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ANALYSIS OF SMALL CAVE SITES RELATED TO THE UXBENKÁ POLITY:

APPLICATION OF FT-IR TECHNIQUES IN THE STUDY OF RITUAL PRACTICE

by

Clayton Meredith

A thesis

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To the Graduate Faculty:

The members of the committee appointed to examine the thesis of Clayton Meredith find it satisfactory and recommend that it be accepted.

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John Dudgeon, Major Advisor

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Glossary of Terms

A:C	Aragonite to calcite ratio expressed as a wt/wt percentage
C:A	Calcite to aragonite ratio expressed as a wt/wt percentage
Pachychilus	Any species of the gastropod genus *Pachychilus*
Polymorph	A form of solid matter that shares a chemical formula with, but differs in crystal structure from other polymorphs of the same compound
Wavenumber	Unit of measure for infrared radiation defined in terms of number of oscillations per centimeter of distance (also expressed as cm^{-1})

Chronological Definitions

Definitions of chronological periods vary considerably within the Mesoamerican culture area. For this purpose the delineations of chronological periods employed in this text are defined here.

Paleoindian period: The period from initial colonization of North America to 7,000 BCE

Archaic period: 7,000 BCE to 2,000 BCE

Preclassic period: 2,000 BCE - 250 CE

Classic period: 250 CE – 900 CE

Postclassic period: 900 CE – 1697 CE

Abstract

ANALYSIS OF SMALL CAVE SITES RELATED TO THE UXBENKÁ POLITY:
Application of FT-IR techniques in the study of ritual practice

Thesis Abstract – Idaho State University (2014)

Survey of the mountainous area south of Uxbenká revealed two previously undocumented rockshelters and two complexes of small cave sites containing artifacts possibly relating to performance of circuit rituals delineating space associated with maintaining political authority at the polity. FT-IR analysis of *Pachychilus* shells recovered from Tzib'te Yux Rockshelter demonstrate that shell materials were not subjected to burning prior to deposition and were likely processed *in situ*. Methods of analysis of *Pachychilus* shells are also considered with particular emphasis on sample preparation when conducting carbonate polymorph analysis, concluding that boiling leaves no detectable signal in shell remains. ^{14}C dates of materials from Tzib'te Yux reveal that the earliest occupation of the rockshelter occurred in the late Pliestocene making it the earliest stratified archaeological deposit currently documented in the Southern Maya Lowlands. These deposits also demonstrate a diverse subsistence pattern relying on a variety of small game and invertebrate resources.

Chapter 1: Introduction

Project Scope and Goals

Following the work of Moyes (2006), this study seeks to understand the role of cave ceremonies in the political consolidation of Uxbenká and to expand upon the existing body of research on cave contexts in Southern Belize. The first stage of this research consisted of a survey of the mountainous areas south of the small Maya polity of Uxbenká directed by local informants to identify small caves used in cave ceremonies. Goals of the survey include documenting cave resources, many of which have been extensively looted and are in danger of further degradation through time, and gaining a better understanding of the temporal scope of cave rituals in the area. This served to broaden the base of caves analyzed both spatially and temporally and to ensure that examinations of ritual change associated with caves sites were not reflective of changes in practice at individual cave sites, but reflective of a larger religious or ideological change. Survey also served to identify the position of cave sites in an attempt to examine features of landscape correlated with cave usage.

A single rockshelter identified in this process, Tzib'te Yux, was selected for intensive excavation and laboratory analysis of associated artifacts. Initially, the goal of these excavations was to investigate changes in treatment of *Pachychilus spp.* shells encountered in a midden context (a pattern observed at numerous sites in Belize), but an unexpectedly long time sequence of deposits in the area shifted focus to identification of ritual deposition of *Pachychilus* shells in rockshelter contexts that may be primarily the product of subsistence activities. Midden deposits of radically different ages were found to have similar shell composition. Given the length of this sequence, continuity of ritual practice is highly unlikely, suggesting that deposition of *Pachychilus* shells is either subsistence based during later deposition events associated with the Maya, or that deposition of shells in rockshelter contexts for ritual purposes closely resembles the earlier deposits resulting from consumption of food resources.

Determination of the nature of these deposits as ritual or subsistence based relies on analysis of the shells themselves along with associated materials. Comprehensive analysis of *Pachychilus* shell treatment as a result of processing for consumption in ritual or subsistence contexts was carried out using Fourier-transform infrared (FT-IR).

Laboratory analysis of *Pachychilus* shells was undertaken to further explore the role of *Pachychilus* deposition at rockshelter sites in Belize. The goals of this phase focused on the treatment of *Pachychilus* shells prior to deposition within Tzib'te Yux Rockshelter and the subsequent diagenesis of this material. Treatment of jute shells prior to deposition is of critical importance to understanding the role of *Pachychilus* in Maya rituals, the nature of rituals conducted at rockshelter sites, and the archaeological visibility of this activity with reference to subsistence activities. Rockshelter sites containing *Pachychilus* deposits have been described as the return of materials associated with the underworld to the underworld (Halperin, et al. 2003), a component of the *cuch* ritual (Pohl 1983), hunting shrines (Brown and Emery 2008), or the offering of refuse to the death gods. Analyzing the treatment of this material is one possible approach to analyzing the difference between these ritual depositions and consumption for subsistence reasons. If shells have been boiled for extended periods of time the return of shells to the underworld would be suggested as extended boiling would be indicative of the creation of 'high water' through its contact with *Pachychilus* shells. If shells have been burned, several possibilities exist: shell remains in rockshelters are the byproduct of resource production associated with the manufacture of lime for corn processing (Nations 1979) and plaster production, the burning of shell resources accompanies the burning of lithic remains that are offered to earth gods inhabiting rockshelters, or interaction between *Pachychilus* shells at the surface with subsequent burning events in the context of cooking fires altered the composition of shells.

Goals of FT-IR analysis included examination of the response of modern *Pachychilus* shells to various treatments to determine if ritual treatment of shell materials leaves a detectable signal, as well as to examine the utility of visual examinations of shell material in the field to determine what conditions the material was subjected to prior to deposition. Treatments examined included heat treatment by boiling and by treatment in a furnace (a proxy for burning). Diagenetic interactions were also examined to determine what effect the cave environment may have on the treatment signals over time, with worn and calcined modern specimens from fluvial environments being used as proxies for age. A side goal centered on establishing protocols for future FT-IR analysis of *Pachychilus* shells as a component of isotopic studies examining seasonal variation in cave use.

Shell middens and gastropod cooking

Due to the nature of molluscs, and gastropods in particular, as compact sources of protein encased in inedible carbonate packages, some processing must occur to extract edible portions of the animal. This is done, in most cases, quite close to the point where gathering occurs (Waselkov 1987), though in some instances, shell middens occur at a considerable distance from coastal areas (Straus 2006; Nakazawa et al. 2009). Methods of cooking and extracting gastropods vary considerably in both ethnographic accounts and within archaeological contexts. Wandsnider (1997) suggests that cooking of mollusks across cultures reflects the chemical and physical constraints imposed by the composition of the edible portion. Mollusks have low fat and carbohydrate content with a relatively high proportion of protein. This composition requires relatively short cooking times at modest temperatures. Wandsnider points to boiling and steaming (via earth-ovens or expedient pit roasting) as likely candidates for cooking mollusks.

Archaeological and ethnographic evidence suggests that a variety of methods may be employed both between and within sites. At Mesolithic and Neolithic sites on the coast of Portugal, gastropods were boiled using heated stones in pots, steamed in earth-ovens, or roasted at the edge of fire hearths (Stiner et al. 2003). Ethnographic and archaeological evidence from coastal Sonora suggests a variety of methods were used for cooking between the Late Archaic and the present including roasting, boiling, and consumption of raw shellfish (Foster et al. 2008). The different methods employed archaeologically in Sonora appear to reflect both the nature of the shellfish being cooked (large gastropods were more likely to be roasted than small ones) and the expediency of cooking (at sites with a single short occupation, roasting is preferred over steaming or boiling). A final pattern, noted in South Africa (Henshilwood et al. 1994), is the mass production of dried shellfish for consumption elsewhere, a possibility that is considered here briefly.

Use of Tzib'te Yux as a processing site for the mass preservation of *Pachychilus* is unlikely. Several indicators used to identify such processing sites are lacking. Foremost among these is the presence of bivalve remains in quantity. Ethnographic and archaeological examples of mollusc preservation generally center on processing of bivalves due to the physical constraints imposed by the enclosed shells of gastropods and the effort necessary in removing edible portions of gastropods from inedible portions (Waselkov 1987). Cooking bivalves in the shell serves as a preservative measure and also opens the shell allowing access to edible portions whereas additional processing is often required (before or after cooking) to remove edible portions of gastropods from their shells. In the case of *Pachychilus,* spire lopping is necessary to remove edible portions from the shell and is practiced in several ethnographic accounts of their consumption (Halperin et al. 2003; Nations 1979).

In addition to the constraints of processing gastropods, other archaeological indicators of mass processing for drying or preservation of food resources are lacking. Shell midden deposits associated with large scale processing and preservation tend to have very low artifact densities, and tend to be relatively homogenous in composition, lacking faunal materials other than the targeted mollusks (Henshilwood et al. 1994). Tzib'te Yux's faunal and artifact assemblages are dense and exceptionally varied across all excavated areas and stratigraphic horizons encountered to date, suggesting that processing of *Pachychilus* was not the sole focus of activity within the rockshelter at any point in time.

Finally, it is worth noting that the feasibility of drying mollusks of any sort for storage purposes is questionable in the context of a tropical wet forest. Such practices have been demonstrated in South Africa (Henshilwood et al. 1994), and have been suggested in northwestern Mexico (Foster et al. 2008), Wisconsin (Theler 1987), and Venezuela (Antczak and Antczak 2005), but each of these cases involves large gastropods, which would warrant the labor involved in processing them individually, or small bivalves which can be processed in bulk. Furthermore, the above cited examples occur in coastal environments with access to salt which provides additional preservative capacity. In an inland environment access to salt is limited

Evidence suggesting a particular cooking method has not yet been found at Tzib'te Yux. Fire-cracked rock is abundant at all levels, but this may be indicative of earth oven use or the use of boiling stones. Hearths have not yet been identified and may not be preserved given the accretionary nature of shell midden deposits. Establishing the mode of processing *Pachychilus* shells is an important step in establishing chronology of the site and in examining the practice of *Pachychilus* deposition in rockshelters. Changing methods of processing *Pachychilus* could be used as an interpretive tool to more precisely date disparate areas of the shell midden deposit. Furthermore, shifts in processing practice may be indicative of transition to ritual deposition of *Pachychilus* rather than strictly subsistence related processing of gastropods, as the method of preparation for ceremonial foods is often as important as the raw materials used in many Maya communities (Stross 2010).

Earth oven technology (known as the *pib* or *piib*) has widespread use throughout the Northern Lowlands today as a method of cooking meat, and tamales (O'Connor 2010). Evidence for prehistoric use of earth oven cooking can be found in both iconography (Taube 1989), and within artifact assemblages (Simms et al. 2013). Given the absence of comals and the abundance of imagery regarding tamales (Taube 1989), it is very likely that such earth ovens were the primary method of cooking in the Southern Lowlands. The earth oven tradition extends well beyond the Classic period and likely originates with processing of roots and meat during the Archaic period (Salazar et al. 2012). While modern use of earth ovens includes both domestic and ceremonial use, there is a strong association with the cooking of *Pachychilus* for ritual purposes and boiling that will be further elaborated.

Caves: the nexus of ceremony, water, and power

While considerable debate exists as to the relative level of control exhibited by large centers and the nature of political organization among the Maya (See Lucero 1999), there is widespread agreement that religion played a central role in legitimizing and supporting the political structure as a centripetal strategy that aimed to broaden support to peripheral areas. Demarest (1992) describes the role of religion in the formation of galactic polities as the "theater state" suggesting that in the absence of control over resources which are inherently decentralized in the Lowlands, elites instead monopolize the process of ritual and ideology. The New World is particularly ill-suited to commonly accepted models of centralization of power as long distance transport of resources is difficult due to the absence of draft animals. Climatic conditions also preclude the development of monopolies on water or hydraulic systems as the Wittfogel (1956) model demands. Though tenable in many areas of Mesoamerica (Puleston 1977) it is not practical in the rain drenched hilly landscape of Southern Belize.

Ritual and ceremony, in the context of other drivers, likely played a major role in the centralization of power within the Southern Lowlands. Dedication and termination rituals along with ancestor veneration clearly played a role in supporting political structures, particularly during the transition from the Late Preclassic to the Early Classic, when urbanization of populations increased at a rapid pace (Friedel 1998). While site placement and configuration is often the product of ecological constraints, these constraints leave a wide range of options and the placement of sites can be considered largely the product of human agency (Demarest 2009). At Dos Pilas and numerous other sites, it appears that access to features of the landscape related to ritual practices guided the process of site placement (Brady 1997). The layout of individual cities also reflects these cosmological constraints as seen at Chichen Itza where development of the city is laid out with reference to a the Cenote Sagrado and important caves beneath structures (Carlson 1981).

The notion that Maya cities were constructed with reference to sacred elements of the landscape as a cosmogram, or metaphor for the sacred landscape, drawing on Carlson's (1981) earlier work describing Maya site planning in terms of geomancy, has recently been the subject of considerable debate (Ashmore and Sabloff 2002, 2003; Smith 2003). Debate over the role of landscape in structuring Maya site planning centers more on the use of the term "cosmogram" than the actual practice of incorporation of these features within sites at some level or another. It is clear, however, that access to caves and appropriation of these sacred features to legitimize rulers acted to influence both site layout and site. This is particularly clear in cases where appropriation of cave features is not simply a matter of structure orientation or placement, but a constructed feature of the site itself as observed at numerous sites throughout Mesoamerica (Brady 2004).

Similar patterns exist in all regions of the Maya area including the Puuc region (Zubrow, et al. 2011) and the Valley of Mexico. The Pyramid of the Sun at Teotihuacan was built atop a cave feature that was modified with a staircase, constructed walls delineating separate chambers, mud plaster applied to the interior, and basalt ceiling slabs

(Heyden 1975). Modified cave features related to architecture have also been observed at Muklebal Tzul in the Maya Mountains where structures are placed atop a modified spring feature that was excavated to produce maximum visual effect (Prufer and Kindon 2005). Evidence for constructed caves throughout Mesoamerica has led Brady (2004) to identify the practice as a Pan-Mesoamerican tradition. While these examples of constructed cave features solidly link the conceptual significance of caves and settlement patterns, ritual appropriation of natural caves is also common throughout the Maya area and is the predominant place for cave rituals.

Caves are plentiful in the largely karstic regions of Lowland Mesoamerica. These contexts provide a wealth of data on Maya ritual throughout the Lowlands and are well suited to examinations of ritual practice. Caves can also be considered a purely ritual space as domestic occupation is unlikely, and no evidence suggests long-term occupation. In most cases they provide little protection from the elements, and lighting areas within the dark zone is prohibitively costly (Prufer and Brady 2005). Ceremonies conducted in, and associated with, caves are somewhat varied and include space delimiting rituals, rain-making rituals associated with the god Chaak, as well as those associated with the Earth Lords.

Space delimiting rituals have been described both ethnographically and archaeologically and have a close association with caves, settlement patterning, ceremonial circuits, and offerings to the Earth Lords. This pattern has been most extensively documented among the Tzotzil of highland Chiapas where ethnographic and ethnohistoric accounts demonstrate the integration of these rituals into political systems and mechanisms of social control (Vogt 1969). Vogt describes the basis for this integration as "replication" through which ritual symbols mirror the social order at various levels. *Krus* shrines, which are conceptually linked to the liminal role of caves as gateways, are scaled in accordance with their representation of the community level, the hamlet level, the waterhole group, and the individual household. Upward mobility within the political hierarchy of the cargo system is also closely linked with performance and participation within the ceremonial and religious spheres as alternating between ritual and political positions, is a hallmark of ethnographic accounts in many highland communities as well as Aztec communities further to the north (Carrasco 1961). A pre-Hispanic origin of this system has been proposed to explain its widespread occurrence throughout Mesoamerica (Carrasco 1961).

Reliance on such ethnographic accounts must be considered with some level of caution. It now appears that the cargo system developed as the product of economic forces of the colonial period (Rus and Wasserstrom 1980) and that the system observed by Vogt and others has changed dramatically over the past four centuries (Chance and Taylor 1985). The preponderance of similar themes linking power to religious ideology at various levels and across long timescales does, however, demonstrate a clear religious basis for Ancient Maya power structures. This association is clear in the Classic Period when dynastic lineages associated with and descended from gods (Itzamna in particular) are found at numerous sites (Thompson 1970:232). This relationship is less clear in the Preclassic Period though there is considerable evidence that Preclassic shamanistic leaders were the precursor for the widespread *ahau* lineages that ruled through the Classic Period (Freidel and Schele 1988).

Water played a critical role in political organization through control over ritual activities to promote rainfall as early as the Olmec (Grove 1973; Reilly III 1994; Schele 1987). Correlation between cave symbolism and water is remarkably consistent both spatially and temporally across Mesoamerica. Cloud formation, maize (a proxy for fertility), and water can be seen in association with caves in the Late Preclassic at San Bartolo in northwestern Peten (Saturno, et al. 2005) extending to the Post-Classic with the dramatic deposition of Tlaloc censers at Balankanche (Andrews 1970). In some large centers where surface water is scarce or concentrated at few locations on the landscape, hydraulic models may be useful for interpreting consolidation of power as is the case for Caracol, Calakmul, Cerros, Tikal and other sites located away from river systems (Lucero 2002; Scarborough 1983, 1998). While this is not the case at all Maya sites, numerous authors have noted the powerful connotations of water within Maya culture, the role it played in development of the Maya civilization (see Scarborough 1998) and the linkage between elements of landscape and this power.

Among the Maya, water is intricately tied to fertility and conceived to originate from a watery underworld (commonly referred to by the Quiche term Xibalba). Water links the three divisions of the Maya cosmology falling from the sky, emerging from underground, and flowing across the terrestrial realm. Chaak, the god of lightning and rain, is considered to have inhabited a watery cave located beneath a mountain (Thompson 1970:268), and mountains were considered repositories of sacred water. Bassie-Sweet (1996), relying on ethnographic studies, divides water sources into two types: high water, and low water. Low water, that which is in contact with the ground, is considered contaminated and unsuitable for ritual purposes while high water, which flows from the roofs of caves and from high mountains, would be considered suitable and was added to low water to ritually purify it. Water collected from caves was used in ceremonies and was considered to be *Zuhuy* meaning virgin or uncontaminated (Thompson 1956:246; 1970:184). Control over access to this water, be it through physical access or specialist ritual activities, could thus act as a proxy for control over broader, non-sacred water under a hydraulic model of power consolidation.

Given the ritual importance of karstic landforms within the Mesoamerican cultural sphere and the ritual appropriation of materials derived from caves, these elements of landscape should be viewed as sources of extractive resources and critical components influencing settlement patterns and consolidation of power within the development of the Maya civilization. When combined with the presence of extractive resources of a more profane nature, control over karstic landforms serves as a source of power and wealth for elites as well as broader settlements. As such, the utilization of these caves in the form of ritual activity, offerings, modifications, and appropriation of cave symbolism should be expected to intensify during periods of social unrest or intensification of political control over the community. This process of shifts of ritual practice has been documented in the transition to the drought cult correlated with climate change in Chechem Ha Cave during the Late Classic (Moyes, et al. 2009).

Halperin et al (2003) have demonstrated, through analysis of dozens of sites throughout the Maya area, a linkage between cave contexts and *Pachychilus* shell deposition, and have proposed that this linkage is based on returning the shells to the earth (based on ethnographic evidence). Deposits of Pachychilus shells are common in cave and burial contexts throughout the Maya lowlands. Rockshelter sites, however, provide the richest sources with numerous examples of massive deposits exceeding the quantities found at surface sites occurring from Chiapas (Lee et al. 1988) to Belize (Wrobel et al. 2007; Prufer 2002). Often these deposits are associated with burials, but Pachychilus concentrations are quite high even outside sediment associated with burials in cave and rockshelter contexts. Caves Branch Rockshelter has been interpreted as lower class burial sites spanning from the Late Preclassic to the Terminal Classic, though considerable variation in grave goods exists over this period (Wrobel et al. 2013). Mayahak Cab Pek (located in the Maya Mountains near the sites of Ek Xux and Muklebal Tzul) also contains numerous burials found in association with *Pachychilus* shells (Prufer 2002). In this case, the burials range from the Preclassic to the Late Classic. Considerable evidence exists linking rockshelter sites within the Maya area to mortuary ritual associated with *Pachychilus* deposits, suggesting that these small cave and rockshelter sites held considerable significance and were important components of ritual processes that spanned considerable lengths of time (though not with continuity of practice throughout this period).

The distinction between ritual usage of *Pachychilus* and subsistence based consumption is not a mutually exclusive proposal. Implications of ritual function of Tzib'te Yux and the *Pachychilus* shells within does not discount their use as a food resource nor the consumption of *Pachychilus* shells exclude them from use in ritual contexts. Ethnographic accounts suggest feasting events associated with sacrifice and deposition often have a ritual component. The material offerings given to the gods may, in some instances, be consumed after the essence of the material has been removed (O'Connor 2010; Flores and Kantun Balam 1997). Stross (2010) provides an exhaustive examination of food use in Maya ritual including several ethnographic and archaeological examples of distinctions made between food for human consumption and food consumed by deities. Often, foods that are harmful to humans, distasteful, poisonous, or byproducts of food production fall into the realm of food for the earth gods. Given this, it is not unreasonable to consider spent *Pachychilus* shells as a type of food offering placed in contexts related to earth gods and transitional environments between the underworld and the overworld.

The Southern Belize region

Despite over a century of sporadic investigations, the archaeology of Southern Belize remains a poorly understood region within the Mesoamerican cultural sphere. In the early 19th century, extensive investigations into the Maya ruins of what is now Toledo District were conducted beginning with Thomas Gann's work at Lubaantun (Gann 1997). The British Museum's expeditions in the late 1920s expanded upon Gann's early observations and conducted extensive excavations at both Lubaantun and Pusilha (Joyce 1929; Joyce, et al. 1927; Joyce, et al. 1928). Investigations in the region accelerated in the late 20th century with the discovery of Uxbenka, Xnaheb, and Nim Li Punit (Hammond 1975; Hammond 1999) and a regional picture began to emerge. Since 2001 the Pusilha Archaeological Project (PUSAP), Toledo Regional Interaction Project (TRIP), and the Uxbenka Archaeological Project (UAP) have greatly expanded our understanding of the regional interactions between these polities.

Figure 1.1 Location of the Southern Belize Region in relation to the major sites mentioned in the text.

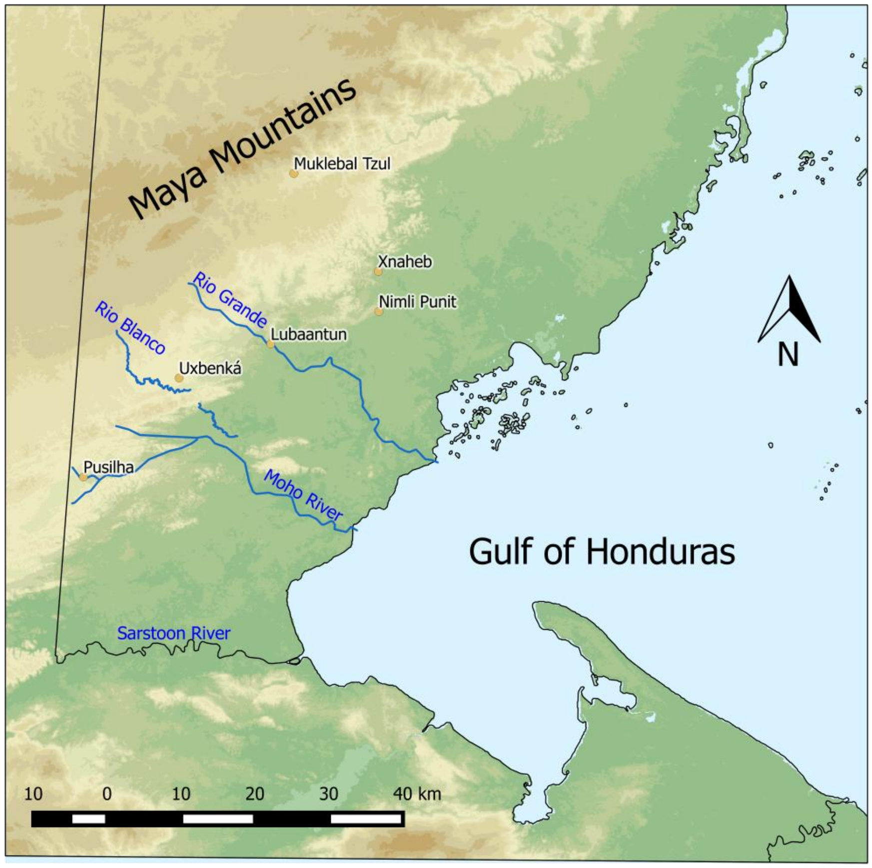

Figure 1.2 Location of Uxbenká within the Southern Belize Region.

The earliest occupation of the region, though well documented in the north at Cuello, Colha, and Pulltrouser Swamp, and cave sites in the upper Belize River Valley (See Bischoff and Fyfe 1968 for a review), is poorly documented in Southern Belize and is known from surface collections near Big Falls to date to the Late Pleistocene (Zhang and Zhang 2006).

Southern Belize sits in a peripheral region with the Petén Basin to the west, the Southern Lowlands dominated by Copan to the south, and a series of larger polities in the

Belize Basin to the north (Figure 1.1). The area is circumscribed by the Maya Mountains to the north and west, a coastal plain yielding to the Caribbean and several coastal Classic and Postclassic Maya saltworks (McKillop 1996) to the east, and a region of infertile swampland to the south that shows little evidence of prehistoric occupation beyond the Preclassic ruins of San Felipe (Voorhies 1969). This relative geographic isolation seems to have produced a distinctive region within the broader Maya cultural sphere as demonstrated by several lines of evidence (Leventhal 1990). The polities of Southern Belize are of uncharacteristically similar size and closely packed together (Figure 1.2). Hammond (1975) suggests that this is evidence of single politically dominant force based in Pusilha or Nim Li Punit. Epigraphic evidence in the region does not support this, however, as there are few references to nearby polities (a single reference to Nim Li Punit is made at Uxbenka). References to Tikal at Uxbenka , epigraphic references linking Nim Li Punit to Altun Ha, and Copan, and references linking Copan to Lubaantun, and Pusilha (Wanyerka 2009) suggest that the sites of Southern Belize were not under the control of a single polity. The epigraphic evidence also casts doubt on the hypothesis of regional hegemony as linguistic differences seem to separate the various polities of Southern Belize indicating that they may have been politically aligned with, or descendent from disparate polities in other regions. Recent archaeological evidence demonstrates limited economic interactions between Southern Belize sites suggesting that the sites of Southern Belize were independent polities (Braswell, et al. 2004; Braswell, et al. 2005; Fauvelle 2012; Prufer, et al. 2011), and an absence of archaeological and epigraphic evidence suggests that the polities of Southern Belize were not engaged in conflict with one another.

Architecture in the region is distinguished from other areas by the absence of the corbel arch and presence of what is known colloquially as the Southern Belize façade consisting of faced natural hillsides leading to the illusion of larger structures. The façade pattern is present in other areas, but has not been observed in the areas surrounding southern Belize and is notably present at all major sites in the area including Uxbenká, Nim Li Punit, Lubaantun, and Xnaheb. Pusilha's Gateway Hill is a particularly large example of this form (Braswell, et al. 2004). Ballcourts surrounded by walls also serve to differentiate this region though they have not been observed at Uxbenka or Xnaheb and their presence at Lubaantun is speculative (Leventhal 1992).

The political organization of Southern Belize demonstrates a host of peculiarities distinguishing it from other regional Mesoamerican powers. The presence of small polities that seem to be only loosely aligned does not fit with the larger view of Maya "states" dominating large regions. The presence of small polities in the Late Classic Period is also notable as a political vacuum was clearly not present and despite interaction with distant, more powerful polities, the region as a whole was not dominated by a hegemonic outside state. While suggestions have been made that the political structure of the Maya was temporally dynamic (Marcus 2003) and the presence of regional differences in Maya society in the post-contact period have been noted (Jones 1983), the Southern Belize region remains somewhat anomalous in an archaeological context. Questions of the nature of this political organization remain unanswered, and the role of religion and ideology in supporting this alternative structure has not been investigated. The bulk of the evidence for this alternative structure arises from ceramic and epigraphic data as well as the lack of fortification structures within the region suggesting limited economic links between sites in the area and a low level of conflict between them.

The Middle Preclassic period was characterized by relative homogeneity in ceramic forms and political organization that appears to have been disrupted during the Late Preclassic (Reese-Taylor and Walker 2002). Hansen (1998) has suggested that this proliferation of ceramic forms is the result of increasingly diverse trading relationships that emerged after the collapse of El Mirador. These trade routes have been cited as a driving force in the rise of Tikal in the Early Classic (Sharer 2003). However, the transitional period is not well understood, and further investigations into political structures during the period are warranted particularly in more isolated areas. Uxbenka presents a unique opportunity to examine the rise of elites during the Late Preclassic to Classic period transition.

To date, investigations at Uxbenka have been focused on developing a site chronology. This research has revealed that monumental construction at the site core of Uxbenká began in the Terminal Preclassic with modifications to existing landforms (Culleton, et al. 2012). Major site level reconstructions were conducted in Group B during the Early Classic period, including changes to the orientation of structures in the site and expansion of the landform upon which it is built (Aquino, et al. 2012). This may indicate a reorganization of the political hierarchy at the site and a weakness of the ideological underpinnings of leadership in the area.

Understanding the political underpinnings of Uxbenká requires attention to ritual activity in addition to political centers. Investigations at Kayuko Naj Tunich, located 3 km south of and within view of the site core, have identified a modified cave including a wooden canoe that may have been used as a proxy for underground water sources used in dedicatory rituals or circuit rituals delineating boundaries (Moyes and Prufer 2009). Wood from within this cave has been dated to the Terminal Preclassic period through the Early Classic suggesting that its modification was coeval with the earliest phase of monumental construction at Uxbenká and that it was maintained for several centuries thereafter. Moyes interprets this site as a foundational shrine for Uxbenká.

Geologic Context

Uxbenka and the Rock Patch lie between two distinct but related colinear geological regions: the Maya Mountains to the north and the Motagua Fault Zone to the south. The Maya Mountains are composed of intrusive igneous rock formed during the Triassic and uplifted periodically until the mid-Cenozoic (Miller 1996). This area, modern Toledo district, is characterized by thinly bedded mudstones, as well as fractured limestone of Cretaceous and Cenozoic age (Ower 1928). Uplift and subsistence in the area through the course of geologic time has produced a variety of sedimentary deposits with varied composition (Schafhauser, et al. 2003). The oldest exposures in the region are found near Punta Gorda in an uplifted section of the Lower-Cretaceous dolomitic Coban formation and its contemporary the recently described pelagic limestones of the Punta Gorda formation (Schafhauser, et al. 2003). Overlying this is the Upper-Cretaceous Campur formation and the related La Cumbre formation, exposures of which are found in the foothills of the Maya Mountains stretching from the modern town of Mafredi in the Northeast and trending southwest into Guatemala (Petersen, et al. 2012). The Campur formation consists of rudist bearing limestones with inclusions of chert

(Bateson and Hall 1977). The La Cumbre formation is derived from the same material, but was formed by the collapse of portions of the Campur formation and subsequent movement of this material. La Cumbre deposits consist of megabreccias, conglomerates, and turbidite deposits. As the area that is now the Toledo district was located in a foreland basin created by the collision of the North American and Caribbean plates during this period, the Campur and La Cumbre formations contain a variety of terriginous molasse-like inclusions eroded from areas to the south and southwest. Following frequent bouts of uplift and inundation, this basin has also been filled with sediments and clastics originating from the Maya Mountains, and local areas of high relief may contain exposures from both periods leading to the availability of allochthonous materials from either the Maya Mountains or the Motagua Fault System.

The area immediately surrounding the site of Uxbenka sits on the Toledo Formation (locally known as the Toledo Beds, and as the Sepur formation in Guatemala) composed of highly fissile mudstone that degrades quickly upon exposure to the elements. Frequent Eocene age sandstone outcrops also occur in this formation along with disconformous outcrops of the older Cretaceous limestones. This formation is easily weathered and fluvial systems have produced numerous low lying hills which were and are the preferred areas of settlement. The variation in the underlying geology as well as the tendency to weather quickly has been cited as the reason for the exceptional productivity of farmland in the area as well as the short fallow periods utilized by the modern inhabitants of Santa Cruz and the surrounding villages (Ower 1928; Prufer 2007). Soils in the area have been extensively characterized by Wright et al (1959) with four classes occurring near the site of Uxbenka. Aguacate sandy clay is present to the west of

Santa Cruz. Mafredi fine sandy clay is present to the northeast and is interdigitated with Cimin clay. To the west, Machaca complex soils composed of degraded mudstone dominate. Machaca complex soils are poorly drained, but are the preferred habitat for the abundant and economically important cohune palm (*Attalea cohune*). This classification also states that the most productive soils (particularly for cacao and *milpa* farming) in the region occur in the San Antonio Valley surrounding Uxbenká. Slightly lower productivity soils occur in the limestone underlain area surrounding Pusilha.

South of the site of Uxbenká the Rio Blanco (a tributary of the Moho river) flows eastward at the foot of a limestone horst, known locally as the Rock Patch, before dropping into Hokeb Ha Cave and reemerging on the southern side of the Rock Patch as Blue Creek. The Rock Patch rises abruptly 250 meters above the riverbed below from a fault with a strike running at 210° that characterizes the landforms between the Maya Mountains and the Motagua Fault to the south (Dixon 1955). The fault is part of the larger Southern Boundary Fault Zone which contains numerous faults delineating the southern edge of the Maya Mountains, though the main escarpment of the Maya Block has retreated northward to its current position (Bateson and Hall 1977). The displacement of the fault delineating the Rock Patch has not been established, but must exceed the total height of the Rock Patch above the riverbed as the Toledo Formation has been completely eroded from even the highest peaks in the area.

The Rock Patch is a karstic limestone block of the La Cumbre formation composed of shallow water subangular clastics as well as massive limestones that has been sporadically investigated over the course of the last 30 years with increasing frequency due to improved infrastructure in the region. It is a rugged terrain formed by karst processes including frequent dolines (endorheic basins known throughout the Caribbean as “cockpits”) formed by the collapse of ancient cave systems, as well as numerous active and inactive cave systems. Hammond (1975:11) describes similar outcrops of Cretaceous age limestone in the vicinity of Lubaantun as containing siliceous bands and flinty deposits near the summit of such ridges as well as at the base. Siliceous materials described by Hammond and observed within the Rock Patch fall into two classes: river cobble inclusions incorporated during formation that range from fine sand to over 20 cm in diameter, and silicified limestone which may form either blocks or lenses. Soils in the area are extremely thin owing to the slope and the porous nature of the limestone which also precludes the formation of any form of surface water. Vegetation in the area is a dense tropical lowland evergreen broadleaf hill forest on all but the steepest of slopes. Steeper areas are covered in closed shrubland vegetation or bare rock due to the lack of soil development. The area between the Rio Blanco and the escarpment is farmed, but south of the fault, hunting and logging are the only economic activities that take place. Attitudes about the Rock Patch in the village vary greatly and numerous stories of supernatural occurrences abound resulting in infrequent trips to the area. Experienced hunters and practitioners of bush medicine, however, are familiar with the area and were of great help in conducting this study.

Chapter 2: Materials and Methods

Calcium carbonate exists naturally in three polymorphs as well as several unstable hydrated polymorphs. At the surface, calcite, aragonite, and vaterite are the most commonly encountered. Two of these polymorphs (vaterite and aragonite) are metastable under conditions that exist at the earth's surface, and will spontaneously convert to calcite over various timescales. Vaterite is the least stable polymorph having a carbonate disordered structure displaying hexagonal crystal symmetry (Kamhi 1963; Wang and Becker 2009). Vaterite is also the most soluble in water and undergoes rapid transformation to calcite under conditions present at earth's surface (Kralj, et al. 1997; Plummer and Busenberg 1982). Vaterite may form abiogenically under specific conditions but its occurrence is extremely rare (Grasby 2003; Rowlands and Webster 1971). It is rarely present in the shells of some mollusc species particularly in areas that have undergone repair, unusual mineral growth (as with pearls), or initial stages of shell development, though this is typically in small quantities and is dependent on stabilization via cations, or organic materials (Spann, et al. 2010). Given the rarity of vaterite and its instability under the conditions examined, little discussion need be devoted to it.

Aragonite and calcite are considerably more stable and far more abundant polymorphs. The crystalline structure of these two polymorphs is quite similar and is distinguished by the position of carbonate ions within the lattice structure of the material. Aragonite has an orthorhombic crystal structure while calcite has a rhombohedral orientation (de Villiers 1971). The structure of aragonite is slightly more dense than calcite (Russo, et al. 2010). Though aragonite is metastable on the surface it is formed at depth when calcites undergo a phase transition and through precipitation reactions of carbonates under specific parameters at the surface. High pressure conditions favor the formation of carbonate (Salje and Viswanathan 1976) allowing it to form in some metamorphic minerals with sufficiently high pressures and low temperatures (Hacker, et al. 1992). Formation through precipitation is somewhat more complex with several parameters influencing the development of aragonite over calcite. In the marine environment supersaturated calcite precipitates to form primarily calcite at temperatures below 5° C (Burton and Walter 1987). Above this temperature aragonites are favored. Higher magnesium ion concentrations also favor aragonite formation and play a key role in directing formation of calcite or aragonite in cave formations (Frisia, et al. 2002; Railsback, et al. 1994). In cave systems the role of temperature and evaporation rate has not been well established.

Biogenic aragonite is derived from a variety of species including the shells of many molluscs, and the exoskeletons of anthrozoans (Lowenstam 1981). Aragonite deposition is favored in many organisms and occurs despite temperature and pressure conditions favoring calcite formation due to precise biochemical controls that initiate crystal formation. β-sheets of silk-like proteins play a role in directing carbonate deposition and allow organisms to produce highly structured layered composite materials consisting of proteins, calcite, and aragonite (Falini, et al. 1996). Maintenance of ion and carbonate concentrations at mineralizing surfaces also plays a role in this process and allows many molluscs to produce shells composed purely of aragonite.

After the death of aragonite producing molluscs, a metastable aragonite will decay over time to produce calcite given sufficient volatile materials. Dissolution and recrystallization speeds this process greatly. Phase transitions within biogenic aragonites may also be accelerated by the inclusion of water and other volatile compounds within the crystal lattice which introduce crystal defects into carbonate structures and may stabilize intermediates acting as a catalyst and reducing the activation energy of the transition (Hacker, et al. 1992). The rate and equilibrium position of this reaction is dependent on temperature as well as impurities in the carbonate lattice. Higher temperatures favor calcite formation and the transition can be driven to completion over relatively short timescales (minutes to hours) at temperatures of 380-400° C for biogenic aragonites and 450-470° C for abiogenic aragonites (Yoshioka and Kitano 1985). Partial phase transition may occur at somewhat lower temperatures.

Sample Preparation

Pachychilus shells were collected from the profiles of excavations at Tzib'te Yux rockshelter from the east profile of unit 3 at 10cm intervals to a depth of 50cm. This profile was chosen as it sits beneath the sculpture located in a central area of the rockshelter and contained a continuous sequence of deposition uninterrupted by breakdown from the rock face above. Due to the position between the rock face and a rise in the bedrock this trough is unlikely to have been cleared of material as it is difficult to access. Additional samples were recovered from unit 5 in the red clay layer containing Archaic artifacts. Modern spent *Pachychilus* shells were collected from the north bank of the Rio Blanco 200 meters upstream of the rockshelter.

All shells were rinsed with water and scrubbed with a toothbrush to remove adhering sediments. Many of the modern shells are coated with a thin deposit of travertine. These deposits were observed on living snails in the area and may be the result of pre or post-mortem deposition. The adhered deposits are considerably softer than the shells and were ground off of any adhering surfaces using sandpaper. In most cases travertine could be removed in a single piece by applying gentle pressure with dental tools. Similar travertine deposits were observed on the archaeological specimens, but are more likely the result of drip formations occurring within the rockshelter. These were removed using a similar procedure. Samples were then subjected to sonication for a period of 10 minutes to remove any remaining material adhered to the surface. Sonication is known to induce vaterite to calcite transitions, but this is generally over longer time scales and has been shown to involve "relay" interactions between individual fine particles (Berdonosov, et al. 2005). Sonication of whole specimens is unlikely to produce similar transitions. To ensure that such reactions are not occurring, geologic specimens were also subjected to the cleaning and grinding protocol to test for such transitions. Modern samples were broken into smaller pieces using a hammer. 50-100 mg samples consisting of relatively flat shell fragments with both interior and exterior surfaces intact were subjected to heating for one hour at temperatures ranging from 50 to 500°C at 50° increments.

Grinding of samples presents somewhat of a problem as mechanically induced transitions are known to take place between calcite, aragonite, and vaterite (Burns and Bredig 1956; Pesenti, et al. 2009). Such transitions may be induced by sheer strain on the crystal structure and have been observed in samples ground in ball mills over long lengths of time (10 or more hours) (Pesenti, et al. 2009), or through the surface distortions in crystal lattice structures caused by small particle size (Forbes, et al. 2011). The duration of sample grinding and resulting particle sizes derived from the protocol employed in this study are unlikely to produce such alterations, but geologic and biogenic aragonites were subjected to this protocol and alterations were examined by comparing spectroscopic results against whole specimen micro-FTIR spectra.

In the context of this study, I developed consistent protocols for use within archaeological research for similar studies. To achieve this goal, grinding methods were tested on geological and modern samples to assess the repeatability of each and the variation within grinding methods. Samples were ground following two protocols. The first grinding protocol followed Russo et al (2010) and was conducted in a SPEX SamplePrep 6770 freezer mill at a temperature of -196°C with a 2 minute cool time and a 2 minute grind time. The second employed a ball mull (Wig-L-Bug) for 30 second and 2 minute grinding times. Powders from both methods were passed through a 4Φ (62.5 μm) mesh. The repeatability of measurements on the resulting powders was compared to determine the most efficient and most consistent method.

3 mg of the resulting powders were then pressed in 300 mg of optical grade anhydrous KBr at a pressure of 20,000 psi to produce pellets with 1 wt% calcium carbonate. Standards for generating calibration curves were prepared following the same sample preparation protocol on commercially available geologic samples of aragonite and calcite from Chihuahua, Mexico in mixtures ranging from 10 to 100 wt% aragonite.

FT-IR spectra were obtained using a Thermo Nicolet Nexus 670 infrared spectrometer with a resolution of 4 cm^{-1} in transmission mode (Figure 2.1). 128 scans were integrated for each sample. The spectra were analyzed in the low energy fingerprint region with specific regard to the characteristic peaks of aragonite (1083, 859, 713, and 710 cm^{-1}) and calcite (877, and 713 cm^{-1}) . Peak height ratios of the 859 and 877 cm^{-1}

peaks have been used to generate calibration curves allowing for an accuracy of ±1 wt% accuracy in mixtures composed of 20-80 wt% aragonite, and ±5 wt% outside this range (Compere and Bates 1973). These results were compared with the results of subtracting the area under the 713 cm^{-1} peak from the 700 – 713 cm^{-1} region which produces similar precision (Russo, et al. 2010). Calibration curves were generated using mixtures of geologic calcite and aragonite powders in mixtures ranging from 100% calcite to 100% aragonite in 10 wt% increments.

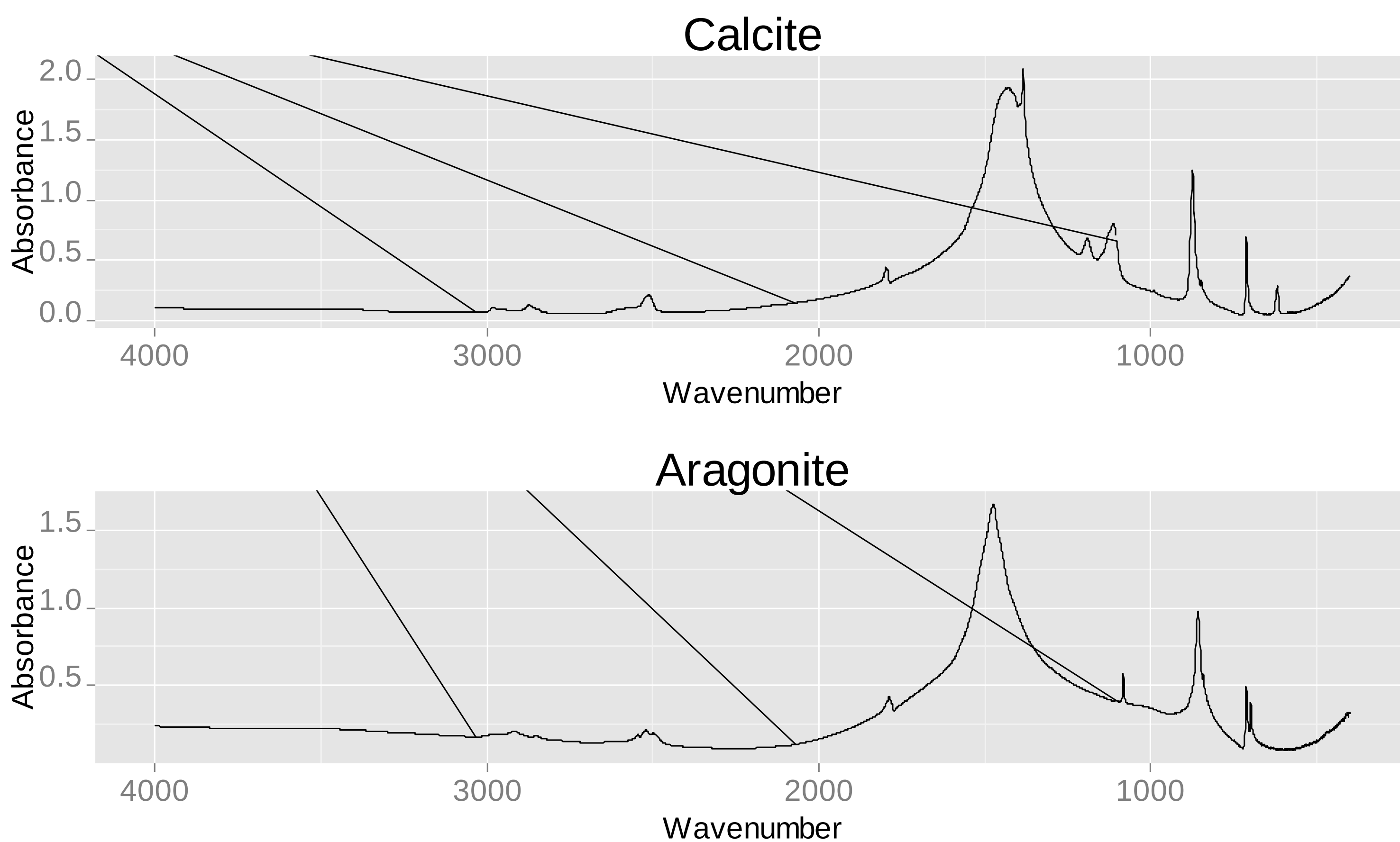

Figure 2.1 Pure geologic calcite and aragonite spectra

FT-IR measurements were verified using X-Ray diffraction (XRD) analysis of geologic aragonite and calcite specimens as well as limited verification of archaeological specimens. XRD measurements were carried out on powders prepared for FT-IR analysis using a Bruker D-8 Discover at a range of 20-60° 2Θ. Calcite to aragonite ratios were determined using the ratio of the areas under the calcite 104 and aragonite 221 peaks following Dickinson and McGrath (2000). Geologic aragonite standards used for generating a calibration curve were found to contain no detectable trace of calcite. After a 1 hour treatment at 500°C samples from the same specimen had no detectable level of aragonite. Binary mixtures of these two powders were used to produce the FT-IR calibration. These XRD measurements also confirm that cryogenic grinding protocol described above does not lead to significant transition between polymorphs in geologic carbonates and is therefore, unlikely to produce transitions in biogenic carbonates.

Variation between modern shells was found to be minimal and dependent largely on the level of calcine deposits on the exterior of the shell, suggesting that some deposition occurs within the shell in heavily calcined specimens. For this reason, individual modern shells without visible calcified deposits were chosen for each treatment protocol and XRD measurements of each of these shells were conducted to confirm a lack of contamination. Variation within individual shells was also assessed using samples recovered from different portions of individual modern and archaeological shells. The body whorl, spire, collumella, and apex of modern shells were sampled to assess the degree of variation between these regions. No appreciable differences were found and all measurements on archaeological samples, heat treated samples, and modern analogs were conducted on samples obtained from the body whorl due to ease of cleaning.

Microstructural examination of modern and archaeological specimens was also conducted to examine the disturbance in crystal habit and orientation due to heat treatment. Shell specimens were mounted in Epo-Thin epoxy and thin sectioned for examination using low power scanning electron, and light microscopy. SEM-EDS measurements were also taken to examine magnesium content. Low magnesium content of archaeological specimens with reference to modern exemplars would suggest leaching has taken place as magnesium is lost preferentially during calcium carbonate dissolution (Schroeder 1969). Due to the role of magnesium in directing the crystal structure of calcium carbonate, assessment of magnesium content in fresh and ancient shells is crucial to determining the preferred polymorph of allochthonous carbonates resulting from diagenesis rather than pre-depositional treatment.

Chapter 3: Results

Survey conducted over the course of the 2012 and 2013 field seasons documented two rockshelters bringing the total known in the vicinity of Uxbenká to three (Figure 3.1). In addition, six cave complexes were noted each consisting of at least one cave, and three containing cultural materials. Considerable variation exists between these complexes suggesting quite different functions.

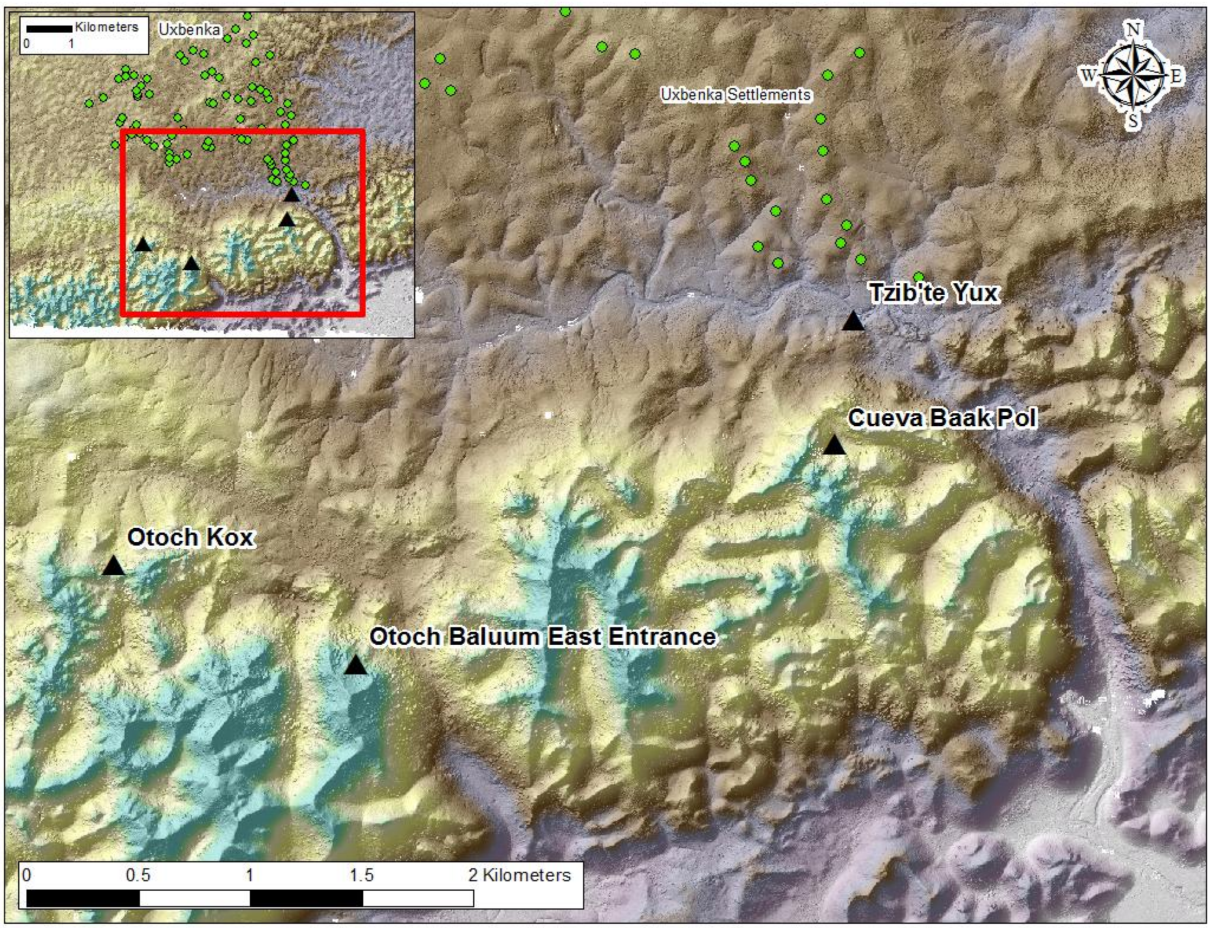

Figure 3.1 Location of cave sites surveyed during the 2012 and 2013 field seasons (map created by Amy Thompson)

Complexes Without Cultural Material

Along the north and west facing slopes east of Hokeb'el Ha 2.7 km southeast of the Uxbenká site core six small caves were documented during the 2012 field season (Meredith 2012). The as yet unnamed group consists of small relict caves ranging in elevation from 274 to 319 meters in elevation, and containing no observed cultural materials. The largest of the six (12CS10) is a narrow keyhole shaped cave on a north facing slope located at an elevation of 307 meters. Other features within this area can best be described as rockshelters as they do not possess a dark zone. 12CS08 is a small rockshelter consisting of a flat triangular shaped 3 m x 3 m triangular rock ledge sheltered from the elements by an overhang with a low 2 m extension into the rock face. The remaining four are much smaller and are noted primarily because they indicate that conditions exist for larger karst formations in the area. 12CS11, though too constricted to enter, may extend much further into the rock face given the presence of nest material from *Cuniculus paca*. Air currents suggest the passage to be breathing out at a scale consistent with the presence of a larger passage and an informant's dogs could be heard rustling far into the reaches of the cave. These factors suggest that, while no cultural materials were found in direct association with these rockshelters, further survey and investigation is warranted as larger caves may be present in the area.

During the 2013 field season, a local informant described a well known cenote 1 km southwest of Santa Cruz as bearing water even in the dry season and suggested it as a likely candidate for archaeological materials. The area consisted of a limestone joint running SSW through which a stream had eroded forming a suffosion sinkhole leading to a corridor 12 m deep and varying from 1 to 2 m in width. A small stream runs at the base of this fissure, appearing at depth at the NNE end of the fissure and dropping into a small hole at the SSW end, from which air currents could be felt. It is doubtful that this stream is perennial given its small size even after heavy rains, but informants insisted that it contained water even during the height of the dry season. The walls of this corridor provide a very detailed stratigraphic record including numerous sections of conglomerate of various sizes. The composition of this conglomerate varies widely and some cobbles appear to be of metamorphic origin. The surrounding area contains numerous small entrances to low (less than 2 m high) cave passages forming a low maze cave with typical corridors aligned along the dip of the limestone and oriented at regular angles and frequently intersecting one another. No cultural material was recovered in the area, but again, owing to the presence of disappearing streams and air currents emanating from the deepest recesses of the corridors, further study of the area is warranted as it may connect to a larger cave system. This possibility is compelling given that this cave is one of only two known to occur north of the Rio Blanco in the vicinity of Uxbénka (the other being Zotz cave located north of the site), and may have a separate cultural significance particularly if it exists as a permanent source of water.

Investigating reports of numerous caves in the area, an escarpment west of the trail following the valley above Hokebel’ Ha Cave was targeted for preliminary survey. The area is very rugged and consists of large talus cones extending to the north and east from a high escarpment. Two large cave openings were observed high on this escarpment, but without technical climbing gear, these could not be entered and explored. Accounts from the village suggest that this area contains numerous caves containing ceramics which are difficult to access and rarely visited owing to the harsh terrain, distance from the village, and difficulty navigating to these caves even after they have been initially visited.

Otoch Kox

Otoch Kox ("House of the Curassow") Cave Complex is located 3 km southwest of Santa Cruz and consists of a very large overhang 25 m high and extending over 100 m along in an east to west direction. At the center of this overhang 6.5 meters up the limestone face, a small cave enters the limestone in a southerly direction (Figure 3.2). This area is well known to the villagers as it sits at the base of the Rock Patch and is a popular hunting ground. At the time that it was first described a large tree trunk had been propped against the face of the rock to allow access. 23.5 m west of the cave entrance, the dripline extends to 2.6 m from the rock face and forms a rectangular surface measuring 2.6 m x 3.4 m. Rock fall from the precipice of the overhang has formed what appeared initially to be a structure. The shape of the rock fall is quite convincing and a looter's pit measuring 95 x 120 cm with a depth of nearly a meter is located on the eastern edge of this area. Further investigation of the blocks suggests that they are naturally occurring and not the result of human activity, and salvage excavation of the looter's pit yielded no cultural materials aside from spire lopped *Pachychilus* shells. Within the rockshelter jute are visible on the surface between the rock fall and the cave entrance, though deposits contain considerably lower concentrations of *Pachychilus* shells than those found at Tzib'te Yux to the east or Tutuil Witz located immediately down slope to the north.

A ladder was constructed to access the cave above Otoch Kox Rockshelter and it was found to be a small alcove composed of conglomerate walls, with a fine dust floor containing abundant breakdown from the low ceiling. Remnants of three curassow (*Crax rubra*) nests were observed on the eastern side of the cave, and it is clear that the area has been heavily disturbed through bioturbation and possibly looting. The cave contained ceramics in great abundance, mostly piled on ledges along the walls. Though this practice has been observed in other areas during the Classic Period (Pendergast and Savage 1971:117), it may also be the product of looting. The bulk of this material is composed of unslipped striated orange wares characteristic of water jars, though some burnished black slipped sherds similar to the Lucha Incised variety (Gifford, et al. 1976) were also recovered. *Pachychilus* shells are also abundant at the surface. At the south end of the cave, a line of stone is oriented from east to west and may be the remains of an altar though the level of disturbance and limited excavations to date prevents certain assessment of this. A test pit was dug just north of this alignment which indicated that other than some *Pachychilus* shells that had penetrated to greater depth as a result of bioturbation, all cultural materials are located on the surface. The presence of modern curassow eggshell fragments located at considerable depth within this pit also suggests that the entirety of the cave can be considered heavily bioturbated.

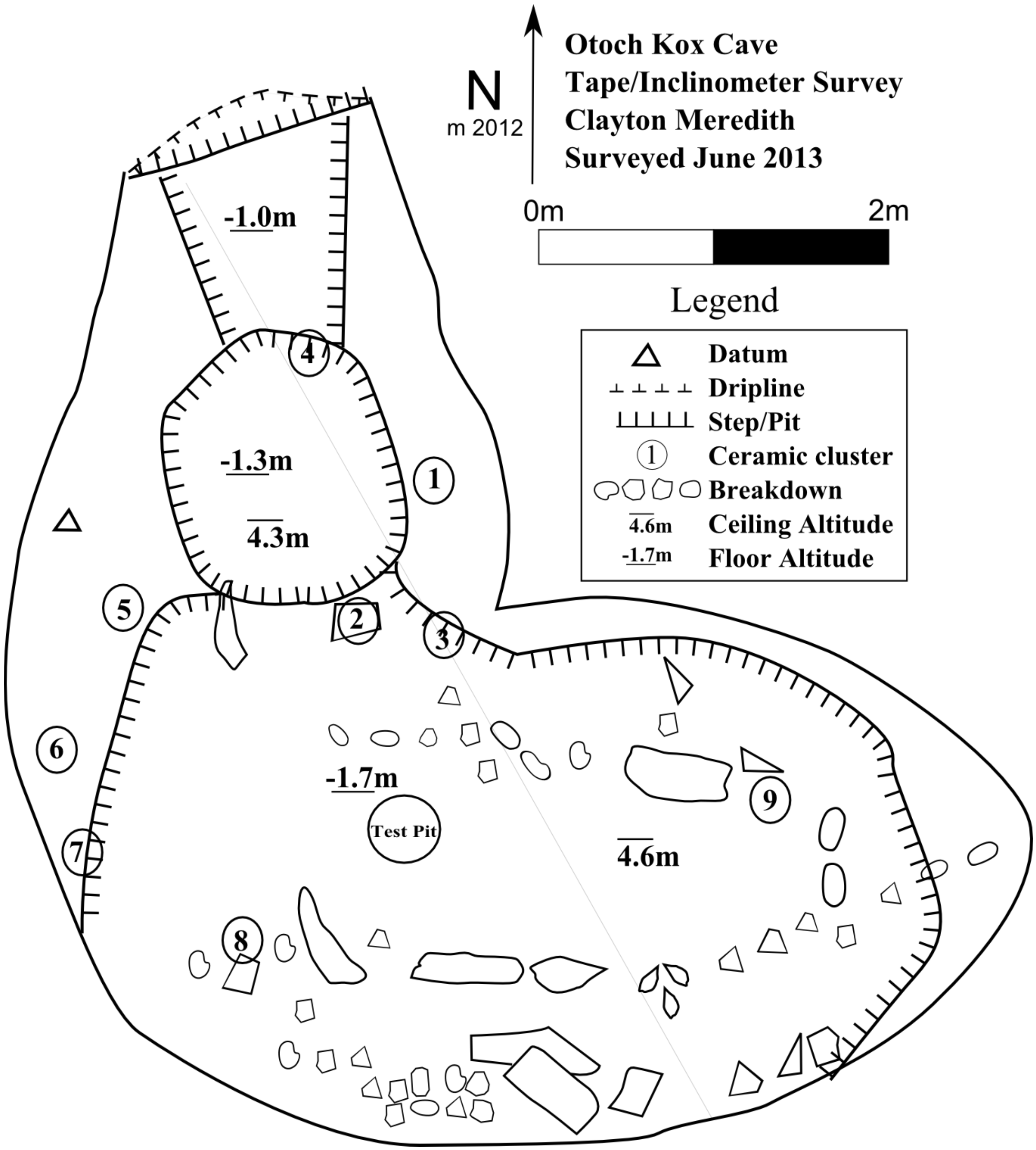

Figure 3.2 Otoch Kox Cave Map

Cueva Baak Pol Complex

The Cueva Baak Pol Complex was first encountered following the advice of an informant in 2012. The complex was first visited in the early 1980s by a bush doctor searching for medicinal plants and had subsequently been visited by several members of his family. The complex consists of three small rockshelters and a single cave on the south face of a steep ridge 2.7 km southeast of Santa Cruz. All four of these sites overlook a small, isolated, and very steep valley that drains to the east into the valley above Blue Creek Cave. The area may be accessed by climbing the prominent ridgeline south of Santa Cruz or via a long and rugged trek from Hokebel' Ha Cave, though the former is more direct and less strenuous. From west to east the features were named 12CS03, 12CS06, 12CS05, and 12CS04. Each is composed of a small, relict cave/rockshelter (only 12CS04 has a permanent dark zone and can be considered a true cave) and all are located along a sheer rock face at an altitude extending from 308 to 330 m. Each contains cultural materials that appear to have been partially looted though there is considerable variation between the materials in each.

12CS03 has a large opening (4 m wide and 5 m tall) and extends east northeast into the rock face a distance of 17 meters. Bats are abundant and a soft, undisturbed guano layer covers the entire floor of the cave, suggesting that the deposits are likely undisturbed. At the rear of the cave two large orange unslipped striated jar body sherds representing approximately one fourth of a vessel, but themselves non-diagnostic, were noted at the surface. Along the ledge at the entrance of the rockshelter ceramics were piled near the drip line including the complete rim of a high necked unslipped orange jar similar in style to those of the Triunfo Striated variety dating to the Early Classic in the Petén (Smith and Gifford 1966). The bulk of these ceramics are striated non-diagnostic body sherds. Also included in this group is a peculiar iron fragment, resembling a meteor fragment, though this has not been confirmed. Aside from limited collection near the drip line, this cave was not systematically investigated due to the risks associated with excavations in guano deposits.

12CS06, located about 20 meters east and 10 meters downhill from 12CS03, is the most thoroughly investigated of the complex, having been the subject of excavation during the 2013 field season (Figure 3.3). A flat sheltered area projects from the vertical cliff face into which a narrow cave extends opening into a small chamber. Human remains visible at the surface within the cave were excavated during the 2013 field season. The burial had been disturbed by looting and was scattered across the entirety of the chamber in which it was found. Skeletal elements were generally well preserved and the majority of the skeleton was recovered, though cranial elements were not present. Grave goods were quite sparse and consisted solely of obsidian blades. Osteological analysis of the remains is pending. Aside from these remains, no other cultural materials are present at the surface of the cave, and a test pit placed in the northwest chamber was also found to be culturally sterile.

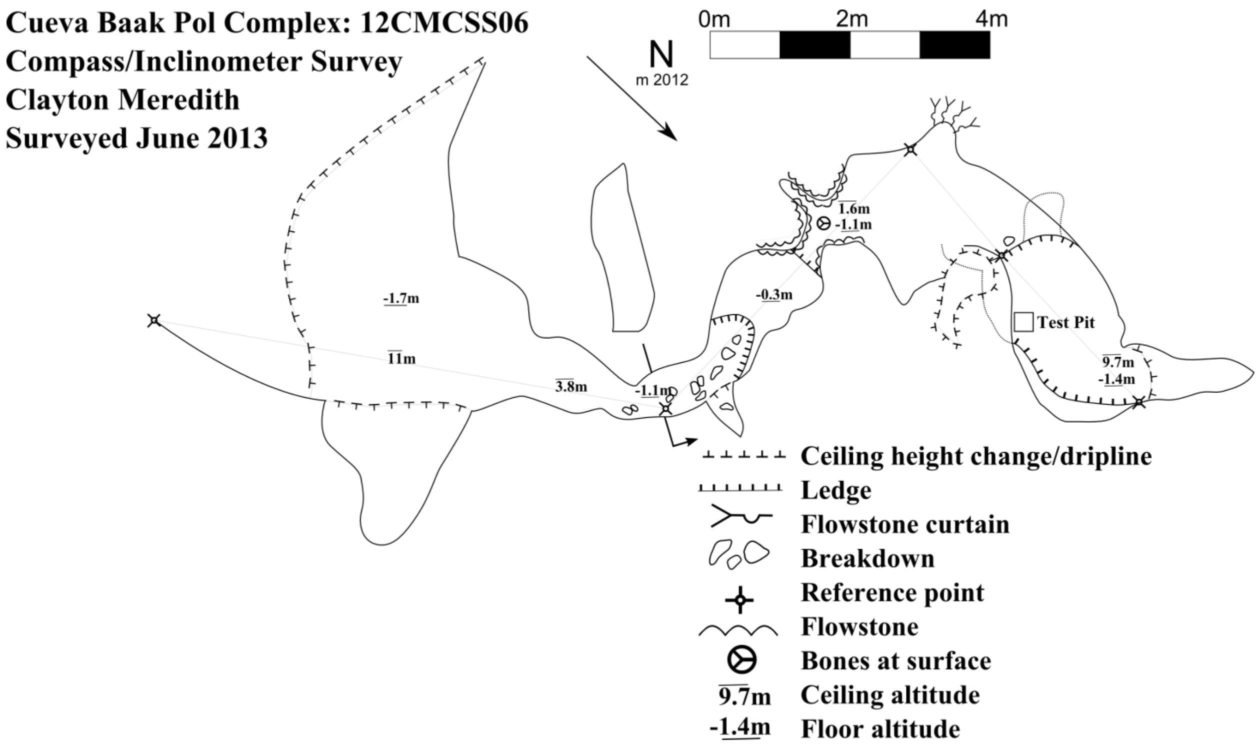

Figure 3.3 Cueva Baak Pol Map

12CS05 is located immediately to the east of 12CS06 (5 meters east and 10 meters upslope) and is considerably more difficult to access. A wall was constructed on the approach slope to the rockshelter. Evidence of architecture exists within the rockshelter as well, though it has been heavily damaged by looters and its form cannot be assessed. Though it extends only 9 m into the rock face, it contained a rich ceramic assemblage consisting primarily of thick jar forms with red paste that is fire clouded on the exterior, black slipped interiors and outcurving rims. Their form and color is similar to Remate Red found at Lubaantun and Nim Li Punit suggesting deposition during the Late Classic Period, though black slipped exteriors are more common for this style in jars from Nim Li Punit (Fauvelle 2012). Like 12CS03, this rockshelter is inhabited by numerous bats (large fruit bats in this case) and was not suitable for excavation without personal protection equipment.

10 m east of 12CS06 and at the same elevation as 12CS04 and 12CS06, a nearly complete vessel was encountered on a partially exposed rock ledge. The vessel is missing both the rim and base, though kill holes are visible near what remains of the base. The burnished unslipped vessel cannot be definitively placed owing to the lack of a rim profile, but is consistent with Hammond's description of the Turneffe Unslipped type at Lubaantun (Hammond 1975) and the Turnip Unslipped type from Nim Li Punit (Fauvelle 2012).

20 m east of 12CS06 and at roughly the same elevation 12CS04 extends just 2 m into the rock face. The small entrance to this rockshelter is partially blocked by a stone wall and opens into a small chamber that contained a single partial vessel (Figure 3.4). The vessel has not, as yet, been assigned to a ceramic sphere owing to its unique properties. A curious face shaped arrangement of appliqué cacao pods appears on the body of the vessel (Figure 3.5). No other artifacts were found at the surface in this area.

Figure 3.4 Placement of vessel within 12CS04

Figure 3.5 Detail of face appliqué on vessel recovered from 12CS04

Otoch Baalum Complex

During the 2013 field season local informants lead me to a cave on an east facing slope across a hollow from Yok Baalum Cave. Four caves were reported to be in the area. Two were found to be a single cave system with two entrances, a third was briefly investigated and the fourth remains unvisited, though local informants visited the area and confirmed a fourth entrance during the course of mapping the complex. The entire system is a relict cave located at an altitude above 350 m. Otoch Baluum 1 is a large cave system comprised of 152 m of passageways between the north and west entrances (Figure 3.7). A squeeze prevents direct passage between the two sides of the cave and the western segment is considerably larger. The western passage drops abruptly at the base of a west facing limestone block into a large chamber. Aside from a single complete vessel at the easternmost end of this passage, the cave is devoid of all artifacts. The recovered vessel is an unslipped monochrome red bowl with a short ring base (Figure 3.6). Short ring bases are common in the Terminal Classic and the form resembles the Roaring Creek Red variety possibly indicating economic interaction with the Sibun Valley to the north (Jordan 2013). The northern entrance is much more expansive and only a narrow passage linking it to the north entrance lies in the dark zone. The ceramic assemblage in this portion of the cave is much more diverse, but consists primarily of as-yet unidentified large bowl forms. Ceramic scatters are abundant throughout the cave including two walled-off alcoves. The cave, though only briefly surveyed and mapped, is a good target for future excavations. Otoch Baluum 2 lies 150 meters to the west and is considerably smaller than Otoch Baluum 1. Ceramics are absent at the surface, but three undisturbed low walls constructed from broken speleothems and stones taken from within the cave block access to certain areas and directs movement through the cave to certain areas.

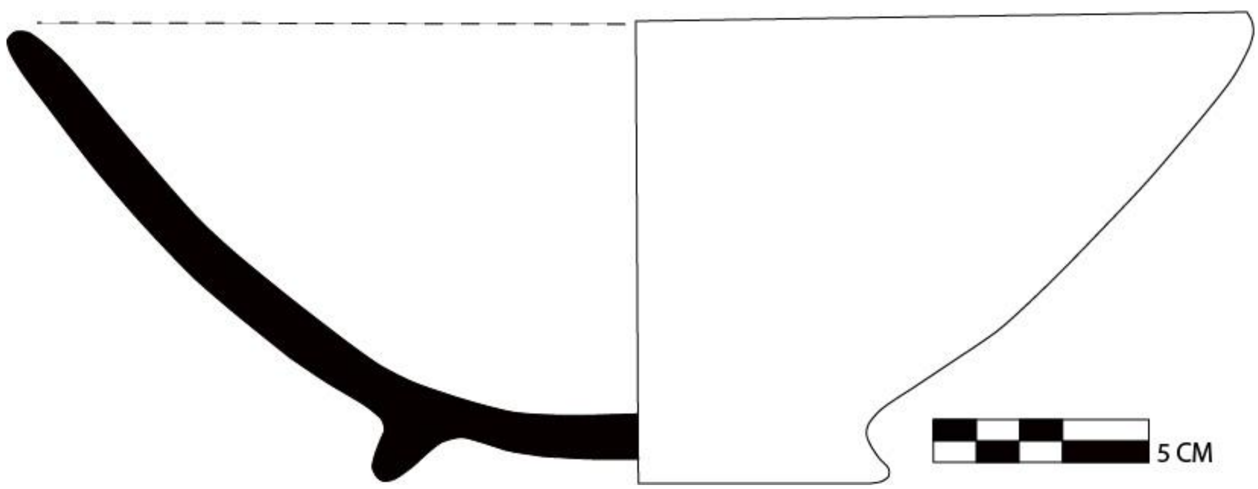

Figure 3.6 Otoch Baluum vessel 1 (rim profile by Jillian Jordan)

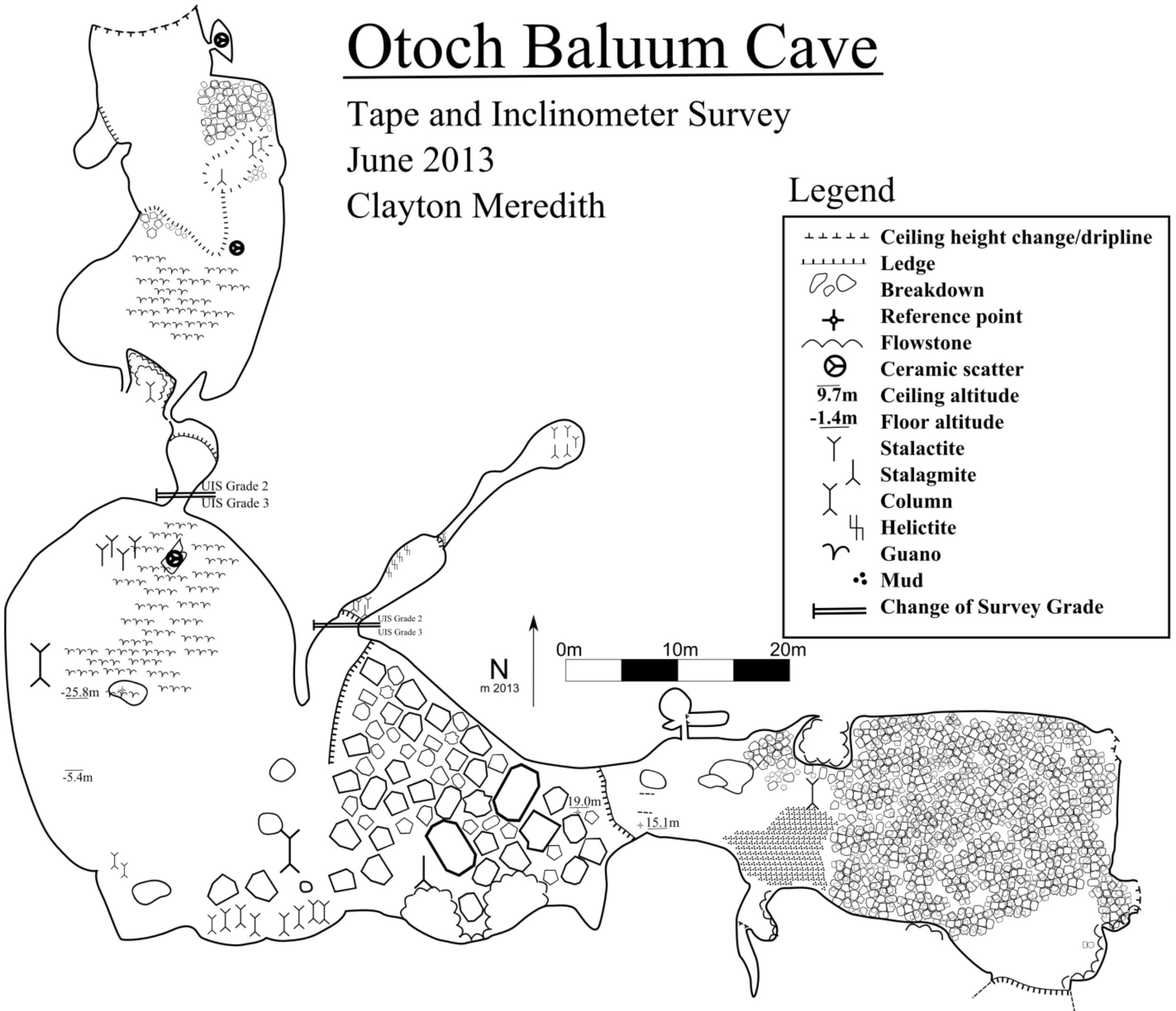

Figure 3.7 Otoch Baluum Cave Map

Tzib'te Yux

Tzib'te Yux Rockshelter is the most heavily investigated of the surveyed area. It was first encountered during geoarchaeological investigations at the Rio Blanco. The rockshelter sits at the base of an escarpment 8 meters above the river during low flow. The escarpment is the result of the fault separating the Rock Patch composed of the La Cumbre formation to the south and the low hills of the Toledo beds to the north. The fault runs along an east to west trend, is visible at least 500 m to the west, and continues east of the river for some distance though it reaches its steepest point above a pool in the Rio Blanco at Tzib'te Yux. The rockshelter is 37 m long and 4.5 m wide at its widest point and is protected by a silicified conglomerate overhang (Figure 3.8). Due to piping along the fault, the matrix and clasts of this conglomerate have taken a siliceous texture such that they are workable and produce sharp, though coarsely textured cutting edges. The floor of the rockshelter is quite flat and composed entirely of *Pachychilus* shells interrupted only by large breakdown from the rock face above.

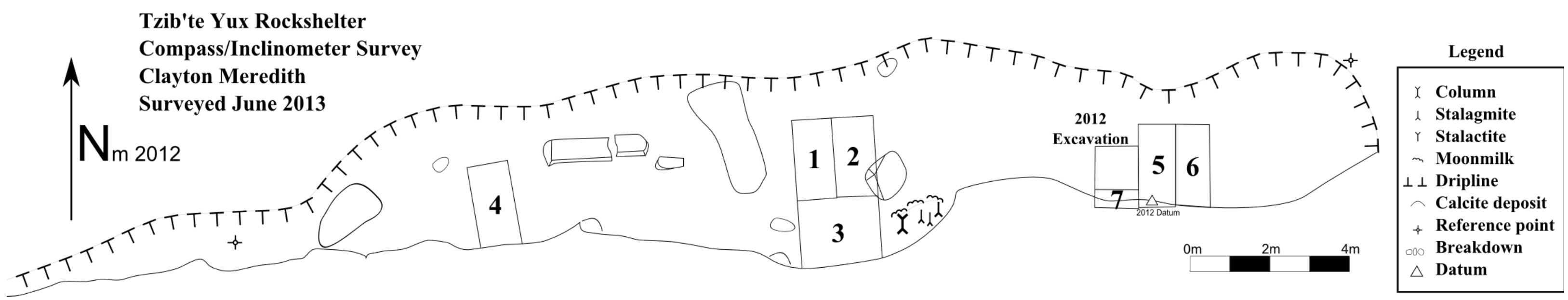

Figure 3.8 Map of Tzib'te Yux Rockshelter

The most striking feature of the rockshelter is the remnant of a plaster façade that once covered the overhang to a height of 2 meters (Figure 3.9). Small patches of plaster, generally not exceeding 20 cm in diameter, containing whole *Pachychilus* shells occur sporadically across the entire limestone face within Tzib'te Yux suggesting that at one time the entire face had been coated in plaster. At the center of the escarpment a large remnant of this plaster remains with a height of over 2 meters and a width of 1.5 meters though there are several interruptions where the plaster has eroded away and a speleothem has grown over a portion of the west section. In places this plaster exceeds 20 cm in thickness and it too contains abundant *Pachychilus* shells as well as fragments of chert and large fragments of charcoal (Figure 3.10). Though its form cannot be ascertained due to weathering, it is clear that this is the remnant of a large plaster sculpture with an accompanying freize extending on both sides.

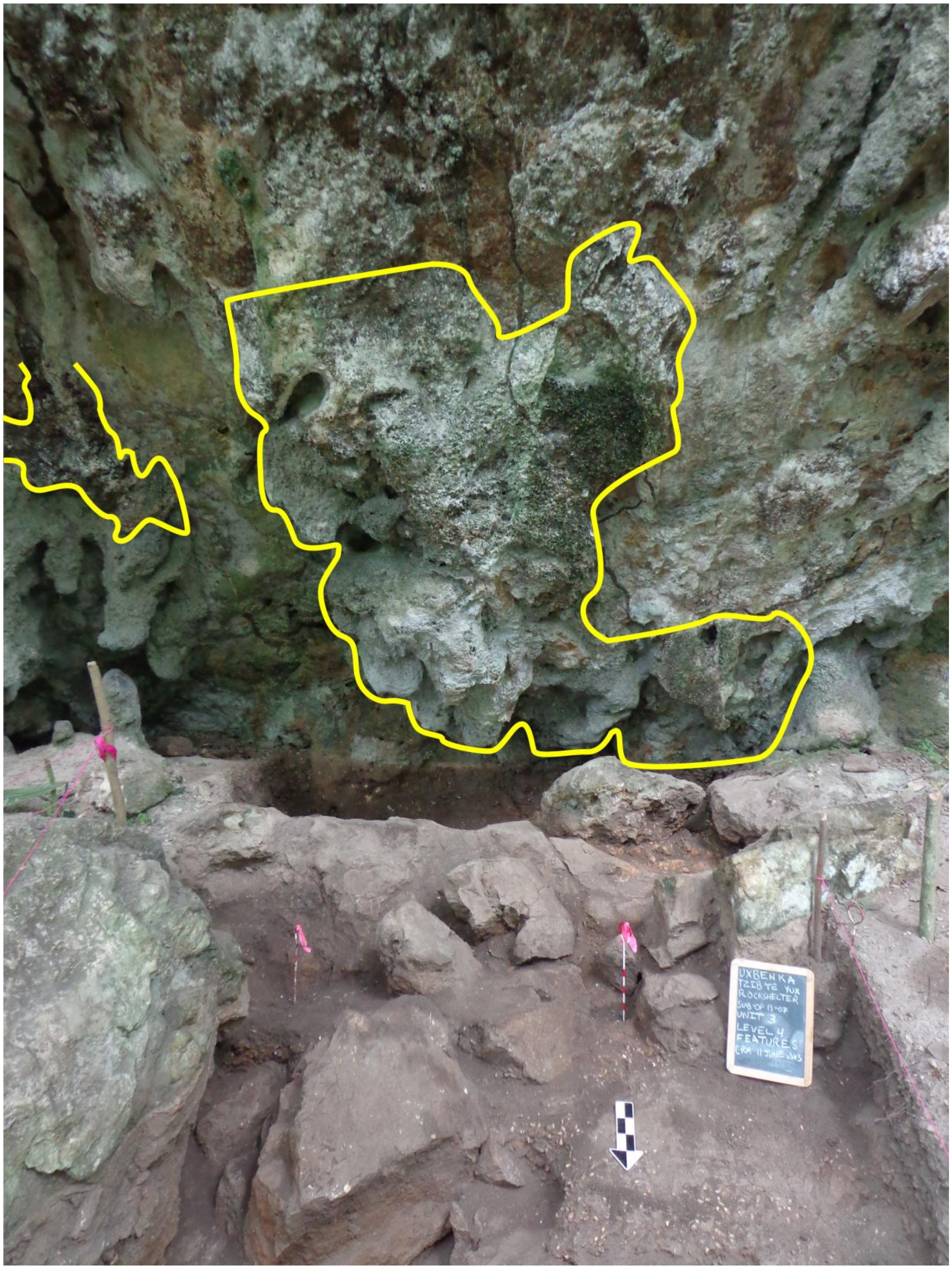

Figure 3.9 View south from 2013 central trench (units 1, 2, and 3) with sculpture outlined for clarity

Figure 3.10 Tzib'te Yux sculpture as viewed from the east detailing Pachychilus shell content and plaster thickness

A 1-x-1 test pit was dug within Tzib'te Yux during the 2012 field season revealing a deep shell midden deposit overlying a red (5YR 3.5/4) clay rich formation containing numerous lithic artifacts. Four distinct levels were noted consisting of a culturally sterile yellow (7.5YR 5/8) silty clay, the red clay layer noted above, a compacted jute midden horizon consisting of 60% *Pachychilus* shells by volume in a calcareous silty clay loam matrix, above this lies an unconsolidated jute deposit of similar composition though texture is markedly different (Figure 3.11). The bulk of Pachychilus shells within both the consolidated and unconsolidated deposits are spire lopped indicating that they were consumed, but the absence of significant quantities of ceramic sherds suggests that they were not boiled within the rockshelter. All ceramic materials from within the rockshelter (with the exception of vessel 1 discussed below) are non-diagnostic, unslipped, coarse, striated body sherds. This assemblage suggests a utilitarian function, but their occurrence is in quantities too low to account for the number of jute present within the rockshelter. This is consistent with the findings of other rockshelters in the region including those of the Caves Branch Rockshelter which was used as a mortuary complex, which suggests a ritual deposition of refuse rather than feasting events as a common practice within the Southern Maya Lowlands (Halperin, et al. 2003). The lithic assemblage consists primarily of chert flakes, 18% of which exhibit clear signs of heat treatment (potlids or fire spalls). No pattern of variation exists within the deposit suggesting that there was little change in the practice throughout the course of deposition. Two obsidian flakes retaining cortex were also recovered from this unit.

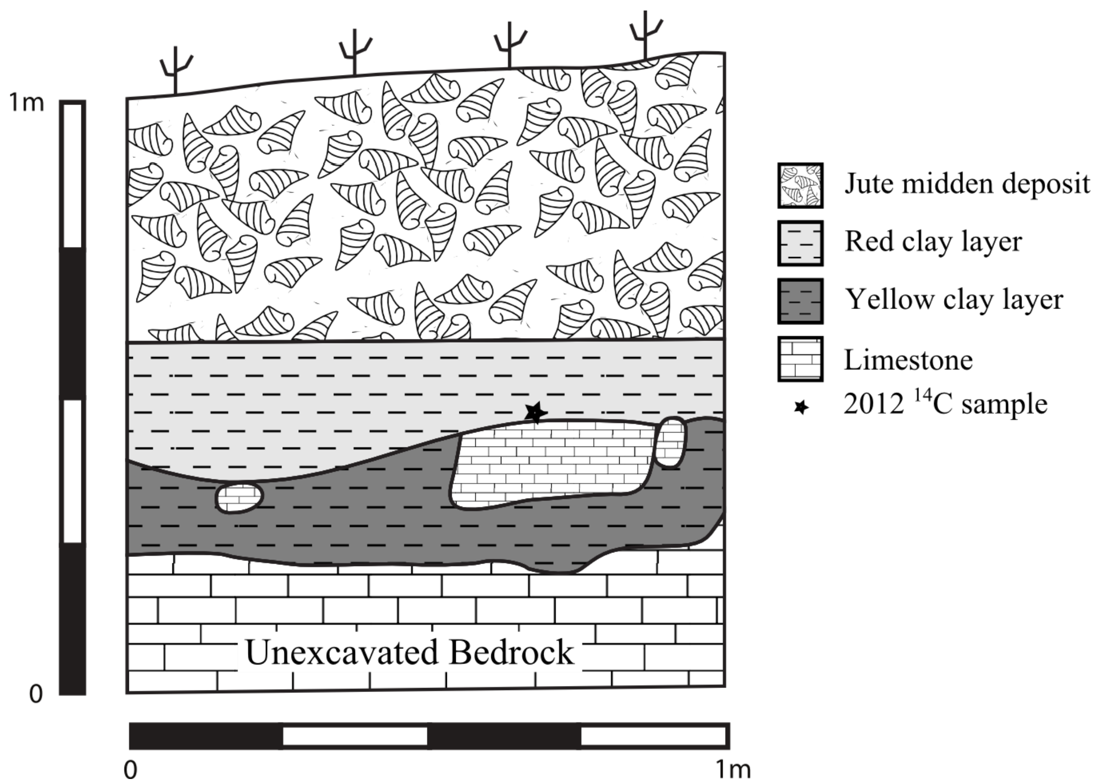

Figure 3.11 South profile of 2012 excavation

Pachychilus shell content decreases markedly below the jute midden deposit. A single AMS radiocarbon date of 10,526 - 10,571 (95.4% probability) radiocarbon years before present was obtained for the contact between the yellow and red clay layers suggesting that three large scrapers recovered from the red clay layer may be considerably older and represent a Pre-Archaic occupation of the site.

Excavations in 2013 confirmed the presence of the Paleoindian horizon, and drastically expanded the scope of materials ascribed to this period. The Paleoindian horizon, initially thought to encompass only the red clay layer at the eastern end of the rockshelter, was found to include the compacted lower portions of the jute midden in central portion of the rockshelter based on charcoal from this deposit in unit 2 dated to 9,402 – 9,570 BP (2σ). Though it has not been dated directly, the continuity of the compact jute midden as exposed by excavations in unit 4 and in the eastern excavations (units 5 through 7) suggests the entirety of the rockshelter contains deposits dating to the Paleoindian period. The great antiquity of this horizon is consistent with the lack of ceramics recovered from the area, but the abundance of shell remains is nonetheless striking. Excavation of the red clay horizon in unit 5 (though not completed due to time constraints) revealed long bones likely belonging to tapir (*Tapirus bairdii*) demonstrating the rockshelter was used for processing of game; the first such find in Southern Belize. Lithic evidence recovered from unit 5 also supports a very early occupation of the site. Charcoal recovered from beneath a Lowe-style blade (characterized by alternate uniface bevel flaking) within this horizon was dated to 10,277 – 10,441 RCBP (2σ) (Figure 3.12). Though points of this style are attributed to the Late Archaic or Early Paleoindian period (Kelly 1993), this find suggests that the technology behind these points may have been developed much earlier. Charcoal associated with a larger dome scraper recovered from unit 5 was dated to 8,577 – 8,430 RCBP (2σ) suggesting that though the red clay deposit is relatively shallow, it may represent a very long occupation of the area (Figure 3.13).

Figure 3.12 Alternate beveled uniface recovered from 2013 Tzib'te Yux excavations resembling the distinctive style characteristic of Lowe points

Figure 3.13 Dome scraper recovered from level dated to the Paleoindian period during 2013 excavations at Tzib'te Yux

The central trench provided a wealth of faunal remains that await zooarchaeological analysis but include numerous teeth from geomyids, various skeletal and dental elements of pacas (*Cuniculus paca*), carnivore canines and carnassials recovered from beneath the sculpture, numerous fragments of deer long bones, a possible howler monkey (*Alouatta pigra*) tooth, a partial turtle carapace (species unidentified), and a single complete queen conch (*Lobatus gigas*) shell (Figure 3.14).

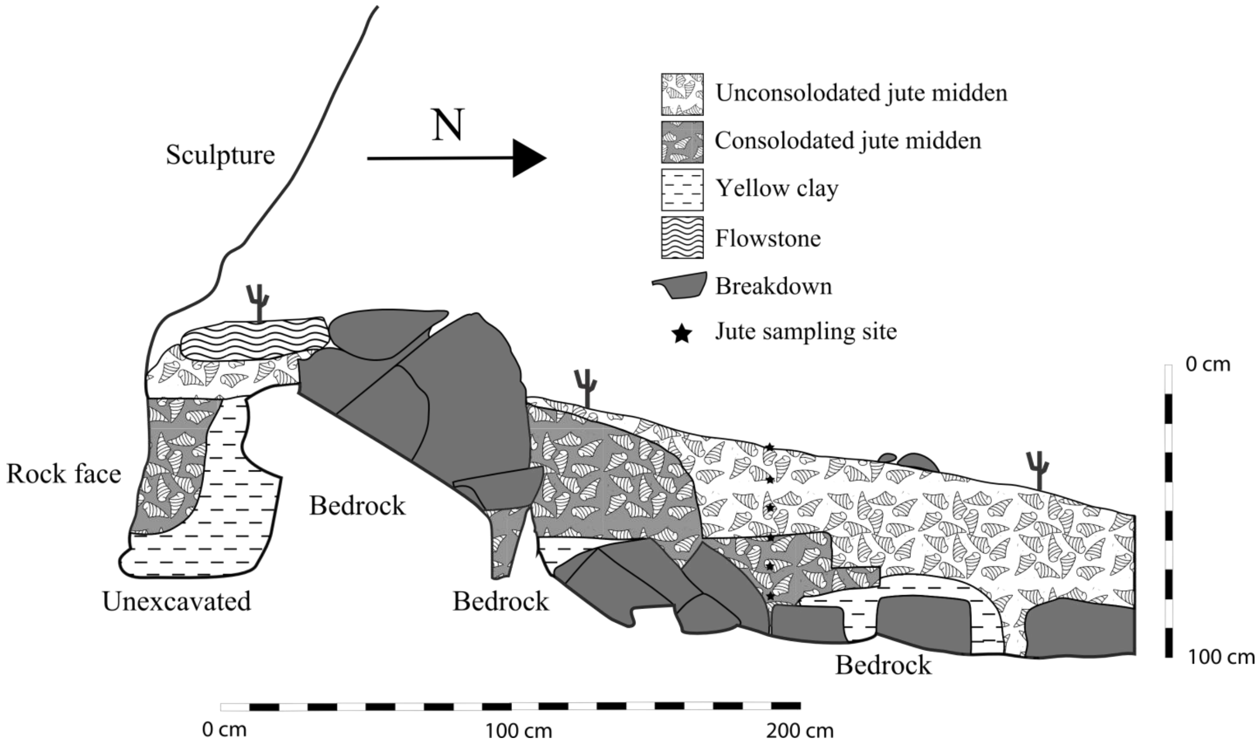

Figure 3.14 2013 excavations central trench (units 1 and 3) west profile

The burial of a single individual oriented in an extended supine position facing north was encountered to the south of the 2012 test pit against the back wall of the rockshelter. The individual is likely a male based on cranial and pelvic morphology and displays signs of advanced age (fused vertebral elements, heavily worn teeth, and evidence of periodontal disease). Immediately west of the cranium and clearly associated with the burial half of a Late Preclassic bowl containing three obsidian blades was interred with the individual.

A human mandible was also recovered from level 2 of this unit. Based on tooth eruption sequence (m1 is erupted and m2 has significant crown development but has not yet erupted) the child’s age was assessed at 2-3 years old at death. This isolated and shallow skeletal element indicates an additional burial at the surface subject to scattering likely resulting from bioturbation. This consistent with isolated human skeletal elements recovered in the 2012 test pit as well as disarticulated remains from the central and western trenches.

Shell Remains

Invertebrate remains include shells from at least two species of *Pachychilus* (*P. indiorum* and *P. glaphyrus*). Other Pachychilus species may be present, but this is difficult to assess given similarity of various species including *P. largillierti* to *P. indiorum*, and the propensity for the diagnostic outer lip of the shell to break after deposition. Fragments of bivalve shell (likely *Nephronaias ortmanni*) are quite common throughout the rockshelter and were identified by local informants as “pemech” which they considered to be edible but not particularly palatable. Ten specimens of complete *Pomacea flagellate* were collected and numerous fragments resembling these shells were collected during 2013 excavations. These are considered inedible by locals and given their relatively infrequent occurrence, they are considered here as to have been incidentally collected during the gathering of jute. Distinctively flared shells of *Neocycotus dysoni* were also frequently encountered, but were considered to be naturally occurring given their presence in the surrounding forests. Crab claw fragments are also abundant having been recovered from every level within the jute deposit in every excavation. Though these could not be identified to species, they are very likely the locally available blue land crab (*Cardisoma guanhumi*) found in abundance in the surrounding forests.

Preservation of shell remains differed markedly throughout the jute midden deposit. Variation is primarily in texture and hardness. Despite their considerably greater age, the shells recovered from the red clay horizon remain in a much better state of preservation. Shells from the overlying jute midden are much more friable and were frequently broken over the course of excavation while those from deeper deposits retained their shape during excavation and were often recovered whole. All *Pachychilus* shells recovered from the red clay horizon had been spire lopped indicating they were processed for consumption though no spires were recovered from this horizon. In the overlying jute midden deposits >90% of shells are spire lopped based on analysis of subsamples that were passed through 1/8” screen and a substantial deficit of the spires is apparent consistent with other rockshelter studies in the area suggesting a practice of processing the jute at another location and depositing them ritually within rockshelters.

Heat Treatment

Heat treatment of samples produced no observable color changes associated with carbonate polymorph changes. Natural variation of shell color (ranging from pure white to red, black, or brown) was retained in all heat treated specimens. Texture changes were not observed after heat treatment beyond a general increase in friability of shells associated with loss of organic matrix. Specimens heated to temperatures exceeding 825°C, the temperature at which calcium oxide forms during lime burning, become extremely friable and take on a bleached color owing to reaction of carbonates and loss of CO_2. Local informants agreed with this description and described the modern production of lime from spent jute shells procured for food as consisting of burning in fires used for cooking within the home for extended periods (typically overnight). After being subjected to burning, the shells become friable and are crushed to produce lime used in corn processing.

Polymorph Analysis

Initial attempts to measure polymorph ratios based on peak area ratios of the 713 cm^{-1} (calcite) and 700 cm^{-1} (aragonite) peaks proved unsuccessful and yielded results that conflict with FT-IR measurements in of the 859 and 877cm^{-1} peaks and with XRD measurements of archaeological specimens due to baseline shifts, and variations in the overlap of the two peaks. Comparison of absorption at 859 and 877cm^{-1} yielded considerably better results (Figure 3.15). The ratio of absorption at 859 to the absorption at 877cm^{-1} was used to generate a calibration curve for aragonite to calcite (A:C) ratios ranging from 0 to 0.6 (R^2=0.946) and the ratio of absorption at 877 to 859cm^{-1} for A:C ratios between 0.3 and 1 (R^2=0.982) following Compere and Bates (1973). Cited ratios, unless otherwise noted, report the results of analysis based on ratios of the 859 and 877cm^{-1} absorptions.

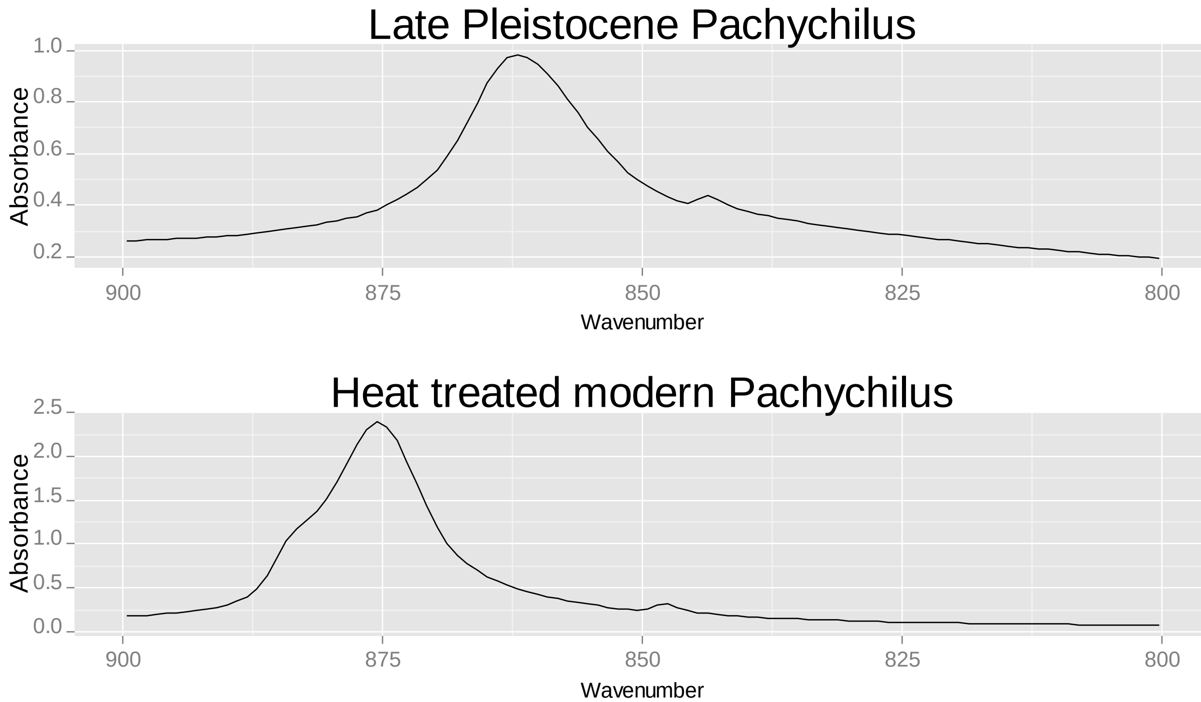

Figure 3.15 Baseline corrected spectra of archaeological specimen and heat treated specimen (note the shift in peak position from aragonitic specimen at top to calcitic at bottom)

XRD and FTIR measurements of *Pachychilus* shells collected from the Rio Blanco immediately north of Tzib'te Yux confirmed that jute shells are of an aragonitic composition. No detectable level of calcite was found in fresh shells examined by XRD except in cases where visible carbonate deposits were noted on the shell surface. Thus, calcite deposits forming in the river may be considered predominantly calcitic in nature though this may vary seasonally due to temperature and changes in ion concentration. Vaterite is difficult to measure using vibrational spectroscopy techniques and is known to occur in some mollusk species, but XRD measurements confirm that no detectable levels of vaterite occur in any shells analyzed. Samples obtained from various portions (body whorl, columella, and spire) of individual modern spent jute shells suggest that no detectable variation exists in the carbonate polymorphs of different portions of the shell structure (Table 3.1).

Table 3.1 Aragonite to calcite ratios of modern Pachichylus shell

Shell Number	Sample Location	Projected A:C Ratio
1	Columella	1.08
1	Spire	1.07
1	Body whorl	1.07
2	Body Whorl	1.02
3	Body Whorl	0.94
4 (Heavily calcined)	Body Whorl	0.76

Heat treatment of modern shell specimens determined that conversion of aragonite to calcite occurred only at temperatures above 300°C (Table 3.2). At 300°C only slight conversion occurs within 1 hour. At 350°C 87% conversion of aragonite to calcite occurs within 1 hour. At temperatures exceeding 400°C, complete conversion occurs in less than 30 minutes. Boiling of modern shell specimens resulted in no measurable conversion from aragonite to calcite even in samples subjected to prolonged boiling in excess of 24 hours.

Table 3.2 Predicted aragonite to calcite ratios of heat-treated samples (highlighted values correspond to linear regions of the calibration curve)

Temperature Regime °	Time (hrs)	859/877 model	877/859 model
200	1	0.962839348	1.910909069
250	1	1.022717946	2.664273384
300	1	0.94382137	1.746736137
300	1	0.847070242	1.189286763
350	1	0.157075167	0.22666727
400	1	-0.513726459	0.036030907
400	0.5	-1.254908201	-0.053216802
450	1	-1.747593439	-0.087667967

Archaeological specimens ranged in composition from a low of 83% aragonite to a high of 100% aragonite. No correlation was observed between depth of specimen collection and calcite concentration. Samples from deposits associated with the Maya show no evidence of heating and no correlation between depositional environment or friability with calcite content. A single outlier from a depth between 10 and 20 cm below the surface (specimen 2 from this layer) was noted during sample preparation to be partially encrusted in calcite. As such, the anomalously high calcite content is likely due to taphonomic sources. Within the Archaic/Paleoindian horizon, there was no detectable trace of calcite in any of the samples.

Microscopy

SEM and optical images of heat treated modern shell cross sections indicate that recrystallization, as indicated by homogenization of the prismatic and crossed lamellar shell layers, occurs at the same temperatures that polymorph conversion occurs. Shells heated to temperatures exceeding 350°C lack the distinctive layering visible in untreated shells. Under low power optical microscopy the linearly organized crystals are replaced by disorganized aggregations of very short calcite crystals. SEM images appear entirely homogenous in these samples. Shells heated to temperatures below 300°C do not display any change to crystal structure.

All shells analyzed from Tzib'te Yux Rockshelter retain the layered appearance of modern shells to varying degrees. Samples from contexts associated with the Maya retain a distinctly visible signature of crystal orientation and are virtually indistinguishable from modern specimens. Samples from the Archaic/Paleoindian horizons retain the distinctive layering, though it is partially obscured (Figure 3.16). Unlike the heat treated samples, samples from the lowest level of the Archaic/Paleoindian horizon do not contain disordered regions of calcite crystals visible under optical microscopy.

SEM-EDS measurements of modern and ancient shells failed to provide evidence of leaching, as magnesium concentrations were below the limit of quantification in both archaeological and modern samples. Anomalously high concentrations of yttrium were observed, however, in both archaeological and modern specimens. It is likely that yttrium is substituted for calcium within the calcium carbonate lattice.

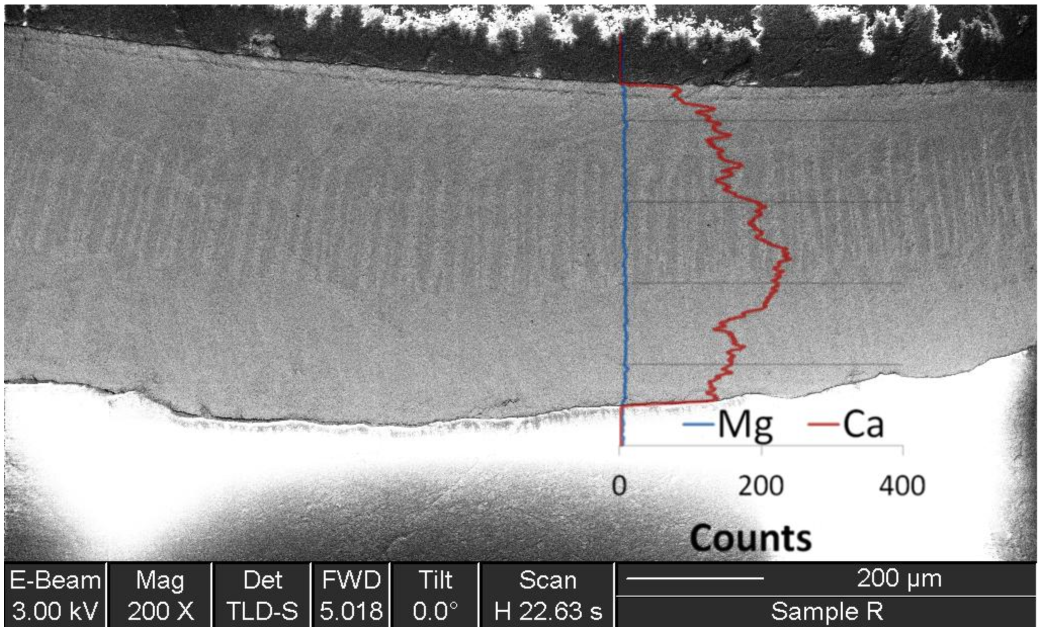

Figure 3.16 EDS linescan of calcium and magnesium concentrations within a section of shell recovered from the earliest dated horizon. Note the persistence of four distinct carbonate layers.

Chapter 4: Discussion

Cultural materials from cave complexes

While more extensive excavations are needed to determine if more complete portions of vessels are present it seems that the cave complex assemblages, consisting of partial vessel ceramic scatters, including the western half of Otoch Bahluum, the elevated cave of Otoch Kox, and the ceramic bearing caves of the Cueva Bak Pol complex, are consistent with ritual circuit activity. The time frame of the ceramics suggests that this pattern occurs throughout the duration of Uxbenká's occupation and possibly extending beyond the period of monumental construction within the site core. Two examples of complete vessels exist, but the Terminal Classic bowl recovered from Otoch Bahluum 1's north half may suggest temporal restriction of ritual circuits or the shifting ritual practices in the caves south of Uxbenká approaching the abandonment of the site.

Tzib'te Yux

Aside from the Preclassic style vessel associated with the burial on the eastern end of Tzib'te Yux Rockshelter, no diagnostic ceramics were recovered within the rockshelter. The site likely functioned as part of a ceremonial circuit or the site of ritual activity related to the sculpture, but it is clear that this is only a minor component of the site's history. The presence of unslipped body sherds that clearly do not represent whole vessels suggests that boiling of *Pachychilus* shells did not occur within the rockshelter. Given the pre-ceramic component of the site, this may be the result of the temporal distribution of deposition of the midden deposit rather than an accurate reflection of the ceramic density within deposits related to the Maya occupation. Other cooking methods cannot be ruled out; however, no evidence of earth ovens was found in any portion of the rockshelter. This may be due to the accretionary nature of shell midden deposits, the tendency for quick infilling in shell middens, and the porous nature of the deposit which encourages downward movement of charcoal and fire affected soils.

Plaster sculptures and friezes are exceedingly rare in cave contexts across Mesoamerica. Graham (1997) presents the only publication of a sculpture similar to that found in Tzib'te Yux rockshelter. The sculpture was located at the mouth of La Pailita cave in northwestern Petén, Guatemala. Prior to its destruction by vandals at some point prior to the 1968 field season, it consisted of a 1.47 m tall masonry form covered in plaster depicting a life-sized seated Chaak resting upon a masonry throne. Graham's brief account also mentions the presence of a plaster mask within the small cave and vessels ascribed to the Early and Late Classic periods. Like Tzib'te Yux, La Pailita cave contains no dark zone and therefore can best be described as a rockshelter, and based on the account of his investigation included in his autobiography (2011) it can be inferred that the cave is a relict. No mention of other ceremonial debris is made and the site was only briefly surveyed. Graham suggests that such sculptures were likely not rare, but were only infrequently preserved. Following the destruction of the sculpture, no further work was undertaken at the site and little else is known about the ceramic assemblage or associated ritual paraphernalia. The sculpture at Tzib'te Yux, though badly deteriorated and unidentifiable, suggests that the rockshelter held great ritual significance likely owing to its proximity to Hok'ebel Ha Cave and its prominent position overlooking the Rio Blanco.

The earliest occupation layers from Tzib'te Yux are the earliest documented remains in Southern Belize that have been recovered *in situ*. Aside from sporadic reports of Paleoindian artifact finds around the area of Big Falls, no evidence had previously been encountered from the time period in this region. After the site was first identified as possibly containing Paleoindian materials, a concerted effort was made to identify other potential sites of occupation in the area over the course of the 2012 season. Surveys conducted along the fault line to the east and west of Tzib'te Yux were unsuccessful in locating additional rockshelters or caves suitable for human occupation. Lithic implements uncovered during the course of geoarchaeological investigations on the north bank of the Rio Blanco during the 2012 and 2013 field seasons suggest that evidence of Archaic and possibly Paleoindian occupation of the area is not restricted solely to Tzib'te Yux Rockshelter. Further investigation of this area is warranted to determine the viability of sites in the area for study of the earliest inhabitants of Belize. Within Tzib'te Yux, the presence of spire lopped *Pachychilus* shells that appear to be contemporary with lithic material in the deposit suggests a relatively broad food base utilizing molluscs from nearby streams. The presence of fire-cracked rock, uncovered in the red clay layer during the course of excavation in unit 5 during the 2014 field season, suggests that *Pachychilus* snails may have been cooked using boiling stones in baskets or other perishable materials. Alternatively, earth ovens may have been used to steam *Pachychilus* and other materials. Lacking direct evidence for this, in the form of excavated features and discrete groups of fire-cracked rock, wider application of FT-IR techniques to identify fire affected shells and soils is warranted in future analyses. This indirect evidence could be further analyzed through microbotanical evidence to examine the types of vegetation being cooked and the fuel used, as different temperature regimes are desired when roasting, boiling, or steaming molluscs.

Utility of IR Measurements for Study

FT-IR measurements of the 700 and 713cm^{-1} peaks utilized in this study had considerably lower precision than initially expected. R^2 values for calibration curves generated by using known mixtures of geological aragonite and calcite were 0.856 for modeled 700/713 peak area ratios, and 0.913 for 700/713 peak height ratios. The precision of similar studies is noted as 1% wt for mixtures between 5% and 95% aragonite with less precise values outside these ranges. The values obtained using calibration standards in this study are considerably less precise as indicated by negative A:C ratios and ratios exceeding a value of 1 (see Table 3.2). Samples of modern shell known to contain no measurable amount of calcite (as confirmed by XRD measurements) varied in projected aragonite composition from 96% aragonite to 139% aragonite. In most instances, aragonite composition seems to be overestimated. However, the paucity of archaeological samples bearing measured calcite concentrations above 10-15%, along with the extremely rapid conversion under high heat conditions suggests that the archaeological assemblage has not been heat treated. The negligible effect of boiling on aragonite composition precludes this analysis from further study utilizing FT-IR measurements.

A number of factors contributed to this weakness. Measurements centered at 700cm^{-1} are near the detection limit for the MCT detector utilized in this study. Near the limits of the detector, fringing becomes a problem as can be seen on the baseline at wavenumbers below 700cm^{-1} (sinusoidal fluctuations of the baseline seen in Figure 2.1). A number of factors can lead to fringing including room vibrations, slight imperfections in prepared sample shape (particularly wedges), and destructive interference due to scattering. Fringing is only slightly problematic within this dataset as it is quite small (<1%) relative to the signal strength of the 713cm^{-1} band. At low aragonite concentrations, the relative contributions of the 700cm^{-1} absorption and the fringing bands are more closely matched. Because of this, the precision of highly calcitic samples is likely to be considerably lower than those with high aragonite concentration.

The influence of particle size can also be noted in the spectra obtained over the course of this study. Baseline slope and FWHH measurements were used to select cryomilling for grinding (though the benefit over using a Wig-L-Bug is slight). Baseline slope in the final measurements is very consistent and has a minimal effect on the resulting spectra. However, the 700 and 713cm^{-1} absorption bands suffer from considerable asymmetry due to the Christiansen effect as a result of relatively large particle sizes (Kong and Yu 2007). Modeling of the relative contribution of each peak is complicated by this asymmetry and is responsible for the low precision observed in measurement and the occasional overestimation of aragonite content in samples. Observations of absorption spectra should, ideally, be conducted on powders with a maximum diameter below that of the wavelength of interest (Chalmers 2002). For observations at 723cm^{-1} (the shortest wavelength edge of the region investigated here) this corresponds to a particle size of 13.8μm, or 78% smaller than the maximum particle allowed by the 62.5μm sieve employed for sorting samples. This discrepancy does not invalidate the results of the study, but should advise future attempts that require more precise measurements. Increased signal strength through concentrations greater than 1% wt may also yield greater precision at the expense of reduced visibility of more absorptive peaks in the spectrum. Fringing and peak asymmetry also lead to broadening of the peak base which skews the line shape from the typical Gaussian distribution of solids to one better modeled by a Lorentzian curve more commonly used for modeling gases. Future examinations of this spectral region would benefit from greater sample concentrations, increased acquisition times, and a more stringent sieving regime.

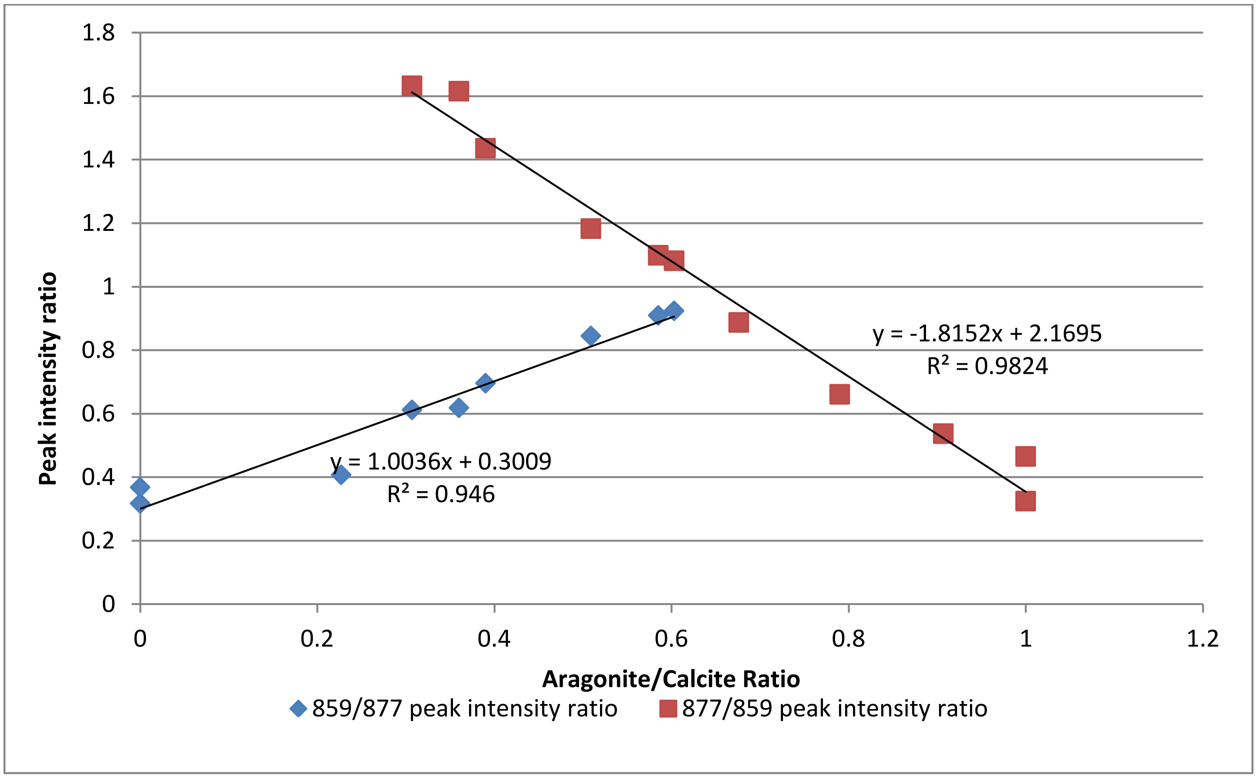

Figure 4.1 Geologic standard calibration

The method outlined by Compere and Bates (1973), though somewhat crude, produces consistent and easily interpreted results of sufficiently high precision for assessment of heating in jute shells that have not undergone extensive recrystallization (Figure 4.1). Improvements on the precision of such measurements may be possible using curve-fitting approaches though attention to small peaks contributing to line shape is critical and hampered attempts at data interpretation using this method during the course of this study.

Matrix proteins comprise less than 5% of the outer layers of fresh mollusc shell material by mass (Zhang and Zhang 2006), but analysis of the amide A and amide B absorptions located at 3300 and 3100cm^{-1}, respectively (Kong and Yu 2007), should be possible as no interfering carbonate bands occur in this region. The strongest IR absorption bands for proteins are those associated with the amide I, II, and III absorptions, but these are swamped by the very strong v_3 asymmetrical absorbance of carbonate centered around 1470cm^{-1}. At the concentrations utilized for carbonate analysis (1%wt), modern shell exhibits only a slight shoulder at 3300cm^{-1} and no signal at 3100cm^{-1} precluding concomitant analysis of shell proteins as a result of burning. In archaeological specimens, no absorption was detected at either position.

Shell Polymorph Composition

Several factors suggest that the observed ratios of aragonite to calcite are representative of the shells as deposited rather than extensive diagenetic modification of the materials. Lack of Mg in both modern and ancient shells suggests that aragonitic composition is not the result of dissolution of calcium carbonates and subsequent deposition of diagenetic aragonite; lacking magnesium, calcite would be the preferred polymorph should recrystallization occur. FT-IR and XRD analysis of heavily calcined modern samples collected from the Rio Blanco as well as the aragonite to calcite ratios of calcined shells from the Maya horizon confirm that calcium carbonate is deposited as calcite in both the fluvial and karstic environments.

Maintenance of stable temperatures is the limiting factor in partially converting aragonite to calcite in modern shells. Heating experiments conducted here on mollusc shell specimens as well as thermodynamic considerations of calcium carbonate structure

(Bischoff and Fyfe 1968; Salje and Viswanathan 1976) suggest that the range of temperatures under which aragonite may partially convert on timescales relevant to cultural modification is very narrow. With only slight change in polymorph composition at 300°C over a duration of 1 hour and full conversion occurring at 400°C in under 30 minutes, it is difficult to conceive of a process by which partial conversion of aragonite could occur utilizing fire. Because of this, precise analysis of the polymorph composition is not necessary for analysis of ritual practice involving shell materials if materials were roasted or boiled.

Earth ovens present a more difficult problem that has yet to be solved. Earth ovens are capable of producing a very wide range of temperatures depending on the stage of cooking. Open pit fires, prior to the addition of material to be cooked, vegetative matter adding moisture, and soil to retain heat, may rise to temperature of 400-900ºC (Shipman et al. 1984). Temperatures within earth ovens may easily reach sufficient levels to convert aragonite to calcite, and can be high enough to convert geologic carbonates to calcium oxide in both ethnographic and archaeological contexts (Piazza 1998). The efficiency, long durations at relatively stable temperatures, and variable temperature regimes in different portions of these ovens suggests that it is possible for partial conversion to occur for at least some shells. However, other earth oven cooking methods do not rise to temperatures sufficient to induce polymorph alteration of biogenic carbonates. Homsey (2010) reports that expedient earth ovens reaching and sustaining temperatures high enough for cooking (maintaining temperatures just below 100 ºC), can utilize fires that never exceed 300 ºC. At such temperatures, conversion to calcite would not occur in shell materials. Furthermore, such expediently prepared oven styles, lacking a deep pit and consisting of shallow mounds of dirt over small fires, would leave little trace in a shell midden context. Given the variation that exists in earth oven technology, experimental approaches like the boiling conducted here, would not be useful in determining the cooking methods used at Tzib'te Yux.

As demonstrated here, boiling jute shells does not produce temperatures sufficient to induce polymorphism changes in biogenic aragonites even when these temperatures are maintained for long periods. As Bischoff and Fyfe (1968) note, the reaction of pure aragonite under aqueous conditions is quite slow at temperatures at or below 100°C. This appears to be true for biogenic aragonites as well, despite their tendency for phase changes at lower temperatures.

Observed differences in friability and color of shells can thus be attributed to the loss of protein matrix in shell materials and natural variability of shells prior to deposition, respectively. Color variations cannot be used as an accurate assessment of burning particularly when the diagnostic outer lip and parietal wall of the aperture are missing (as is typically the case). Without examining these portions, species level designation is impossible leading to a greatly increased possible color variation from the black shelled *P. indiorum* to the mottled white *P. glaphyrus*. Intra-species and intra-individual coloration also differs markedly, further complicating assessments. Heat treatment of shell materials as part of this study produced minimal changes in color (generally a lightening of existing color culminating in complete bleaching just before conversion to calcium oxide).

Chapter 5: Conclusion

Survey of the Rock Patch south of Uxbenka was successful in demonstrating the widespread and previously undocumented use of small cave sites in the area. It is clear that these small sites, in addition to the more diverse assemblages at Kayuko Naj Tunich, Hok'ebel Ha Cave, and Yok Baluum, held considerable religious significance and likely form part of a larger boundary marking ceremonial circuit. Though rockshelters and caves are conceptually linked among the Maya, considerable variation exists in the artifact assemblages between caves and rockshelters identified in this study. Rockshelters in the Rock Patch (Tzib'te Yux, Tutuil Witz, and the Otoch Kox complex) are sites of mass *Pachychilus* shell deposition, while cave sites rarely contain any specimens at the surface, and were not recovered during the limited excavations. Ceramic deposition does not appear to occur at rockshelters proper; though the cave associated with Otoch Kox rockshelter is clearly an exception. Though ethnohistoric data suggests that no clear distinction is made, the variation in assemblage patterns suggests that there may be considerable differences in the rituals performed at each location. This finding is consistent with other rockshelter investigations in the region (Wrobel et al. 2007).

The use of this area appears to span the entire length of occupation of Uxbenká, and in the case of the ring based vessel recovered from Otoch Baluum, may extend beyond the abandonment of the site. Though more extensive excavations will be required to confirm this, it appears that the temporal span of each of these small caves is relatively limited as opposed to more elaborate shrines like that found at Kayuko Naj Tunich. The presence of partial vessels, many of which can be refitted, at each site suggests that the area formed a part of a boundary marking ceremonial circuit. Further excavation and attempts to refit sherds from different cave assemblages may lead to more evidence for this. The presence of Paleolithic/Archaic remains at Tzib'te Yux is an unexpected discovery that promises to greatly expand the understanding of early occupants of Southern Belize. Other rockshelter excavations in the region have recovered evidence of Archaic occupation, but this is the first find of such material *in situ* (Wrobel et al. 2007). The possibility of an ancient camp site with butchering, given the preponderance of lithic materials and the presence of faunal remains that have not yet been analyzed, presents an unprecedented opportunity for the study of hunter-gatherer subsistence patterns in the area. Further, documentation of *Pachychilus* shells that can be firmly associated with the lithic materials present, based on analysis of polymorph composition and microstructure, suggests a relatively broad subsistence base for early occupants of the area. Stratigraphically, the shell midden deposit appears homogenous, but this belies the long sequence of occupation. It is likely that frequent short duration occupations of the rockshelter have produced a highly interdigitated palimpsest of deposits, and techniques including the use of FT-IR will be necessary to document the site properly and better understand the inhabitants of the area.

Because of the inability to exclude boiling as treatment of shell materials, the question of shell processing at Tzib'te Yux remains unanswered. The striking continuity of the deposits is, however, indicative of a need to reexamine the function of rockshelters within Maya society. Aside from ceramic density (which clearly indicates a change at the first natural stratigraphic change across the rockshelter), the faunal assemblage may be useful in analyzing changing patterns of use. Comparison of the side of faunal elements recovered from the Maya associated deposits and the earlier deposits may be an appropriate determinant of changing usage within Tzib'te Yux. Overrepresentation of left side elements within the Maya horizon may be indicative of ritual deposition of material that serves both as a food resource and as material utilized as part of a ritual function (Pohl 1981). If, however, the there is no change in distribution of side, and species composition remains constant, or is consistent with subsitence activities rather than animals associated with plumage, pelts, or other elements of regalia or ceremonial importance, utilization of the rockshelter for processing associated strictly with subsistence activities during the Maya occupation would be probable.

The evidence presented here is a cautionary example of assumptions regarding use based on context. At present, the possibility that deposition of *Pachychilus* shell remains at Tzib'te Yux during the Maya occupation was strictly related to subsistence cannot be ruled out. Given the proximity of the rockshelter to a lotic environment containing abundant protein resources, it may have been, during some component of Maya occupation, little more than a convenient place to process and consume resources that would have been burdensome to carry to the site core. At other phases, especially during the construction of the plaster sculpture, the site clearly held considerable importance in a ritual sphere, possibly related to its location near a major cave site with ideologically significant association with water. Without reliable dating of the Maya component of the shell midden as well as the sculpture itself, the nature of this component will remain unknown.

The similarity of deposits across long time frames at Tzib'te Yux has profound implications for the study the process of ritualization during the emergence of political complexity. In contrast to the early use of cave sites as foundational shrines at Uxbenká, rockshelter contexts in the area were in use prior to, and may have been in use at the time of, foundation of the Uxbenká polity. As such, it presents a unique opportunity to study the process of ritualization of susbsitence related activities during the formation of complex political structures, and increasing levels of interaction extending beyond the Southern Belize Region.

While determining the exact temporal sequence of occupation at Tzib'te Yux is out of the scope of this project, and the precise timing of the development of political complexity at Uxbenká remains contested, it is clear that at a minimum large deposits of Archaic period detritus related to subsistence activities would have been evident to the Maya utilizing Tzib'te Yux rockshelter. Midden deposits associated with the Maya must be interpreted with consideration given to the possible interaction between subsistence and ritual. Analysis of rockshelter contexts as ritualized midden deposits may be a productive avenue of further research. Such an approach has been applied in shell midden deposits in the islands of the Torres Strait with particular attention to faunal remains demonstrating through Practice Theory, that midden deposits consisting of ordinary refuse can function as part of a ritualized element of the landscape (McNiven 2013).

Separating ritual contexts from strictly subsistence based ones remains problematic, but future attempts at determining the nature of activities at Tzib'te Yux rockshelter may benefit from additional analysis of mortuary practices associated with rockshelters in the Southern Lowlands as components of ritualized midden deposits in a manner similar to that employed by Luby and Gruber (1999) in the San Francisco Bay

Area. Walker's (1995) typology of ritual midden deposits in the Southwest may also provide a theoretical framework for further analysis of midden deposits associated with the Maya occupation. Methodologically, this analysis will focus on the faunal assemblage as noted above, as well as the lithics recovered during excavation. Much of the lithic assemblage present throughout the deposit was burned not as a component of heat treatment of source material, but after having been knapped. Changes in burning practices, if associated with changes in the faunal assemblage, may be indicative of a shift from subsistence based activities to ritualized deposition of refuse, particularly if the date of such a shift can be correlated with the construction of elements of the plaster façade.

Archaeological science techniques have long been used to examine the development of agriculture and the economic interactions within Mesoamerica, but the use of advanced techniques has been inadequately applied to questions of ideology and religion in favor of iconographic methods. This study demonstrates the utility of such an approach to examinations of material from an hypothesized ritual context. Based on the results of this analysis, further attempts to illuminate the specifics of Maya ritual are possible, but such an approach must be cautious about the assumption of function and meaning of an assemblage based on context, as demonstrated here. The presence of very slightly altered carbonates, combined with the extensive stable isotope record developed in conjunction with paleoclimate studies (Kennett, et al. 2012) presents a unique opportunity for analysis of seasonality of *Pachychilus* consumption (be it strictly subsistence based or associated with ritual) based on fluctuations in oxygen isotopes over the course of the year provided that residence times of water within the fluvial system and surrounding groundwater reservoirs is short enough for rapid responses to fluctuations in oxygen isotope composition of precipitation. The faunal assemblage recovered from Tzib'te Yux, the richest sample recovered yet from Uxbenká, also presents opportunities for further research on subsistence patterns in the area spanning an unusually long sequence of occupation within the region.

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