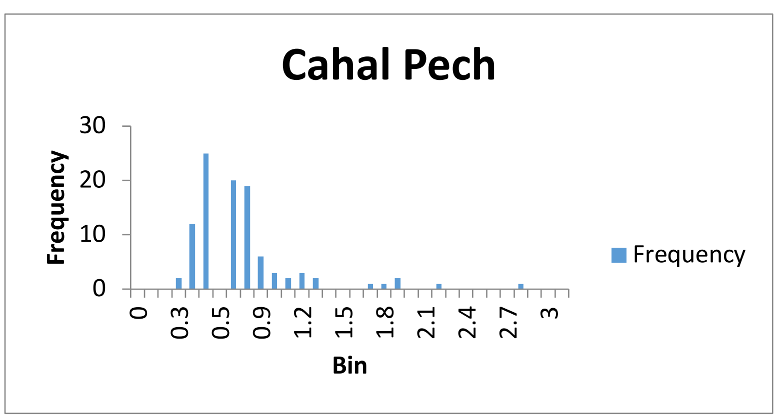

Figure 4.4. Histogram of bin and frequency for Cahal Pech.

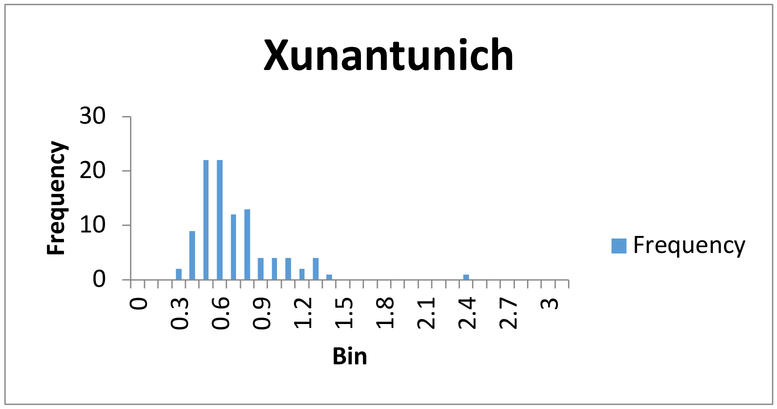

Figure 4.5. Histogram of bin frequency for Xunantunich.

Although the histograms provide a nice visual aid for the line lengths of large grain inclusions from each site, it was unclear if there was any statistical significance between the sites based on bin and frequency alone. Therefore, the 100 length measurements taken from each site were used and a t-test was conducted.

t-Test: Paired Two Sample for Means

	Cahal Pech	Xunantunich
Mean	0.67897	0.65631
Variance	0.167207	0.087585
Observations	100	100
Pearson Correlation	0.241592	
Hypothesized Mean Difference	0	
df	99	
t Stat	0.511421	
P(T<=t) one-tail	0.305097	
t Critical one-tail	1.660391	
P(T<=t) two-tail	0.610195	
t Critical two-tail	1.984217	

Table 4.6 T-test statistics for grain size.

Thus, there is no statistically significant difference in the grain size from sherds selected from the two sites. From the 100-line lengths taken from the Cahal Pech and Xunantunich slides, one observation stands out. The variance at Xunantunich is much lower than Cahal Pech, indicating that the sherds from Xunantunich were much more selective in their recipe. This is observable in the histograms as well as the summary statistics. However, in order to fully perform a grain size analysis more measurements must be taken as the sample size was relatively small for such analysis.

Dimensions

As this research continued it was clear that there were some differences in the samples between the sites that were not easily quantifiable. One such example of this was feel. When reviewing the sherds that were exported to the United States to be made into thin sections, it became clear that there was a noticeable difference in the way the sherds from Cahal Pech felt compared to those from Xunantunich. The Xunantunich sherds typically felt sturdier and thicker. One way of quantifying this was to measure the sherds thickness. Measurements from the exported sherds were taken and the averages are as follows. Cahal Pech: 5.7 mm, Xunantunich: 6.9 mm. This was done by using calipers on 15 of the exported sherds from each site. While the number of sherds to measure was limited to the exported sample size, and wall thickness varies within any vessel and by vessel form, it was interesting to find that in fact the Xunantunich sherds tended to be slightly thicker than those from Cahal Pech.

This may be reflected in the paste composition, looking at both the data from the portable digital microscope as well as the thin section slides. Both showed Xunantunich to contain slightly more calcite inclusions, and the texture recorded from the descriptive portion of the microphotography data showed Xunantunich to be medium, whereas the three contexts from Cahal Pech were typically finer. Other factors, such as Cahal Pech contexts displaying more degrees of oxidization, could be the result of thinner sherds heated quickly. To determine if the measurements were statistically significant, another t-test was performed, demonstrating that thickness was statistically different between the samples from the two sites (Table 4.7).

Unpaired *t* test results

P value and statistical significance:
The two-tailed P value equals 0.0033
By conventional criteria, this difference is considered to be very statistically significant.

Confidence interval:
The mean of Group One minus Group Two equals -1.2533
95% confidence interval of this difference: From -2.0519 to -0.4548

Intermediate values used in calculations:
t = 3.2150
df = 28
standard error of difference = 0.390

Table 4.6. T-test results for thickness calculated through graphpad.com.

Group	Cahal Pech	Xunantunich
Mean	5.6680	6.9213
SD	1.1713	0.9527
SEM	0.3024	0.2460
N	15	15

Table 4.7. T-test results for thickness (calculated through graphpad.com).

Summary

From all of the data collected and analyzed it is clear that there were some notable differences between the MMB pottery from each site. The data from the portable digital microscope data offered several insights into the recipes used at Xunantunich and at several context from Cahal Pech. One notable observation is that the sherds from Xunantunich tended to be coarser.

The thin section analysis provided further insight into the recipes between sites. Statistically significant results were found in the mineral contents when t-test were performed. In addition, grain size analysis showed that there was less variability among the Xunantunich samples.

Chapter 5 - Discussion and Concluding Remarks

The purpose of this thesis is to address questions concerning the relationship between Cahal Pech and Xunantunich during the Terminal Classic period through ceramic analysis of Mount Maloney Black pottery at each site. This was done by analyzing specific characterizations of the pottery temper as a means for understanding the ‘recipes’ used in pottery production at each site. This process included gathering samples from four contexts, (1) Cahal Pech, Plaza H, (2) Xunantunich, (3) Cahal Pech Plaza H, Cahal Pech A1A2, and (4) the Cahal Pech outlier, Zopilote Group. Once the samples were selected, microphotography of the sherds was collected for point count data which yielded information regarding compositional characteristics. Furthermore, sherds were exported from Plaza H and Xunantunich for thin-section petrography, which aided in the understanding of the mineral and grain size compositions. Through microphotography, point count data, and thin section petrography, a better understanding of the similarities and differences between each pottery sample was possible.

As originally hypothesized, the presence of MMB pottery in Plaza H at Cahal Pech was either due to the importation of ceramics from Xunantunich during the TC, or because the residents of Cahal Pech were also producing MMB style pottery during this time. From the data gathered in this thesis, it appears that there is enough statistical significance differences to support the latter hypothesis.

This conclusion is based on the following lines of evidence: rim form, texture, thickness, color, and mineral content. As discussed in the beginning of this thesis, one of the first noticeable difference in the MMB pottery from Plaza H at Cahal Pech was that although it is found in a Terminal Classic deposit, the rim forms mainly reflected that of

LC-I and LC-II lip orientation. However, the majority of the sherds examined in this analysis were body sherds, and therefore more data on rim sherds should be considered for further analysis. The possibility that the termination of the Cahal Pech core was sufficiently earlier than Xunantunich that the LC-II lip orientation was still dominant also needs to be considered, although the dating of the south of H-1 special deposit lies outside the realm of this thesis.

Point count data from the portable digital microscope photos showed that the texture of the sherds from Xunantunich was on average coarser than those from all three contexts from Cahal Pech. Another observation that should be considered is the samples from all context at Cahal Pech tend to contain higher degrees of oxidization. This would indicate differences in the heating process between the two sites.

Another differentiating feature was thickness of the sherds themselves. Measurements of the sherds found that those from Xunantunich were slightly thicker on average, which produced statistically significant results. This could be from differences which occurred during the manufacturing process, including differences in overall vessel size.

Lastly, the findings of statistical significance in several of the mineral components from the thin section slides shows differences in recipes between sites. The categories of calcite and other yielded statistically significant results when t-test were run, and the category of quartz as very statistically significant. The larger and more abundant quartz inclusions from the Plaza H thin sections, and the finding of dolomite in the Xunantunich samples, therefore, may be indicators of different recipes between site assemblages.

Because these are utility wares, it is a reasonable assumption that these two types were made near the centers where they were found, although ultimately this should be tested against broader patterns in the Upper Belize Valley. But assuming local production, why then did the inhabitants of Cahal Pech ramp up production of MMB pottery in the TC? To address this question, it is important to take historical context into consideration. As previously mentioned, the TC was a time of shifting political and economic dynamics in the upper Belize Valley, possibly due to environmental factors. Recent paleoclimate data suggests that the TC also corresponds with a time of extended drought (Kennett et al. 2012). Changes in a pottery complex at a site can reflect a shift in supply and demand. The shift from an abundance of ash-temper wares, such as Belize Red, found in earlier deposits at Cahal Pech, to an abundance of a calcite-temper ware, Mount Maloney Black, found in the deposits south of H1, could be due to supply and demand. As calcite temper vessels are better at water storage than ash tempered vessels (Rice 1987), possibly the increased in MMB at Cahal Pech reflects the need for water storage in a time of drought, or could be reflective of the intrinsic value placed on such vessels. Alternatively, the discontinuity in the production of ash tempered pottery could have been affected by ruptures in the supply networks for volcanic ash, or simply reflect stylistic or production changes over time.

Previous research has indicated high degrees of variability within samples of MMB from Xunantunich alone (Garcia 2008), and therefore more research comparing other samples from the two sites would prove beneficial, particularly for confirming that these differences were not due to chance. Additional analysis of the thin section slides could also increase the amount of statistical information available. Measuring different aspects of the thin section as well as microphotographs could provide data to run different statistical analyses.

The data presented in this thesis were analyzed as a means for addressing questions concerning an increase in Mount Maloney Black pottery in Terminal Classic deposits at Cahal Pech. This was done qualitatively as well as quantitatively through both microphotography as well as thin section petrography. The results of the study show differences between the recipes used at each site. Whether or not production sites were nearby, the increase of MMB pottery to over 30% of the decorated wares in the Cahal Pech Plaza H ceramic assemblage provides yet another example of the cultural changes that were unfolding in the upper Belize Valley during the Terminal Classic period. These changes in pottery traditions and the peri-abandonment deposits at Belize Valley sites are important reflections of the resilience and ingenuity of the Maya people during this critical transitional period in their history.

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APPENDIX A
MICROPHOTOGRAPH POINT COUNT DATA

Table A.1. CHP point count percentages.

Photo #	Context	Matrix	Calcite	Rock fgmt	Void	Oxide	Other
CHP-3	EU-13, Lvl-2	85%	13%	0%	2%	0%	0%
CHP-4	EU-13, Lvl-2	86%	12%	1%	0%	1%	0%
CHP-6	EU-13, Lvl-2	89%	11%	0%	0%	0%	0%
CHP-7	EU-13, Lvl-2	78%	11%	7%	0%	4%	0%
CHP-8	EU-13, Lvl-2	88%	12%	0%	0%	0%	0%
CHP-9	EU-13, Lvl-2	86%	11%	3%	0%	0%	0%
CHP-13	EU-13, Lvl-2	84%	12%	0%	0%	4%	0%
CHP-14	EU-13, Lvl-2	91%	9%	0%	0%	0%	0%
CHP-16	EU-22B/24B, Lvl-2	93%	5%	0%	0%	2%	0%
CHP-17	EU-22B/24B, Lvl-2	83%	17%	0%	0%	0%	0%
CHP-20	EU-22B/24B, Lvl-2	81%	16%	2%	1%	0%	0%
CHP-23	EU-22B/24B, Lvl-2	97%	3%	0%	0%	0%	0%
CHP-26	EU-22B/24B, Lvl-2	85%	12%	0%	1%	2%	0%
CHP-27	EU-22B/24B, Lvl-2	91%	8%	0%	1%	0%	0%
CHP-28	EU-22B/24B, Lvl-2	85%	10%	0%	1%	4%	0%
CHP-29	EU-22B/24B, Lvl-2	96%	2%	0%	0%	2%	0%
CHP-30	EU-22B/24B, Lvl-2	98%	1%	0%	1%	0%	0%
CHP-31	EU-22B/24B, Lvl-2	98%	2%	0%	0%	0%	0%
CHP-34	EU-34, Lvl-3	75%	24%	0%	0%	1%	0%
CHP-35	EU-34, Lvl-3	70%	26%	0%	0%	4%	0%
CHP-38	EU-34, Lvl-3	80%	14%	5%	1%	0%	0%
CHP-42	EU-34, Lvl-3	88%	9%	0%	3%	0%	0%
CHP-44	EU-34, Lvl-3	86%	14%	0%	0%	0%	0%
CHP-45	EU-34, Lvl-3	86%	13%	0%	1%	0%	0%
CHP-46	EU-34, Lvl-3	79%	19%	0%	0%	2%	0%
CHP-48	EU-34, Lvl-3	80%	20%	0%	0%	0%	0%
CHP-50	EU-34, Lvl-3	86%	13%	0%	0%	1%	0%
CHP-51	EU-34, Lvl-4	93%	6%	0%	1%	0%	0%
CHP-52	EU-34, Lvl-4	87%	13%	0%	0%	0%	0%
CHP-53	EU-34, Lvl-4	87%	12%	0%	1%	0%	0%
CHP-55	EU-34, Lvl-4	85%	15%	0%	0%	0%	0%
CHP-56	EU-34, Lvl-4	82%	14%	0%	0%	4%	0%
CHP-57	EU-34, Lvl-4	79%	18%	0%	0%	3%	0%
CHP-58	EU-34, Lvl-4	84%	16%	0%	0%	0%	0%
CHP-59	EU-34, Lvl-4	82%	11%	0%	0%	7%	0%

CHP-60	EU-35, LVl-2	72%	25%	0%	3%	0%	0%
CHP-63	EU-35, LVl-2	91%	7%	0%	0%	2%	0%
CHP-64	EU-35, LVl-2	76%	23%	0%	1%	0%	0%
CHP-66	EU-35, LVl-2	76%	24%	0%	0%	0%	0%
CHP-67	EU-35, LVl-2	75%	22%	0%	0%	1%	2%
CHP-71	EU-35, Lvl-3	85%	12%	0%	1%	2%	0%
CHP-73	EU-35, Lvl-3	78%	17%	0%	0%	5%	0%
CHP-75	EU-35, Lvl-3	76%	22%	0%	0%	2%	0%
CHP-77	EU-35, Lvl-3	83%	17%	0%	0%	0%	0%
CHP-78	EU-35, Lvl-3	82%	17%	0%	0%	1%	0%
CHP-80	EU-35, Lvl-3	77%	22%	0%	0%	1%	0%
CHP-81	EU-35, Lvl-3	90%	10%	0%	0%	0%	0%
CHP-87	EU-35, Lvl-3	89%	9%	0%	0%	2%	0%
CHP-89	EU-50, Lvl-2	83%	17%	0%	0%	0%	0%
CHP-92	EU-50, Lvl-2	82%	18%	0%	0%	0%	0%
CHP-94	EU-50, Lvl-2	78%	20%	0%	0%	2%	0%
CHP-98	EU-50, Lvl-2	77%	20%	0%	0%	3%	0%
CHP-101	EU-50, Lvl-2	77%	22%	0%	0%	1%	0%
CHP-102	EU-50, Lvl-2	88%	8%	4%	0%	0%	0%
CHP-110	EU-50, Lvl-2	83%	16%	0%	0%	1%	0%
CHP-114	EU-50, Lvl-3	81%	14%	0%	0%	5%	0%
CHP-116	EU-50, Lvl-3	74%	22%	0%	0%	2%	0%
CHP-117	EU-50, Lvl-3	68%	32%	0%	0%	0%	0%
CHP-118	EU-50, Lvl-3	78%	22%	0%	0%	0%	0%
CHP-125	EU-50, Lvl-3	76%	22%	0%	0%	1%	1%
CHP-126	EU-50, Lvl-3	78%	20%	0%	1%	1%	0%
CHP-131	EU-50, Lvl-3	74%	25%	0%	0%	1%	0%
CHP-139	EU-51, Lvl-3	75%	25%	0%	0%	0%	0%
CHP-140	EU-51, Lvl-3	77%	22%	0%	1%	0%	0%
CHP-141	EU-51, Lvl-3	80%	13%	0%	3%	4%	0%
CHP-147	EU-51, Lvl-3	62%	38%	0%	0%	0%	0%
CHP-149	EU-51, Lvl-3	74%	21%	0%	4%	1%	0%
CHP-151	EU-51, Lvl-3	81%	18%	0%	1%	0%	0%
CHP-152	EU-51, Lvl-3	76%	20%	0%	1%	3%	0%
CHP-162	EU-51, Lvl-3	60%	38%	0%	1%	1%	0%
CHP-165	EU-51, Lvl-4	54%	40%	3%	0%	3%	0%
CHP-166	EU-51, Lvl-4	71%	29%	0%	0%	0%	0%

CHP-170	EU-51, Lvl-4	77%	23%	0%	0%	0%	0%
CHP-173	EU-51, Lvl-4	82%	15%	0%	1%	2%	0%
CHP-177	EU-54, Lvl-3	81%	14%	0%	0%	5%	0%
CHP-179	EU-54, Lvl-3	70%	26%	0%	0%	4%	0%
CHP-182	EU-54, Lvl-3	74%	26%	0%	0%	0%	0%
CHP-183	EU-54, Lvl-3	77%	20%	0%	2%	1%	0%
		81%	17%	0%		1%	

Table A.2. Point count percentages Xunantunich.

Photo #	Context	Matrix	Calcite	Rock fgmt	Void	Oxide	Other
XU-1	EU: A-3-1, Lvl-2, 1st Ter/3c	70%	30%	0%	0%	0%	0%
XU-2	EU: A-3-1, Lvl-2, 1st Ter/3c	74%	23%	0%	0%	3%	0%
XU-5	EU: A-3-1, Lvl-2, 1st Ter/3c	72%	25%	0%	1%	2%	0%
XU-7	EU: A-3-1, Lvl-2, 1st Ter/3c	88%	7%	0%	1%	4%	0%
XU-11	EU: A-3-1, Lvl-2, 1st Ter/3c	69%	30%	0%	1%	0%	0%
XU-13	EU: A-3-1, Lvl-2, 1st Ter/3c	71%	28%	0%	0%	1%	0%
XU-16	EU: A-3-1, Lvl-2, 1st Ter/3c	83%	14%	0%	2%	1%	0%
XU-17	EU: A-3-1, Lvl-2, 1st Ter/3c	79%	18%	0%	2%	1%	0%
XU-18	EU: A-3-1, Lvl-2, 1st Ter/3c	78%	20%	1%	1%	0%	0%
XU-22	EU: A-3-1, Lvl-2, 1st Ter/3c	81%	17%	0%	0%	2%	0%
XU-31	EU: A-3-1, Lvl-2, 1st Ter/3c	68%	32%	0%	0%	0%	0%
XU-32	EU: A-3-1, Lvl-2, 1st Ter/3c	85%	12%	0%	0%	3%	0%
XU-37	EU: A-3-1, Lvl-2, 1st Ter/3c	80%	19%	0%	0%	1%	0%
XU-41	EU: A-3-1, Lvl-2, 1st Ter/3c	72%	24%	0%	0%	4%	0%
XU-44	EU: A-3-1, Lvl-2, 1st Ter/3c	84%	10%	0%	1%	5%	0%
XU-48	EU: A-3-1, Lvl-2, 1st Ter/3c	78%	18%	0%	2%	2%	0%
XU-52	EU:A-3-1, Lvl-2, 1st Ter	68%	32%	0%	0%	0%	0%
XU-53	EU:A-3-1, Lvl-2, 1st Ter	73%	27%	0%	0%	0%	0%
XU-58	EU:A-3-1, Lvl-2, 1st Ter	87%	12%	0%	0%	1%	0%
XU-60	EU:A-3-1, Lvl-2, 1st Ter	61%	35%	0%	2%	2%	0%
XU-62	EU:A-3-1, Lvl-2, 1st Ter	69%	27%	2%	2%	0%	0%
XU-64	EU:A-3-1, Lvl-2, 1st Ter	69%	31%	0%	0%	0%	0%
XU-66	EU:A-3-1, Lvl-2, 1st Ter/below 3rd	71%	28%	5%	0%	1%	0%
XU-69	EU:A-3-1, Lvl-2, 1st Ter/below 3rd	77%	21%	0%	2%	0%	0%
XU-72	EU:A-3-1, Lvl-2, 1st Ter/below 3rd	78%	16%	0%	2%	4%	0%

XU-73	EU:A-3-1, Lvl-2, 1st Ter/below 3rd	77%	22%	0%	1%	0%	0%
XU-81	EU:A-3-1, Lvl-2, 1st Ter/below 3rd	91%	3%	0%	1%	4%	1%
XU-83	EU:A-3-1, Lvl-2, 1st Ter/below 3rd	73%	26%	0%	1%	0%	0%
XU-86	EU:A-3-1, Lvl-2, 1st Ter/below 3rd	72%	28%	0%	0%	0%	0%
XU-89	EU:A-3-1, Lvl-2, 3B	63%	28%	0%	2%	7%	0%
XU-91	EU:A-3-1, Lvl-2, 3B	42%	56%	0%	2%	0%	0%
XU-92	EU:A-3-1, Lvl-2, 3B	83%	15%	0%	1%	1%	0%
XU-96	EU:A-3-1, Lvl-2, 3B	69%	31%	0%	0%	0%	0%
XU-98	EU:A-3-1, Lvl-2, 3B	73%	26%	0%	1%	0%	0%
XU-100	EU:A-3-1, Lvl-2, 1st Ter/below burnt	91%	9%	0%	0%	0%	0%
XU-106	EU:A-3-1, Lvl-2, 1st Ter/below burnt	83%	17%	0%	0%	0%	0%
XU-109	EU:A-3-1, Lvl-2, 1st Ter/below burnt	76%	24%	0%	0%	0%	0%
Average		75%	23%	0%	1%	1%	0%

Table A.3. Point count percentages A1/A2.

A1/A2	Context	Matrix	Calcite	Rock fgmt	Void	Oxide	Other
A1A2-1	1C East, 1	85%	11%	2%	1%	1%	0%
A1A2-2	1C East, 1	82%	16%	0%	2%	0%	0%
A1A2-3	1C East, 1	84%	14%	0%	0%	0%	2%
A1A2-5	1C East, 1	85%	15%	0%	0%	0%	0%
A1A2-6	1C East, 1	84%	12%	3%	1%	0%	0%
A1A2-9	1B East, 1	87%	13%	0%	0%	0%	0%
A1A2-10	1B East, 1	86%	13%	0%	1%	0%	0%
A1A2-13	1C West,1	77%	20%	0%	0%	3%	0%
A1A2-14	1C West,1	80%	20%	0%	0%	0%	0%
A1A2-15	1C West,1	93%	4%	0%	1%	2%	0%
A1A2-16	1C West,1	90%	7%	1%	1%	1%	0%
A1A2-17	1C West,1	84%	16%	0%	0%	0%	0%

A1A2-18	1B West,1	72%	28%	0%	0%	0%	0%
A1A2-19	1B West,1	72%	28%	0%	0%	0%	0%
A1A2-20	1B West,1	59%	38%	0%	0%	3%	0%
A1A2-21	1B West,1	67%	33%	0%	0%	0%	0%

Table A.4. ZPL point count percentages.

ZPL	Context	Matrix	Calcite	Rock fgmt	Void	Oxide	Other
ZPL-1	EU-2, Lvl-3	84%	13%	0%	1%	1%	1%
ZPl-3	EU-2, Lvl-3	87%	13%	0%	0%	0%	0%
ZPL-5	EU-2, Lvl-3	79%	21%	0%	0%	0%	0%
ZPL-6	EU-2, Lvl-3	87%	13%	0%	0%	0%	0%
ZPL-9	EU-2, Lvl-3	92%	6%	0%	1%	1%	0%
ZPL-12	EU-2, Lvl-3	86%	8%	4%	1%	1%	0%
ZPL-14	EU-2, Lvl-3	91%	7%	2%	0%	0%	0%
ZPL-15	EU-2, Lvl-3	82%	18%	0%	0%	0%	0%
ZPL-18	EU-2, Lvl-3	58%	42%	0%	0%	0%	0%
ZPL-19	EU-2, Lvl-3	89%	11%	0%	0%	0%	0%
ZPL-26	EU-2, Lvl-3	65%	30%	3%	0%	2%	0%
ZPL-30	EU-2, Lvl-3	59%	41%	0%	0%	0%	0%
ZPL-31	EU-2, Lvl-2	91%	9%	0%	0%	0%	0%
ZPL-33	EU-2, Lvl-2	89%	9%	0%	0%	2%	0%
ZPL-34	EU-2, Lvl-2	81%	17%	0%	0%	2%	0%

APPENDIX B
MICROPHOTOGRAPH POINT COUNT DESCRIPTIONS

Table B.1. CHP point count descriptions

Photo #	Context	Shape of Inclusions	Color and Description	Texture
CHP-3	EU-13, Lvl-2	Round to Subround	Brown with thin orange outer edges	Fine
CHP-4	EU-13, Lvl-2	Round to Subround	Brown with thin orange outer edges	Fine
CHP-6	EU-13, Lvl-2	Subround	Greyish Brown	Fine
CHP-7	EU-13, Lvl-2	Round to Subround	Half orange half brown	Fine to medium
CHP-8	EU-13, Lvl-2	Round to Subround	Brown	Fine
CHP-9	EU-13, Lvl-2	Round to Subround	Greyish brown with thin orange outer edges	Fine to medium
CHP-13	EU-13, Lvl-2	Subround	Half orange half dark grey	Medium
CHP-14	EU-13, Lvl-2	Round	Greyish brown	Very fine
CHP-16	EU-22B/24B, Lvl-2	Round	Brown	Very Fine
CHP-17	EU-22B/24B, Lvl-2	Round to Subround	Brown	Fine
CHP-20	EU-22B/24B, Lvl-2	Round to Subround	Half brown, half orange	Medium
CHP-23	EU-22B/24B, Lvl-2	Round	Grey	Fine
CHP-26	EU-22B/24B, Lvl-2	Round	Greyish brown	Fine to Medium
CHP-27	EU-22B/24B, Lvl-2	Round	Bright orange	Fine
CHP-28	EU-22B/24B, Lvl-2	Round to Subround	Dark grey center, orange outer edges	Fine to Medium
CHP-29	EU-22B/24B, Lvl-2	Round	Brown	Very Fine
CHP-30	EU-22B/24B, Lvl-2	Round	Brown	Very Fine(clay-like)
CHP-31	EU-22B/24B, Lvl-2	Round	Brown	Very Fine(clay-like)
CHP-34	EU-34, Lvl-3	Round to subround	Brown center, orange outer edges	Medium

CHP-35	EU-34, Lvl-3	Round	Orange	Fine to Medium
CHP-38	EU-34, Lvl-3	Varying: round to angular	Dark brown center, orange outer edges	Fine to Medium
CHP-42	EU-34, Lvl-3	Round to subround	Brown	Fine
CHP-44	EU-34, Lvl-3	Round	Greyish brown	Fine
CHP-45	EU-34, Lvl-3	Round to subround	Half orange, half brown	Fine
CHP-46	EU-34, Lvl-3	Varying: round to angular	Brown center, orange outer edges	Medium
CHP-48	EU-34, Lvl-3	Round to subround	Mostly brown, slight orange	Medium
CHP-50	EU-34, Lvl-3	Round	Brown	Fine
CHP-51	EU-34, Lvl-4	Round to subround	Half orange, half brown	Fine
CHP-52	EU-34, Lvl-4	Round to subround	Half orange, half brown	Fine
CHP-53	EU-34, Lvl-4	Round	Grey	Fine
CHP-55	EU-34, Lvl-4	Round to subround	Brown center, orange outer edges	Medium
CHP-56	EU-34, Lvl-4	Round to subround	Half orange, half brown	Medium
CHP-57	EU-34, Lvl-4	Round	Brown	Fine
CHP-58	EU-34, Lvl-4	Round	Brown	Fine
CHP-59	EU-34, Lvl-4	Round	Brown	Fine
CHP-60	EU-35, Lvl-2	Round to subround	Brown center, orange outer edges	Medium
CHP-63	EU-35, Lvl-2	Round	Brown center, orange outer edges	Fine
CHP-64	EU-35, Lvl-2	Round to subround	Brown center, orange outer edges	Medium
CHP-66	EU-35, Lvl-2	Round	Brown	Fine to Medium

CHP-67	EU-35, Lvl-2	Varying: round to angular	Brown	Medium
CHP-68	EU-35, Lvl-2	Varying: round to angular	Orangish brown	Medium to Coarse
CHP-71	EU-35, Lvl-3	Round	Brown center, orange outer edges	Fine to Medium
CHP-73	EU-35, Lvl-3	Round to subround	Brown	Fine to Medium
CHP-74	EU-35, Lvl-3			
CHP-75	EU-35, Lvl-3	Round	Orange	Fine
CHP-77	EU-35, Lvl-3	Round to subround	Orangish brown	Medium
CHP-78	EU-35, Lvl-3	Round	Brown	Fine to Medium
CHP-80	EU-35, Lvl-3	Round to subround	Brown center, orange outer edges	Medium to Coarse
CHP-81	EU-35, Lvl-3	Round	Brown center, orange outer edges	Fine
CHP-87	EU-35, Lvl-3	Round	Greyish brown center, orange outer edges	Fine
CHP-89	EU-50, Lvl-2	Round	Greyish brown	Fine to Medium
CHP-90	EU-50, Lvl-2			
CHP-92	EU-50, Lvl-2	Round	Greyish brown	Fine to Medium
CHP-94	EU-50, Lvl-2	Round to subround	Orange	Medium
CHP-95	EU-50, Lvl-2			
CHP-98	EU-50, Lvl-2	Round	Brown	Fine to Medium
CHP-101	EU-50, Lvl-2	Round to subround	Brown center, orange outer edges	Medium to Coarse
CHP-102	EU-50, Lvl-2	Round	Brown	Fine
CHP-110	EU-50, Lvl-2	Varying: round to angular	Brown	Fine to Medium

CHP-114	EU-50, Lvl-3	Varying: round to angular	Brown	Fine
CHP-116	EU-50, Lvl-3	Varying: round to angular	Brown center, orange outer edges	Fine
CHP-117	EU-50, Lvl-3	Varying: round to angular	Brown center, orange outer edges	Coarse
CHP-118	EU-50, Lvl-3	Round to subround	Brown center, orange outer edges	Medium
CHP-121	EU-50, Lvl-3			
CHP-125	EU-50, Lvl-3	Round to subround	Half brown, half orange	Fine
CHP-126	EU-50, Lvl-3	Round to subround	Brown center, orange outer edges	Medium to Coarse
CHP-131	EU-50, Lvl-3	Varying: round to angular	Half brown, half orange	Coarse
CHP-139	EU-51, Lvl-3	Round to subround	Brown	Coarse
CHP-140	EU-51, Lvl-3	Round to subround	Brown	Medium
CHP-141	EU-51, Lvl-3	Round	Grey	Very Fine
CHP-146	EU-51, Lvl-3			
CHP-147	EU-51, Lvl-3	Round to subround	Greyish brown	Coarse
CHP-149	EU-51, Lvl-3	Round to subround	Brown	Medium
CHP-151	EU-51, Lvl-3	Round to subround	Half brown, half orange	Fine to Medium
CHP-152	EU-51, Lvl-3	Round to subround	Greyish brown	Medium to Coarse
CHP-165	EU-51, Lvl-4	Varying: subround to angular	Half brown, half orange	Very Coarse
CHP-166	EU-51, Lvl-4	Round to subround	Grey	Medium
CHP-170	EU-51, Lvl-4	Round to subround	Brown	Fine to Medium
CHP-173	EU-51, Lvl-4	Round to subround	Orangish brown	Very fine

CHP-177	EU-54, Lvl-3	Round to subround	Brown center, orange outer edges	Fine to Medium
CHP-179	EU-54, Lvl-3	Round to subround	Orange	Medium
CHP-182	EU-54, Lvl-3	Round to subround	Brown center, orange outer edges	Medium
CHP-183	EU-54, Lvl-3	Varying: round to angular	Brown	Fine to Medium

Table B.2. Xunantunich characteristics.

Photo #	Context	Shape of Inclusions	Color and Description	Texture
XU-1	EU:A-3-1, Lvl-2, 1st Ter/3c	Round to subround	Greyish brown	Medium
XU-3	EU:A-3-1, Lvl-2, 1st Ter/3c	Subround	Orange	Medium
XU-5	EU:A-3-1, Lvl-2, 1st Ter/3c	Round to subround	Greyish brown	Medium
XU-7	EU:A-3-1, Lvl-2, 1st Ter/3c	Round	Greyish brown	Very fine
XU-11	EU:A-3-1, Lvl-2, 1st Ter/3c	Round to subangular	Half grey, half orange	Coarse
XU-13	EU:A-3-1, Lvl-2, 1st Ter/3c	Round to subround	Half grey, half orange	Medium to coarse
XU-16	EU:A-3-1, Lvl-2, 1st Ter/3c	Round	Brown	Fine
XU-17	EU:A-3-1, Lvl-2, 1st Ter/3c	Round	Brown	Fine
XU-18	EU:A-3-1, Lvl-2, 1st Ter/3c	Round to subround	Half brown, half orange	Medium
XU-21				
XU-22	EU:A-3-1, Lvl-2, 1st Ter/3c	Round	Orange	Fine to medium
XU-31	EU:A-3-1, Lvl-2, 1st Ter/3c	Round	Orange	Fine to medium
XU-32	EU:A-3-1, Lvl-2, 1st Ter/3c	Round to subround	Grey	Medium
XU-37	EU:A-3-1, Lvl-2, 1st Ter/3c	Round	Grey	Fine
XU-41	EU:A-3-1, Lvl-2, 1st Ter/3c	Round to angular	Grey	Medium to coarse

XU-44	EU:A-3-1, Lvl-2, 1st Ter/3c	Round	Brown	Fine
XU-48	EU:A-3-1, Lvl-2, 1st Ter/3c	Round	Greyish brown	Fine
XU-52	EU:A-3-1, Lvl-2, 1st Ter	Subround	Half grey, half orange	Medium to coarse
XU-53	EU:A-3-1, Lvl-2, 1st Ter	Round to subround	Grey center, orange outer edges	Medium to coarse
XU-58	EU:A-3-1, Lvl-2, 1st Ter	Round	Grey	Fine
XU-60	EU:A-3-1, Lvl-2, 1st Ter	Round to angular	Grey	Medium to coarse
XU-62	EU:A-3-1, Lvl-2, 1st Ter	Round to subround	Brown	Medium
XU-64	EU:A-3-1, Lvl-2, 1st Ter	Round	Grey center, orange outer edges	Fine to medium
XU-66	EU:A-3-1, Lvl-2, 1st Ter/below 3	Subround to subangular	Orange	Coarse
XU-69	EU:A-3-1, Lvl-2, 1st Ter/below 3	Subround to subangular	Half brown, half orange	Coarse
XU-72	EU:A-3-1, Lvl-2, 1st Ter/below 3	Round to subround	Grey	Medium
XU-73	EU:A-3-1, Lvl-2, 1st Ter/below 3	Round to subround	Orangish brown	Medium
XU-81	EU:A-3-1, Lvl-2, 1st Ter/below 3	Round	Grey	Fine
XU-83	EU:A-3-1, Lvl-2, 1st Ter/below 3	Round to subround	Half grey, half orange	Medium to coarse
XU-86	EU:A-3-1, Lvl-2, 1st Ter/below 3	Round	Grey	Fine
XU-89	EU:A-3-1,Lvl-2, 3B	Round	Greyish brown	Medium
XU-91	EU:A-3-1,Lvl-2, 3B	Round to angular	Grey	Coarse
XU-92	EU:A-3-1,Lvl-2, 3B	Round to subround	Brown	Fine to medium
XU-96	EU:A-3-1,Lvl-2, 3B	Round to subround	Greyish brown	Medium
XU-98	EU:A-3-1,Lvl-2, 3B	Round	Brown	Fine
XU-100	EU:A-3-1, Lvl-2, 1st Ter/below burnt	Round	Half brown, half orange	Fine
XU-102				

XU-104				
XU-106	EU:A-3-1, Lvl-2, 1st Ter/below burnt	Round	Half brown, half orange	Fine
XU-109	EU:A-3-1, Lvl-2, 1st Ter/below burnt	Round to subround	Brown	Medium

Table B.3. A1A2 characteristics.

A1/A2	Context	Shape of Inclusions	Color	Texture
A1A2-1	1C East, 1	Round/subround	Mostly brown with orange outer edge	Fine
A1A2-2	1C East, 1	Round/subround	Bright orange	Fine to medium
A1A2-3	1C East, 1	Round/subround	Orange	Fine
A1A2-5	1C East, 1	Round	Brownish orange	Fine
A1A2-6	1C East, 1	Round/subround	Orange fade to brownish	Fine to medium
A1A2-10	1 B East, 1	Round	Bright orange to brownish orange	Fine
A1A2-11	1 B East, 1	Round/subround	Orange	Fine to medium
A1A2-13	1C West,1	Round	Greyish brown	Medium
A1A2-14	1C West,1	Subround to angular	half orange half brown	Medium
A1A2-15	1C West,1	Round	Brown	Very fine
A1A2-16	1C West,1	Round	Greyish brown	Very fine
A1A2-17	1C West,1	Round/subround	Greyish brown	Very fine
A1A2-18	1B West,1	Round/Subround	Greyish brown	Medium to coarse
A1A2-19	1B West,1	Round/subround	Brown	Medium
A1A2-20	1B West,1	Subround/angular	Half orange half brown	Coarse
A1A2-21	1B West,1	Subround/subangular	Orangeish brown	Coarse

Table B.4. ZPL characteristics.

Photo #	Context	Shape of Inclusions	Color/description	Texture
ZPL-1	Eu-2, Lvl-3	Round	Orange/brown	Fine
ZPL-3	Eu-2, Lvl-3	Round	Orange	Fine to Medium
ZPL-5	Eu-2, Lvl-3	Round	Half Brown, Half Orange	Very Fine
ZPL-6	Eu-2, Lvl-3	Round	Tan and Orange	Fine
ZPL-9	Eu-2, Lvl-3	Round	Orange	Very Fine
ZPL-12	Eu-2, Lvl-3	Round	Brown	Very Fine
ZPL-14	Eu-2, Lvl-3	Round to Subround	Brown	Very Fine
ZPL-15	Eu-2, Lvl-3	Round to Subround	Greyish Brown with Orange	Medium
ZPL-18	Eu-2, Lvl-3	Round	Brown	Medium to Coarse
ZPL-19	Eu-2, Lvl-3	Subround	Brown	Medium
ZPL-26	Eu-2, Lvl-3	Subround	Orangish Brown	Coarse
ZPL-30	Eu-2, Lvl-3	Subround to Subangular	Orangish Brown	Coarse
ZPL-31	EU-2, Lvl-2	Round	Orangish Brown	Fine
ZPL-33	EU-2, Lvl-2	Round	Brown	Very Fine
ZPL-34	EU-2, Lvl-2	Round to Subround	Half Orange Half Brown	Fine to Medium

APPENDIX C
THIN SECTION POINT COUNT DATA

Table C.1. Thin section point count percentages.

Sample #	Matrix	Calcite	Quartz	Grog	Other
MBV001	49%	32%	16%	3%	0%
MBV010	59%	38%	3%	0%	0%
MBV014	49%	36%	4%	11%	0%
MBV016	54%	40%	4%	2%	0%
MBV020	63%	30%	6%	1%	0%
MBV023	52%	45%	3%	0%	0%
MBV024	62%	32%	6%	0%	0%
MBV031	60%	37%	0%	3%	0%
MBV034	58%	39%	3%	0%	0%
MBV038	63%	32%	5%	0%	0%
MBV045	49%	50%	0%	1%	0%
MBV047	54%	36%	1%	3%	6%
MBV049	57%	37%	1%	3%	2%
MBV050	42%	54%	2%	1%	1%
MBV051	46%	45%	1%	4%	4%
MBV057	62%	38%	0%	0%	0%
MBV058	52%	43%	0%	5%	0%
MBV061	57%	31%	2%	10%	0%
MBV063	49%	43%	0%	0%	8%
MBV065	53%	40%	0%	7%	0%

APPENDIX D
T-TEST CALCULATIONS

Matrix:

Unpaired *t* test results

P value and statistical significance:

The two-tailed P value equals 0.0753

By conventional criteria, this difference is considered to be not quite statistically significant.

Confidence interval:

The mean of Group One minus Group Two equals 4.80

95% confidence interval of this difference: From -0.54 to 10.14

Intermediate values used in calculations:

t = 1.8879

df = 18

standard error of difference = 2.543

Calcite:

Unpaired *t* test results

P value and statistical significance:

The two-tailed P value equals 0.0461

By conventional criteria, this difference is considered to be statistically significant.

Confidence interval:

The mean of Group One minus Group Two equals -5.60

95% confidence interval of this difference: From -11.09 to -0.11

Intermediate values used in calculations:

t = 2.1423

df = 18

standard error of difference = 2.614

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Quartz:

Unpaired *t* test results

P value and statistical significance:

The two-tailed P value equals 0.0056

By conventional criteria, this difference is considered to be very statistically significant.

Confidence interval:

The mean of Group One minus Group Two equals 4.30

95% confidence interval of this difference: From 1.43 to 7.17

Intermediate values used in calculations:

t = 3.1463

df = 18

standard error of difference = 1.367

Grog:

Unpaired *t* test results

P value and statistical significance:
The two-tailed P value equals 0.3582
By conventional criteria, this difference is considered to be not statistically significant.

Confidence interval:
The mean of Group One minus Group Two equals -1.40
95% confidence interval of this difference: From -4.52 to 1.72

Intermediate values used in calculations:
t = 0.9429
df = 18
standard error of difference = 1.485

Other:

Unpaired t test results

P value and statistical significance:
The two-tailed P value equals 0.0356
By conventional criteria, this difference is considered to be statistically significant.

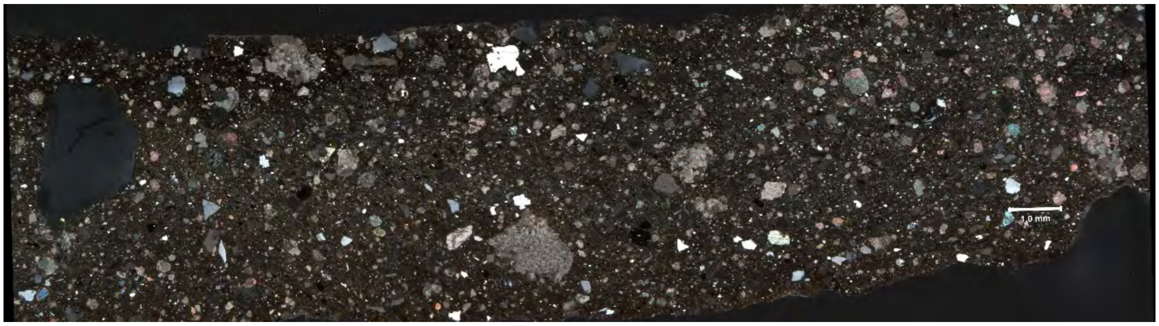
Confidence interval:
The mean of Group One minus Group Two equals -2.10
95% confidence interval of this difference: From -4.04 to -0.16

Intermediate values used in calculations:
t = 2.2718
df = 18
standard error of difference = 0.924

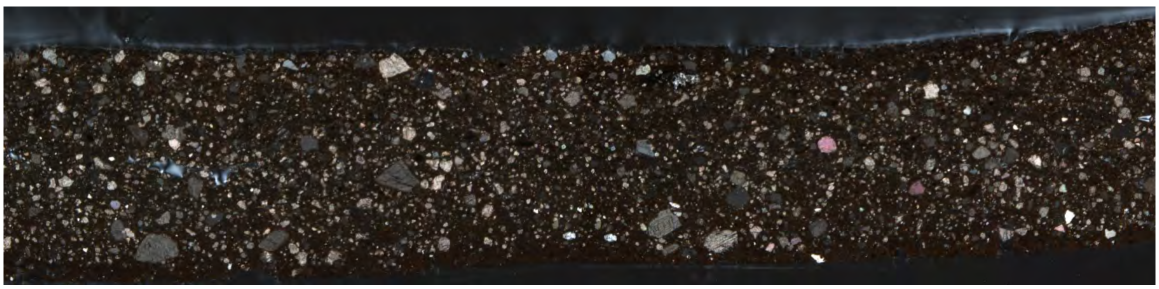
Appendix 14. t-test for other in thin section slides calculated on graphpad.com.

APPENDIX E

THIN SECTION SLIDES (ICE)
E.1 FIGURES MBV 001-038 FROM CAHAL PECH

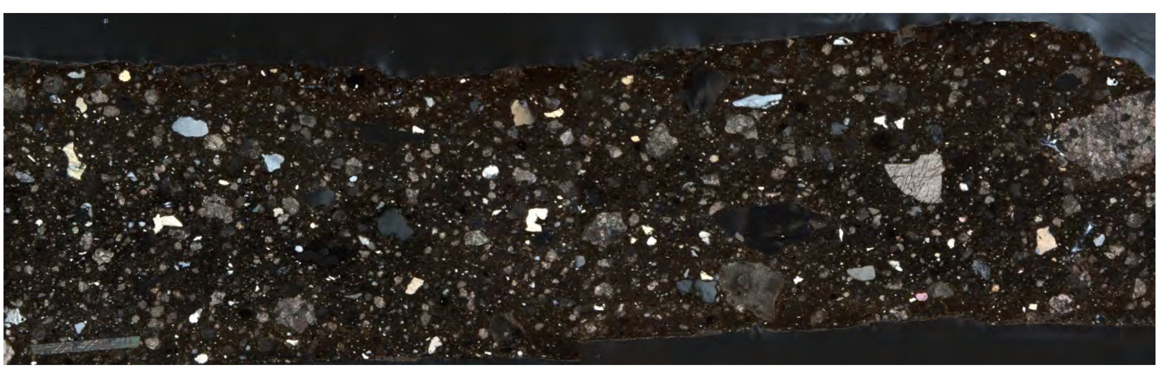


MBV 001

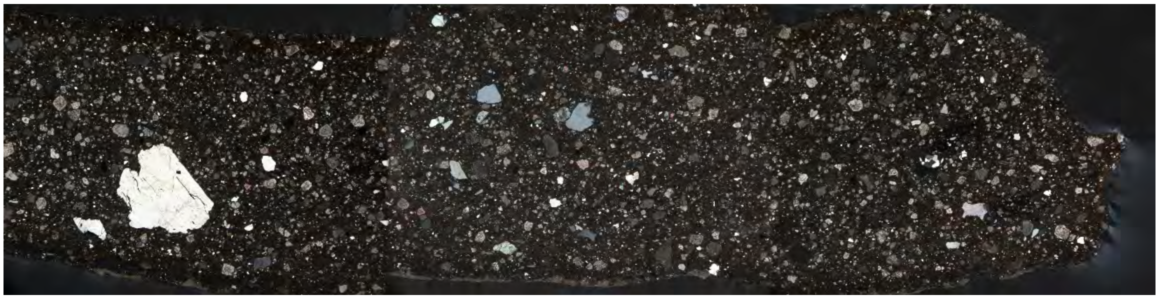


MBV 010

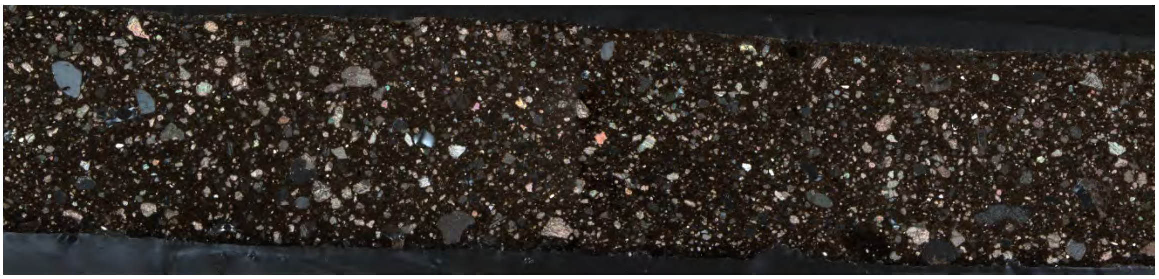
MBV 014



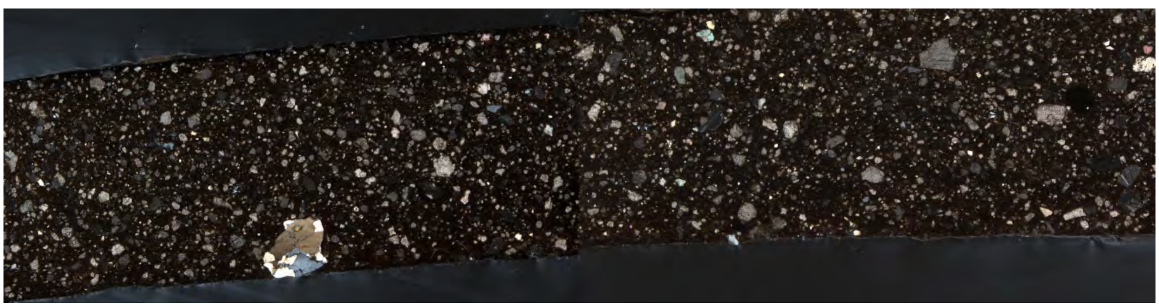
MBV 016



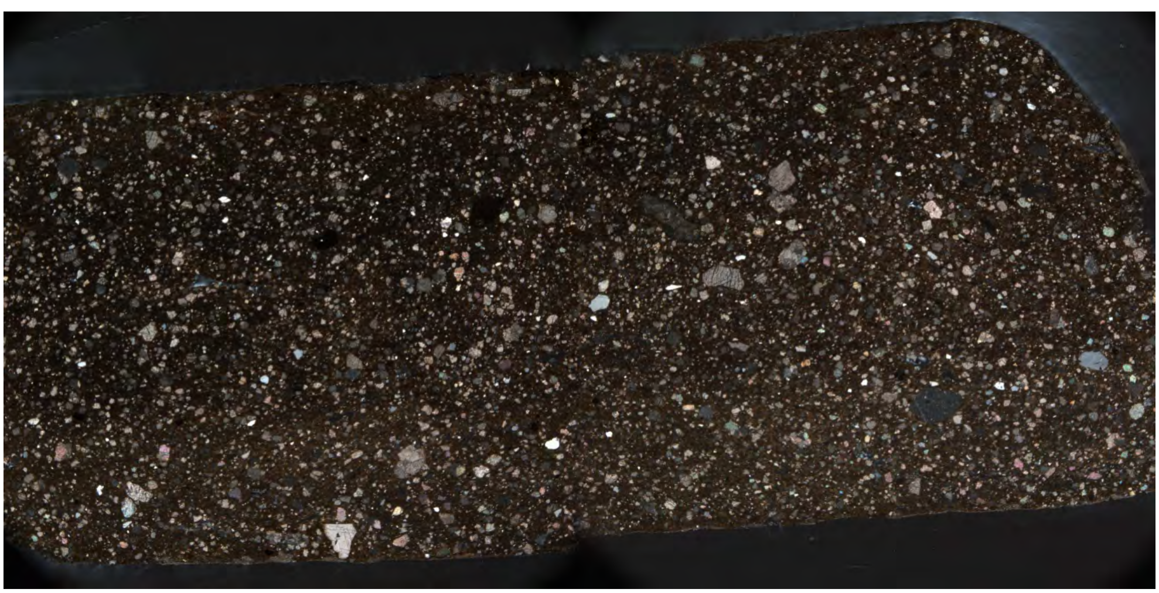
MBV 020



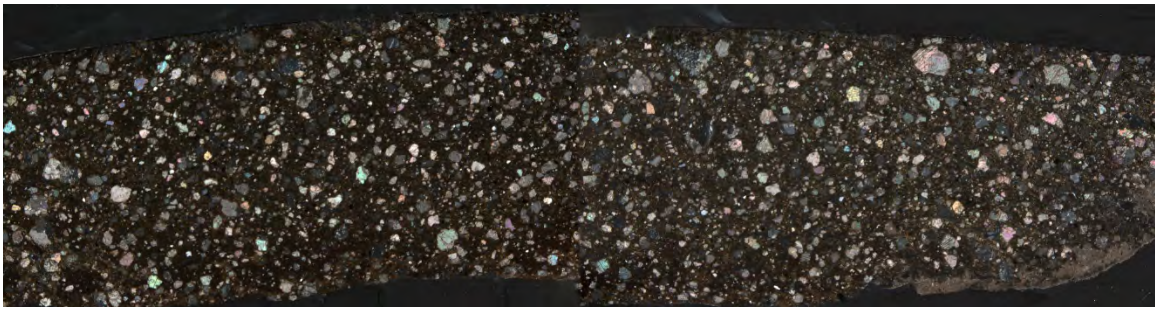
MBV 023



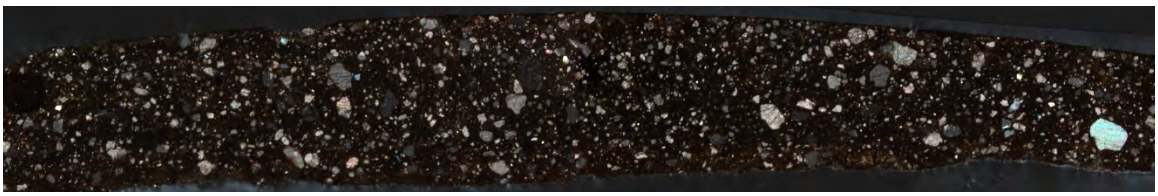
MBV 024



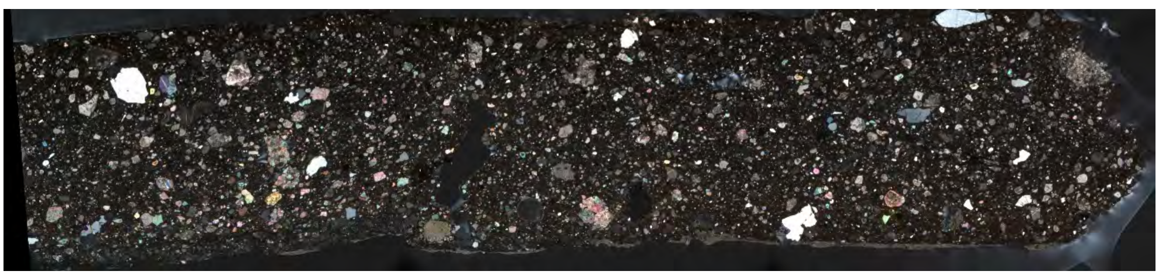
MBV 031



MBV 033



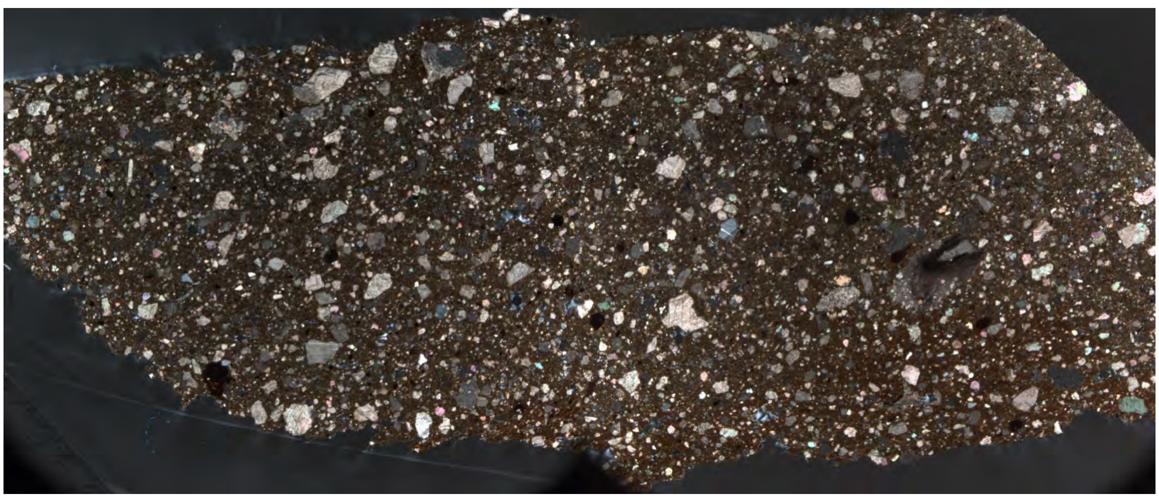
MBV 034



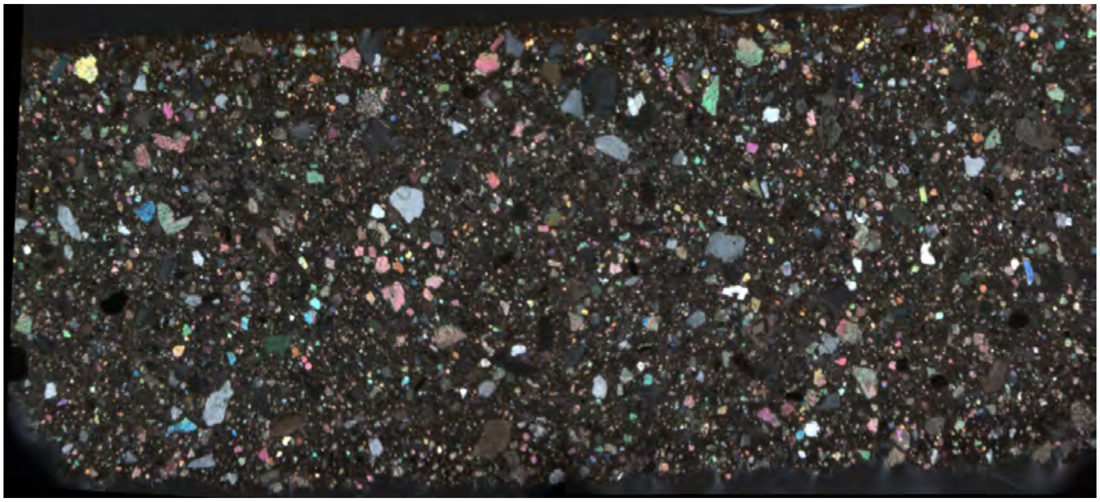
MBV 038

E.2 FIGURES MBV 043-065 FROM XUNANTUNICH

MBV 043

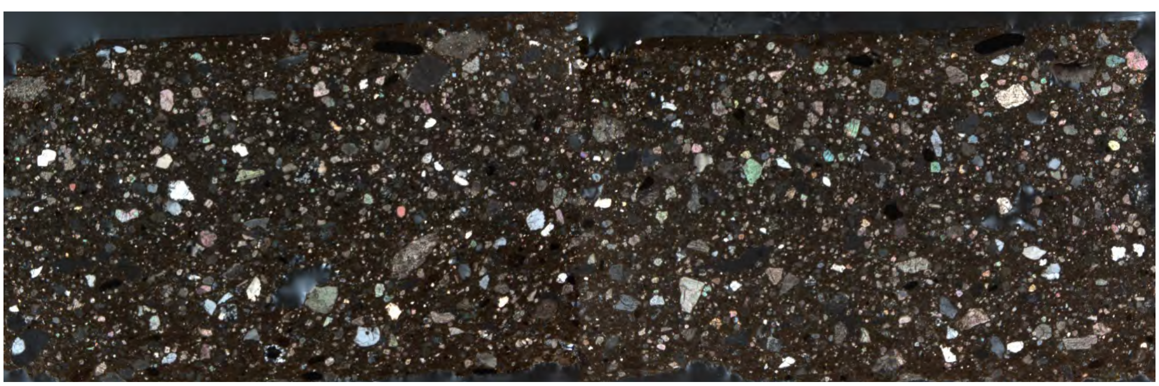


MBV 045



MBV 047

MBV 048



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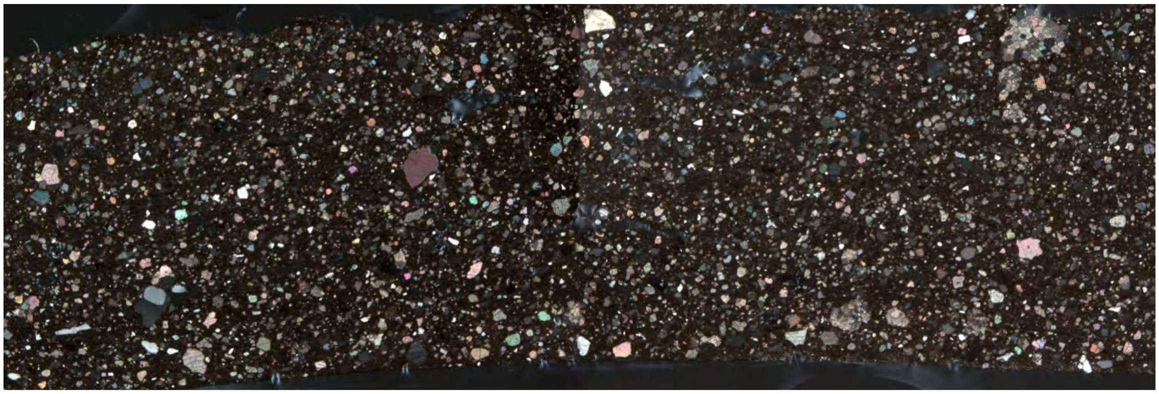
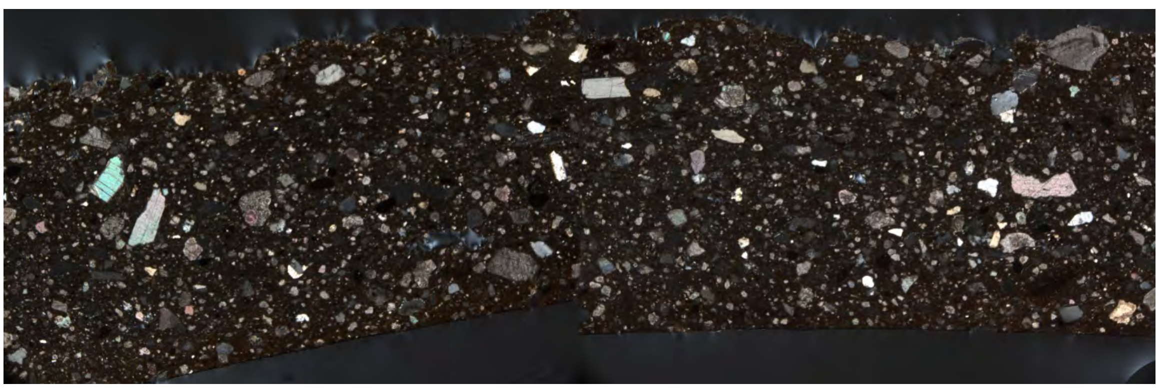
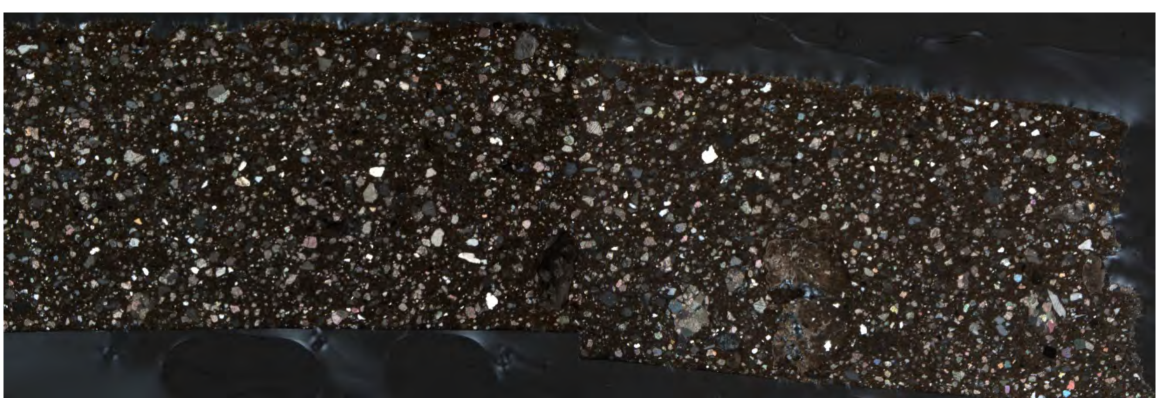


MBV 050

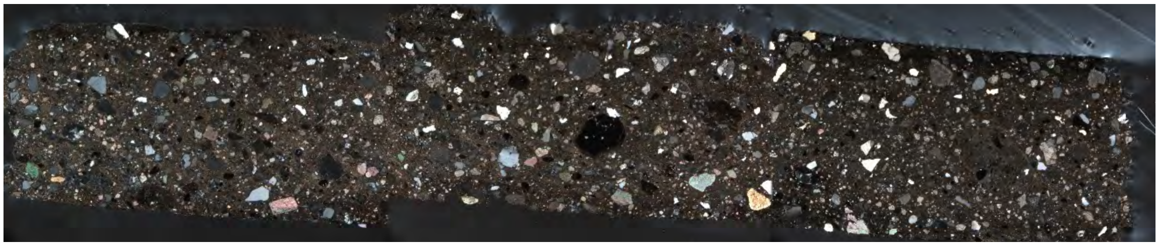
MBV 051



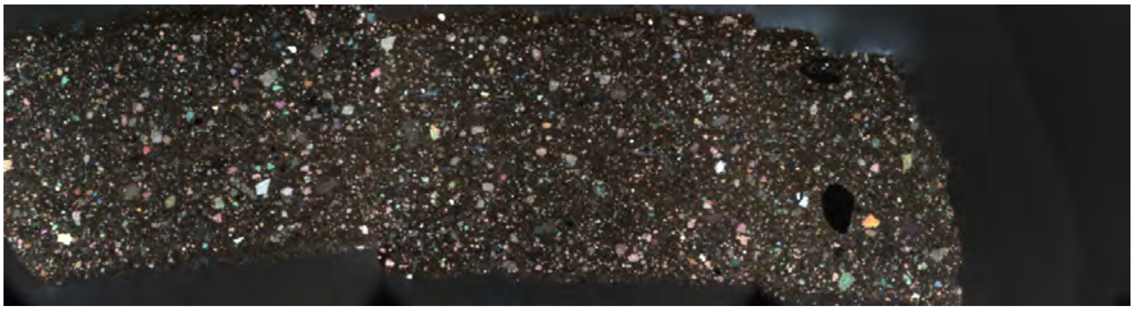
MBV 057



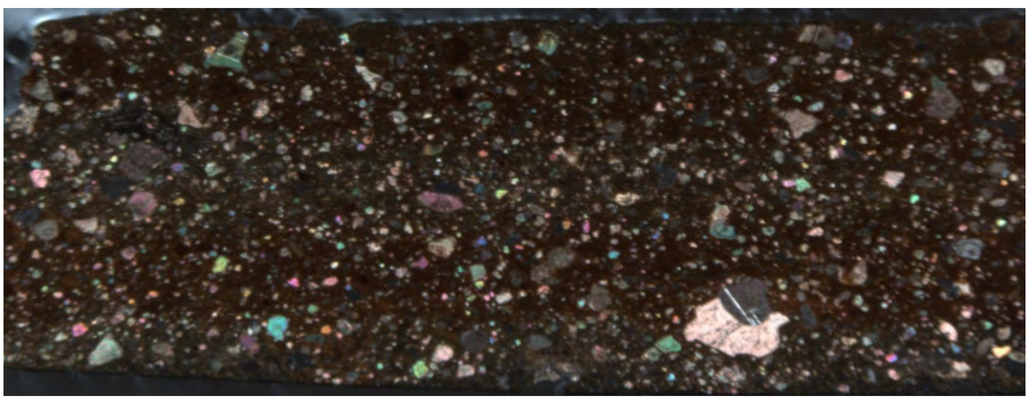
MBV 058



MBV 061



MBV 063



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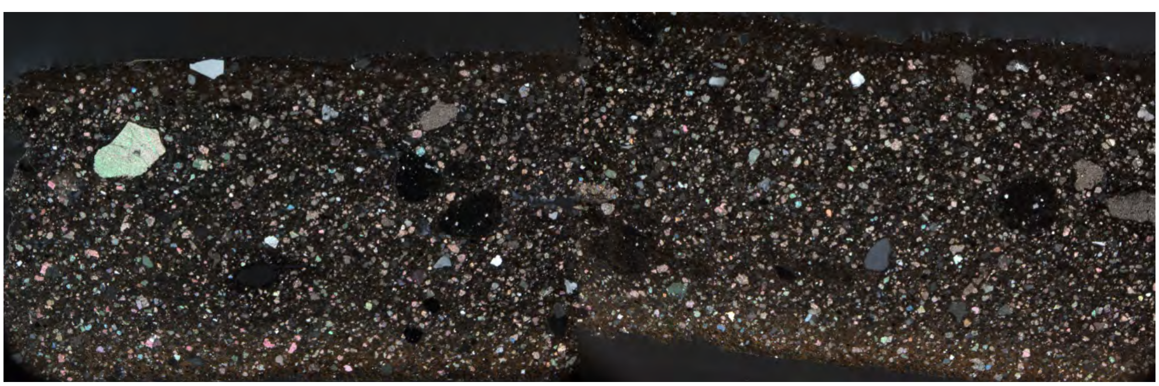

MBV 065