# The Belize Valley Archaeological Reconnaissance Project:

# A Report of the 2006 Field Season



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**Cover:** Carved jadeite pendent, Structure H1 Tomb, Cahal Pech, Belize. Adapted from a photo by M. Schwanke (2006).

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# THE 2006 SEASON OF INVESTIGATIONS

Between June and August 2006 the Belize Valley Archaeological Reconnaissance (BVAR) Project conducted its nineteenth field season under the direction of Dr. Jaime Awe. During the season the bulk of the work was focused on the Caves Branch Rockshelter and Cahal Pech (see map overleaf).

Dr. Gabriel Wrobel and James Tyler continued work at the Caves Branch Rockshelter, excavations re-initiated the previous season. These excavations were aimed at evaluating principal periods of utilization of this mortuary site and generating a demographically-representative skeletal population. In addition, a reconnaissance program was launched in the Caves Branch Valley in search of additional rockshelter sites. The Deep Valley Rockshelter site was deemed particularly promising and was thus mapped and tested by excavations (Hardy & Wrobel, this volume). As part of this reconnaissance the monumental Deep Valley 2 surface site was the subject of intensive explorations (Jordan & Wrobel, this volume).

Bryan Haley continued his geophysical prospection, this time focusing on the plazas of Xunantunich and Cahal Pech (Haley, this volume). Tracy Sweely returned to Baking Pot to follow-up with test excavations on electromagnetic surveys conducted in search of buried "hidden mounds" (Sweely, this volume).

The previously uninvestigated northeastern portion of the monumental epicenter of Cahal Pech (Plaza H) was the focus of excavations aimed at clarifying the architecture and function of this area. These excavations resulted in the unexpected discovery of a rich Terminal Classic tomb.

The Pook's Hill investigations (1999-2005) have generated a wealth of archaeological materials from expansive horizontal stripping. Since the cessation of excavations in 2005 much of the archaeological remains are now the focus of detailed and on-going analyses. Some of the preliminary results of these analyses are presented here, with James Stemp providing a comprehensive review of the non-obsidian chipped stone assemblage (Stemp, this volume); Geoffrey Braswell studied the obsidian assemblage from the site (Braswell, this volume); Christopher Morehart has analyzed the carbonised paleobotanical remains recovered as carbon samples and as light fractions from floated soil samples (Morehart, this volume); and Isabel Villaseñor has subjected plaster and limestone samples to a wide gamut of laboratory analyses including microscopy, petrography, spectrometry, spectroscopy and X-Ray fluorescence (Villaseñor & Helmke, this volume).

The success of the 2006 season relied on the efforts and collaboration of many. On behalf of the project we would like to thank the Institute of Archaeology and the National Institute of Culture and History for granting us a permit to conduct the research described in this volume. The staff of the Institute of Archaeology has been exceedingly helpful and we extend our appreciation for all their continued assistance along the way.

At the University of Mississippi we had the support and technical assistance of the Office of Research and Sponsored Programs.



In San Ignacio we owe a special thank you to the proprietors and staff of the Cahal Pech Village. We value their help, appreciate their patience, and thank them for giving us a home. Particular thanks to Dan and Miriam Silva, Lenny Wragg, and their staff.

Despite the challenges of the field season, every member of the BVAR staff was exceptional in their professionalism, and never lacking in their dedication. Indeed, none of the work described herein could ever have been accomplished without their devotion and perseverance. For all these qualities and their ability to laugh at adversity, we would like to thank José "Jim" Puc, Nazario Puc, Gilberto Puc Jr., Rafael Guerra, Myka Schwanke, Bryan Haley, Norbert Stanchly, and James Tyler. Myka Schwanke and Rafael Guerra deserve special thanks for their invaluable assistance in efficiently handling matters of logistics and recruitment.

We would also like to thank the students of the BVAR field school, particularly (in alphabetical order): Jessica Hardy, Jill Jordan, Nicole Minkin, Colleen Milligan, Gwendolen Raley, and Danielle Tanguis for their enthusiasm and hard work.

Finally, we are especially grateful to our families for their love and patience during our long absences as well as for all their support and assistance.

Christophe Helmke – Copenhagen, Denmark

Gabriel Wrobel - San Ignacio, Belize

Jaime Awe – San Ignacio, Belize

# PRELIMINARY REPORT ON THE EXCAVATIONS AT DEEP VALLEY ROCKSHELTER (DVR-1), CAYO DISTRICT, BELIZE

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#### INTRODUCTION

During the 2006 summer field season of the Belize Valley Archaeological Reconnaissance (BVAR) project, exploration of the area surrounding Caves Branch Rockshelter (CBR) led to the discovery of three rockshelters. One of these was chosen for test excavation. When it was determined that the rockshelter lies within a few kilometers of the Deep Valley surface site, it was given the designation Deep Valley Rockshelter 1 (DVR-1). The primary objectives of the research at DVR-1 were to survey and map the rockshelter and adjoining caves, to excavate test units to determine the nature of DVR-1 as a location of ancient Maya activity, and to investigate the relationship, if any, between DVR-1 and other caves and rockshelters in the Caves Branch River Valley.

#### LOCATION

DVR-1 is located within the steeply-sloped river bed of the Caves Branch River, approximately three kilometers southwest of the Caves Branch Rockshelter. From the western river bank the limestone face of the mountain is visible, but the rockshelter itself is hidden behind dense vegetation. Access to the rockshelter is limited: from the north and west, a steep and densely forested set of hills are contended with to access the eastern entrance of the rockshelter. A quicker and somewhat easier route is across the Caves Branch River from the southeast and up the steep riverbank. Before the summer rains, the river was approximately 50 cm deep and was easily forded on foot. With the rise of the river during the rainy season, a canoe was utilized to cross the river. The density of forest surrounding the rockshelter and the massive limestone cliff-face hindered our ability to record accurate GPS positions or to use geophysical technology to survey the rockshelter.

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#### SITE DESCRIPTION AND PRIMARY ANALYSIS

DVR-1 was initially mapped using a Brunton and a Disto laser distance measure. In addition to the preliminary map, in July 2006, Bryan S. Haley used a Leica TCR307 total station to create topographic maps of DVR-1 (Figures 1 and 2). The rockshelter measures approximately 36 meters in length, with a maximum depth of 12 meters from the furthest recessed wall to the dripline.

Within the shelter itself, the ground surface slopes gently downward to the west, but is otherwise clear and relatively level. Beyond the dripline, the ground drops sharply south and east toward the river and is densely forested. The northern end of the rockshelter slopes sharply there uphill: was no disturbance by water run-off observed during the season. The western end of the rockshelter curves north and west around the side of the mountain and a portion of the ground surface remains relatively level, providing access to another small rockshelter to the west that was not explored due to a complete lack of surface artifacts. Within the wall of the rockshelter are many natural crevices, including one near the center in which several ceramic sherds were found. East of this crevice is a deep area of collapse and debris, beyond which is a large cleft in the limestone This area may have wall. once been the site of a personmade platform built to provide access to a small cavern but



**Figure 1:** Plan of DVR-1, showing the location of test excavations. The drip line forms the eastern extent of the rockshelter; all other lines represent limestone faces. Note the cave at the northern end.

this conjecture will require further investigation. It is likely the collapse of this area was due to a cavern or sinkhole beneath the fill that created a sink. No artifacts are visible in

the profile of the collapse. A narrow, shallow passage is visible, but has not been thoroughly explored, though several large ceramic sherds were noted inside. There is also some disturbance on the floor of the entrance that may indicate looting activity. Located in the north end of the shelter is a cave. In the first passage to the cave there is evidence of human manipulation of speleothems in the form of a stalagmite possible broken to allow access to the deeper chamber within. The cave curves west and opens into a deep chamber. In the west end of the shelter is a shallow cave which was not explored during the 2006 field season due to time restraints, limited accessibility and a very territorial nest of fire ants.



Figure 2: Topographic plan of DVR-1. Plan and survey by Bryan S. Haley (2006-2007).

#### **METHODOLOGY**

Excavations at DVR-1 were undertaken as test excavation units (Figure 2) designed to recover artifacts for dating the ancient usage of the rockshelter, to determine the degree of site use, and for comparison with data from other rockshelters. The first excavation units (1 and 2) were placed for their association with surface features. Excavation Unit 1 (Operation 1B) was placed where human bone fragments were visible

on the surface during the initial exploration of the site and Excavation Unit 2 (Operation 1A) was placed beneath a large wall crevice where ceramic sherds were found. Excavation Units 3 (Operation 1B), 4, 5, and 6 (Operation 1A) were expansions of these initial units. Excavation Unit 7 (Operation 1C) was placed in a recessed area near the western cave opening, but was abandoned in the interest of time. Excavation Unit 8 (Operation 1D) was placed inside the northern cave, near the center of the deepest chamber, where several ceramic sherds were found on the surface. All excavation units measured 1 x 1 meter, and were plotted from points placed during the initial mapping; all excavations were also aligned to principal cardinal directions. The silty grey limestone matrix at Deep Valley Rockshelter is characteristic of rockshelters in the area (see Wrobel and Tyler 2006:6) and is particularly subject to bioturbation. Though relatively easy to excavate, the soil lacks clearly-defined stratigraphy and is loosely packed, making it difficult to maintain baulks. Arbitrary 20-cm levels were chosen due to the lack of clear stratigraphy. Levels were measured according to elevation from Datums 0 and 1. Datum 0 was associated with Test Area B, which included Excavation Units 1 and 3. Datum 1 was associated with Test Area A, which included Excavation Units 2, 4, 5, and 6.

# **EXCAVATION RESULTS AND ARTIFACT ANALYSIS**

Excavations in the rockshelter were conducted in two primary operations. Excavation Unit 1 (Operation 1B) was expanded south when a particularly diagnostic polychrome sherd (Figure 3) and two obsidian blades were found. This decorated sherd is that of an Early Classic (c. 250-550) basal flange serving dish, which is related to the polychrome types of the Hermitage Complex (see Gifford 1976). It was found in association with two obsidian blades, each measuring approximately three centimeters in length. Besides these ritual artifacts, Operation 1B also exhibited a profusion of other types of material culture. Many utilitarian ceramic sherds as well as large river cobbles, shell, and domestic items such as fishing weights were found.

Initially, Excavation Unit 2 was placed directly below a wall crevice which contained several pottery sherds. It was characterized by dense distribution of shell and a large amount of utilitarian pottery Excavation Unit 2 was sherds. eventually expanded into a 2 x 2 m operation and many of the most diagnostic finds of the season were made as part of this operation. An intricately carved jadeite bead (Figure 4a), three pieces of polished jadeite (all measuring c. 3-cm in diameter) and two obsidian blades were found in the southwest corner



Figure 3: Exterior rim of Early Classic polychrome sherd.

of Excavation Unit 2. Excavation Units 4 and 5 were placed to the south and west, respectively, to establish whether there were any more such objects and whether there was any pattern to their distribution. No pattern was observed, however, but more diagnostic items were discovered during these expansions in this area. Jadeite, modified quartz crystal, fishing weights, obsidian, and several drilled and shaped pieces of marine shell of varying size (Figure 4b) were found scattered throughout Operation 1A. A human patella and a fragment of human long bone shaft were found in the eastern portion of Excavation Unit 4. These had no direct association with the artifacts listed above and no other human remains were uncovered in Operation 1A during the 2006 Season.



Figure 4: Artifacts recovered from Excavation Unit 2. a) carved jadeite bead (above left); b) perforated marine shell disks (above right).

The ceramic assemblages in Operations 1A and B were similar. The majority were utilitarian wares, probably cooking and storage vessels. Several fishing weights and spindle whorls were found intermingled with the more exotic objects (obsidian blades, beads, and jadeite). Artifact analysis is incomplete, but the few ceramics which have been examined can be attributed to the Classic period (c. AD 250-950).

Both Operations 1A and 1B were characterized by a density of freshwater snail shells (*Pachychilus*) known locally as "jute". The shell deposit was so thick in the rockshelter that, during the early days of excavation approximately one five pound bag of jute shell was collected for every two-gallon bucket of matrix. Therefore within the first five days of excavations, over thirty thousand jute shells were processed. The extremely time-consuming collection, washing, and cataloging of shell led to the adoption of a sampling method recommended by Keith Prufer (2006 pers. comm.), who had encountered similar amounts of shell during other cave and rockshelter excavations in the Toledo District of southern Belize. A 20 x 20 x 10 cm cuboid was excavated from each level in each excavation unit in both operations. All of the shell was collected from these cuboids and the frequency of shell was computed to a matrix ratio. In both operations the shell from the first four levels of excavation averaged between one-fourth and one-fifth of the matrix excavated. Deeper levels showed a slight decline in shell, with between one-fifth and one-eighth shell to matrix ratio. Shell sample ratios were not taken in the test

Excavation Unit 8 within the northern cave because only four shells were found in the meter-deep excavation.

Jute shells are commonly found in the Maya region and are still used by modern Maya groups as a dietary supplement (Halperin et al 2003:214). In archaeological sites, jute shell is found in domestic contexts as well as ritual ones, and jute is often found in caves (Glassman and Bonor Villarejo 2005:287; Healy et al 1990:175). While crossing the river on the way to DVR-1, living jute are still visible everywhere in the cobblestone river bed. It seems plausible that the Caves Branch River is the source of the jute found in the rockshelter. It would certainly be an expedient source to harvest if the Maya did indeed access the rockshelter via the river as we have done. When jute are consumed the tip of the shell's spire is commonly broken off to facilitate the extraction of the meat from the shell. Most of the larger jute at Deep Valley have been modified in this fashion, however, it bears noting that almost no shell tips were found. Though these tips are small and some may not have been recovered during the excavations, few were observed within excavation units or in the backfill. Beyond their use as a protein source, archaeological and ethnographic evidence points to the ceremonial value of jute (Halperin et al 2003:214, 216; Healy et al 1990:178). Concentrated deposits are often found in mortuary contexts and in household caches, in shrines as well as caves, and are interpreted as ceremonial deposits. Ethnographic accounts note that the Lacandon Maya consume jute during ritual feasts and then take the discarded shells to local caves as an offering to the gods of rain and fertility (Halperin et al 2003:214, 215). Surprisingly, almost no jute was found inside the cave at Deep Valley, but the sheer bulk of shell in the main area of the rockshelter leads to the conclusion that it must have had important significance to the Maya who used the site. The primary question, then, to be addressed in further research, is whether the jute were consumed at the site, or represent the remains of ritual feasting that took place elsewhere and which were subsequently deposited at the site as offerings.

Excavations in the northern cave were limited to the single test Excavation Unit 8, due to time and accessibility. Because no datum was placed within the cave, elevations were taken from surface level and excavations ended at 99 cm from the surface. The climb down into the cave is slippery and steep, the matrix inside the cave is thick and wet, and limited lighting equipment made visibility troublesome. The cave entrance curves west and two meters in drops sharply three meters into a deep, round chamber. Several small piles of olla sherds were observed on the floor, but test excavations encountered no buried ceramics. However, the partial remains of a large animal were found. Analysis of these faunal bones will be conducted during the 2007 field season. Upon preliminary observation, it has been hypothesized that they belong to a large modern mammal, such as a tapir. There are no visible cut marks on the bones to indicate human processing, but the bone is heavily eroded.

# **OBSERVATIONS**

This preliminary investigation of DVR-1 indicates that the site was used during the Classic period. This period was marked by the apogee of some major Maya polities (Sharer 2006). Rural provinces became increasingly linked with larger centers which increased their access to prestige goods such as polychrome pottery, which fluoresced during this time. Mythology, tradition, and ritual became important factors to the legitimization of new forms of government, so there was a resurgence of ceremonies performed both in settlement plazas and in sacred places on the landscape such as caves (McNatt 1996:84, 86; Prufer 2002:1, 54; Sharer 2006:386, 563, 726). Many of these rituals involved the deposition of ceremonial offerings in caves. These sorts of offerings, most dating to the Classic period, have been reported in most of the rockshelters and caves documented in Belize (McNatt 1996:84).

Even within the Caves Branch region, extreme variation has been documented in recently explored caves and rockshelters. The nearby Caves Branch Rockshelter did serve as a ceremonial site in the Late Classic, but its primary function was that of a rural cemetery during the earlier Protoclassic period (Bonor Villarejo 2001:73-75; Wrobel and Tyler 2006:6). The assemblage and quantity of ceremonial wares at Deep Valley, as well as the noticeable lack of burials and earlier artifacts indicate it served a different function. Keith Prufer (2002:194; 2005:199, 211) has argued that cave type, morphology, and proximity to settlements may have affected the manner in which the Maya utilized caves and rockshelters. In the case of DVR-1, another factor influencing the regularity and nature of use may be the limited accessibility of the site. Prufer (2002:359) noted limited accessibility as a factor in the differential artifact assemblage at an unnamed rockshelter that he has investigated. Seasonal flooding, dense vegetation, and the steep climb to the site may have affected how often the Maya used DVR-1 as well as what degree of importance it held in the ancient symbolic landscape. It seems likely that crossing of the Caves Branch River during the rainy season would have been difficult and sporadic.

# CONCLUSION

In 2002, Keith Prufer conducted a regional survey of cave and rockshelter variation similar to the one I propose for the Caves Branch River Valley. He investigated the area surrounding the settlements of Ek Xuk and Muklebal Tzul in the southern Mava Mountains of Belize. The rockshelters he examined reflect the extreme variation typical of the Maya region (Prufer 2002:358, 361, 375, 405). Artifact assemblages at two of these rockshelters (an unnamed rockshelter and Chab'il Uk'al Rockshelter) resemble those of DVR-1 (Prufer 2002:359, 367). These two rockshelters were interpreted as having ideological significance for the ancient Maya and as having been used for private and public religious rituals, respectively. The specific types and deposition patterns of artifacts at the southern Belize rockshelters and DVR-1 are not identical, though these rockshelters vielded similar types of Classic period artifacts. It does bear note that artifact assemblages at the southern Belize sites also contain much more elaborate objects such as incensarios not, as yet, noted at DVR-1 or at Caves Branch Rockshelter. This possibly indicates usage by non-elite segments of the society, which is also indicated by the settlement patterns of the Caves Branch River Valley (Wrobel and Tyler 2006). The artifact assemblages, combined with the limited accessibility of DVR-1, indicate that DVR-1 resembles Prufer's (2002:361) example of a Classic period ritual site, likely utilized for more private religious rituals. Caves in Prufer's (2002:204, 639, 2005:187) study displayed distinctly different artifacts and ideological significance. This division of cave and rockshelter, both physically and ideologically, is reflected also at DVR-1, where the material culture found in the northern cave was profoundly different, and noticeably lesser than that of the rockshelter itself. Prufer (2005:187) documented each site in his two settlement regions as having discrete significance to the Maya of the Ek Xuk region as well as demonstrating general similarities which reflect participation in "the larger sphere of Mayan and Mesoamerican belief systems and practices" (Prufer 2002:4). Juan Luis Bonor Villarejo (2001:71), who excavated at Caves Branch Rockshelter in the nineties also suggested that a single settlement group may have used multiple caves and rockshelters for multiple practical and sacred functions. The same may be said of sites in the area surrounding DVR-1.

One research question to be addressed in the 2007 field season at DVR-1 is whether it was used as the primary site of ritual events, or as the location of ceremonial "dumping". Most evidence points to a secondary deposition hypothesis. The majority of jute at DVR-1 have had their tips removed, but a negligible number of shell tips were discovered, indicating that the shells were processed elsewhere and brought to the rockshelter for subsequent ceremonial deposition. Also, minimal charcoal was found, and there was no other evidence of food preparation to indicate the jute was cooked at the site. The secondary deposition hypothesis is supported by ethnographic accounts of seasonal feasting followed by a pilgrimage to, or ritual in, a cave involving ceremonial offerings (Halperin et al 215; Healy et al 1990:175). The secondary deposition interpretation is also supported by the fragmentary nature of other artifacts collected from the excavation units, particularly the broken pottery. While the presence of ceremonial tools could indicate on-site rituals, there are numerous reports, both archaeological and ethnographic, of the secondary ritual deposition of such items (Halperin et al 214-216; Healy et al 1990:175; McNatt 1996:83; Prufer 2002:108, 110). Preliminary observations conclude that the majority of ceremonial and domestic artifacts found at DVR-1 were manufactured, processed, or consumed elsewhere and placed in the rockshelter as an offering.

The work that has been undertaken at DVR-1 is preliminary. Most artifact analyses are incomplete and results of future examinations may result in alternate hypotheses for the use of DVR-1 by the ancient Maya. Work during the 2007 field season should result in a better understanding of the variation of rockshelters and caves in the Caves Branch River Valley and how they are related to each other and to nearby settlements.

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# **RECONNAISSANCE AND PRELIMINARY SURVEY AT THE SITE OF BAATEELEK, CAVES BRANCH RIVER VALLEY, CAYO DISTRICT, BELIZE**

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#### INTRODUCTION

The site of Baateelek was first identified by Juan Louis Bonor while reconnoitering the area surrounding the Caves Branch Rockshelter (CBR) during the 1995 field season. The site was reported to the Belize Department of Archaeology though it was not investigated further. The site was "rediscovered" in 2006 by members of the Belize Valley Archaeological Reconnaissance (BVAR) Project who were taken there by three guides from Ian Anderson's Caves Branch Adventure Co. and Jungle Lodge. They identified the site as "The Lost Maya Ruins" and had been taking tourists there. As part of the BVAR efforts, the site, which remained unnamed in the government archives, was formally designated as Baateelek (lit. "Battle-star" in Yukatek). Initial survey confirmed the presence of slate monuments, as was originally reported by Bonor, as well as many plazas with pyramidal and exceptionally long range-type structures. Many caves and rockshelters have been documented in the Caves Branch River Valley though little is known about surface sites. This brief report provides an overview of the preliminary survey at Baateelek, conducted over the course of a week in July 2006.

# BACKGROUND

The majority of work in the Caves Branch River Valley has focused on the important caves in the area, including Petroglyph Cave and Footprint Cave (Graham et al. 1980) with relatively little attention to surface sites other than the survey of Deep Valley (DPV) and excavation at a small *plazuela* group designated Deep Valley Lookout in 1978 (Davis 1980). Deep Valley is a minor ceremonial center located 17 kilometers southeast of Belmopan. It consists of two groups connected by a raised causeway (or *sacbe* in Yukatek) that measures 7.2 meters wide. The sacbe was bisected by the construction of the Hummingbird Highway. Group A lies to the north of the Hummingbird Highway and consists of a single plaza (c. 50 x 34 m) surrounded by "four large pyramids and six low rectangular mounds" (Davis 1980: 69). Group B lies 74 meters to the south of the Group A and consists of a single plaza (c. 20 x 33 meters) surrounded by five low rectangular mounds, one small pyramid and one large pyramid. Davis identified a number of housemounds to the southeast of the two groups though they were not mapped.

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No excavations were conducted at the ceremonial center though Deep Valley Lookout was excavated and was found to date to the Spanish Lookout phase (A.D. 700-900). Deep Valley Lookout is located just off the Hummingbird Highway and is approximately 400 meters to the northwest of Deep Valley. Davis called Deep Valley Lookout a housemound though it is actually a single structure atop a small raised plaza. The mound measured 2.6 meters in height and 22 meters in diameter and consists of a pyramidal structure built over an earlier platform (Davis 1980: 72). The pyramid dates to the Spanish Lookout Phase and was built in a single construction phase (Davis 1980: 93). Thirty-seven slate fragments, one slate disk and two slate awls (referred to as "needles") were found scattered atop the pyramid (Davis 1980: 122). Davis suggests that the slate objects were deposited atop the mound after abandonment. It should be noted that one of the fragments (46 cm long x 10 cm wide x 3.2 cm thick) appeared to be "shaped like a miniature stela with a rounded top, flat back, and slightly rounded front" (Davis 1980: 123).

# SURVEY RESULTS AND OBSERVATIONS

Baateelek is located approximately 390 meters from Deep Valley and lies to the south of the Hummingbird Highway. Both Deep Valley and Baateelek are part of a larger settlement area referred to as the Deep Valley Settlement Area. Initial inspection identified between 3 and 5 plazas though it was difficult to determine a precise number due to the thick bush covering the site. The spatial configuration of the site core is consistent with many Lowland Maya centers, but particularly so with central Belizean sites such as Cahal Uitz Na in the Roaring Creek Valley (Conlon and Erhet 1999), Cahal Pech in the Belize River Valley (Awe et. al. 1991), and Hershey in the Sibun River Valley (Thomas 2003). The structures are tightly clustered around adjoining plazas which in turn means that many of the structures border more than one plaza. A large portion of the site core is composed of long, steep-sided range-type structures comparable to structures at Cahal Uitz Na (Conlon and Erhet 1999).

During a week of preliminary survey in July 2006, a preliminary topographic map (Figure 1) of the largest plaza at Deep Valley was produced. Survey was conducted using a Leica TCR307 total station. Even though the site of Baateelek forms part of the larger Deep Valley Settlement Area, it is clear that the site is larger than the previously reported Deep Valley site. Consequently it was deemed warranted to designate the Baateelek as a separate entity and to provide its plazas with its own discrete designations. Consequently, the largest plaza at Baateelek was termed Plaza A. Two permanent datums were placed in Plaza A as well as many temporary datums. Plaza A is aligned on a north/south axis and measures c. 60 meters north-south and between 30 and 50 meters east-west. The tallest structure (Structure A3), located on the western side, is a platform measuring approximately 5 meters high above modern plaza surface that supports a small pyramidal structure at its center. Courses of cut stone were visible in a few places along the structure. The pyramidal structure measures 3.5 meters in height from the top of the platform (or approximately 8.5 meters from plaza level) and divides a raised plaza (Plaza D) located atop the western structure into two parts (a northern and a southern one). The small raised Plaza D cannot be seen from plaza level suggesting private usage in antiquity. The small, raised, private plaza measures approximately  $20 \times 20$  meters on the northern side of the pyramidal structure and  $10 \times 20$  meters on the southern side. Due to time constraints a more detailed map of the raised plaza could not be completed in 2006.



Figure 1: Topographic plan of Plaza A. Plan and survey by Jillian Jordan.

The southern side of Plaza A is defined by Structure C1, which measures 5 meters in height and articulates with the western structure at the southwestern corner of the plaza. The southern structure appears to be a similar type of platform though without a pyramidal structure atop it. The small Plaza C, hidden from view from Plaza A, is located behind the south of Structure C1, though was not mapped.

The eastern structure (Structure A2) is a long range-type structure that measures approximately 4 meters in height. The northern edge of the structure extends past the northern structure by nearly 20 meters bringing its total length to almost 80 meters. There

is a large looter's trench, measuring c. 6 x 3 meters, located in the center of the Structure A2 revealing many courses of cut stone.

The northern structure (Structure A1), the only true pyramidal structure in the plaza, measures approximately 6 meters in height and has a large looter's trench penetrating its frontal primary axis. The trench measures approximately 3.5 x 7 m (E-W and N-S, respectively). A large slate slab (Figure 2) measuring approximately 1.5 meters in length, was found lying on the western edge of the looter's trench. The slab does not appear weathered perhaps suggesting it was removed from the pyramid during looting activity. The function of the slab is not clear though it may have been the capstone of a tomb, akin to those used in elite tombs at Pacbitun, located 33 km to the west (Healy et al. 1995).



Figure 2: Slate slab found on the western edge of the looter's trench, northern Structure A1. Photograph by Gabriel Wrobel.

Another slate slab, designated Monument 1 (Figure 3), was also identified in Plaza A along with a few slate fragments that were probably once part of a larger monument. This piece is larger (approximately 1.7-m long), has been shaped and resembles the five slate monuments documented at the site of Cahal Uitz Na in the Roaring Creek River Valley (Awe and Helmke 1998). Monument 1 has been designated as such because it is sufficiently different in size and physical configuration from the more commonplace and traditional limestone stelae known in the Central Lowlands (Christophe Helmke, pers. comm. 2007). Monument 1 is undoubtedly in a secondary context considering the extensive evidence of looting at the site.



Figure 3: Monument 1. Photograph by Gabriel Wrobel.

No artifacts were found on the surface of the site or in any of the large looters trenches, a similar pattern was also found at the site of Pechtun Ha in the Sibun River Valley (McAnany 2003) and X-Ual-Canil in the Macal River Valley (Iannone 2004). The lack of artifacts suggests that the site was rapidly constructed and occupied for short time. McAnany hypothesizes that settlement in the Sibun was the result of "the transplantation of a social hierarchy or the creations of an administrative node, perhaps to develop cacao orchards" (McAnany 2003: 79). A similar case has been made by Iannone, who has suggested that X-Ual-Canil is a late addition to the region, representing a transplanted segment of the Cahal Pech elite (Iannone 2004). Though at present we lack concrete evidence the site of Baateelek, much like Pechtun Ha and X-Ual-Canil, appears to be late addition to the area. Also of note is a large, cone-shaped stone, resembling a speleothem, located in one of the adjoining plazas suggesting an association between Baateelek and the many caves in the area.

Baateelek appears to have been constructed according to the preexisting landscape atop a naturally elevated surface with little modification to the natural topography evidenced by the irregular dimensions of Plaza A and the natural limestone protruding out of one of the plazas. The 20-meter discrepancy between the northern and southern borders of Plaza A suggests that there was little to no modification to the natural surface prior to construction. In one of the adjoining plazas natural limestone can be seen protruding above plaza level suggesting few construction phases as sites with a long occupation history exhibit lengthy successions of superimposed plaster floors that eventually conceal such features of the natural topography. We hope to conduct excavations in this plaza during the 2007 field season and will focus on testing this hypothesis.

# CONCLUSION

Though only a preliminary survey has been completed it appears that Baateelek is a medium-sized major center and is the largest site, documented to date, in the Caves Branch River Valley. The size of the site in turn suggests that it may have been the local administrative center for the area in antiquity. While the relationship of Deep Valley and Baateelek is still unknown, Groups A and B of Deep Valley may have been peripheral groups related to the larger administrative center similar to the configuration of satellite sites around other major centers in the Belize River Valley. The examples of Floral Park and Ontario as satellites of Blackman Eddy and Baking Pot come readily to mind (see Driver and Garber 2004). We view the relationship between Deep Valley and Baateelek to be similar, and hope that further investigation will help to determine the specifics of the roles and interactions between the two sites.

# **FUTURE RESEARCH**

The primary goal for the 2007 field season will be to complete a topographic map of the entire monumental site epicenter at Baateelek as well as a survey of the periphery, time permitting. Following the survey phase, test units will be placed in the plazas and the looters' trenches will be cleared to reveal construction phases. An analysis of the ceramic assemblage will be used to construct a chronology and identify the type and style similarities with other sites. Data recovered from these planned excavations will be used to construct a chronology for Deep Valley and possibly link the site to others in the Caves Branch River Valley and the surrounding area.

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# RESULTS FROM THE 2006 GEOPHYSICAL SURVEY OF PLAZAS AT XUNATUNICH AND CAHAL PECH

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#### **INTRODUCTION**

Geophysical surveys were performed at plazas at Xunantunich and Cahal Pech in the summer of 2006 in conjunction with the Belize Valley Archaeological Reconnaissance (BVAR) field school as part of continuing research to evaluate the utility of these techniques on a range of targets in the region. Electrical resistivity profiling and magnetic gradient techniques were used. Based on results from the 2005 season, electrical resistivity has the potential of delineating buried architecture, while magnetic gradient can be used to detect various burned features.

#### **METHODS**

### **Electrical Resistivity**

Electrical resistivity instruments measure the of subsurface resistivity variation using probes placed on the surface (Loke 2000:1). One advantage of the technique is that the approximate depth of maximum sensitivity is equal to the separation distance of the probes. Archaeological applications often use profiling type surveys, where a fixed probe separation distance is used to create a plan view map of anomalies at a chosen depth (Reynolds 1997:446). Generally the resistivity distribution is closely related to the amount of moisture contained in the subsurface material (Clark 1996:27; Weymouth 1986:319). Archaeological features that may produce resistivity contrasts include buried stone architecture, tombs, and compacted floors (Aitken 1961:71; Weymouth 1986:321).

#### **Magnetic Gradient**

Magnetic gradiometers are passive instruments that measure the gradient of the magnetic field strength at a point on the Earth's surface. Archaeological features exhibit either permanent or induced types of magnetism. Permanent magnetization, also called remnant magnetism, is created when hearths, perishable structures, and other features are burned (Heimmer and Devore 1995:12). Induced magnetism, or magnetic susceptibility, is increased by the organic content of pits and middens in the presence of the magnetic field of the Earth (Clark 1996:65-66). Iron targets also produce strong magnetic gradients and these can obscure the relatively subtle archaeological targets.

*The Belize Valley Archaeological Reconnaissance Project: A Report of the 2006 Field Season*, edited by Christophe G.B. Helmke and Jaime J. Awe, pp. 19-25. Belize Institute of Archaeology, National Institute of Culture and History, Belmopan. © 2007

# RESULTS

### **Cahal Pech**

During the 2005 field season, Plaza B was surveyed with electrical resistivity using a probe separation of 0.5 meter, yielding several anomalies (Figure 1). Excavation by the Texas State University field school under the direction of James Garber revealed the presence of an early platform surface associated with one of these (labeled Anomaly #1 in Figure 1) (Haley and Wrobel 2006).



Figure 1. Electrical resistivity results for Plaza B at Cahal Pech from the 2005 field season.

For the 2006 field season, a resistivity survey was conducted in Plaza C and the area to the north. Two probe separation distances (0.5 meter and 1.0 meter) were used to better reveal information about the vertical extent of anomalies. Readings were recorded at a density of 0.5-meter along the east-west axis and 1.0-meter along the north-south axis. Excavation undertaken by the Belize Valley Archaeological Reconnaissance



**Figure 2.** Electrical resistivity results for Plaza C at Cahal Pech from the 2006 field season. **a)** Resistivity results with 0.5-m probe separation distance (above left); **b)** results with 1.0-m probe separation distance (above right).

(BVAR) field school in Plaza C focused on a number of architectural features, including two wall segments that extend into the plaza. The goal of the geophysical survey was to determine the extents of these walls and to delineate any other features within the plaza.

Work at Cahal Pech was affected by an intermittent problem with the resistivity meter, which produced a series of mosaic patterns and numerous spiked readings. After processing techniques were used to reduce the impact of this problem on the data, a number of anomalies became apparent (Figure 2). Although they do not clearly define them, anomalies on the eastern side of the survey area (labeled Anomaly #1 and #2 in Figure 2) are probably related to one of the partially exposed walls or terraces and other unexcavated architectural features. The structure that defines Plaza C to the north might be related to anomalies labeled #3, #4, and #5, which change rapidly from the 0.5 meter data set to the 1.0 meter data set. If this is a structure, #4 and #5 might represent the northern edge of this structure, which is still buried. Anomalies #6 and #7 may correspond to some additional buried architectural feature located within the plaza.

A magnetic gradiometer survey was also conducted in Plaza C and, like the resistivity meter, an equipment malfunction occurred. However, unlike the resistivity meter, it was impossible to collect data and repairs were not possible in the field. The results therefore do not appear in this report.

# Xunantunich

After a repair to the electrical resistivity meter, an electrical resistivity survey of Plazas A-I and A-II at Xunantunich was conducted. Parameters were identical to those used at Cahal Pech. The goal of the survey was to delineate any features within the plaza, including the base of a wall extending from Structure A-1 that may have served to separate the two plazas (Leventhal and Ashmore 2004:173).

The results of the survey are shown in Figure 3. One anomaly (labeled Anomaly #1 in Figure 3) is located near the northwest corner of structure A-6 and oriented about the same as the standing structures. It is rectangular, exhibits high resistivity, and becomes slightly less defined in the deeper data. Jason Yeager (pers. comm. 2007) indicated a perishable structure housing stelae was once located in this vicinity. Testing is recommended for this anomaly to determine if it is archaeological or modern. In addition, the results contain several large and irregular anomalies (labeled Anomaly #2 through #7 in Figure 3), similar to those produced in the 2005 season at Cahal Pech and Pook's Hill (Haley 2006). The size and high resistivity signatures of these are indicative of buried natural limestone, but this interpretation can only be confirmed by test excavations. Smaller, high resistivity anomalies (labeled #8 through #14 in Figure 3) are more likely to be of archaeological significance. The wall foundation to the southeast of Structure A-1 is not visible in the data, probably because it was obscured by the substantial amount of collapse visible on the surface during the survey.

# DISCUSSION

One lesson learned from the 2006 season is that the harsh sub-tropical environment of the area can adversely impact electronic equipment such as geophysical



**Figure 3.** Electrical resistivity results for Plazas A-I and A-II at Xunantunich from the 2006 field season. **a)** Resistivity results for 0.5-m probe separation distance (above left); **b)** results for 1.0-m probe separation distance (above right).

instruments. Three equipment failures occurred during the 2006 field season. Since repair service is not easily obtained in Central America on these instruments, these incidents can cost time and even prematurely end the field season. Surveyors should ensure that geophysical instruments are in optimal working condition before they depart for the field.

The 2006 season results include a new first: a clear rectangular pattern in the plaza at Xunantunich. It is the best candidate for an unambiguous cultural feature

obtained so far in Belize by the author. However, it is impossible to determine if the anomaly is ancient or modern without further investigation.

In general, the interpretative challenges experienced with the 2005 data continued with the 2006 data. The anomalies of interest tend to be high resistivity, amorphous, and quite variable in size. The lack of regular patterning or distinct signatures means that determining which features are natural and which are archaeological is difficult or impossible. With respect to certain regions, cultural complexes, and archaeological feature types, identification is based largely on pattern recognition. For example, burned houses found on Mississippian sites in the southeastern United States typically produce obvious, distinct, square patterns unlike anything caused by natural phenomena (Johnson et al. 2000).

Three primary problems are to blame for the aforementioned interpretative difficulties. First, the composition of archaeological features and the typical subsurface geology (limestone) are often similar if not identical. One way to address this problem is to focus on three dimensional techniques such as ground penetrating radar and electrical resistivity tomography so that the vertical extents of anomalies are better understood. Second, geophysical surveys performed on archaeological sites in Belize are still in their infancy and are few in number. A better understanding of how geophysical instruments react to the array of archaeological feature types can be achieved with a more extensive database. Lastly, and perhaps most importantly, the amount of test excavation performed in coordination with the geophysical data is very limited. Only with more ground truthing can geophysical anomalies be better understood and the full potential of the technique realized.

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## ELECTROMAGNETIC SURVEY FOLLOW-UP EXCAVATIONS AT BAKING POT, BELIZE

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#### **INTRODUCTION**

In June of 2004 the Belize Electromagnetic Explorations Program (BEMEP) conducted a geophysical survey using Electromagnetic Induction (EMI) at various locations at the site of Baking Pot, Belize. The primary reason for the survey was to try to locate limestone, non-platform dwelling floors in the settlement zone, for which no clear surface indications exist. Results of the survey indicated five promising anomalies of interest in the settlement zone approximately 300 m west of Group 2 (Sweely and Trainor 2005a). The Belize Valley Archaeological Reconnaissance Project (BVAR) field staff generously initiated five 1 x 1 m test excavation units to examine what subsurface conditions were generating these anomalies (Hoggarth and Swain 2005). These excavations were unfortunately concluded prematurely, ending at 1.0 m below the modern ground surface, which is to say 0.5 m short of the depth of penetration of the EMI instrument used in the survey. In 2006, the author returned to Baking Pot to expand one of these excavations, originally carried out to examine a discrete region of low-conductivity thought to represent a buried limestone, non-platform dwelling floor.

Expanding upon previous efforts entailed extending the 2004 BVAR Excavation Unit 1 (Hoggarth and Swain 2005) to a depth of 1.5 meters. In the original excavation unit that extended to only a depth of 1.0 m, Hoggarth and Swain (2005) reported finding no subsurface features and only a few lithics, ceramics and pieces of daub. Although during the 2006 field season Sweely was unable to locate the exact location of the original excavation, a new excavation was conducted in the region of the lowconductivity anomaly, as near as possible to the original excavation. Results of this excavation indicated the presence of a living surface or trash deposit as well as evidence of a possible "dissolved" limestone, non-platform floor, which may be responsible for the low-conductivity anomaly found in the 2004 EMI survey.

#### **BEMEP RESEARCH GOALS**

As its primary goal, BEMEP examines the social significance of ancient Maya commoner dwellings, in the form of non-platform floors, as they evolved through time. EMI survey with follow-up ground truth excavation seeks evidence for "invisible settlement", i.e. dwellings that are not visible at the contemporary ground surface. By locating non-platform dwellings and examining the socio-economic differences between their inhabitants and the occupants of platform dwellings, BEMEP seeks to examine what

social bases existed for dwelling differentiation and what caused some households to persist and expand into platform dwellings while others did not.

Secondarily, BEMEP uses EMI to survey selected plaza locations in order to create a conductivity signature catalogue for cultural features found in these types of locations. During an EMI survey at the site of Minanha, Sweely and Trainor (2005b) recorded distinct conductivity signatures for caches, crypts, and construction features.

# FOLLOW-UP EXCAVATIONS AT BAKING POT

For a thorough explanation of the EMI technique, a description of the field operations for the EMI Surveys conducted at Baking Pot in 2004, and results of said surveys, the reader is referred to Sweely and Trainor 2005a. During the 2004 EMI Survey one of the areas surveyed for settlement was designated Baking Pot Operation 1, or B-OP1. B-OP1 was set approximately 300 m west of Group 2 and 100 m north of the seasonal river channel (Figure 1). The survey grid measured 100 x 100 m, for a total survey area of 10,000 square meters. Thick grasses covered the grid and thus surface visibility was poor. B-OP1 (Figure 2) had within its bounds two visible platforms, BKP M-68 and M-71. According to a GPS map provided by William Poe after the 2006 excavation, the grid was also found to contain one low platform, M-69, which was not visible at the time of the survey nor at the time of the excavation because of poor visibility due to the presence of thick grasses. A possible two-track path bisected the grid along its northern end and there were several slight depressions of various sizes throughout the grid. The survey grid is shown in two sections because data was collected in two stages due to intermittent failure of the data-recording device used in the survey. The discrete regions of low-conductivity located in the SW and NE corners of B-OP1 are significantly lower than those associated with the surrounding matrix. The 2004 season BVAR Excavation Unit 1 was designed to examine the low-conductivity anomaly in the SW corner because it possesses several qualities that indicate it has a high probability of representing a buried limestone, non-platform floor.

# **Anomaly Selection**

There are several reasons that the low-conductivity anomaly in question is thought to indicate a limestone, non-platform floor. First, the difference in conductivity value between the low-conductivity anomaly and the mid-range conductivity values characteristic of a majority of the survey grid, is approximately 8 mS/m. This difference in value is substantially larger than expected in a survey of a relatively homogenous clayey matrix such as the alluvial one found in this region of the Baking Pot site. The low-conductivity indicates the presence of a buried substance that is significantly more resistant to an electromagnetic current than the surrounding matrix. Such resistance has been associated with limestone, in the form of bedrock, or a limestone, non-platform floor (see Sweely 2005). Since bedrock has not been encountered within 2 meters of the ground surface at the site of Baking Pot, and is generally buried upwards from 10 meters below the ground surface (Audet, pers. comm., 2006), it is highly unlikely that the anomaly indicates naturally occurring bedrock.



Figure 1. Map of the site core of Baking Pot, showing the location, size and distribution of electromagnetic surveying operations of the 2004 and 2006 field seasons.



**B-OP1**, vertical orientation

**Figure 2.** Close-up of the 2004 EMI survey grid B-OP1, showing the location of housemounds M-68, M-69 and M-71 as well as the results of the EMI survey conducted in 2004. Plan and survey by Tracy Sweely.

Second, Willey et. al. (1965), at the site of Barton Ramie, discovered limestone, non-platform floors buried beneath visible platforms, at depths of 1.6 meters beneath the contemporary ground surface at the base of mounded platforms. Thus there is a precedent for such features being located at significant depths in the alluvial matrices found in the region.

Third, the shape of the anomaly is very similar to a low-conductivity anomaly discovered at Chau Hiix, Belize (Figure 3), during a 1996 pilot study using EMI to survey vacant terrain (Sweely 2005). This anomaly was found to represent a limestone, non-platform floor. Both the BOP-1 anomaly as well as the one found at Chau Hiix, are discrete and "crescent" in shape, possibly indicating limestone dwelling floors oriented around patios or courtyards.

#### **Field Operations**

In June 2006, Tracy Sweely, the principal researcher for BEMEP, returned to Baking Pot, to expand upon the 2004 Excavation Unit 1. Sweely, with the assistance of Bill Qiroz and several students from the Cahal Pech Field School first attempted to



**Figure 3.** Plan of the 1996 EMI survey conducted at Chau Hiix (Op. CHS-1001-96), with the location of limestone, non-platform floors indicated.

relocate the 2004 Excavation Unit 1. Since GPS coordinates for the 2004 excavations were not available (William Poe pers. comm., 2006), Sweely used GPS coordinates she received from Bill Poe in 2004 for the two platforms located within the 2004 EM survey grid, M-68 and M-71. The coordinates of the platforms were used to triangulate to the location of the 2004 Excavation Unit 1. Although, it was not possible to re-locate the exact location of the original BVAR excavation due to poor visibility from the 1 to 2 meter tall overgrowth of dense grasses in the survey area, a follow-up excavation designated as 2006 Excavation Unit 1, was placed as near to the original excavation as possible using triangulation from the mounded platforms specified above (Figure 4a).

Sweely, Qiroz and several of the field school students then set to excavating the 1 x 1 m excavation unit to a depth of 2.0 meters below modern ground surface, over a period of 3 days. Excavation was conducted using BVAR protocols as outlined in the BVAR and Cahal Pech Field School Readers. Levels were excavated by horizon, forms completed for each level, artifacts collected, features mapped, profile of most significant baulk drawn, photos and GPS coordinates secured, and excavation notes recorded. The excavation notebook was copied and along with the forms and artifacts collected, was submitted to BVAR staff.

In addition to the 1 x 1 m excavation unit, a

series of 10, 2-cm diameter cores were examined by Sweely and Qiroz, radiating out at 5 and 10 m from the center of the excavation unit in cardinal directions and at an azimuth of 235 degrees (Figure 4b). Coring was conducted in order to obtain lateral subsurface matrix information in the region of the low-conductivity anomaly beyond the limits of the excavation unit. The sampling pattern was designed to encompass representative regions of the low-conductivity anomaly.

#### RESULTS

Level 1 of 2006 Excavation Unit 1, which measured from 0 to approximately 35 cm below datum, was composed of a very dark, grayish-brown clay (Munsell 10 YR 3/2). Artifacts included 63 ceramic sherds, 67 chert flakes, 1 obsidian flake and 1 obsidian microblade.

The subsurface matrix changed at approximately 35 cm below datum to a dark,

gravish-brown clay with dark vellowish-brown mottling (10 YR 4/6). This level, Level 2, measured from approximately below datum to 35 cm approximately 75 cm below datum Artifacts collected consisted of 191 ceramic sherds, 153 chert flakes, 1 chert scraper, 1 modified chert flake and 1 quartz tool tip fragment. In the collection of chert debitage in Level 2, a full chert reduction sequence was evident, including chert cores, one with cortex and one without. In addition, between 60 cm below datum and 75 cm below datum, many limestone pebbles were encountered as well as a noticeable number of limestone fragments 2-3 cm in diameter near the bottom of Level 2. Nine such limestone fragments were collected.

At approximately 75 cm datum the below matrix changed to a dark, vellowishbrown sandy clay (10 YR 4/4) with dark gravish-brown inclusions (10 YR 3/2). This level, Level 3, was concluded at approximately 90 cm below Artifacts collected datum. consisted of 11 ceramic sherds and 12 chert flakes. In addition, evidence of limestone pebbles and fragments dramatically decreased, with only a few limestone pebbles evident at the bottom of Level 3.

# 100.0 **M68** \$0.0 60.0 40.0 M69 M71 20.0 100.0 **M68** \$0.0 60.0 40.0 M69 M71

**Figure 4.** The 2004 EMI survey grid B-OP1. **a)** Location of BVAR 2006 Excavation Unit 1 indicated by a black square (above); **b)** location and distribution of sampling cores marked off by smaller black dots.

## Because there was

insufficient time to continue excavating the unit, a 2 cm diameter corer was employed to examine the matrix beyond 93 cm below datum where Level 3 was concluded. The corer was used in the center of the excavation unit to examine the matrix from 93 cm below

datum to 200 cm below datum. Level 3 matrix continued until 122 cm below datum at which point the matrix changed to a yellowish-brown sandy clay (Munsell 10 YR 5/4) until 197 cm below datum. The matrix of the remaining 3 cm of the core consisted of a yellowish-brown clayey sand (Munsell 10 YR 5/4). No artifacts were encountered in the core sample.

The south baulk of the 2006 Excavation Unit 1 was profiled and all of the excavation unit baulks were photographed. The south baulk profile indicated a change in Level 2 composition at approximately 60 cm below datum where an increase in limestone fragments and pebbles was noted during excavation. The transition to Level 3 at 75 cm below datum noted during excavation is not clear in the profile.

Of the 10 core samples taken, all exhibited similar stratigraphy to that described for the excavation unit. Core samples revealed matrix changes from Level 1 to Level 2 between 25 cm and 40 cm below surface and matrix changes from Level 2 to Level 3 between 60 cm and 70 cm below surface. A few small, eroded ceramic fragments were encountered in the core samples, but none were collected.

# INTERPRETATIONS

The large number of artifacts, the full chert tool reduction sequence and the limestone fragments found in the 2006 BVAR Excavation Unit 1, indicate the presence of a living surface or possibly a trash deposit probably located in Level 2. To date, no analysis of the ceramic artifacts has been carried out, so no temporal information associated with the indicated living surface is available. The artifacts found could possibly be associated with M-69, located approximately 15 meters to the north of the excavation.

Results of the 2006 Excavation Unit 1 were substantially different from those described for the 2004 Excavation Unit 1 by Hoggarth and Swain (2005). While subsurface matrix composition was found to be similar between the Excavation Unit 1 of the 2004 and 2006 seasons, artifact counts were significantly greater in the 2006 excavation. In addition, no limestone fragments were reported in the 2004 excavation and no daub was reported in the 2006 excavation. One explanation could be that the 2006 excavation was sufficiently distant from the 2004 excavation such that it captured substantially different subsurface conditions, perhaps including a discrete living surface or trash deposit.

Of the five excavations carried out by BVAR in 2004, all were reported to have very little ceramics, lithics and daub (Figure 5).<sup>1</sup> Excavation Units 2 and 5 nearest to M-69, in locations of mid-range and lower-mid-range conductivity respectively and Excavation Unit 6 in a region of high-conductivity, revealed small amounts of artifacts. No limestone fragments were reported, as expected and consistent with previous studies (Sweely 2005; Sweely and Trainor 2005c), since these excavations were not in low-conductivity areas. Excavation Unit 4, located in the region of low-conductivity in the northern corner of the grid and approximately 20 m north of M-68 uncovered small amounts of artifacts. The presence of small pieces of limestone was reported for this excavation as expected based on its location in a region of low-conductivity.

<sup>&</sup>lt;sup>1</sup> Note that due to time constraints, Location #3 was omitted from excavation in 2004.



**Figure 5.** The 2004 EMI survey grid B-OP1, showing the location of BVAR 2004 Excavation Units 1 through 6. Plan and survey by Tracy Sweely.

While no physically substantial limestone floor was encountered in 2006 Excavation Unit 1, the low-conductivity anomaly may still have been generated by the presence of limestone. Limestone fragments and pebbles were encountered between 60 and 75 cm below datum in the 2006 Excavation Unit 1 and limestone fragments were reported in the 2004 Excavation Unit 4 in the NE corner of the grid 20 meters north of M-68 (Figure 5) within the only other region of low conductivity found in the grid.

Although there were few, the limestone fragments may indicate the presence of a predominantly "dissolved" limestone, non-platform dwelling floor. It is possible that moisture and pH conditions of the subsurface matrix at Baking Pot could have caused the limestone to dissolve over time. Many of the floors found at Baking Pot have been found in a dissolved or highly eroded state (Jaime Awe, pers. comm., 2006). It is also possible that the dissolved limestone from a dwelling floor could be trapped in the clay matrix "in solution" rather than having been leached away over time, and thus may still be generating the low-conductivity anomaly found in the EMI Survey data. A similar finding of low-conductivity being associated with alluvially-deposited limestone fragments in a clay matrix, both naturally occurring and of anthropogenic origin, was encountered by McCoy at the site of Palaikastro, Crete (Floyd McCoy pers. comm., 2006).

Finally, it is also possible, though improbable, that the low-conductivity anomaly was being generated by the subsurface matrix composition of Level 3 in the area. Level 3 subsurface matrix consisted of a sandy-clay. If the matrix at this level had been very dry at the time of the EMI Survey it might have generated a low-conductivity due to the sand

content of the matrix. No comments regarding the moisture content of the matrix had been made in the excavation report of the 2004 Excavation Unit 1 and so moisture conditions of the matrix of Level 3 at the time are unknown. It is worth stating that in order for the Level 3 matrix to generate a low-conductivity, it would have had to have been virtually devoid of moisture at the time of the EMI Survey, as the clay component of a subsurface matrix is highly conductive even with a low percentage of moisture content. At the time of the survey the rainy season had already started, but may not have saturated the matrices to the depth of the Level 3 matrix.

## CONCLUSIONS

While evidence of a living surface or trash deposit was indicated in the 2006 Excavation Unit 1 associated with the low-conductivity anomaly found during the 2004 EMI Survey, it is not clear what subsurface conditions generated the anomaly. It is possible that a dissolved limestone, non-platform floor is generating this anomaly, as well as the other low-conductivity anomaly in the northern corner of the grid. But, this interpretation is undermined because no limestone fragments were reported in the 2004 Excavation Unit 1. The differences in excavation results between the two field seasons are suspect and may be resulting from the very "ephemeral" nature of the possibility of a dissolved limestone floor. Soil tests designed to examine the subsurface matrix for the presence of higher levels of calcium and potassium within the anomaly area and lower levels of these minerals outside of the anomaly area, could lend credence to the idea that a limestone, non-platform floor dissolved, leaving behind only limestone in solution and artifact evidence of a living surface. Finally, it is notable that the two, low-conductivity areas found in the EMI survey grid are associated with the presence of small mounds, M-68 and M-69, indicating that these mounds might be associated with more extensive living surfaces.

Given the results of earlier studies (Sweely 2005, Sweely and Trainor 2005c), the results of the current study, despite uncertainties, suggest that continued survey in settlement zones using the EMI technique is warranted. The current study along with previous studies indicate that such low-conductivity anomalies of the appropriate size and shape for limestone, non-platform floors might yield evidence anywhere along a continuum between "residual" i.e. eroded or dissolved limestone, non-platform floors with artifact evidence for living surfaces, and more physically substantial examples of such floors. If future surveys also continue to indicate as the current and previous studies do, that regions of mid- and high-range conductivities are associated with a lack of subsurface evidence of living surfaces and floors, the effectiveness of the technique for locating both residual and substantial limestone, non-platform floors would be confirmed. Such continued research would demonstrate the viability of the EMI technique for locating invisible settlement and enable the systematic study of non-platform dwellings.

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# ANALYSIS OF THE NON-OBSIDIAN CHIPPED STONE TOOL ASSEMBLAGE (2001-2005) FROM THE ANCIENT MAYA SITE OF POOK'S HILL, BELIZE

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#### **INTRODUCTION**

Excavations undertaken between 2001 and 2005 by the Belize Valley Archaeological Reconnaissance (BVAR) Project under the direction of Jaime Awe and led by Christophe Helmke, at the ancient Maya site of Pook's Hill located in the Cayo District of Belize, yielded 2800 non-obsidian chipped stone tools. The primarily chert and chalcedony lithics were recovered from a medium-sized *plazuela* group designated as PKH1 (for Pook's Hill, Group 1) consisting of nine masonry structures. The *plazuela* platform itself, as well as Structures 1A, 1B, 1C, 2A, 2B, 4A and 4B were excavated. A small quantity of additional lithic artefacts were recovered as surface finds, some originally found in 1992, and from salvage excavations of Structure PKH-M1, a small nearby housemound located to the southeast of the main *plazuela*.

#### LITHIC RAW MATERIALS AND TYPES FROM POOK'S HILL

There were eight types of silicates identified in the non-obsidian chipped stone tool assemblage excavated from Pook's Hill in 2001-2005. They included: 'local' chert, chalcedony, 'river cobble' chert, 'river cobble' chalcedony, 'imported' chert, 'unknown' chert or chalcedony, quartzite and dolomitic limestone. This identification of the different lithic raw material types was based on visual observation of material grain size and colour. Currently, there is no archaeological survey for chert or chalcedony sources in the Belize Valley of the Cayo District of which I am aware (many archaeologists cite Wright et al. 1959 as a general geological reference), although some recent geological work has been undertaken in relation to karst and caves in the Cayo District (Alt 1995, Miller 1996, Reeder et al. 1996) and there is a provisional geologic map of Belize (Cornec 1986).

#### 'Local' Chert

Presently, it is believed that the local cherts used by the Maya at this site were acquired from the following locations: 1) Roaring Creek and along its banks, and 2) limestone outcrops in and around the site itself. The 'local' cherts consist of a variety of materials ranging in grain size from coarse to fine and in colour from dark grey to white/clear (Appendix C), with some banded, mottled, and translucent varieties. Currently, no specific sources for the local cherts have been identified. It appears the

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inhabitants of Pook's Hill acquiring their raw materials from a variety of sources throughout the lengthy occupation of the site occupation. As previously mentioned, there does not appear to be any obvious association between the colour and grain size of the lithic raw materials and specific outcrops or sources.

There are at least 26 different varieties of 'local' chert identified in the chipped stone artefacts recovered from Pook's Hill. These varieties of chert were created through visual identification and categorization based on combination of colour and colour patterns, texture (grain size), degree of opacity/translucency, and the presence/absence of voids, inclusions, cortical veins, and microfossils. Although these raw material varieties have been identified, no connection to specific source locations have been determined as of yet.

## **'River Cobble' Chert**

'River cobble' cherts were identified based on the presence of cortical surfaces that were obviously water-rolled and smoothed. These are easily distinguished from the rougher, white/grey porous cortex of cherts recovered from land-based limestone matrices. Many of these surfaces have been previously observed by J. Stemp on river cobbles from Roaring Creek, and the Mopan and Macal Rivers. The river is approximately between 300 to 500 metres away from the site, so it would be an easily accessible source of this silicate. They were most likely obtaining cobbles from the river based on their occasional use in masonry and also based on the partly shaped granite blocks (which also occur as cobbles in the river) (Christophe Helmke, pers. comm. 2006).

Throughout the Cayo District within the limestone geology, there are lenses and nodules of chert of varying qualities (Arem 1991: 134; Bishop et al. 1999: 208). The majority of the tabular cherts exist as extremely thin layers or veins that would be difficult and time-consuming to remove from the limestone. Some of the tabular chert could have been employed to produce simple flakes or flake tools. The nodules of chert are typically range from the size of a grapefruit to the size of a large golf ball. As with the tabular cherts, it could be possible to use some of these small nodules as sources of material for simple flake production. Generally, the quality of the tabular and nodular chert varies from medium-fine to coarse in grain size. It has been suggested that some nodules were probably obtained opportunistically during quarrying for facing stones (as seems likely for Pook's Hill as well).

Although there is no obvious pattern in relation to certain varieties (i.e. qualities) of chert being used to make certain classes of tools at the site, with both the production of formal tools and simple core reduction represented by low and high quality cherts, much of the 'river cobble' chert is incorporated in the production of formal tools, such as large bifaces. The biface fragments and the bifacial thinning flakes represent 36.0 % of all the 'river cobble' chert recovered from this site compared to 14.8 % of the local limestone matrix chert. This does not seem to be related to quality of stone as there are both high and low quality land-based cherts and 'river cobble cherts', but seems more a factor of size. A number of river cobbles seem large enough to have permitted the reduction of the nodules/cobbles to produce large tools, such as oval bifaces and general-utility bifaces. Some bifaces seem to be the products of macroflake reduction as seen at locations such as Colha (Shafer and Hester 1983; Hester 1985).

#### Chalcedony

The chalcedony recovered at Pook's Hill was likely of local origin or within the general vicinity of the site; although no specific chalcedony outcrops or quarries have been identified. This chalcedony was identified based on its translucent or semi-translucent appearance and its fibrous quartz texture (Andrefsky 2005: 55, Fig. 3.2; Arem 1991: 100). It is possible that some of the chalcedonies originated in other locations in Northern Belize such as Progresso, Pulltrouser Swamp, Kichpanha, or Laguna de On (Hester and Shafer 1984:158; McAnany 1989:334; Shafer 1982:168; Mitchum 1991:45; Oland 1999:105), and were imported to the site. It is difficult to determine the potential quantities of chalcedony that may have come from further afield; as such, the chalcedony material type may contain fibrous quartz silicates that are both local and imported.

One pattern of reduction is associated with chalcedony at Pook's Hill. Most of the chalcedony artefacts recovered represent basic, multi-directional core reduction for the production of simple, unmodified flakes. Although some chalcedony was used in the production of some formal tools (as evidenced by biface fragments and some bifacial thinning flakes), these are comparatively few in number. The reasons for the reduction patterns observed in this assemblage are likely due to two factors: 1) the small size of chalcedony core fragments and flakes and 2) the internal composition of chalcedony, which includes more voids, microvoids and impurities that might affect the ease of formal tool manufacture (see Hester and Shafer 1984: 160, 164; Oland 1999; Shafer 1983: 219; Stemp 2001: 30).

## **'River Cobble' Chalcedony**

Only one variety of 'river cobble' chalcedony has been identified at Pook's Hill. As explained above, the external cortical rind was primarily used to identify its suspected point of extraction and the fibrous, translucent quality of the stone was used to classify it as a chalcedony or chalcedonic chert. Like the chalcedony described above, evidence from the site suggests this raw material was used, however sparingly, in simple flake production rather than the manufacture of formal tools.

## **'Non-Local/Imported' Chert**

'Non-local/imported cherts' primarily consist of cryptocrystalline silicates referred to as 'Chert-bearing zone [CBZ]' chert (Hester and Shafer 1984; Shafer and Hester 1983), 'Northern Belize chert-bearing zone [NBCBZ]' chert (Speal 2006) or 'Northern Belizean chert [NBC]' chert (McAnany and Peterson 1984). They were identified based on visual descriptions of the raw material from the extensive chert deposits in central Northern Belize (Hester and Shafer 1984:164, Mitchum 1994:54, Shafer and Hester 1983:521, McAnany 1989:334) and my own observations of this raw material from sites such as Colha, Altun Ha, Lamanai, Marco Gonzalez and San Pedro (Stemp 2001, 2004a, 2004b). None of these cherts has been chemically sourced (see Cackler et al. 1999, 2000, Tobey 1986, see also Boxt and Reedy 1985).

At greater distances from Pook's Hill are chert quarries or outcrops that may have been exploited, but this seems unlikely given the direct associations of these sources of lithic raw material with other Maya communities. These include the LDF chert 'pit' (chalcedonic chert?) reported at El Pilar (Bullet Tree) [222-005] (BRASS/El Pilar Program 2002: 14), the small workshop located in the modern cemetery in San José Soccutz (Jason Yaeger, pers. comm., 2005), or the chert quarry at San Lorenzo, near Xunantunich (Ashmore et al. 2004: 309). Sources of chert and production workshops have also been identified in the Upper Belize River Area (Ford and Olson 1989). It is likely that any chert originating from these locations that may have arrived at Pook's Hill did so in the form of finished tools traded into the Roaring Creek Valley. It does not seem plausible that the Maya from this site traveled great distances to acquire cobbles or cores that they would then reduce in the *plazuela*. Some finished tools may have also been acquired from a workshop identified by J. Garber and K. Brown (pers. comm., 2004; see Stemp 2004c: 97) behind the Iguana Creek Resort, west of Belmopan along the Western Highway.

## 'Unknown' Chert/Chalcedony

The 'unknown' raw material category refers to those cherts or chalcedonies that are so heavily weathered, patinated, and/or burnt that their original tool grain size and/or colour cannot be reliably identified (Rasic 2004; Stapert 1975; Rottlander 1975; Mandeville 1973). It appears that the burning of silicate tools at Pook's Hill was accidental or the unintentional by-product of other activities (e.g. burning of middens to reduce noxious odours; see Helmke et al. 2001: 423). This is based on the random pattern of burning across raw material categories and the severity of the burning that would have destroyed the internal integrity of the raw material (Luedtke 1992; Purdy 1974; Purdy and Brooks 1971). Because of the lack of patterned or controlled lithic burning, it is doubtful the Maya were heat-treating chert or chalcedony to improve its flaking qualities (see Crabtree and Butler 1964; Shafer 1983). There would be no need to heat treat very high quality fine-grained cherts, although these are as frequently burnt as the lower quality stones from this site.

## **Dolomitic Limestone**

In addition to chipped tools manufactured from various types of chert and chalcedony, a small proportion of the flaked lithic assemblage also consists of dolomitic limestone or dolostone (Bishop et al. 1999: 205). This chemical, calcareous sedimentary rock was recognized based on its fine/medium to medium grain texture, which has a fine 'sugary' appearance, and its cream-light brown to beige-brown colour (Bishop et al. 1999: 205). Although it fractures conchoidally, leaving recognizable attributes such as a bulb of percussion, an éraillure scar, and concentric ripples, these features are not as well defined as on finer-grained cherts, for example. The dolomitic limestone recovered from Pook's Hill was most likely collected from the limestone geology surrounding the site given that dolomite forms by the alteration of calcite by solutions rich in magnesium (Arem 1991: 67, 128, 132; Bishop et al. 1999: 69, 205). Based on its flaking qualities and possibly the size of the fragments recovered from the limestone matrix, dolostone was only used to produce simple flakes and was not incorporated into formal tool

production systems. This sedimentary stone is considered a locally available raw material.

## Quartzite

Finally, there was a very small quantity of quartzite, more accurately 'orthoquartzite' (Arem 1991: 140; Bishop et al. 1999: 198) recovered at Pook's Hill. This primarily white to whitish-cream coloured stone possesses a medium/coarse to coarse-grained texture, which is basically composed of tiny quartz crystals cemented together by silica, calcite or iron oxides (Bishop et al. 1999: 198). The quartzite found around PKH-1 likely originates in the limestone matrix. Some chert artefacts recovered from this site have some quartzite in them. Quartzite tends to demonstrate intercrystalline fracture and does not produce the clean, conchoidal fracture of finer-grained cryptocrystalline silicates. As such, the Maya were not using it to make formal tools.

# FORMAL TOOL TYPOLOGY AND ADDITIONAL CLASSES

The designation of a formal tool is based on the observation of recognized morphologies (technological/functional and stylistic traits) that adhere to the typology established for the lithic assemblage from Pook's Hill. This typology was developed based on the tool typology established at Colha in Northern Belize (Shafer and Hester 1983) and the tool descriptions from the Peten region of Guatemala at sites such as Tikal and Uaxactun (Kidder 1947; Moholy-Nagy 1976), as well as sites such as Barton Ramie (Willey et al. 1965), Altar de Sacrificios (Willey 1972), and Seibal (Willey 1978). Other tools that might not be considered 'formal' or pre-meditated in their design were also included in this category if they demonstrated unique, identifiable features related to morphological characteristics and/or functional performance. In addition to the formal tool types identified at Pook's Hill, other lithic artefact classes have been recognized. These consist of both bifacial and unifacial tool types and the waste material from tool manufacture, repair and recycling that do not conform to the formal tool classification.

# **Oval Bifaces**

These are the typical tear drop-shaped bifaces described at many sites throughout the Maya Lowlands (see 'celts', 'chopping tools' and 'choppers' below). They tend to be thin and mildly asymmetrically biconvex in cross-section; however, the biconvexity can be mildly planar on the ventral surface in some instances (McAnany and Peterson 2004: 284 refer to them as 'lenticular' in cross section). This biface type conforms to the smaller, narrower forms described by Shafer and Hester (1991: 89; Hester 1985) at Colha that were excavated from the Late Classic period workshops. While the butt end is converges to a mildly rounded end and often possesses at patch of cortex, the distal (bit) tends to be convex or rounded in plan view. Although these tools have been associated with agricultural activities (McAnany 1989; Shafer 1983), use-wear data from Marco Gonzalez and San Pedro (Stemp 2001, 2004a; Stemp and Graham 2006) suggest oval bifaces could be used for a wider range of activities.

#### **General-utility bifaces**

These thick, heavy bifaces have often been referred to as 'celts', 'chopping tools' or 'choppers' (Kidder 1947:Fig.61; Rovner 1975; Rovner and Lewenstein 1997:19; Thompson 1991:147; Willey 1972:157-161, 1978:105-108; Willey et al. 1965:423). They are both chronologically and spatially wide-spread throughout the Maya Lowlands, occurring in various forms at sites such as Uaxactun (Kidder 1947), Piedras Negras (Coe 1959), Altar de Sacrificios (Willey 1972), Seibal (Willey 1978) and Tikal (Becker 1973; Moholy-Nagy 1976) in Guatemala. They have also been recovered in Belize at Aventura, Santa Rita, Chan Chen, and Patchchacan (Andresen 1976), Barton Ramie (Willey et al. 1965), Colha (Shafer and Hester 1983), Pulltrouser Swamp (Shafer 1983), San Antonio (Shafer and Hester 1986), El Pozito (Hester et al. 1991), Altun Ha (J. Stemp, pers. comm. 2007), Stann Creek (Graham 1994), Ambergris Cave (Hult and Hester 1995; Stemp 2001), and Laguna de On (Masson 1993, 1997), as well as in Mexico at Becan (Thompson 1991) and Mayapan (Proskouriakoff 1962). Although the Colha chronology suggests that specific general-utility biface forms that are "... thick and heavy, with marked biconvex or diamond-shaped cross sections and carefully trimmed and shaped bits" (Hester 1985:200; also see Shafer and Hester 1991: 89) are Late Classic in date, such chopping tools are highly variable in form and are mainly recognizable as heavy bifacial tools in different chronological contexts. Their dimensions are variable, but they are usually thicker and heavier tools than the oval bifaces. Usually the distal or bit ends are much more severely damaged than other tool edges. My general-utility biface category is a combination of those described at Colha (Hester 1985; Shafer and Hester 1983, 1991) and the 'Chunky bifaces or celts' described by McAnany and Peterson (2004:285), which are thicker, heavier tools that are asymmetrically biconvex in cross section. Sometimes, large bifaces such as these will have the distal or bit ends ground down to produce slightly sharper more durable chopping tools. Grinding appears to be accomplished by smoothing the chipped distal ends of these tools using an abrasive sand, likely mixed with water.

## Lenticular, Lozenge and Bipointed Bifaces

The "Late Facet" of the Postclassic period heralds the disappearance of sidenotched points at Colha, and the bipointed lenticular ['lozenge', 'laurel leaf'] bifaces become the dominant lithic type (Hester and Shafer 1983:525, Fig.4, 533, Fig. 10a,b,f,g; Michaels 1989:151; Shafer 1985:282). Many of these tools, primarily the lenticular and lozenge bifaces made of chalcedony and chert, were finely flaked using soft-hammer percussion. However, the lenticular biface fragments from Pook's Hill seem to be a mix of the finer, thinner bifaces and the thicker, wider styles of this artefact type described from the Belize Valley (Willey et al. 1965: 416, Fig. 264, c-h) and other locations like Piedras Negras (Coe 1959: Fig. 3b, c, 3), Baking Pot (Ricketson 1929, Pl. 14d, e), and San José (Thompson 1939: 169, Pls. 25a, 11b, 3). But, as Willey et al. (1965:423) state, distinguishing between the thicker variety and the thinner variety is quite subjective or arbitrary.

#### **Biface Preforms**

These are lithic pieces that represent any stage in the manufacturing process of a specific biface form after the initial or most preliminary modification of the flake/blade blank or nodule (Muto 1971; see Callaghan 1979). Preforms were typically not continued to their final form due to flaws in the raw material, a non-repairable manufacturing error (see Shafer and Oglesby 1980: Figs.5, 13), accidental loss, or intentional discard.

## **Re-used and Recycled Bifaces**

These are tools that would have originally been classed as other biface types, but that have experienced either a change in function or more obviously, a change in form. In most cases if the original tool type was identifiable, the artefact was classed in that category. The secondary, tertiary, etc. uses were also documented based on observable characteristics. Use-wear analysis of these tools will be documented separately. Tools that are considered expedient or *ad hoc* may fall into this category (see Dockall and Shafer 1993; McAnany 1986). These tools were typically either exhausted for their primary task, broken during use, or recovered after accidental loss or intentional discard. *Ad hoc* or recycled tools may have been used to perform tasks other than those for which they were originally designed, or used as sources of raw material. Most of the tools in this category were recycled into hammerstones (see Hult and Hester 1995; Stemp 2001).

## Thick, Narrow Bifaces

Thick, narrow bifaces are typically bifacially flaked tools that have asymmetrically biconvex transverse cross-sections with nearly parallel (or mildly expanding/tapering) sides. They will usually be around 3-4 cm thick and 3-4 cm wide. A specific sub-category of these bifaces will have a long, thin flake removed from one end, usually extending from the distal (bit) end along the longitudinal midline/dorsal spine of the tool. This flake scar that is typically produced on the dorsal surface often possesses a hinge termination. Elsewhere, Stemp (2002: 164, 165, 2004c: 110, 111) has referred to this thinning of the tool end as 'fluting' for lack of any better description. Willey et al. (1965: 430) describe it with the bit end having "... a characteristic gouge-like channel on one of its wider surfaces. The channel has been made by removing a single long flake". The extreme rounding or grinding/smoothing of the lateral margins and flake scar ridges is likely the product or use and/or hafting (see Mitchum 1991: 46). More complete examples are described by Willey et al. (1965: 424, Fig. 270: a-e, 430, 433, 435, Fig. 276, h-m) as bifacial gouges. They have been noted at Tikal and Baking Pot (Willey et al. 1965:433; Ricketson 1929, pl. 14a, k). Another sub-category, referred to as small bifacial chisels, are also identified at Barton Ramie. They are more tapered at both ends with more rounding or blunting (Willey 1965: 431, Fig. 274e-g, 433). There does not appear to be the extreme channelling as seen on the 'gouges'.

## **Bifacial Adzes**

These typically large, heavy tools are typically plano-convex to plano-triangular or mildly plano-trapezoidal in cross-section with a triangular to somewhat rectangular outline. Most of the flaking is bifacial. The distal end is produced by removing a single transverse flake across the face of the tool, but at least some other flaking is also present. The angle of intersection of this distal (bit) end surface and the ventral surface of the tool is at least 65° or more (see Shafer 1991: 33). As an adze, this tool is intended to be hafted with the plane of the bit end or blade parallel with the ground surface at a 90° angle to the shaft or handle. Some other examples are noted from the Belize Valley (Willey et al. 1965: Figs. 270h-k, 274d).

# Stemmed Thin Bifaces

Stemmed thin bifaces are bifacially flaked complete tools or proximal or medial fragments thereof that are less than 1.5 cm in thickness and possess a long or tapered stem for hafting purposes. Some of these forms may resemble lozenge-shaped bifaces from Colha (see above).

# Miscellaneous Bifaces and Biface Fragments

This is a catch-all category for those bifacial tools that do not fit the criteria for any other identified biface category or that have been modified or damaged to such an extent that their original form is no longer recognizable.

*Miscellaneous thin bifaces*. This category of tools is composed of those tools or fragments of bifaces less than 1.5 cm thick that cannot be accurately assigned to any other tool category. In the majority of cases, these fragments represent either a medial edge fragment, a distal tip fragment, or the proximal/stem section of broken tools that have been traditionally classified as projectile points, knives or lanceolate bifaces. The thin biface fragments recovered appear to be from tools that were originally produced using soft-hammer percussion, such as that associated with antler or wooden billets and/or some finer pressure flaking.

*Miscellaneous thick bifaces*. Much like the miscellaneous thin biface category, this is primarily a catch-all tool class for medial edge fragments, distal tip fragments and biface stems thicker than 1.5 cm that were not complete enough to be included in any other tool category. Many of these fragments were probably edges from oval, general-utility, or adze form bifaces. The miscellaneous thick biface fragments generally exhibit similar reduction techniques to those associated with the large, thick bifaces, particularly the oval and general-utility tools. Based on the original bifacial scarring on these fragments, tool production was accomplished using percussors that ranged in density from heavy hammerstones to some 'lighter' or 'softer' hard-hammers, such as the limestone hammers described above.

*Biface edge fragments*: These primarily thick edge flakes were either failed attempts at bifacial thinning, re-sharpening flakes on large bifaces, or the result of use-related impact. They possess a smooth interior surface with a pronounced bulb of percussion sometimes including an éraillure scar, and end in a feather termination. The striking platform for these flakes is located on one of the original faces of the biface from which they were removed. Often a ring-crack is observed on the biface surface where impact occurred and suggests that the re-sharpening attempts were undertaken using a hard-hammer percussor or were the accidental result of impact upon contact with a hard material (i.e. stone or wood). The exterior surface of these flakes is covered in flake scars from earlier bifacial thinning events on the tool. The edge where originally the interior and exterior surfaces met usually possesses heavy crushing, as well as both step and hinge termination scars.

## Flakes and Flake Tools

*Cortical and non-cortical flakes.* Flakes were removed from tools, cores, other larger flakes, or blades. They can generally possess any combination of length and width, but are usually thin in cross-section. In order to be classified as a flake, a piece must be unretouched and possess one or more of the following technological features: a striking platform, a bulb of percussion, an éraillure scar, concentric rings on the interior surface [Hertzian cone (Tsirk 1979)] (Andrefsky 2005: 19, Fig. 2.7; Crabtree 1972:64). Distal ends of flakes will possess either: feather, step, hinge, plunging, or snap terminations (Cotterell and Kamminga 1987; Cotterell et al. 1979). Flakes are usually discarded as waste material in the lithic manufacturing process, but they can be used as *ad hoc* tools or modified into other tool forms. Flakes were identified as whole if they were at least 90 % complete and possessed part of a striking platform. In most instances, incomplete whole flakes were missing part of the distal tip, the striking platform, or one lateral edge.

Non-cortical flakes possess none of the original cortex or stone rind on their exterior surface (Andrefsky 2005 106; McSwain 1989:117). In this analysis, non-cortical flakes have been termed 'tertiary' (Magne 1989:17; Odell 1989:195; Sullivan and Rozen 1985:756). They are generally considered to be products of later phases in tool production.

Cortical flakes possess one or more of the technological features described above, in addition to some cortex on their exterior surface (Andrefsky 2005: 103-106; McSwain 1989:117, Sheets 1975:375). The percentage of cortex on the exterior surface can range from 100 % [total coverage] to less than 1 %. While the amount of cortex retained by a flake has been used to determine its stage in the reduction process of lithic tool manufacture (Collins 1975; Sheets 1975; see Odell 1989; Mauldin and Amick 1989), factors such as the original shape of the stone nodule, and the type of tool manufacture [i.e. soft-hammer bifacial thinning vs. hard-hammer flake production] can affect the amount of cortex possessed by a flake. A special type of cortical flake called a 'citrus' or 'citrus peel' flake has what is essentially a rind of cortex that may occur completely or partially around the edge of the tool (Aldenderfer 1991b: 126, Fig. 3). When viewing this flake from either the ventral or dorsal surface, its appearance is similar to an orange or lemon slice. This is completely different from the 'orange peel' or tranchet-bit flake resulting from adze production described by Shafer (1976).

In this analysis, a flake possessing 100 % cortex on its exterior surface is termed 'primary'. Flakes possessing between 99 % and 1 % cortex are termed 'secondary' (Magne 1989:17; Odell 1989:195; Sullivan and Rozen 1985:756). Secondary cortex flakes are coded 'secondary 2' if they possess less than 50 % cortex on the exterior surface and 'secondary 3' if they possess between 50 % to 99 % cortical covering on the exterior surface. Tools coded 'primary' are believed to be the earliest phase of reduction, while those coded 'secondary 3' and 'secondary 2' are considered to be subsequent, but not necessarily rigidly ordinal, reduction stages.

Although it is understood that percentage of cortex is not solely restricted to a specific stage in reduction, studies have revealed that cortex in any amount is overwhelmingly present in early reduction stages and only rarely in others, especially in biface production (Magne 1989:17; Mauldin and Amick 1989:67; Odell 1989: 185). According to Tomka (1989:141, Fig. 2), while the highest percentage of flakes with 1-50 % cortex are produced by core reduction with no specific pattern of decortication, biface production produces the highest aggregate percentage of flakes with variable cortex coverage.

It is understood that classification of reduction into stages is not as definitive as some believe due to factors such as raw material type and/or availability, core size, the intensity of reduction, the nature of regional raw material procurement and reduction systems, and stylistic and functional factors (Sullivan and Rozen 1985:756). However, cortical flake categories can be utilized to determine the general reduction patterns occurring in the assemblages. The subdivision of cortical flakes into stages is done for ease of technological analysis, since tool manufacture is seen to occur as a continuous process (Muto 1971; Sheets 1975; Shott 1996).

*Macroflakes*. Traditional macroflakes, like those described from Colha, are typically larger than 30 cm in length (Shafer 1979:58, 1985; Shafer and Hester 1983:524) and may be cortical or non-cortical. In the Maya lithic industry of Northern Belize, they usually serve as blanks for the manufacture of other tool forms such as large bifaces, but may be used as *ad hoc* tools. At Pook's Hill, large flakes (typically around 12 cm or larger) have also been termed macroflakes as they are substantially larger than the mean average of recovered flake sizes. These flakes are large enough to have served as blanks for smaller bifaces, points, or other tools.

*Bifacial thinning flakes or re-sharpening flakes (percussion).* These pieces are primarily thin flakes removed from bifacial tools in an attempt to modify, reshape, repair, or resharpen the original tool. Bifacial thinning flakes may possess various amounts of exterior surface cortex, although they are restricted to categories 'secondary 3 and 2' and 'tertiary' flakes (see Root 2004: 73), and represent later stages in the reduction process. Bifacial thinning flakes have been identified in this assemblage based primarily on the possession of part of the bifacial edge of the original biface (Shafer 1983; McAnany 1986, 1989). These flakes were removed using billet or soft-hammer percussion technique. The varieties of flakes in this category predominantly possess the lipped striking platforms similar to those recovered from the Early Postclassic workshop deposits at Colha (Shafer 1979; Shafer and Hester 1983:531; Crabtree 1972: 74; Hayden and Hutchings 1989:247) and often correspond to the Distinctive Expanding Billet flake

variety described by Hayden and Hutchings (1989:246, Fig.6). However, 'harder'hammer percussion flakes (Hayden and Hutchings 1989:249) possessing striking platforms that are bevelled at right angles to the tool surface are also included. These platforms usually exhibit cone-like fractures indicative of a small contact surface, as well as ring-cracks that characterize flakes recovered primarily from Preclassic and Late Classic deposits at Colha (Shafer and Hester 1983:524, Fig.6a, c-e). Typically, these flakes possess a non-cortical faceted platform with a bending initiation (Root 2004: 73, Table 4.1), although some hard-hammer exceptions have been noted. Bifacial thinning flakes can be used as *ad hoc* tools; however, they were rarely modified into other tool forms, per se. Small, end-stage bifacial thinning flakes associated with bifacial shaping, classified as stage 5 by Callahan (1979) can be the product of percussion or pressure flaking (see 'Bifacial thinning or shaping (pressure)' below).

*Bifacial thinning or shaping flakes (pressure).* Flakes placed in this category are usually small and thin, typically less than 1 cm in size in Maya assemblages I have seen. The striking platforms of these flakes are typically faceted or ground to some degree. In fact, these flakes are difficult to recognize if the striking platform is absent (see Root 2004: 73). According to Root (2004: 73-74, Table 4.1): "Flakes produced early in pressure flaking have multiple scars on their dorsal surfaces and are curved in long section and slightly expanding, or petaloid, in plan view. Flakes produced during final bifacial pressure flaking have parallel sides and a single dorsal arris than runs from platform to distal tip".

*Unifacial retouch flakes.* In order for these flakes to be properly identified in an assemblage, they must be at least 80% complete, with, at least, part of the striking platform present. These flakes tend to be small, often under 1 cm in length and width. Additionally, Root (2004: 75, Table 4.1) includes seven other attributes to identify unifacial retouch flakes: "1. feather terminations; 2. single-faceted, non-cortical platforms; 3. plano-convex to bi-convex cross sections; 4. parallel to expanding lateral flake margins; 5. long sections that are straight with a slight curve sometimes present only at distal end; 6. at least two dorsal flake scars that originate from the same direction as the flake; and 7. an axis of percussion that is about 90 degrees".

*Retouched flakes and macroflakes.* These may be cortical or non-cortical flakes or macroflakes that have been deliberately retouched through percussion- or pressure-flaking and may have been modified into another tool form. There is no specific shape or size for the individual tools, nevertheless, those that are classed together will share certain morphological and/or technological similarities [i.e. denticulated, notched]. Denticulated flakes usually possess at least one edge that has been unifacially flaked or retouched into a 'sawtooth'-like profile. Although, bifacial denticulation is possible, it is rare. Notched flakes typically exhibit an obvious concavity in at least one lateral margin and rarely on the distal end. This concavity is the result of unifacial retouch of the tool to produce a steep, semi-circular edge. The flake scars within the notched zone are often stacked with step and hinge-shaped terminations. Notching can typically occurs on the dorsal surface, but can appear on the ventral surface as well.

## **Blades and Blade Tools**

Blades. Blades are defined as any flake that was produced using a prepared core and blade technique (see Crabtree 1968). Technologically, blades will likely possess some or all of the following: parallel or sub-parallel lateral margins, dorsal flake ridges that are parallel or sub-parallel with the lateral margins, at least two flake-removal scars evident on dorsal surface, an axis of applied force which is approximately parallel with flake margins, a length-to-width ration of at least 2:1, and plano-convex, plano-triangular, plano-rectangular or plano-trapezoidal cross sections (Andrefsky 2005: 253; Crabtree 1972: 42; Root 2004: 75, table 1). Complete blades or proximal blade fragments possessed technological features similar to flakes including: striking platforms, ringcracks, éraillure scars, a bulb of percussion, and concentric rings [Hertzian cone (Tsirk 1979)]. Some medial and distal fragments also possessed concentric rings, while distal fragments primarily ended with feather terminations (Cotterell et al. 1979). In some instances, step, hinge and outre-passé terminations were also possible (Cotterell and Kamminga 1987). Blades are smaller than macroblades, usually measuring less than 10 cm in length (Shafer 1979:63). Blades may be used as *ad hoc* tools or modified into other tool forms. Some blades may retain portions of cortex, but this is rather rare. The crosssections of blades may be used to determine relative stages of core reduction with planotriangular cross-sections indicative of early stage removal and plano-trapezoidal crosssections indicative of later stage removal (Hartenberger and Runnels 2001).

*Bladelets or microblades.* A bladelet is small flake that possesses a length at least twice its width and that was produced using a prepared core (microcore) and blade (bladelet) technique (see Crabtree 1968 for blades; Andrefsky 2005: 258). These tools were mostly either triangular or trapezoidal in cross-section, but with some possessing more than two exterior ridges. Bladelets are usually short and parallel-sided. Complete bladelets or proximal bladelet fragments will possess the same technological features described for blades and flakes [see above]. Also like blades, some medial and distal bladelet fragments may possess concentric rings, while distal fragments primarily ended with feather terminations (Cotterell et al. 1979). In some instances, step, hinge and outre-passé terminations were also possible (Cotterell and Kamminga 1987). Whole bladelets usually measure less than 5 cm in length and less than 1-0.75 cm in width. Bladelets may be used as *ad hoc* tools or modified into other tool forms. Some bladelets may retain portions of cortex, but this is rather rare.

*Retouched blades*. These are blades that possess one or more sections that have been deliberately modified primarily by pressure-flaking, or less frequently by percussion flaking. The blades have not necessarily been changed into another specific tool form, but have retained their general shape. Backed blades are included in this tool category. Blades that were unifacially retouched on the proximal end resembled examples from the Late Classic deposits at Colha and were classed as stemmed blades (see below). Similar to tools on flakes, the blades or blade fragments could also be deliberately modified into other tool forms. Comparable tool forms are not necessarily standardized, but usually possess similar shapes or features.

*Stemmed blades*. Stemmed blades, usually much smaller and less well made than the Late Preclassic macroblades, appear in Northern Belize at sites such as Colha, Cuello, Northern River Lagoon, Lamanai, Kichpanha, San José (Hester 1982:199), El Pozito (Hester et al. 1991:74), Pulltrouser Swamp (McAnany 1989: 335) and coastal sites on Ambergris Caye (Hult and Hester 1995; Stemp 2001), but are also widely spread throughout the Maya world. At the Operation 2007 workshop from Colha, the stemmed blades average 71 mm in length, 25 mm in width, and 8 mm thick (Roemer 1991:58). However, Shafer and Hester (1983:531) noted that these artefacts varied in length from 6 to 12 cm. Most of the stemmed blades possess only one exterior ridge and are planoconvex in cross-section (Roemer 1991:58). Unifacial distal retouch is the typical technique employed to produce a point on these tools (Roemer 1991).

*Macroblades*. The term macroblade is used to distinguish the larger blade production in the later Middle and Late Preclassic from the smaller prismatic blade production in the Late Classic. The macroblades from Middle Preclassic deposits at Colha are large and wide (averaging 15 cm long by 6.5 cm wide) with a simple single facet or cortical platform. They were produced using the hard-hammer percussion method and may be modified by further retouch, often unifacial, to produce other tool forms or as parent cores for the removal of burin spalls (Potter 1991:21,23, Fig.2f,g, 24; Shafer and Hester 1983). Macroblades were also used as the blanks for the manufacture of other tool types diagnostic of the Middle Preclassic found in the biface sub-assemblage. Macroblade blanks from the Late Preclassic have been described as "... large prismatic flakes, usually ranging between 100 and 300 mm long, which were systematically removed from a specially prepared core. Their length tends to be over twice the width and one or more medial ridges are found on the dorsal surface ..." (Shafer 1979:63; see also Shafer 1991:33; Shafer and Hester 1983:529). Macroblades usually served as blanks for the production of stemmed macroblades; however, some may have been used as tools themselves.

*Retouched macroblades.* These are macroblades that have been intentionally retouched on one or more edges. Retouched macroblades have not necessarily been modified into other identifiable tool forms, as such tool forms are included under other tool classes.

*Stemmed macroblades*: Large stemmed macroblades; also referred to as 'daggers' or tanged macroblades, are known from such Northern Belize sites as: Ambergris Caye, Cuello, Colha, Kichpanha, Laguna de On, Northern River Lagoon, Pulltrouser Swamp, San Estevan, Nohmul, Chan Chen, Cerros Beach, Cerros, San José, Louisville, Sarteneja, Boom and Santa Rita Corozal (Andresen 1976; Dockall and Shafer 1993; Hester 1982; Hester et al. 1991; Hult and Hester 1995; Lewenstein 1987; McAnany 1986, 1989b; Masson 1993; Mitchum 1991, 1994; Mock 1994; Potter 1993; Rovner 1975; Shafer 1982, 1991; Shafer and Hester 1983:524). The examination of specimens from Pulltrouser Swamp has shown their use as spear points and knives (Shafer 1983).

The modified macroblade occurs in various shapes, but the only formal macroblade tools are those with bifacially chipped stems that account for one third of the total tool length (Shafer 1991:35). The smallest forms of this tool may not possess bifacially retouched stems (Mitchum 1991:46). Examples of outline variation are the

rounded shoulder, slightly tapering stemmed macroblades from Cerros (Mitchum 1991:46), and the contracting stem variety from El Pozito (Hester et al. 1991:72). The tool's cross-section is described as lenticular to slightly convex in shape (Shafer 1991:38).

Stemmed macroblades are made on macroblade or, less commonly, on macroflake blanks and are manufactured by hard-hammer percussion (Shafer 1991:38). The majority of these tools were made on larger blades from opposed platforms of larger prepared cores. The striking platform of the blade was reworked into the stem of the macroblade (Mitchum 1991:46).

*Flake-blades, macroflake-blades, and flake-bladelets.* A flake-blade, macroflake-blade, or flake-bladelet is defined as any flake that possessed a length at least twice its width. However, it was not produced using a prepared core, macrocore, microcore, macroblade, blade, or bladelet technique, but was usually struck from an unprepared simple flake core. Consequently, the sides of these tools are rarely parallel. The resultant flake may have been produced accidentally; however, it is usually struck from a core using a direct percussion technique. There can be many or no previous flake scars on the dorsal surface of a macroflake-blade, flake-blade, or bladelet depending upon when in the reduction continuum it was produced. All of the technological attributes described for flakes, blades and bladelets may be used as *ad hoc* tools or modified into other tool forms. Some of these tools or fragments may retain portions of cortex on their dorsal surfaces.

# **Other Tool Types – Unifacial/Bifacial**

*Burins (gravers/incisors).* Burinated tools are either flakes or blades, or fragments thereof that have been deliberately produced by the removal of an edge with a transverse blow. This transverse blow creates the right angled longitudinal flake-scar that intersects with the other transverse tool edge or breakage plane to form the burin. Burins are traditionally seen as having been used to engrave or chisel hard materials, such as bone or antler (Andrefsky 2005: 161).

*Scrapers*. The tools classified as scrapers were identified by the presence of at least one edge that was deliberately retouched to a minimum 55 degree angle. In the majority of instances retouch is no the dorsal surface; retouch is almost always unifacial.

*Drills and borers*. These tools are typically produced on the distal ends of blades or flakes; however, lateral margins and proximal ends of flakes or blades may be retouched into points suitable for rotary motions. Often, the 'drill bit' sections of the blades are unifacially retouched on the dorsal surface to form a point with steep margins, but some alternating dorsal-ventral retouch may also provide the same result. Microdrills are produced on small flakes or microblades. Drilling tools may also be produced on polyhedral microcores or through the bipolar reduction of small nodules/pebbles (Aldenderfer 1991a: 208).

## **Blocky Fragments**

This category of artefacts is essentially a catch-all classification for those lithics that are not included in any of the other categories. In the majority of instances, blocky fragments are manufacturing or refurbishing debitage or tool fragments that no longer retain identifiable technological characteristics that permit placement in another lithic category (see Root 2004: 73, Table 4 for 'shatter' or McAnany and Petersen 2004: 292 for 'angular debris'). Often a single interior surface is not identifiable and it is difficult to easily identify or distinguish proximal or distal ends relative to the parent or objective piece from which they were removed. Typically, bulbs of percussion are absent features as well. Their shapes and sizes vary considerably as does their stage in the reduction processes, although they are most commonly associated with simple core reduction. Some blocky fragments do possess cortex. Some were used as *ad hoc* tools.

#### **Burin Spalls**

Typically, these are thin, narrow flakes that were produced during the manufacture or repair of a burin or burinated tool (see above). The spall is produced when a piece of stone is removed transversely from the longitudinal edge/margin of a flake or blade to create a right angle on the parent piece from which the spall is removed. Often, two flakes (spalls) are removed at right angle to one another to create the burin (Andrefsky 2005: 254). The burin spall is usually the debitage or waste material from this technique (Stemp 2001: 24). The burin spall can be used as an *ad hoc* tool. In the Maya area, burin spalls have been used to drill or perforate hard materials like shell (Iannone and Lee 1996; Hohmann and Powis 1996; Shafer and Hester 1991).

## Heat Spalls or Heat-fractured Fragments

These lithic pieces are produced when an artefact is heated or burnt (Mandeville 1973; Purdy 1974; Purdy and Brooks 1971; Rasic 2004: 116-127). They do not possess any of the technological characteristics of flake production and exist in two forms. The true spalls or 'pot lids' usually possess a smooth bulbar interior surface that has literally popped off its parent piece. The other heat-fractured fragments usually possess very coarse, uneven interior surfaces revealing evidence of heat fracture and heat-crazing or cracking. Curved or wavy (crenated) fractures are sometimes also present on thermally altered lithic artefacts (Purdy 1975). Due to the heat modification of the internal structures of these pieces, they are rarely used as tool themselves or modified into any other form.

## Flake, Blade, and Flake-blade Cores and Core Fragments

These are the remnant lithic masses or parent pieces of stone from which flakes and blades are removed. Cores and fragments thereof may be produced by random, multidirectional blows with little attention devoted to the appearance of the resultant flakes or blades or they may be produced in specific ways to manufacture flakes or blades of specific shapes or dimensions (i.e.: prismatic blade cores). The formal core types included in this analysis included: polyhedral blade cores (see Crabtree 1968; Sheets 1975), polyhedral bladelet cores, pyramidal flake cores, discoidal flake cores, macroflake cores, blade cores, flake-blade cores, flake-bladelet cores and macroblade cores. Often exhausted cores and core fragments are discarded as waste materials; however, they may serve as *ad hoc* tools such as hammerstones or be modified into other tool forms.

## **Core Tablets or Platform Rejuvenation Flakes**

Core tablets are produced when a blade core, typically a polyhedral blade core, is struck a side blow perpendicular to the long axis to remove the proximal or platform end of the core. This technique is employed to create a new striking platform for the removal of more blades on nearly exhausted cores or those with damaged or reduced striking platforms (Crabtree 1972:60).

## Hammerstones

Chert hammerstones are not restricted to any temporal period, and may be found throughout the chronological range of artefacts in the Maya Lowlands. These hammerstones usually appear as either battered nodules or recycled cores with heavy battering on one or more of their edges (Mitchum 1991:50; Shafer 1991:40; Willey et al. 1965: Fig. 278h); however, exhausted bifaces or biface fragments may also be recycled into hammerstones (Hult and Hester 1995; Stemp 2001). At Pook's Hill, chert hammerstones have been identified based on extensive crushing or pitting of one or more surfaces or edges.

## **GENERAL OBSERVATIONS: TOOL TYPES AND RAW MATERIALS**

When considering the patterns of tools production at Pook's Hill in relation to raw material types certain patterns emerge that are worthy of note prior to discussing the lithic assemblage at this site in greater detail. Of the 2800 lithic artefacts recovered, 1605 (57.3 %) were produced from 'local' chert, 125 (4.5 %) were made from 'river cobble' chert, 77 (2.8 %) were manufactured from chalcedony, 3 (0.1 %) were made form 'river cobble' chalcedony, 4 (0.1 %) were produced on imported/non-local chert, 949 (33.9 %) were of 'unknown' chert or chalcedony types, 31 (1.1 %) were manufactured from dolomitic limestone and 6 (0.2 %) were made from quartzite. Not surprisingly, local chert is represented in all tool classes based on its availability and the general ease with which it can be transformed into standardized formal tools and more informal or *ad hoc* flake tools. Large bifaces of different types, both thin and thick, and various forms of smaller bifaces are regularly made form local chert. Local chert preforms and flaking debitage all point toward the manufacture of formal tools at the site as do the blades and single blade core fragment.

'River cobble' chert, although less abundant than local chert, is also used to produce formal tools. In this case, large bifaces (oval, general utility), adzes, and some

Table	1
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Tool type	Local chert	'River cobble' chert	Chalcedony	'River cobble' chalcedony	Non- local/importe d chert	'Unknown' chert or chalcedony	Dolomitic limestone	Quartzite	Total
Oval bifaces	15	16	0	0	0	9	0	0	40
General-utility	28	8	0	0	0	6	0	0	42
Ground-bit celts	1	1	0	0	0	0	0	0	2
Biface hammerstones	1	0	0	0	0	1	0	0	2
Lenticular bifaces	4	0	0	0	1	3	0	0	8
Thick, narrow bifaces	12	0	0	0	0	2	0	0	14
Bifacial adzes	8	2	0	0	0	1	0	0	11
Stemmed thin hifaces	6	2	1	0	0	1	0	0	10
Miscellaneous thin hifaces	14	1	2	0	0	17	0	0	34
Miscellaneous thick	17	5	1	0	0	17	0	0	40
Biface edges	38	0	4	0	0	11	0	0	53
Biface preforms	6	1	0	0	0	4	0	0	11
Bifaces recycled into hammerstones	1	0	0	0	0	0	0	0	1
Drills	14	0	0	0	0	8	0	0	22
Gravers	0	0	0	0	0	2	0	0	2
Scrapers	2	0	0	0	0	3	0	0	5
Macroblades	1	0	0	0	0	3	0	0	4
Retouched macroblades	0	0	0	0	0	1	0	0	1
Stemmed Macroblades	0	0	0	0	0	2	0	0	2
Blades	12	0	2	0	0	10	0	0	24
Retouched blades	2	0	0	0	0	1	0	0	3
Stemmed blades	1	0	0	0	0	0	0	0	1
Total	183	36	10	0	1	102	0	0	332

Table 1:	Formal	tool	types	by raw	material	type at	Pook's Hill.

Table	2
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Tool type	Local chert	'River cobble' chert	Chalcedony	'River cobble' chalcedony	Non- local/importe d chert	'Unknown' chert or chalcedony	Dolomitic limestone	Quartzite	Total
Flakes (100% cortex)	20	2	0	0	0	11	0	0	33
Flakes (>50% cortex)	67	7	4	0	0	21	2	0	101
Flakes (<50% cortex)	285	38	21	2	0	85	6	0	437
Flakes (0% cortex)	386	4	26	0	2	260	16	1	695
Bifacial thinning flakes (<50%	23	12	0	0	0	10	0	0	45
Bifacial thinning flakes (0% cortex)	85	0	8	1	0	50	0	0	144
Macroflakes (>50% cortex)	1	0	0	0	0	1	0	0	2
Macroflakes (<50% cortex)	1	0	0	0	0	0	0	0	1
Macroflakes (0% cortex)	1	0	0	0	0	0	0	0	1
Retouched flakes (>50% cortex)	3	1	0	0	0	1	0	0	5
Retouched flakes (<50% cortex)	5	0	0	0	0	3	0	0	8
Retouched flakes (0% cortex)	11	0	1	0	0	4	0	0	16
Notched flakes (<50% cortex)	0	0	0	0	0	1	0	0	1
Notched flakes (0% cortex)	0	0	0	0	0	1	0	0	1
Flake-blades (>50% cortex)	2	0	0	0	0	0	0	0	2
Flake-blades (<50% cortex)	4	3	0	0	0	6	1	0	14
Flake-blades (0% cortex)	15	0	0	0	0	11	2	0	28
Macroflake-blades (0% cortex)	0	0	0	0	0	1	0	0	1
Flake-bladelets (0% cortex)	3	0	0	0	0	2	0	0	5
Retouched flake- blades (0% cortex)	1	0	0	0	0	0	0	0	1
Bifacial thinning pressure flakes (0%	1	0	0	0	0	0	0	0	1
Unifacial retouch flakes (0% cortex)	4	0	0	0	0	1	0	0	5
Burin spalls	1	0	0	0	0	0	0	0	1

Simple flake cores	21	1	0	0	1	4	0	0	27
Discoidal flake	4	0	0	0	0	0	0	0	4
cores									
Simple flake core fragments	125	4	0	0	0	26	0	0	155
Pyramidal flake core fragments	2	0	0	0	0	0	0	0	2
Discoidal flake core fragments	1	0	0	0	0	2	0	0	3
Flake-blade core fragments	2	0	0	0	0	0	0	0	2
Blade core fragments	1	0	0	0	0	1	0	0	2
Blocky fragments	320	16	7	0	0	289	4	5	641
Blocky fragments recycled into	1	0	0	0	0	1	0	0	2
Potlids and burnt fragments	10	0	0	0	0	51	0	0	61
Simple flake cores recycled into	9	0	0	0	0	0	0	0	9
Simple flake cores recycled into	3	0	0	0	0	2	0	0	5
Hammerstones	2	0	0	0	0	0	0	0	2
Hammerstone fragments	2	1	0	0	0	2	0	0	5
Total	1422	89	67	3	3	847	31	6	2468

Table 2: Informal tool types by raw material type from Pook's Hill.

thinner bifaces constitute primary tool types made from this raw material. There are some flakes, simple flake cores fragments and a flake core, but informal tool production is less frequently represented.

Chalcedony was used to manufacture some formal tools, primarily thin bifaces, but is also represented by some blade fragments. Production debitage occurs in the form of flakes and blocky fragments, but no chalcedony cores or core fragments were recovered during excavations.

There are very few lithic artefacts made from 'river cobble' chalcedony at Pook's Hill. It appears this raw material was not necessarily that abundant or was not chosen form some possibly technological reason. This raw material type is represented by flakes and flake fragments, one of which is a tertiary bifacial thinning flake, which implies the use of 'river cobble' chalcedony in biface manufacture. There may also be another reason why this raw material is not heavily represented in the assemblage at Pook's Hill. Both chert and chalcedony from Roaring Creek were primarily identified based on their exterior cortical rinds. If an artefact did not retain some cortex, it was usually not classified as a 'river cobble' material.

Non-local/imported stone is rare at this site. It is assumed the lenticular biface at Pook's Hill was imported in finished form. The other lithics are so few in number that it

is difficult to say anything more substantial about them, with the exception of their origins outside the local vicinity.

Interestingly, Andrefsky's (2005: 159, Fig. 7.13) expectation that a high abundance of both high and low quality cherts should result in the production of both formal and informal tools in an assemblage holds true for Pook's Hill. Moreover, due to the relative ease of access to abundant, good quality stone for chipped tool manufacture, there is little effort to substantially curate tools (see below).

Although most lithic artefacts are patinated to some degree and many show traces of burning, only those tools that are heavily burnt and/or completely patinated were classified as 'unknown'. In reality, they could be of various types of stones from many different locales. Because there are no obvious burning or patination patterns by raw material type and that some tools in all classes are found in this category, it does not reveal a substantial degree of information about relationships between stone types and tool types.

Dolomitic limestone was restricted to informal core reduction to produce expedient flakes. Only cortical and non-cortical flakes and flakes-blades and some blocky fragments made form this raw material were recovered from the site.

Similarly, the crystalline structure of quartzite influenced Maya stone tools production with this raw material. At Pook's Hill, quartzite is restricted to informal tool production in the form of one tertiary flake fragment and some blocky fragments.

In terms of basic technological/morphological sub-divisions within the assemblage, the non-obsidian lithic artefacts were classified as formal (332 or 11.9%), while the remaining were considered informal tools (2468 or 88.1%). Formal tools included large and small bifaces, biface edges, blades, biface preforms, some drills, gravers, and scrapers, stemmed macroblades and stemmed blades, whereas informal technology was primarily represented by production debitage (i.e. flakes, cores and blocky fragments, and a small number of minimally modified, primarily unifacially retouched flakes or flake-blades).

# **Oval Bifaces**

A total of 40 oval bifaces and biface fragments were recovered from Pook's Hill. In terms of raw material, oval bifaces were primarily manufactured from chert (37.5%) and 'river cobble' chert (40.0%), with a lesser quantity of bifaces (22.5%) classified as 'unknown' chert or chalcedony based on extreme burning and/or patination. Cherts tended to be fine-grained or medium-grained. The 'river cobble' chert was in fact favoured for the production of these bifaces, at least in part due to cobble size. It is possible some longer flatter cobbles were chosen to produce these tools. This supposition is partly based on the morphology of the bifaces themselves and the high percentage of cortical 'river cobble' flakes (92.2%) and cortical bifacial thinning flakes (100.0%). This frequency of different flake types of 'river cobble' chert suggests little reduction of 'river' cobble' chert flakes (n = 63) coupled with the absence of any tertiary bifacial thinning flakes raise the possibility that river cobbles may have been reduced on the banks of Roaring Creek and the finished bifaces were transported back to the *plazuela*. By contrast, the slightly higher percentage of non-cortical flakes in the assemblage (see below) suggests some macroflakes of local chert, were used as the 'blanks' for oval biface production. Overall, there is minimal evidence for extreme tool use in terms of edge crushing or steep bit end angles. The only clear evidence for tool recycling based on technological evidence is the use of a medial core fragment as a core to produce simple flakes. The only whole oval biface recovered, made from 'river cobble' chert, measured  $13.4 \times 5.7 \times 3.0$  cm.

## **General Utility Bifaces**

There were two whole general-utility bifaces, 40 biface fragments and one fragment used as a hammerstone recovered from this site. Of these, 29 (67.4 %) were made from local chert, 8 (18.6 %) were 'river cobble' chert, and 6 (14.0 %) were made from unknown cryptocrystalline silicates. Overall the quality of the cherts varied from medium-fine to coarse. Many of the fragments (14 or 35.0%) were distal ends, suggesting that at least some tools broke while being used in the *plazuela* itself or within its general vicinity. This is different from the pattern observed for oval bifaces, in which 33.3 % were proximal fragments and only 12.8 % were distal. The argument could be made that activities involving oval bifaces occurred more frequently at a distance from the *plazuela* and when bifaces broke, the distal ends were left behind. The suggestion that 'river cobble' chert oval bifaces may have been made away from the site is also a possibility for the general-utility bifaces based on the same debitage patterns noted above. In terms of use, these bifaces exhibit heavier damage on their bit ends, perhaps due to contact with harder materials. There is some evidence for re-sharpening of distal ends, but the only obvious examples of recycling involve the conversion of one of the chert whole bifaces into an ad hoc discoidal flake core and the use of the medial chert fragment as a hammerstone. The only complete whole biface of this type was made from local chert [10.9 x 6.3 x 4.0 cm].

# **Ground-bit Celts**

Only two of these celt fragments were identified in the assemblage from this site. Both were identified by the obvious, deliberate grinding/polishing on or near their distal ends. The medial fragment was manufactured from local chert, while the distal fragments were made from 'river cobble' chert. In terms of their morphologies and dimensions, the two tools are large, heavy bifaces, similar to general-utility forms. After breakage, there is no evidence that these fragments were modified or used again based on a macroscopic examination.

# **Lenticular Bifaces**

Eight lenticular bifaces were recovered from Pook's Hill. One was a whole tool manufactured from local chert; most fragments were medial (62.5 %). These tools were made from quite fine-grained stone. Half were made from local chert, while three were specimens of unknown chert or chalcedony. Interestingly, the only formal tool made from 'non-local/imported' chert was a medial lenticular biface fragment. It is well made and the stone is fine. Where it was produced is not known, but the raw material does not

resemble varieties that are classified as local. There is no evidence for curation of these fragments after breakage. The only whole lenticular biface measures  $8.1 \times 2.3 \times 0.9$  cm.

## Thick, Narrow Bifaces

Sometimes referred to as chisels or gouges, the thick, narrow bifaces constitute 0.5 % of the assemblage from Pook's Hill. There are 14 or these tools, of which two (14.3 %) are whole, three (21.4 %) are proximal fragments, seven (50.0 %) are medial fragments and two (14.3 %) are distal fragments. Most of these bifaces (12 or 85.7 %) were made of medium-fine to medium-coarse local chert. The remainder was classified as 'unknown' chert or chalcedony. The distal ends tend to be heavily ground or polished from use as do the lateral margins and some of the flake scar ridges on the dorsal and ventral surfaces. This rounding of the higher topography is most likely due to hafting. The distal ends also possess some flake scarring associated with use, but there is no evidence for tool recycling. Broken tool fragments were not employed for other activities. The average size of a whole thick, narrow biface from Pook's Hill is 12.1 x 3.2 x 3.3 cm.

## **Bifacial Adzes**

There was a total of eleven bifacial adzes and fragments thereof excavated from the site between 2001-2005. Most were manufactured from local chert (8 or 72.7 %), with two being made on chert river cobbles. The other adze fragment was classified as an 'unknown' cryptocrystalline silicate based on the severity of burning. Only two whole adzes and one distal end fragment, all of local chert, were recovered. The mean bit end angle on these tools was 66°; however, if the whole biface from Structure 1A is excluded from these calculations, the mean edge angle for adzes is quite steep  $(77^{\circ})$ . These tools ranged from plano-triangular in cross-section to mildly convexo-trapezoidal, and tended to be long and narrow. There is no evidence for tool curation, with the exception of some re-sharpening of the tools' distal ends. The dimensions of the two whole tools were 10.6 x 5.5 x 3.3 cm (from Str. 2A) and 15.5 x 5.1 x 2.7 cm (from Str. 1A). The whole biface from Structure 1A is morphologically different from the other tools and fragments as it tended to be longer and thinner and more finely made overall, with some grinding of the ventral surface near the bit end. The distal bit angle for this tool was approximately  $56^{\circ}$ , suggesting its use for wood-working activities required a sharper edge. None of the tools was obviously curated beyond some minor bit end repair.

# **Stemmed Thin Bifaces**

There were five whole stemmed thin bifaces and five fragments in the assemblage from this site. Of these, six were manufactured from local chert, two were made on 'river cobble' chert, one was made from chalcedony and one was classified as 'unknown' chert or chalcedony. These bifaces range considerably in size and shape; however, all possess an obvious long tang or stem. The mean dimensions in this class of bifaces were  $6.3 \times 2.6 \times 0.7$  cm. There is some evidence for edge re-sharpening or repair of these tools.

#### **Miscellaneous Thin Bifaces**

There were 34 miscellaneous thin bifaces or fragments of various shapes and sizes in this assemblage. The majority (27 or 79.4 %) were medial fragments that could have once been parts of a number of different types of thin biface. Given the morphological and technological attributes remaining on these fragments, it was not possible to place them in any more specific tool type. The one whole tool manufactured from local chert has some damage; therefore it was placed in this category. In terms of raw material classification, these bifaces demonstrate the following distributions: 14 (41.2 %) local chert, 1 (2.9 %) 'river cobble' chert, 2 (5.9 %) chalcedony, and 17 (50.0 %) 'unknown' chert or chalcedony. There is very little evidence to suggest the tools or fragments were reused or reworked after discard. The one notable exception is a local chert medial fragment that was notched on the lateral margin. This deliberate notching on the ventral surface of the tool fragment after breakage is an obvious example of recycling.

#### **Miscellaneous Thick Bifaces**

Similar to the miscellaneous thin bifaces above, this tool type mostly consists on medial fragments (30 or 75.0 %). These fragments are typically burnt to various degrees with some demonstrating evidence of severe burning. Only one whole tool manufactured from an 'unknown' silicate was classed as a miscellaneous thick biface; however, it, like the thin biface discussed above, was damaged and heavily patinated. Many of these tool fragments were made of local chert (17 or 42.5 %) and 'river cobble' chert (5 or 12.5 %). Only one chalcedony medial fragment was identified in the assemblage, but it is suspected that it may actually be a part of perform that was destined to become a thin biface of some kind. The suggestion is that the preform broke during some early in the production sequence. The rest of the artefacts in this category were 'unknown' cherts or chalcedonies (17 or 42.5 %). Examination of the whole tool and the fragments does not reveal obvious evidence of tool reuse or recycling.

## **Biface Edges**

Fifty-three biface edges and biface edge fragments were excavated from Pook's Hill between 2001-2005. Of these, 3 (5.7 %) were cortical and the rest were non-cortical. The majority were removed from bifaces made from local chert (38 or 71.7 %), while 4 (7.5 %) came from chalcedony tools, and 11 (20.8 %) from bifaces classified as 'unknown' lithic material. The chalcedony biface edges are all non-cortical and represent thinner bifaces than the majority of edges from other raw material categories. Moreover, there are no biface edges of 'river cobble' chert. This may provide further support for the suggestion that some 'river cobble' biface production was occurring away from the *plazuela* itself. Because the biface edges seem to be the product of two different types of activity (accidental removal during biface production or removal during use-related impact), this seems plausible. The biface edges that are likely the product of accidental removal do not typically possess distal end crushing or obvious macropolishing of their exterior surfaces, whereas the edges that were the product of impact-related actions typically possess this pattern of crushing and/or polish. Both edges with some use-wear

and those without were found in the *plazuela* suggesting that some large biface repair or rejuvenation was likely occurring there. Once the biface edges were removed from the parent bifaces, it appears there was no concerted attempt to use them for other activities, although use-wear analysis would certainly narrow down this possibility. At least three (5.7 %) bifaces edges or fragments were deliberately retouched after detachment from the parent biface.

# **Biface Preforms**

The eleven biface preforms are fragments all represent earlier stages in the production of large bifaces, such as oval or general-utility types. Just over half of the performs (6 or 54.5 %) were made from local chert, while the remaining examples were either 'river cobble' chert (1) or 'unknown' chert or chalcedony (4 or 36.4 %). The fragments of these performs (3 proximal, 5 medial, 1 distal) represent breakage of the tool before completion, while the two whole specimens seem to indicate performs that were reduced too much. They seem to have become too small to produce the large bifaces for which they were originally intended. There are no obvious flaking errors on these 'blanks'. Although there may be other reasons why the tools were not completed, any other suggestions would be speculative at best. The preforms seem to have been discarded or abandoned after breakage. The only example of reuse or recycling is provided by the distal fragment of local chert that was employed as a hammerstone. The single proximal 'river cobble' chert fragment recovered at Pook's Hill may support earlier suggestions that some reduction of this raw material type was occurring in the *plazuela*, but that biface production may have also taken place away from the site core.





#### Flakes

One thousand two hundred and sixty-seven flakes were recovered during the 2001-2005 field seasons at Pook's Hill. There were 696 (54.9%) tertiary flakes [0% cortex], 437 (34.5 %) secondary 2 flakes [<50 % cortex], 101 (8.0 %) secondary 3 flakes [>50 % cortex], and 33 (2.6 %) primary flakes [100 % cortex]. The distribution of flake types recovered between 2001-2005 demonstrates comparatively few primary and secondary 3 flakes and a substantial number of secondary 2 flakes. This pattern indicates the full range of reduction with some decortication and substantial end stage flaking. The data support both biface reduction from cobbles, as well as reduction of cobbles or cortical nodules to produce flakes and some flake tools. Most of the flakes from this site were made from 'local' chert (759 or 59.9%), with the rest being 'unknown' chert or chalcedony (377 or 29.8%), 'river cobble' chert (51 or 4.0%), chalcedony (51 or 4.0 %), dolomitic limestone (24 or 1.9 %), 'river cobble' chalcedony (2 or 0.2 %), 'nonlocal/imported' chert (2 or 0.2 %) and quartzite (1 or <0.1 %). Therefore, the majority of the lithic raw material used in tool production was obtained from the local area, primarily from the limestone geology and from the Roaring Creek. Some interesting patterns emerge with respect to the frequencies of flake types produced from local chert, chalcedony, and the 'river' cobble chert. The local chert and chalcedony generally indicate debitage that would be associated with some biface production and basic core reduction to produce *ad hoc* flakes or simple flake tools, although there is a slightly greater percentage of chalcedony secondary 2 flakes (41.2%) than chert secondary 2 flakes (37.7%) and no primary cortical flakes made from chalcedony. The pattern of cortical and non-cortical flakes of 'river cobble' chert is significantly different with a large number of secondary 2 flakes (74.5%) and comparatively few tertiary flakes (7.8%). This may be the result of one or more reduction strategies at Pook's Hill. The first is the reduction of smaller river cobbles with reduced volumes compared to exterior rind area as it would be more difficult to produce non-cortical flakes. Additionally, simple core reduction of small cobbles in the *plazuela* should produce more cortical debitage than biface production; another suggestion is that biface production using 'river cobble' chert (see oval, general-utility bifaces, biface performs above and bifacial thinning flakes below) was less frequently undertaken in the site core and may have also occurred elsewhere.

The most common type of striking platform on flakes from the site was flat (53.0 %), with a significant quantity of cortical platforms (170 or 19.9 %). There were also some lipped and facetted platforms which may be associated with some biface production, possibly earlier in the reduction sequence. Most whole flakes and distal flake fragments possessed feather terminations (78.4 %), suggesting fairly skilful flaking.

Although some flakes were deliberately modified into other tool forms (see retouched and notched flakes, gravers, drills and scrapers below), the vast majority show no signs of alteration. Some were likely used as *ad hoc* tools, but how many and for the completion of which tasks can only be more accurately determined following use-wear analysis.



## **Bifacial Thinning Flakes**

There were 190 bifacial thinning flakes recovered from the site between 2001-2005. This number only constitutes 6.8 % of the entire assemblage from Pook's Hill and 13.0 % of all the flake debitage. Forty-five (23.7 %) were secondary 2 flakes, while the rest (145 or 76.3 %) were tertiary.
The pattern of raw material distribution for the bifacial thinning flakes excavated from the site is 109 (57.4 %) 'local' chert, 12 (6.3 %) 'river cobble' chert, 8 (4.2 %), 1 (0.5 %) 'river cobble' chalcedony and 60 (31.6 %) 'unknown' chert or chalcedony. Interestingly, there are no secondary 2 bifacial thinning flakes manufactured from chalcedony and no tertiary flakes made from 'river cobble' chert. In terms of the 'river cobble' chert, this observation may be due to the difficulty in identifying the raw material type when cortex is not present and/or it may be due to the fact that bifaces made from river cobbles were not manufactured in large quantity in the *plazuela* itself (see above). As such, there is little evidence for later stage tool reduction of 'river cobble' chert bifaces based on bifacial thinning flakes. This supposition may be more tenable when considering the ratio of whole bifacial thinning flakes and fragments to whole large bifaces recovered within the *plazuela*.

Local chert	RC chert	Chalcedony	Unknown chert
12:1	6:1	8:1	30:1

Table 3. Ratio of whole bifacial thinning flakes and fragments to whole large bifaces at Pook's Hill.

It is difficult to interpret this ratio for the 'unknown' raw material type as it could, in reality, contain a large number of chert, 'river' cobble chert, or chalcedony bifacial thinning flakes.

Based on platform types, the bifacial thinning flakes at Pook's Hill consist of: 1) soft-hammer, facetted lipped flakes; 2) soft-hammer, facetted flakes; 3) hard-hammer facetted flat platform flakes; 4) hard-hammer flat platform; and 5) a small variety of other platform types. Of the striking platform types identified on the whole flakes and proximal flake fragments, 49.1 % were lipped, 64.8 % were facetted, and only 3.7 % were cortical or partially cortical. Many (32.4 %) of the flakes were both lipped and facetted, suggesting soft hammer reduction. There does not seem to be any pattern of association between raw material type and reduction type. All raw material types tend to possess similar percentages of soft-hammer and hard-hammer flakes. The termination types of the flakes suggest quite successful removals when compared to the terminations for flakes (above). Most bifacial thinning flakes were thin with feather terminations (85.1 %). Like the striking platforms, there are no patterns of association between raw material types.

In terms of evidence for repair, reuse, and/or recycling of these flakes, there is some evidence to suggest that roughly 6.0 % were re-sharpening flakes based on the presence of crushed platforms, edge rows, or macropolish on the dorsal surface, particularly near the proximal ends. However, it appears that bifacial thinning flakes were not recycled into other tools, although some may have been used as expedient or *ad hoc* tools with no modification of the edge. As with the flakes (above), any further evidence of reuse or recycling of these artefacts might be obtained following use-wear analysis.



## Macroflakes

Four macroflake fragments made from local chert (3) and an 'unknown' raw material (1) were recovered from the site. Three were cortical (1 - proximal, secondary 2; 2 - distal, secondary 3) and one proximal chert fragment was tertiary. All of the fragments seem to have come from whole flakes that would have been too small to have served as 'blanks' for large biface production; however, one or two may have been of appropriate size to produce a small, thin biface. None of these fragments was curated to any obvious degree.

## **Retouched Flakes**

Twenty-nine deliberately retouched chert flakes were recovered between 2001-2005 at Pook's Hill. Nineteen (65.5 %) of the flakes were produced from 'local' chert, one (3.4 %) was made from 'river' cobble' chert, one (3.4 %) was made from chalcedony, and eight (27.6 %) were 'unknown' chert or chalcedony retouched flakes. Five (17.2 %) of the 29 flakes were secondary 3, 8 (27.6 %) were secondary 2 and 16 (55.2 %) were tertiary.

Most retouch was marginal or short, in terms of its invasiveness from the edge, with the majority of the tools (21 or 72.4 %) been unifacially retouched to produce rather acute edge angles. It is believed most tools were likely intended as cutting or sawing implements. Of the tools with only one edge retouched, seven (33.3 %) had retouch on the right lateral margin, six (28.6 %) possessed retouch on the left edge, another seven (33.3 %) were distally retouched and one (4.8 %) has retouch on the proximal end. Six

flakes were retouched on two edges (5 right and distal, 1 right and left), one flake was retouched on three edges (left, right and distal), and one flake was backed with very steep flaking. Most retouch occurred on the dorsal surfaces of flakes (15 or 51.7 %) with another ten (34.5 %) retouched on the ventral surface, three (10.3 %) bifacially retouched, and one flake (3.4 %) backed.

The retouch consisted of primarily feathered terminations with minimal hinging or stepping to produce low edge angles (mean of unifacially retouched edges: +/- 38°). Aside from the retouch, none of the flakes demonstrate reworking or recycling based on tool morphology and edge shape/profile.

# **Notched Flakes**

There were two notched flake fragments recovered from this site; the cortical (secondary 2) fragment was distal and the tertiary fragment was medial. Both flakes were identified as 'unknown' chert or chalcedony as they had been burnt and partially patinated. The retouch associated with the notching occurred on the dorsal surfaces of the flakes and was marginally invasive, with a distal end notched on the first flake and a left lateral margin notched on the second. The notching produced steeply stacked overlapping scalar, trapezoidal, and irregular hinged and stepped flake scars.

# Blades

A total of 24 blades and fragments were excavated from the site between 2001-2005. Among them were one whole blade (4.2%), seven (29.2%) proximal fragments, ten (41.7%) medial fragments, and six (25%) distal fragments. All of the tools possessed plano-trapezoidal cross-sections, suggesting removal during later stages of the reduction process (see above). Most (12 or 50.0%) were chert, two (8.3%) were chalcedony, and the remaining ten (41.7%) were 'unknown' cherts or chalcedonies. The striking platforms on blades and proximal blade fragments from this site were primarily flat (54.4% flat; 36.4% flat-lipped), with only one cortical platform. All of the distal ends of blades or fragments were feather terminations. It is believed that some of the blades were used, but this cannot be confirmed without the completion of use-wear analysis.

# **Retouched Blades**

Three retouched blade fragments were recovered from Pook's Hill. Two were proximal fragments and one was medial. The proximal fragments both possessed flat striking platforms. All three blade fragments were plano-trapezoidal in cross-section. One proximal fragment and one medial fragment were made from local chert. The second proximal fragment was classified as an 'unknown' chert or chalcedony. Retouch on all fragments was unifacial, with two tools possessing ventral retouch on the left lateral margin and the third having been dorsally flaked on the right side. The retouch produced relatively acute edge angle, ranging from  $33^{\circ}$  to  $45^{\circ}$ .

## **Stemmed Blades**

The single stemmed blade fragment excavated from the site was a proximal end manufactured from local chert. The striking platform was flat. It represents the bifacially flaked stem or tang from the stemmed blade. The stem is mildly bi-convex in crosssection. Following breakage, it does not appear that this fragment was curated to any degree.



## Flake-blades

Between 2001-2005, 16 (36.4%) of the flake-blades or flake-blade fragments recovered at the site were cortical, while 28 (63.6%) were non-cortical. Of the cortical flake-blades, two (12.5%) were secondary 3 and 14 (87.5%) were secondary 2. In terms of raw material types, 21 (47.7%) were made from local chert, 3 (6.8%) were made from 'river' cobble chert, 17 (38.6%) were categorized as 'unknown' chert or chalcedony, and three (6.8%) were dolomitic limestone. All of the whole flake-blades (18) and distal fragments (9) ended in feather terminations; however, data on striking platform type and termination type are included in calculations for 'flakes' (above). These artefacts were not deliberately intended as blades, but seem to be flakes that are minimally twice as long as they are wide. Most of these flake-blades were not modified and likely served as *ad hoc* tools.

## Macroflake-blades

A single non-cortical medial fragment from a macroflake-blade was excavated from Pook's Hill. Based on the severe burning and patination of this artefact, it was types as an 'unknown' cryptocrystalline silicate. There is no obvious evidence of use on the tool.

## **Flake-bladelets**

Five flake-bladelets were recovered from the site. Four were whole tools, while the last was a distal fragment. All five were non-cortical with three made of local chert and two identified as 'unknown' stone types. As with the flake-blades, these seem to be accidentally produced long, thin flakes under 5 cm in length. There is no evidence for use based on a cursory examination of the surface sand edges of the artefacts.

## **Retouched Flake-blades**

Only one retouched distal flake-blade fragments was found at Pook's Hill. The retouch on this local chert tool fragment was bifacially produced on the left lateral margin. The retouch is primarily marginal to short in invasiveness and not very steep (+/- $40^{\circ}$  on left edge).

## **Unifacial Retouch Flakes**

These small flakes (5) were relatively rare in the assemblage. Four were made of local chert, while the remaining flake was classified as 'unknown' chert or chalcedony. As the name suggests, these tertiary flakes with flat, non-cortical platforms and feather terminations are the result of modifying tool edges. Once produced, they were abandoned or discarded. Their small sizes would have made them difficult to employ for other tasks.

## **Burin Spalls**

A single whole burin spall removed from a flake or blade manufactured from local chert was recovered from Pook's Hill. The spall had a flat striking platform and ended with mildly hinged termination. There is no obvious indication that the spall was used.

## Macroblades

Four medial macroblade fragments made from local chert (1) and 'unknown' stone types (3) were found at the site. Three had plano-triangular cross-sections, while the last one was plano-trapezoidal in cross-section. None of the fragments seem to have been reworked following breakage and discard.

#### **Retouched Macroblades**

Only one proximal retouched macroblade was identified in the assemblage. It possessed a cortical platform and a snap fracture at the distal end. The tool fragment was classified as an 'unknown' chert or chalcedony based on burning and patination. The tool was plano-triangular in cross-section. Bifacial retouch occurred on both the left and right margins of the fragment; this retouch was quite invasive covering most of the dorsal and ventral surfaces of the artefact. Edge angles ranged from  $35^{\circ}$  to  $42^{\circ}$ .

#### **Stemmed Macroblades**

The two fragments from stemmed macroblades represent the proximal stems or tangs from this type of tool. They were bifacial flaked and snapped off at the junction between the stem and blade portions of the tools. Both were identified as 'unknown' raw material types. Based on morphology, they conform to descriptions of stemmed macroblades produced in the Late Preclassic period and later in the Maya lowlands (see above). The stems were mildly plano-ovate in cross-section. Neither fragments bears evidence of reuse or recycling following initial breakage.

#### Drills

A total of 22 drills on flakes or flake fragments have been identified in the Pook's Hill non-obsidian chipped stone tool assemblage. Half (11) were produced on secondary 2 flakes and the other half (11) were made on non-cortical flakes. The majority (14 or 63.6 %) of the drills-on-flakes were manufactured from local chert, while the rest (8 or 36.4 %) were of 'unknown' raw materials. The drills themselves are of various designs with some minor consistency in morphology and technology. Some seem much more informal; others obviously required much more planning and possess greater formality in their design. This tends to argue against standardization of tools for centralized craft-production and seems to point toward greater independence in the creation of these tools. Evidence of this variability can be seen in the sizes and shapes of the tools and their 'bits'. Some larger flakes or fragments have relatively thick points for drilling larger holes, while smaller artefacts not surprisingly have comparatively longer, thinner 'bits'. Eighteen (81.8 %) of these tools have only one 'bit'; however, two drills (9.1 %) have two 'bits' on the same implements and two other tools (9.1 %) have or had three 'bits'.

The steep, marginal retouch [almost like backing] on some flakes from this site was undoubtedly performed to produce long converging drill bits. These are frequently found on the distal ends of flakes or flake-blades, but also occur on lateral margins. The retouch is often dorsal, but some ventral and alternating retouch has been noted as well. These drills are similar to some described at K'axob (McAnany and Peterson 2004: 295, 296, Fig. 11.15).

#### **Other Tool Types – Unifacial/Bifacial**

In the lithic assemblage from Pook's Hill, very few tool forms or shapes, such as gravers/incisors, and scrapers were originally produced for the execution of such tasks.

Most of these tools are secondarily produced on already existing tools or flakes and seem much more expedient or *ad hoc* in use. Some *ad hoc* scraping tools are produced on flakes or the occasional blocky fragment with minimal retouch.

# Gravers

Only two gravers produced on the distal ends of 'unknown' chert or chalcedony flakes occur at the site. Both were made on non-cortical flakes and possess one 'point' that is the product of steep pressure flaking. These are not traditional 'burin'-like tools (see above).

# Scrapers

A total of five scrapers were found at this site. Two (40.0 %) were on cortical [<50 % cortex] flakes and the remaining three were produced on tertiary flake fragments. One whole flake and one distal fragment were local chert; one medial fragment and two more distal fragments were 'unknown' chert or chalcedony types. All of the flaking to produce the steep scraper edges was unifacial on the dorsal surfaces and primarily occurred on the distal ends of the flakes or fragments. However, two scrapers had two retouched edges [1 distal and left; 1 distal and right]. The range of angles on the retouched edges on these tools was  $58^{\circ}$  to  $77^{\circ}$ . Retouch consisted of feather terminated and stepped and hinged flake scars. The tools reveal no signs of repair or re-sharpening following initial retouch to produce the steep scraping edges. It is believed these tools were hafted, but there is no direct evidence to support this based on a macroscopic examination of the tools' surfaces; microscopic examination for traces of haft wear may clarify this. As at a number of other Maya sites, like K'axob (McAnany and Peterson 2004), Marco Gonzalez (Stemp 2001; Stemp and Graham 2006), San Pedro (Stemp 2001, 2004a, b), and Minanha (Stemp 2004c), there were few deliberately manufactured scrapers at Pook's Hill.

# **Core Fragments**

A total of 169 simple flake core fragments were excavated from the site. Of these, 155 (91.7 %) were simple/multidirectional flake core fragments, two (1.2 %) were pyramidal, three (1.8 %) were discoidal, two (1.2 %) were flake-blade, and two (1.2 %) were blade core fragments. An additional five (3.0 %) core fragments were reused as hammerstones or pounding tools. In all, 134 (79.3 %) were made form local chert, four (2.4 %) were produced on river cobbles, and 31 (18.3 %) were manufactured from 'unknown' silicate materials. Collectively, these core fragments constitute 6.0 % of the assemblage from Pook's Hill and 72.2 % of them possess some cortex on their exterior surfaces. These fragments and the whole cores (below) have been used to roughly estimate nodule sizes at the site. It appears nodules chosen by the Maya living here in the Classic period were typically between 6 and 15 cm in diameter.



## Cores

Between 2001-2005, 40 flake cores were excavated from Pook's Hill. Twentyseven (67.5%) were simple/multidirectional cores, four (10.0%) were discoidal, and nine (22.5%) had been used as hammerstones. Most were produced from local chert (34 or 85%), one (2.5%) was made from 'river cobble' chert, one (2.5%) was made from a fine-grained non-local/imported chert, and four were made from 'unknown' types of cryptocrystalline stone. In total, the flake and blade cores represent 1.4% of the assemblage from the site. There was some cortex on the unflaked surfaces of 28 (70.0%) of the cores.

The mean volume of whole cores at Pook's Hill provides minimal information about reduction patterns based on different core types. It appears that discoidal cores were more efficiently reduced than simple/multidirectional cores, likely providing more flakes per core. However, it should be noted that original core size and shape, as well as degree/intensity of reduction, likely affect this observation. It is not known whether most simple flake cores were originally larger than most discoidal cores; however, it does appear that discoidal cores were more heavily exhausted. The lack of whole pyramidal flake cores renders any suggestions about their mean core volume and reduction impossible. It is also recognized that the small numbers of cores in any one core category do not make these data as statistically reliable as would be desired. This same concern is magnified when attempting to determine any reduction patterns represented by cores of different raw material types. There are not enough whole cores produced from the different kinds of cherts and chalcedonies recovered from Pook's Hill to calculate any reliable comparisons. Although cores manufactured from 'river cobbles' always possess some cortex, it is, in fact, the presence of the smoothed or rolled external rind that permits their identification.



	Chert	RC chert	Chalcedony	RC chalcedony	Non-local/imported chert	Unknown chert	Dolomitic limestone	Quartzite
Simple flake cores	179.5				140.0	104.7		
Discoidal flake cores	55.9							

Table 4.	Mean	core	volume	hv	raw	material	type (	$(cm^3)$	
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In sum, the majority of the chert cores and core fragments from Pook's Hill were the basic, multidirectional type with little evidence for standardization or planned core reduction. However, this is not surprising given the number of obsidian blades were found. Many of the tasks likely requiring blades were performed using the obsidian artefacts.

## **Blocky Fragments**

The excavations during the 2001-2005 field seasons uncovered 643 blocky fragments. Of these, 321 (49.9 %) were manufactured from local chert, 16 (2.5 %) were made from 'river cobble' chert, seven (1.1 %) were chalcedony, 290 (45.1 %) were 'unknown' chert or chalcedony, four (0.6 %) were dolomitic limestone, and five (0.8 %) were made from quartzite. Blocky fragments represent 23.0 % of the entire assemblage from Pook's Hill. Fragments rang in size from under 1 cm<sup>3</sup> to as great as 8 cm on a side. Most are the product of core reduction to produce simple flakes and some biface manufacture. However, some minimal bipolar reduction was also occurring at the site, given the recovery of a single fragment with impact traces on opposite ends of the piece. Two of these fragments were used as hammerstones, suggesting some recycling. It is suspected that other blocky fragments may have been used as expedient tools, but confirmation must wait completion of use-wear analysis.

## Heat Spalls and Heat-fractured Fragments

Sixty-one heat spalled fragments or potlids were recovered from this site. Ten (16.4 %) of them were made from 'local' chert, while 51 (83.6 %) of the burnt fragments were made from 'unknown' chert or chalcedony. In all, the percentage of heat spalled fragments or potlids from the site recovered between 2001-2005 was 2.2 %. None of these fragments was used or modified into any other tool form.

## Hammerstones and Fragments

In the assemblage from Pook's Hill, hammerstones and fragments thereof possess heavily crushed surfaces. They are, or were once, generally spherical nodules and tend to have been around the size of a small baseball, although some fragments indicate slightly smaller and larger hammerstones were also used. Although, only two whole hammerstones (both of local chert) and five hammerstone fragments (2 local chert; 1 'river cobble' chert; 2 'unknown' chert or chalcedony) were recovered, some other tools, such as cores and core fragments, one biface, one biface fragment, and one blocky fragment were also used as hammerstones. These tools with crushed or battered edges recycled into 'expedient' crushing or pounding tools. Although this pattern of converting other tool types into hammerstones has been observed in the assemblage at Pook's Hill, it does not appear as a regular practice and does not seem to indicate attempts to conserve raw material. There is little evidence to indicate extreme biface reduction like that seen at some consumer sites, such as Pulltrouser Swamp (McAnany 1989; Shafer 1983) or those on Ambergris Caye (Hult and Hester 1995; Stemp 2001, 2004a, 2006). Furthermore, no limestone hammerstones, similar to the ones from Colha described by Shafer (1991: Fig. 8; Shafer and Oglesby 1980: Fig. 9), were recovered from the excavations at Pook's Hill. There were no antler billets similar to those from the Early Postclassic deposits at Colha found at this site either (Hester and Shafer 1991: Fig.1; Michaels 1989; Shafer 1991).

# EVIDENCE FOR THE ORGANIZATION OF STONE TOOL PRODUCTION AND CRAFT-SPECIALIZATION

When reconstructing the role of the non-obsidian chipped stone tools in the socioeconomy of Late Classic Pook's Hill, both the evidence for stone tool production at the site and the use of stone tools in subsistence and craft activities must be considered.

## **Stone Tool Production at Pook's Hill**

In terms of tool production, there is ample evidence to suggest that the Maya at this site were making their own tools from locally available chert and chalcedony acquired from land-based sources and water-worn cobbles from Roaring Creek. Tool production includes both the reduction of multidirectional, pyramidal, and discoidal cores to make simple cortical and non-cortical flakes for primarily ad hoc use and some manufacture of formal tools such as large bifaces, lenticular bifaces, adzes, thick narrow bifaces, and various thin and thick point forms. There is some evidence for blade manufacture based on the recovery of two blade core fragments and some blade fragments, but blade production is rather limited. Although the formal and informal tools are primarily produced from locally available stone, it appears a very small quantity of imported, finished stone tools from some regional exchange networks was also acquired. The reliance on local stone for tool production with variable use of other silicates can be seen in the percentages of raw material in the sub-assemblages from different structures/locations throughout the site (exception Structure 4a – Burials). Consistently, the Maya at these different locations are relying on local stone, both cherts and chalcedonies, for tool production. Minor variations in 'river' cobble' chert and chalcedony do occur, but reasons for this are difficult to determine. At least one explanation for some differences in the percentages of cherts and chalcedonies throughout the *plazuela* relates to the variable quantities of heavily burnt and patinated lithics at each location. Although the percentages for all burnt raw material do not vary tremendously by structure/location (except Structure 4A - Burials), there is some variation in the 'unknown' stone category based on very heavy to extreme burning that obfuscated reliable attempts to identify stone type more conclusively. Overall, 946 (33.8 %) of the 2800 chipped stone artefacts possessed evidence of some burning, while 2658 (94.9 %) were patinated to some degree.

ІМ-НМІ	Plaza plat.	Structure 1A	Structure 1B	Structure 1C	Structure 2A	Structure 2B	Str. 4A (Burials)	Structure 4A	Structure 4B	Surface
28.6	28.7	29.3	30	37.2	41.1	29.9	69.7	45.8	33.9	16.7

Table 5. Percentage of burnt tools by structure/location at Pook's Hill.

	PKH-M1	Plaza platform	Structure 1A	Structure 1B	Structure 1C	Structure 2A	Structure 2B	Str. 4A (Burials)	Structure 4A	Structure 4B	Surface
Chert	52.4	55.7	61.4	61.3	50.6	56.7	59.2	21.2	45.8	59.0	50
RC chert		3.4	6.7	3.4	0.8	4.4	4.7	3.0	7.1	3.3	16.7
Chalcedony		7.2	1.6	3.4		4.4	3.4		0.6	1.5	
RC chalcedony		0.4				0.2	0.4				
Non-local chert		0.4	0.3			0.2					
Unknown	47.6	32.5	29.3	30.2	47.3	32.8	29.1	69.7	44.6	33.9	33.3
Dolomitic limestone		0.4	0.5	1.1	1.2	1.1	2.1	6.1	1.2	1.8	
Quartzite			0.2	0.2		0.2	0.4		0.6	0.4	
Total	21	237	638	473	243	476	234	33	168	271	6

**Table 6.** Percentages of lithic raw material types by structure/location at PKH-1.

Evidence that identifies a site like Colha as a stone tool production center, such as substantial quantities of reduction debitage, tool preforms (i.e. large biface), manufacturing failures and exhausted production implements, including hammerstones and other tool forms recycled into hammerstones (see Hester and Shafer 1991:156, Fig.1; Shafer and Hester 1983:523, 535), is present at Pook's Hill, but, obviously, on a much reduced scale. Most recovered lithic evidence indicates that informal and formal tool production was fairly evenly distributed throughout the *plazuela* with no obvious foci for the exclusive production of some tool forms.

This site possesses high percentages of cortical debitage (42.3 % of all flakes; 83.4 % of all blocky fragments), as would be expected, given the reduction of cores to produce flakes and the reduction of some nodules to manufacture bifaces. The data strongly suggest that the inhabitants of Pook's Hill were primarily manufacturing, repairing and reworking their tools with the full range of debitage from the earliest to end stages in the reduction continuum documented.

It appears that biface manufacture was performed at this site based on the ratio of lithic debris (whole and fragmentary cortical and non-cortical simple and bifacial thinning flakes) to whole bifaces and the number biface performs and perform fragments recovered (see Table 3). A comparison of the reduction debris frequency estimates from Pook's Hill with those produced during experimental biface reduction indicates that similar reduction was likely occurring. However, smaller percentages of primary and

secondary 3 whole flakes at Pook's Hill suggest that a least some large bifaces, particularly some oval bifaces and lenticular bifaces, were being produced on macroflake blanks. The relatively higher percentage of secondary 2 debitage seems to suggest some decortication of the biface blanks had already occurred prior to biface production. Nevertheless, the large percentage of secondary 2 flakes of 'river cobble' chert suggest a different pattern of reduction than observed for local chert (see above).

	Experimental Proximally- Contracting Biface (Cox and Ricklis 1999)	Experimental General Utility Biface (Stemp 2001)	Experimental Lenticular Biface (Tomka 1989)	Experimental Long Thin Biface (Stemp n.d.)	Estimated debris ratio [large whole bifaces: whole simple and bifacial thinning flakes from Pook's Hill <sup>1</sup>
Original core dimensions (cm)	14 x 12 x 5.0	16.2 x 13.2 x 8.0 (rectangular core)	8.8 x 6.5 x 2.4 (lenticular chert nodule)	17.0 x 8.2 x 4.1 (flat oval core)	n.a.
Biface dimensions (cm)	10.5 x 6.0 x 4.4	9.9 x 6.8 x 5.8	8.2 x 4.4 x 1.0	13.6 x 4.3 x 1.6	n.a.
Primary flakes [100% cortex]	5 (7.0 %)	6 (7.5 %)	10 (5.4 %)	9 (5.8 %)	2.7 (1.9 %)
Secondary (3) flakes [>50% cortex]	24 (34 %) [secondary 2 & 3 combined]	11 (13.8 %)	21 (11.4 %)	19 (12.3 %)	11.2 (7.9 %)
Secondary (2) flakes [<50% cortex]		18 (22.5 %)	42 (22.8 %)	36 (23.4 %)	49.5 (35.1 %)
Tertiary flakes [0% cortex]	42 (56.3 %)	45 (56.3 %)	111 (60.3 %)	90 (58.4 %)	77.5 (55 %)
Blocky fragments	4	7	3	5	106.8
Flake fragments	33	29 (13 cortical)	small flake fragments <sup>2</sup>	67 (19 cortical)	101.6 (39.3 cortical)

#### Notes:

<sup>1</sup> The estimated debris ratio from Marco Gonzalez is calculated in terms of the total number of cortical and noncortical flakes and blocky fragments recovered from the site divided by the total number of large whole bifaces (i.e. - for 1 biface there were 2.7 primary flakes).

<sup>2</sup> Flake fragments are included in the flake categories (primary, secondary 3, secondary 2, tertiary) above. An additional 2,051 flakes, fragments, and chunks passed through ¼ inch mesh.

 Table 7. A Comparison of production debris frequencies from experimental biface reduction to archaeological lithic remains at Pook's Hill.

Blades are not very abundant in the Pook's Hill assemblage. At this site, less than 1.0 % of the assemblage consisted of blades, retouched blades, and stemmed blades. Minor evidence for local blade production is based on the recovery of the two blade core fragments manufactured from local and unknown cherts. There is slightly greater evidence for blade production at Structure 4B than other locations; however, no locations reveal overwhelming evidence for substantial investment in chert blade manufacture.

In addition to local production of formal tools at Pook's Hill, there was an obvious reliance on core reduction to produce flakes or simple flake tools as seen, to various degrees of reliance, at a number of sites in Northern Belize, including Cerros, Cuello, Laguna de On, Marco Gonzalez, Saktunha, San Pedro (Mitchum 1991; Oland 1999; Speal 2006; Stemp 2001, 2004a, 2004b, 2006; McSwain 1991), as well as in Western Belize at Minanha (Stemp 2004c). At Pook's Hill, the ratio of flakes and flake fragments to whole cores was 36.9:1, providing good evidence for core reduction to produce flakes, particularly in the early stages (see McAnany 1986; Dockall and Shafer 1993). If this ratio was recalculated with the inclusion of the whole large bifaces recovered between 2001-2005, the result would be 29.9:1. Again, this is considered good support for arguing core reduction and biface production at the site.

The percentages of flake fragments (21.8 %) and blocky fragments (22.9 %) in the assemblage at this site attest to simple core reduction as a deliberate strategy to produce useable flakes. By contrast, there is very little production of any other more standardized tools at the site, such as drills (0.8 %), and almost no production of scrapers, gravers, or burins (0.3 %). In fact, the Maya at Pook's Hill did not retouch or modify the vast majority of their flakes or blades. They seem to have incorporated any flakes into their tool inventories without further modification of shapes or edges.

In terms of the production locales of the stone tools, accumulations of lithic debitage are primarily represented by construction fill and some midden deposits, obviously indicating secondary refuse. This tends to demonstrate that local production by individuals was likely occurring in or near individual households rather than in more specific, circumscribed workshop areas. Coupled with the relative lack of microdebitage and 'chipping dust' recovered in these deposits at Pook's Hill (see Clark 1986; Moholy-Nagy 1990), the belief is that most stone tool production occurred in individual households for local use as demand required with disposal of waste nearby (see Hayden 1987; Hayden and Cannon 1983, Fig. 16; Moholy-Nagy 1997; Santley and Kneebone 1993).

## Raw Material Availability, Curation, Expediency and Bi-polar Technology

Despite the fact that some tools were heavily used, repaired, re-sharpened and/or recycled at Pook's Hill, there is no regular pattern of excessive curation. Any prolongation or extension of tool use-life (Shott 1989, 1995, 1996; Nelson 1991) is mostly seen on tools that demonstrate some investment in skill and time to produce or that were designed for some more specific tasks. As such, curated tools are primarily large bifaces (general utility or oval). There is no extremely heavy use of large bifaces or fragments, no sequence of large biface use and modification into hammerstones (i.e. sites on Ambergris Caye - Stemp 2001, 2006; Hult and Hester 1995 or Pulltrouser Swamp - McAnany 1986, 1989), and minimal edge repair on smaller bifaces. No other classes of

tools show any extreme use, in the form of very steep edges (due to cycles of use and repair), substantial edge crushing or stacked microflakes with stepped or hinged terminations (i.e. edge rows). There are very few tools modified or used after breakage and no regular pattern of concerted attempts to regularly recycle exhausted or broken tools for any additional, expedient or *ad hoc* use. However, this will be much better understood once the use-wear analysis has been completed.

Very few examples of bipolar reduction have been noted in the assemblage. This suggests that there was little need to exhaust available stone to produce useable tools. Bipolar reduction has been minimally identified by the presence of flakes or blocky fragments with crushed platforms/initiations at opposite ends of the longitudinal axis and patterns of concentric compression rings that originate from these same opposite ends (Andrefsky 2005: 125, Fig. 6.3; see Crabtree 1972; Hayden 1980).

The primary reason for the lack of absence or curation or bipolar reduction is that the Pook's Hill Maya seem to have had ready access to good quality chert and chalcedony throughout their occupation at this site (see Odell 1996; Bamforth 1986). They also produced relatively few specialized tools that would need to be maintained for prolonged periods of use or frequently replaced.

# Stone Tools and Craft-specialization at Pook's Hill

The lithic evidence for tool production and craft-specialization at Pook's Hill seems organized along the lines of a community-wide, cooperative enterprise based on primarily integrated, independent household production (Brumfiel and Earle 1987: 5). Community cooperation, in this instance, was likely reinforced by family/kin-based connections in this small *plazuela* group. However, it is difficult to say whether or not this *plazuela* group represents one large household or a number of related, variably interconnected households (Gonlin 2004: 228; see Robin 2003: 331-333; Inomata and Significant redundancy in the tool sub-assemblages associated with Stiver 1998). different structures or locations at Pook's Hill might be indicative of different households with some degree of autonomy from one another within the larger group. At Pook's Hill, there is little variation in debitage distribution at various loci/structures; a similar situation is described for Late to Terminal Classic Saktunha/Cabbage Ridge. Based on these data, Speal (2006:12-13) states: "... the absence of strong distinctions in debitage among the structures investigated at Saktunha suggests a lack of economic interdependence among households and little evidence of integration at the intrasite scale as lithic production was concerned. This pattern is what one might expect from an economic system emphasizing specialization at the community level". Based on the frequencies of tools types in the sub-assemblages at Pook's Hill, there is strong evidence for some redundancy of tool type distribution and little evidence for any substantial accumulations of some tools in spatially restricted/segregated locations.

In terms of flakes and bifacial thinning flakes, the percentages of cortical and noncortical flakes are variable, but there are no extreme anomalies indicative of substantially different reduction patterns. At all locations, flat striking platforms are most frequently observed on flakes, followed by cortical platforms (with the exception of Structure 4A – Burials). On the bifacial thinning flakes, there is evidence for both hard-hammer and soft-hammer reduction of bifaces. Whereas the *plazuela* platform and Structures 1A, 1B, and 2B tend to provide more evidence of soft-hammer flaking, Structures 1C, 2A, 4A, and 4B indicate higher levels of hard-hammer production based on the distributions of flat, facetted, and lipped striking platforms throughout the site. The terminations on the flakes and distal flake fragments were consistently represented by feather terminations at all locations (except Structure 4A - Burials). The same pattern is more strongly represented by the termination types of the bifacial thinning flakes, suggesting skilful production of bifaces, with comparatively minimal hinge flaking.



Platform types	Flakes	Bifacial thin./ repair	Blades
Cortical	19.9	3.7	9.1
Flat	53.0	11.1	54.5
Flat-lipped	4.7	16.7	36.4
Dihedral	7.1	3.7	
Facetted	8.8	32.4	
Facetted-lipped	1.8	32.4	
Linear	1.3		
Punctiform	2.1		
Crushed	1.4		

 
 Table 8. Percentage of striking platform types on whole flakes and blades and proximal fragments from Pook's Hill.



Termination types	Flakes	Bif. thin./repair flakes	Blades
Feather	78.4	85.1	100.0
Step	2.2		
Hinge	19.0	14.9	
Snap/ 1/2 moon	0.4		

Table 9. Percentage of termination types on whole flakes and distal fragments from Pook's Hill.



	PKH-M1	Plaza platform	Structure 1A	Structure 1B	Structure 1C	Structure 2A	Structure 2B	Str. 4A (Burials)	Structure 4A	Structure 4B	Surface
Cortical	33.3	10.4	17.3	26.8	22.7	16.9	11.0	9.1	22.1	23.4	
Flat	50.0	59.4	53.6	51.9	48.0	55.9	64.4	72.7	45.6	45.8	100
Flat-lipped		4.7	2.4	5.6	5.3	5.1	2.7		5.9	7.5	
Dihedral	16.7	9.4	4.8	6.9	6.7	5.9	6.8		7.4	12.1	
Facetted		9.4	14.9	3.8	8.0	9.3	12.3	18.2	7.4	4.7	
Facetted-lipped		3.1	3.6		1.3	1.7	1.4		1.5	1.9	
Linear			0.6	1.9	2.7	1.7			1.5	1.9	
Punctiform			2.4	1.3	5.3	0.8			5.9	2.8	
Crushed		3.1	0.6	1.9		2.5	1.4		2.9		

 Table 10. Percentage of striking platform types on whole flakes and proximal fragments by structure/location at Pook's Hill.

	PKH-M1	Plaza platform	Structure 1A	Structure 1B	Structure 1C	Structure 2A	Structure 2B	Str. 4A (Burials)	Structure 4A	Structure 4B	Surface
Feather	100	67.6	84.6	76.8	71.6	87.2	81.5	57.1	74.0	74.8	50.0
Step		2.7	1.4	2.2	4.0	1.4			2.7	4.2	
Hinge		29.7	14.0	21.1	24.2	10.8	18.5	42.9	20.5	21.0	50.0
Snap/half moon					1.1	0.7			2.7		

 Table 11. Percentage of termination types on whole flakes and distal fragments by structure location at Pook's Hill.

	PKH-M1	Plaza platform	Structure 1A	Structure 1B	Structure 1C	Structure 2A	Structure 2B	Str. 4A (Burials)	Structure 4A	Structure 4B	Surface
Cortical				8.3		6.7					
Flat			6.5	8.3	33.3	16.7			23.1		
Flat-lipped	50.0	9.1	8.7	8.3	16.7	13.3	27.3	33.3	15.4	42.9	
Dihedral					16.7	10.0					
Facetted	50.0	63.6	30.4	41.7		26.7	45.5		7.7	42.9	
Facetted-lipped		36.5	52.2	33.3	33.3	26.7	27.3	66.7	53.8	14.3	
Linear			2.2								
Punctiform											
Crushed											

**Table 12.** Percentage of striking platform types on whole bifacial thinning flakes and proximal fragments by structure/location at Pook's Hill.

	PKH-M1	Plaza platform	Structure 1A	Structure 1B	Structure 1C	Structure 2A	Structure 2B	Str. 4A (Burials)	Structure 4A	Structure 4B	Surface
Feather	100	81.8	89.6	92.3	100	80.0	75.0	100	86.7	85.7	
Step											
Hinge		18.2	10.4	7.7		20.0	25.0		13.3	14.3	
Snap/ half moon											

 Table 13. Percentage of termination types on whole bifacial thinning flakes and distal fragments by structure/location at Pook's Hill.

	PKH-M1	Plaza platform	Structure 1A	Structure 1B	Structure 1C	Structure 2A	Structure 2B	Str. 4A (Burials)	Structure 4A	Structure 4B	Surface
Cortical										50.0	
Flat					50.0	100	100			50.0	
Flat-lipped			50.0	100	50.0						
Dihedral											
Facetted											
Facetted-lipped											
Linear											
Punctiform			50.0								
Crushed											

 Table 14. Percentage of striking platform types on blades and proximal fragments by structure/location at Pook's Hill.

	PKH-M1	Plaza platform	Structure 1A	Structure 1B	Structure 1C	Structure 2A	Structure 2B	Str. 4A (Burials)	Structure 4A	Structure 4B	Surface
Feather					100	100					
Step											
Hinge											
Snap/half moon											

 
 Table 15. Percentage of termination types on blades and distal fragments by structure/location at Pook's Hill.

Inasmuch as the socio-economic structure, in terms of lithic production and craftspecialization associated with stone tools, demonstrates some degree of connection at the community level, this community cooperation is currently conceived as relatively simple, in terms of organization of labour and control over modes of production. Whether this demonstrates true 'organic solidarity' in a ancient Maya community is difficult to ascertain (Durkheim 1967; see Speal 2006: 20), but some minor degree of diversification of socio-economic roles throughout the community as reflected in the lithic assemblage is apparent.

On a regional scale, undoubtedly some integration between political centers and smaller, more rural or peripheral settlements, like Pook's Hill existed; however, the degree of this integration versus the economic autonomy of these smaller sites is still a topic of some controversy (Chase et al. 1996; Freidel 1986; Lewis 1996; Masson and Freidel 2002; McAnany 1991, 1993; Rice 1987). Just how integrated or independently structured the spheres of exchange involving 'utilitarian' and 'luxury/prestige' items was remains to be seen for the Classic period Maya. Based on the lithic evidence from Pook's Hill, there appears to be unequivocal support for some greater economic autonomy with the inhabitants of this site producing most of their tools from locally retrieved stone for their own use and likely for trade or exchange with neighbouring, but not substantially distant, communities. Unlike the evidence from a coastal site like Marco Gonzalez that was substantially dependent on the acquisition of stone tools from workshops like Colha and seems to have been socio-politically and socio-economically tied to Lamanai as a coastal trans-shipment point (Stemp 2001; Stemp and Graham 2006), Pook's Hill appears to have been a much more self-sufficient and internally managed place in the Late Classic period. Pook's Hill was clearly not a stone tool 'consumer' site, as represented by Santa Rita Corozal (Dockall and Shafer 1993), Cerros (Mitchum 1994), Marco Gonzalez, San Pedro (Stemp 2001), San Juan, Ek Luum, Chan Balam (Hult and Hester 1995), and Pulltrouser Swamp (McAnany 1986, 1989), among others. It may have been similar in some ways to sites like Saktunha (Speal 2006) based on this site's relative lack of dependence, as seen through debitage patterning and raw material types, on other stone tool producers coupled with some necessary economic relationships in more far reaching spheres, including both considerations of distance/resources and utilitarian/luxury categorization.

# THE STRUCTURE AND INTENSITY OF CRAFT PRODUCTION: INDEPENDENT PART-TIME SPECIALISTS

The intensity of independent production is ultimately dependant upon demand, ease of transportation, and availability of resources (Lewis 1996: 368; see also Brumfiel and Earle 1987). At Pook's Hill, it appears that some economic activity was the product of minor craft specialization. Specifically, the lithic assemblage suggests the production of beads (bone, stone), as well as activities associated with wood-working and stoneworking (possibly slate and masonry). However, based on the generalized lithic assemblage with no heavy concentrations on specific tools types and the fairly even spatial distributions of similar tools, this specialization occurred as some combination of individual specialization for the local community and community specialization for wider regional consumption (Lewis 1996: 370, Table 1; Costin 1991, 2001; Santley and Kneebone 1993). Because it is believe that the products were not manufactured from rare or valuable raw materials and that the aesthetic quality or technological complexity required to produce them was not substantially great, the small-scale craft-production at this site does not represent non-centralized attached specialization as defined by Lewis (1996: 375-376; also see Aldenderfer 1990; Costin 2001). At this site, there is no evidence for elite production or control of production of prestige items from valuable and/or exotic raw materials (see Graham 1987 for discussion of 'exotic' raw materials/goods; also see Graham 2002) as at Copan (Aoyama 1995, 1999) or Aguateca (Inomata 2001; Inomata and Stiver 1998; Inomata and Triadan 2000), for example. Obviously, the context of recovery of artefacts from Aguateca is significantly different from that of most Maya sites (including Copan), but even the greater disturbance and recovery from secondary contexts at Pook's Hill allow for the reconstruction of socio-economic activities that were fundamentally different in their organization and degree of specialization.

Part-time specialization in the production of these objects for use and trade is suspected based on relatively low levels of manufacturing debris, the lack of obviously segregated or spatially circumscribed workshop zones, and little technical standardization in the lithic tools used to manufacture these products (see Aldenderfer 1990, 1991a; Aldenderfer et al. 1989; Lewis 1996). The drills for bead production are primarily made on flakes and flake-blades of different sizes and shapes. Some drills have one bit, while others sometimes have up to three bits on the same tool. Interestingly, the different lengths and circumferences of these bits suggest they were specially designed to drill holes of different dimensions (see Aldenderfer 1990). There is more standardization in the morphology of the chisels/gouges recovered from the site, but this is likely related to functional design constraints. Some regularity in the shapes and sizes in the gouges/chisels may indicate that there was more standardization in some wood-working or stone-working. Any workshops, if in fact they can be characterized as such, were likely organized as the Type I workshops as defined by Clark (1986). The production is part-time, organized at the individual or possibly household level, and with production of a couple of different types of objects or crafts, likely not in great numbers or extremely Some locations at Pook's Hill may minimally represent such production; quickly. specifically, there were slightly greater frequencies of drills in the overall subassemblages at Structures 1C, 2A and 4A. Other tools likely associated with certain types of craft-production are relatively evenly distributed throughout in small numbers.

	PKH-M1	Plaza platform	Structure 1A	Structure 1B	Structure 1C	Structure 2A	Structure 2B	Str. 4A (Burials)	Structure 4A	Structure 4B	Surface
Oval		1.7	1.4	1.3	1.6	1.7	1.3		1.8	0.7	
General-utility		0.8	1.9	1.7	0.8	1.7	1.3		1.2	1.8	
Lenticular		0.4	0.3	0.2		0.2	0.9			0.4	
Thick, narrow		0.4	0.8	0.6		0.2	0.9		0.6		16.7
Adzes		0.4	0.6	0.4		0.4				0.4	16.7
Thin (various) <sup>1</sup>		3.0	0.8	1.7	2.5	1.9	1.7		0.6	1.1	
Thick (various) <sup>1</sup>		0.8	2.0	0.4	0.4	1.9	0.9	3.0	1.8	2.2	
Preforms		1.7	0.3	0.2	0.4	0.2	0.4			0.4	

#### Notes:

<sup>1</sup>The greatest variations in percentages for thin and thick (various) categories are mostly due to extremely fragmentary elements.

Table 16. Percentages of large bifaces and fragments in sub-assemblages by structure/location.



	PKH-M1	Plaza platform	Structure 1A	Structure 1B	Structure 1C	Structure 2A	Structure 2B	Str. 4A (Burials)	Structure 4A	Structure 4B	Surface
Blades			1.1	0.6	1.2	1.3			0.6	1.5	
Retouched blades			0.2	0.2						0.4	
Stemmed blades						0.2					
Blade cores						0.2				0.4	

 Table 17. Percentages of blades (simple, retouched, stemmed) blades, blade cores and fragments in sub-assemblages by structure/location



	PKH-M1	Plaza platform	Structure 1A	Structure 1B	Structure 1C	Structure 2A	Structure 2B	Str. 4A (Burials)	Structure 4A	Structure 4B	Surface
Drills		0.8	0.6	0.2	1.6	1.1	0.4		1.8	0.7	
Gravers				0.2					0.6		
Notches			0.2							0.4	
Scrapers		0.4	0.2		0.4	0.2				0.4	

Table 18. Percentages of tools-on-flakes and fragments in sub-assemblages by structure/location.



Tool types	Possible uses associated with craft-production
Thick, narrow bifaces (chisels/gouges)	Wood-working, stone-working
Drills-on-flakes	Bead production (stone, shell)
Large bifaces (bit end crushing)	Stone-working (masonry)
Bifacial adzes	Wood-working

Table 19. Tool types associated with minor craft-production/specialization at Pook's Hill.

Further evidence for primarily subsistence-related domestic activities with some minor degree of craft-specialization involves the examination of the Pook's Hill lithic assemblage based on Lewenstein's (1987) and Aldenderfer's (1990, 1991a; Aldenderfer et al. 1989) work on lithic assemblage composition and economic structure. The nonobsidian chipped stone tool assemblage composition and spatial distribution at Pook's Hill appears to most closely conform to Lewenstein's (1987:26-27, Table 1) category 4 "Subsistence-oriented; no specialized production beyond the domestic unit", which is described as "[l]ittle variability in distribution of subsistence-oriented tools between residential loci". However, there is some evidence to suggest craft specialization involving chisels, adzes, and drills and therefore the type of economy represented by the chipped stone tools at Pook's Hill may fall somewhere between categories 4 and 3 ["Low-level specialization in processing and manufacture"], which has an assemblage described as "[e]ach locus will have subsistence tools. Tool kits associated with nonsubsistence activities will be widespread; may occur at each locus. There will be clusters of nonsubsistence tools in one or more loci which are considered larger than frequencies of these same toolkits in other households". The last criterion is not completely satisfied at Pook's Hill because any 'clusters of nonsubsistence' tools are only occur in minimally greater frequencies at some places than in others.

As previously noted, there are small numbers of hafted, specially designed tools and a large quantity of simple flakes, flake cores and core fragments manufactured from locally obtained stone in the assemblage at Pook's Hill. This assemblage is dominated by ad hoc, minimally modified or retouched, likely hand-held tools that would have been suitable for a wide range of tasks that did not require specific edge designs or other morphological standardization. Based on theoretical, ethnographic and other archaeological evidence (see Aldenderfer 1990: 65-66 for the Peten Lakes District), this represents a typical household assemblage of generalized tools that were relatively easily manufactured, with the possibility that some *ad hoc* tools could certainly be used for some specialized production, if needed (Aldenderfer et al. 1989: 56). The assemblage most closely conforms to the tools expected to for use in general and specific, domestic and extractive activities, with very minimal evidence for some activities that might fit the 'general activity, industrial/specialist' category, specifically a very small quantity of "skilled, low-volume production of commodities" in the form of bead production, and some stone or woodwork (Aldenderfer et al. 1989:49, Table 1; also see Aoyama 1995, 1999).

As noted by Aldenderfer (1990: 66 1991: 210-211; Aldenderfer et al. 1989: 53), some specific tools that are more specialized and require more investment in production, maintenance and repair are larger bifaces needed for a range of heavier tasks (i.e. chopping wood, soil digging). Aside form the large bifaces, the only obviously specialized tools at Pook's Hill a small quantities of drills, gravers, scrapers, some thin bifaces, and perhaps some blade-tools and adzes (see Aldenderfer 1991a: 208-212 for the Peten Lakes region). These are all slightly more difficult to make and possess some standardized morphology because they are specially designed to reliably perform one task repeatedly very well. Likely, all of these tools were hafted for use, suggesting further investment in production based on the need to make the handles as well as the stone elements. Despite the presence of these tools and their suggested functions, Pook's Hill does not possess formal tools in great enough quantity and design specificity that are

representative of industrial/specialist activities in any substantial capacity (Aldenderfer *et al.* 1989:53-58).

# SUMMARY

The non-obsidian chipped stone tools excavated from Pook's Hill represent a fairly generalized, easily produced and maintained, assemblage primarily intended for domestic subsistence and extractive activities with some small-scale craft-production. Tools are primarily made from easily obtained local stone (chert and chalcedony) of varying quality. All tools types, regardless of design, are typically made from these locally procured raw materials. Quite a wide range of tool types were recovered from the site, including formal tools (oval bifaces, general-utility bifaces, adzes, lenticular bifaces, thick and narrow bifaces [chisels], various thin and thick biface forms, blades, macroblades, and drills) and informal tools (flaking debitage, cores and core fragments, some tools-on-flakes, and heat spalls/potlids).

There is good evidence for tool production at Pook's Hill, specifically large bifaces and smaller bifaces, with limited production of blades. Some specialized tools on flakes/blades were also manufactured, including very small quantities of gravers, scrapers, and particularly drills. There was also a heavy reliance on expedient technology in the form of flakes produced through simple core reduction. The Classic period inhabitants of this site employed both formal tools and informal tools in the completion of everyday tasks. Loci identified as spatially segregated workshops for tool production are not present at the site; it appears most Maya households were capable of making the majority of tools that they required, although there are minor clusters of the remains of lithic production spread throughout the *plazuela* (i.e. more evidence for blades at Structure 4B).

Little evidence for curation of the lithic assemblage as a whole has been found. Although some tools, mostly large bifaces, demonstrate more prolonged, heavy use and repair and/or recycling than others, the typical use-life of a tool does not include substantial reworking or reshaping for the completion of other tasks. Once tools broke, they seem to have been discarded with minimal attempts to rejuvenate them or transform them into other functional implements, however temporarily.

The lack of substantial curation of the tools in the assemblage is most likely the result of unrestricted access to good quality stone. Raw material seems abundant, or at least, readily available, ranging in quality from poor (coarse-grained, blocky texture) to very fine-grained (of the same quality as stone described from the CBZ, although not coming from there). This is certainly not the pattern of acquisition, use and re-use/recycling observed at consumer sites, as defined by McAnany (1989), Dockall and Shafer (1993), Hult and Hester (1995), and Stemp (2001; Stemp and Graham 2006).

In addition to evidence for production of stone tools for local use, it appears that at least some craft-production for local consumption and exchange outside the Pook's Hill community was also occurring. In this case, tools such as drills, chisels/gouges, adzes, and large bifaces with heavily crushed edges have been suggested as associated with activities like bone or stone bead production, wood-working, stone-working, and possibly masonry. Although these activities have been generally inferred from tool types, it is acknowledged that similar tools have been demonstrated as multi-functional regardless of morphological design (see Aldenderfer 1990, 1991; Aoyama 1995, 1999; Lewenstein 1987, Stemp 2001, 2004a, 2006). A more accurate sense of the specific functions of the stone tools recovered from Pook's Hill and the frequencies of related activities can only occur following a program of use-wear analysis. For now, the non-obsidian chipped stone tools associated with different craft-specializations at Pook's Hill are relatively few in number and are not obviously spatially concentrated and segregated. This suggests that craft-production at the site was not intensive and was likely organized as a part-time, independent specialization, likely at the individual household or possibly community level (Brumfiel and Earle 1987; Costin 1991, 2001; Lewis 1996; but see Inomata 2001; Inomata and Triadan 2000).

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#### THE OBSIDIAN ARTIFACTS OF POOK'S HILL, BELIZE (1999-2005)

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#### INTRODUCTION

Archaeological investigations (consisting of surface reconnaissance, test-pitting, and both salvage and extensive horizontal excavations) recovered just over 500 obsidian artifacts from a variety of primary and secondary contexts at Pook's Hill (Figure 1). In 2005 and 2006, the author of this report analyzed a total of 496 (total mass = 732.9 g) obsidian tools and byproducts. For several reasons, this number is slightly less than that reported as recovered from the site. First, one artifact labeled as obsidian is made of another material. Second, several pairs of prismatic blade fragments from the same contexts were found to fit. In each case, these refitted pieces were analyzed and counted as a single artifact. Finally, nine excavated artifacts were not present in the sample sent for analysis. Presumably these are still in the storage facility at Pook's Hill, perhaps stored with chert or other stone artifacts.

This report focuses on two fundamental economic questions: (1) From where was obsidian found at Pook's Hill procured?; and (2) What sorts of obsidian tools were produced and consumed at Pook's Hill? Answers to these questions are presented here in two forms. First, the collection is considered from a synchronic perspective. That is, the entire sample is described without regard to chronology. The advantage of this approach is that the size of the full sample is robust. Second, primary contexts with clearly delimited chronologies are considered from a diachronic perspective. In this case, the sample size for each phase or period is much smaller, but changes in procurement and production patterns may be observed.

## VISUAL SOURCE ATTRIBUTION OF OBSIDIAN ARTIFACTS

In order to understand obsidian procurement patterns at Pook's Hill, lithic analysis began with experiments designed to identify the geological sources of the 496 artifacts recovered from the site. A combined method of visual and neutron activation analysis (NAA) sourcing has been described elsewhere (Braswell et al. 1994, 2000). Results of this strategy have been presented for collections from Chichen Itza, Uxmal, Yaxuna, Coba, Ek Balam (Braswell and Glascock 1998), Calakmul (Braswell et al. 2004), Topoxte (Braswell 2000), Quelepa (Braswell et al. 1994), and dozens of Postclassic sites throughout Mesoamerica and lower Central America (Braswell 2003). Source analysis of the Pook's Hill collection is not complete because visual studies have not yet been complemented by NAA, XRF, or some other geochemical technique. In

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**Figure 1:** Detail of the upper Roaring Creek Valley and the environs of Pook's Hill (PKH1). The northern and southern groups and the causeway of the minor center of Chaac Mool Ha are rendered to scale, while *plazuelas* (squares) and housemounds (dots) are conventionalized. The Roaring Creek, which courses from south to north, is rendered to scale, while the smaller tributary creeks are conventionalized. Topography is approximate and derived from 1:50,000 sheets maps of the British Overseas Ordenance Survey (Sheet 24). Contour intervals represent 20-m increments above mean sea level. Note that the entirety of the alluvial valley in this area is below 80 m in elevation. The edge of the floodplain delineates the maximum area that is susceptible to flooding during the rainy season, which in turn explains the complete absence of ancient Maya sites within that area. The grid corresponds to UTM coordinates in relation to the WGS84 datum, aligned to grid north, expressed in kilometer increments. Map based on GPS ground survey and an Othorectified Radar Image (tile 17w88b7), acquired by Intermap Technologies, used under academic license. **Survey by:** C. Helmke (1997-2006), R. Guerra (2000-2006), W. Poe (2000-2002), D. Weinberg (2001-2002), and A. Bevan (2002-2003). **Map by:** C. Helmke & A. Bevan (2006).

particular, the identification of Mexican "black" sources in the collection (primarily Ucareo, Michoacan, and Zaragoza, Puebla) must be considered preliminary, and nearly half (seven of 17) of the pieces assigned to the Ixtepeque source may actually be from El Chayal. A short section below discusses the instrumental sourcing experiments that should be conducted in order verify the visual source assignments described here.

## Methodology and Results of Sourcing Experiments

Classic obsidian collections from the central and southern Maya lowlands are typically dominated by material from just one or two sources located in the Guatemalan highlands. At Topoxte, for example, 65 percent of the Early to Terminal Classic obsidian comes from El Chayal and 24 percent from Ixtepeque (Braswell 2000: Fig. 172). At Late Classic Copan, fully 99.6 percent of the obsidian comes from the Ixtepeque source (Aoyama 1999:131). The decision-making process employed when visually sorting such Early and Late Classic collections is virtually binary: Is it Source A or Source B? An effective sourcing strategy for such collections is to form one or two visual categories representing these groups, and to set aside all visual "outliers" for trace-element assay. The efficacy of the visual sort can be judged by assaying a random sample from the dominant visual group or groups. If accuracy is high for the random sample, it may be assumed that it is also high for the visual group as a whole.

Terminal Classic collections from the Maya lowlands contain obsidian from as many as ten sources, and hence, can be more difficult to source according to visual criteria. More visual categories need to be formed by the analyst, and a significant sample from each must be subjected to trace-element sampling. I find two central Mexican sources—Ucareo, Michoacan, and Zaragoza, Puebla—to be particularly difficult to distinguish from each other (but typically not from other sources) using visual criteria. In an experimental sort of 107 artifacts from Chichen Itza thought to be from these two sources, I was able to identify only 80 percent of them correctly, but NAA did reveal that all 107 artifacts were from these two sources and no other. It seems best, then, to conduct trace-element analysis on all artifacts thought to be from either Ucareo or Zaragoza. Although they are much more distinctive than the Mexican "black" obsidian sources, it can on occasion be difficult to distinguish some artifacts made of Ixtepeque and El Chayal (both in Guatemala) obsidian. In particular, pieces that are both small and clear (that is, lacking both diagnostic color and inclusions) may pose difficulties for the analyst. In such cases, a sourcing decision is made almost entirely on the basis of surface luster.

In the case of Pook's Hill, six visual groups were formed (Table 1). The first, and by far the largest, consists of artifacts thought to come from the El Chayal, Guatemala, source (N=469, 94.6 % by count; m=694.7 g, 94.8 % by mass). The visual sourcing of two of the artifacts assigned to this group was considered to be problematic; one artifact may come from the San Martín Jilotepeque source and a second may come from a Mexican "black" source.

A much smaller visual group (N=17, 3.4 % by count; m=30.1g, 4.1 % by mass) shares visual characteristics consistent with the Ixtepeque, Guatemala source. As mentioned above, the assignment of seven of these artifacts was difficult. All seven of these problematic pieces might be from the El Chayal source.

Site	El Chayal	Ixtepeque	San Martín Jilotepeque	Ucareo	Pachuca	Other or Unknown
Pook's Hill (N=496)	94.8 %	3.4 %	0.4 %	1.0 %	0.4 %	0.2 %
Pusilha (N=4,079)	91.4 %	7.6 %	0.2 %	0.1 %	0.3 %	0.3 %
Xunantunich (N=515)	88.9 %	10.7 %	0.2 %	0.2 %		
Atlas Arq. (N=464)	85.8 %	6.0 %	5.8 %	1.3 %	0.7 %	0.4 %
Yaxha (N=224)	51.3 %	1.8 %	46.4 %			0.4 %
Topoxte (N=325)	42.5 %	37.8 %	19.1 %	0.3 %		0.3 %

**Table 1.** Obsidian sources represented at Pook's Hill, Belize, and other lowland sites.(Data presented as percentages of total counts).

The next largest visual group consists of artifacts tentatively assigned to the Mexican "black" source of Ucareo, Michoacan (N=5, 1.0 % by count; m=6.5 g, 0.9 % by mass). Three of these pieces equally could be from the Zaragoza, Puebla source, and one more may be from Ucareo, Zaragoza, or El Chayal. Two prismatic blade fragments (0.4 % by count; 1.8 g, 0.2 % by mass) made of green obsidian were unambiguously assigned to the Pachuca, Hidalgo, source. Two pieces (0.4 % by count; m=1.1 g, 0.2 % by mass) were assigned to the San Martín Jilotepeque, Guatemala, source, but one may be from El Chayal. Finally, one piece (m=1.6 g, 0.2 % by mass) was judged as too difficult to assign to any particular source.

Sourcing by geochemical means. In order to verify the visual source assignments presented here, a geochemical technique such as NAA should be employed. In this case, I recommend that *all* pieces (N=25) assigned to visual sources other than Pachuca or El Chayal be subject to geochemical sourcing. In addition, the two pieces tentatively assigned to the El Chayal source (but which might come from San Martín Jilotepeque and the Ucareo sources) should also be assayed. Finally, a random sample from the large group unequivocally assigned to the El Chayal source eshould also be assayed in order to determine the statistical accuracy of this major source assignment. A sample of 25 would be sufficient. Thus, a total of about 52 artifacts should be submitted for NAA, XRF, or a similar sourcing technique.

## **Comparison with Other Similar Collections**

The collection of 496 obsidian artifacts from Pook's Hill was only the third such sample from Belize (the others being from nearby Xunantunich and distant Pusilha) that I have analyzed. Other comparable collections studied include materials from Topoxte and Yaxha, as well as samples from a wide variety of sites in the southeastern Peten excavated by Juan Pedro Laporte and members of the Atlas Arqueológico de Guatemala. Table 1 displays, in purely synchronic form, data from all these sites and regions.

Despite the significant distance between the two sites, the sample from Pook's Hill most closely resembles the collection from Pusilha, Toledo District. The most significant difference, in fact, is in the sample sizes: obsidian is much more abundant at

Pusilha than at the other sites, undoubtedly because of its closer proximity to the Guatemalan sources. The Pusilha collection comes from contexts dating primarily to the Late Classic (A.D. 570 - 830) and, to a lesser degree, to the early Terminal Classic periods (i.e., ca. A.D. 830 - 900). Poorly dated and very minor late Terminal Classic and Postclassic components were also noted. Much of the Ixtepeque obsidian at Pusilha (as well as all of the Mexican material) seems to date to the Terminal Classic period. Perhaps the greater relative proportion of Ixtepeque obsidian at Pusilha indicates that this site continued to receive more new (rather than recycled) obsidian from the Maya sources at a later date than did Pook's Hill.

The sample from Xunantunich is evenly divided between two excavations in two loci. One half consists of a Late Classic 2 cache excavated by Anderson in Str. A6. The other half was excavated by Jennifer Braswell in Group D. Occupation there was heavy in Late Classic 2 and, to a lesser extent, Late Classic 3 times. Most importantly, Ixtepeque obsidian makes up only 5.5 % of the obsidian in Anderson's cache, but 15.0 % of the Group D material. This is the result of the somewhat later chronology of occupation in Group D. Again, the lower quantity of Ixtepeque at Pook's Hill is probably a result of site chronology: most of the Maya source obsidian at Pook's Hill reached the site at a date earlier than the Terminal Classic.

The 464 obsidian artifacts collected by the Atlas Arqueológico de Guatemala come from a wide variety of sites located between San Luís Peten in the Maya Mountains and the Flores-Melchor de Mencos highway. Most of the artifacts, however, were recovered from excavated sites in or near the municipio of Dolores, Peten. These sites have significant Preclassic, Classic, and Terminal Classic occupations. The significant quantity of San Martín Jilotepeque obsidian found in the collection reflects Preclassic occupation, and the Ixtepeque, Ucareo, and Pachuca (as well as Zacualtipan) obsidian found in the collection dates largely to the Terminal Classic.

The two sites that least resemble Pook's Hill in terms of procurement patterns are Yaxha and Topoxte. After Xunantunich, these are the second and third closest sites to Pook's Hill. The materials from Yaxha were excavated by the Proyecto Triángulo of the Proyecto Nacional Tikal in the early 1990s. Both Classic and Preclassic contexts were excavated, but very little Terminal Classic or Postclassic material was present. At Topoxte, excavations focused on Preclassic and Protoclassic contexts, as well as Middle Postclassic architecture. This accounts for both the high quantity of both San Martín Jilotepeque and Ixtepeque obsidian (the latter is by far the dominant source found in Postclassic contexts), as well as the lack of Mexican source obsidian dating to the Terminal Classic.

In sum, a comparison of the Pook's Hill collection to others analyzed by the author reveals the closest similarities in obsidian procurement patterns to Late Classic sites. Trace quantities of Ixtepeque obsidian (when compared to Terminal Classic Xunantunich) suggest that relatively little material from this source reached Pook's Hill during the Terminal Classic. Perhaps it was too far down river to receive much material from this source at so late a date. In contrast, small yet significant amounts of Mexican source material reached the site, probably traveling up the Belize River in the Terminal Classic. Nonetheless, the vast majority of the obsidian found at the site comes from the El Chayal source, and probably was brought to Pook's Hill during the Classic period. If there was a substantial Terminal Classic (or even Postclassic) occupation of Pook's Hill,

one hypothesis is that most obsidian consumed during that period was recycled rather than brought newly to the site.

## Diachronic Analysis of Procurement Patterns at Pook's Hill

The question of recycling can be addressed two ways. First, if obsidian recycling was the dominant procurement pattern at Pook's Hill during the Terminal Classic period, then most obsidian dating to that period should indeed come from El Chayal, the predominant source exploited in the Late Classic. Second, technological analysis of Terminal Classic obsidian tools should reveal that much of it is derived from exhausted or broken tools. Here, we consider diachronic changes in procurement patterns.

Table 2 presents obsidian procurement data stratified by period. For the Late Classic and early Terminal Classic periods (defined here as A.D. 550-950), obsidian artifacts from primary and unmixed contexts are considered. In the case of both earlier (A.D. 350-550) and later periods (A.D. 950+), the lack of primary and unmixed deposits necessitates the consideration of obsidian from less secure contexts.

Period	El Chayal	Ixtepeque	San Martín Jilotepeque	Ucareo	Pachuca
A.D. 950+ (secondary, mixed contexts)	188 (91.7 %)	11 (5.4 %)	1 (0.5 %)	5 (2.4 %)	
A.D. 830-950 (primary, unmixed contexts)	58 (95.1 %)	3 (4.9 %)			
A.D. 700-830 (primary, unmixed contexts)	15 (100.0 %)				
A.D. 550+ (Cache 4A2, primary, unmixed)	48 (100.0 %)				
A.D. 350-550 (?) (Secondary, mixed context)	2 (40.0 %)	1 (20.0 %)			2 (40.0 %)

**Table 2.** Obsidian sources at Pook's Hill, Belize, by period (data presented as counts and percentages).

 Pachuca specimens were recovered as part of surface collections at Chaac Mool Ha, not Pook's Hill proper.

Just five obsidian artifacts were recovered from a potentially Early Classic context (Hermitage phase, late facet, A.D. 350-550; Chaac Mool Ha [CMH1], surface collection; see Figure 1). Because these artifacts stem, from surface collections, their assignment to this period must be considered with great caution. Two of these artifacts come from the El Chayal source, two more from Pachuca, and one from Ixtepeque. It is at first tempting to assign the two Pachuca artifacts (in fact, the only two collected from the site) to the "Middle" Classic period, when green obsidian was exported by Teotihuacan to the Maya region. But two facts strongly suggest that these artifacts date to a much later time. First, green obsidian found in late Early Classic contexts in the Maya area is limited to the epicenters of large and important sites, indicating elite-to-elite gift giving rather than commercialized trade (see Spence 1996). Second, one of the two green blade fragments

has a pecked-and-ground platform. This technique is associated not with Classic Teotihuacan (where blades have simple facet platforms) but with Epiclassic and Postclassic sites. In the Maya region, pecked-and-ground platforms are diagnostic of post-A.D. 800 collections. Nonetheless it must be remarked that Chaac Mool Ha is the dominant site in the immediate vicinity of Pook's Hill (it is located 1 km away), which undoubtedly served as an elite satellite to the larger regal center of Cahal Uitz Na (situated 3.9 km to the south) (Figure 1). Thus the site may qualify as a potential recipient of elite-to-elite gifting of Pachuca obsidian, though the pecked-and-ground platform does indeed argue against this conclusion. In sum, these surface finds probably do not date to the Early Classic, but most likely date to an occupation during the Terminal Classic.

Cache 4A-2 contained an important sample of 48 contemporary obsidian artifacts. Despite the primary and unmixed nature of this deposit, a Late Classic date (e.g., A.D. 550+) is all that can be determined at present for the cache on the basis of associated ceramics and stratigraphy. All 48 artifacts from Cache 4A-2 come from the El Chayal source, which fully consistent with a Late Classic date.

Three burials (Bu. 2A-1, 2A-2, and 4A-5) are primary and unmixed contexts dating to the second half of the Late Classic (Spanish Lookout phase, early facet, A.D. 700-830). A total of 15 obsidian artifacts were recovered from these burials, as well as from the unmixed collapse of Terrace 1 of Structure 1A. All of these artifacts come from the El Chayal source.

A larger collection of 61 artifacts dating to the early Terminal Classic (Spanish Lookout phase, late facet, A.D. 830-950) was recovered from Clusters 4, 7, 8, 9, 11, Architectural Unit 11, and Bu. 4A-3. The features designated as Clusters are small diminutive middens and informal deposits of refuse that were located at the corners formed by adjoining structures. These are all primary contexts lacking materials from other time periods. More than 95 % of the obsidian artifacts dating to this phase come from the El Chayal source, the remainder comes from Ixtepeque. What is significant about the sample dating to this period is that the quantity of Ixtepeque obsidian is so low. Comparing Pook's Hill to nearby Xunantunich, the early Terminal Classic collection from Pook's resembles Anderson's Late Classic 2 cache more than the (temporally mixed, but somewhat later) sample from Group D. That is, although some Ixtepeque obsidian reached Pook's Hill for the first time as a small but significant fraction of the assemblage during the early Terminal Classic, much more Ixtepeque obsidian was used at Xunantunich (certainly at least 15.0 %, and probably considerably more) during this same period. A comparison with Pusilha reveals the same pattern.

Finally, 205 artifacts were collected from surface and near-surface contexts that may date to some time after A.D. 950. These contexts are both secondary and temporally mixed. Most of this obsidian comes from the El Chayal source but about 5 % comes from Ixtepeque. All five pieces of Mexican "black" obsidian—probably from Ucareo— comes from these near-surface contexts. Despite the presence of exotic obsidian, the sample is otherwise very similar to the Spanish Lookout phase, late facet collection. The very low level of Ixtepeque obsidian and presence of some central Mexican material suggests that these contexts (considered as a whole) probably do not date to the Postclassic (i.e., after about A.D. 1050).

Three conclusions can be drawn from these comparisons. First, during the early part of the Terminal Classic period, significant quantities of Ixtepeque obsidian reached both Pusilha and Xunantunich, as well as Terminal Classic sites studied by the Atlas Arqueológico de Guatemala in southeastern Peten. At the same time, very little Ixtepeque apparently was traded to Pook's Hill. Second, during the 9<sup>th</sup> century, Ixtepeque obsidian was most probably traded by a riverine system from the southwest to the northeast. This *downstream* system included Mopan River sites such as Xunantunich, but apparently did not extend into the Belize Valley all the way to the Roaring Creek which connects Pook's Hill to this riverine system. That is, the eastern edge or frontier of this downstream exchange system was somewhere in the western Cayo District.

In contrast, the presence of Mexican obsidian at Pook's Hill, indeed in more than double the percentage seen at Xunantunich, suggests that Mexican obsidian might have been traded *upstream* in the Belize Valley from the Caribbean coast. It is precisely at Terminal Classic coastal sites that the greatest quantity and diversity of Mexican source obsidian is found. This conclusion is certainly in keeping with the large quantities of parrotfish documented in the Terminal Classic middens at Pook's Hill, which were obviously brought in from the Caribbean (see Stanchly 2006).

Finally, the high quantities of El Chayal obsidian in Terminal Classic contexts at Pook's Hill suggest that relatively little obsidian was traded to the site during this late period. Instead, most obsidian artifacts found in late contexts probably were recycled. A typological analysis of the material, presented below, supports this conclusion.

# TYPOLOGICAL AND TECHNOLOGICAL ANALYSES

Typological analysis began with the assumption that all obsidian artifacts could be classified into one or more of four lithic industries: the prismatic blade industry, the retouch industry, the casual percussion industry, and the bipolar percussion industry. Each of these represents a distinct series of technological steps and set of behaviors, and is characterized by particular initial preforms, debitage, and final products. Each lithic industry contains within it a certain amount of variation; there is, of course, more than one way to make a prismatic blade or a biface. Nevertheless, the technological chain of behaviors and choices that are made in each industry are relatively distinct. There is much less variation in the technological details of a single industry than there is across all industries. The concept of such behavioral typologies is well established (e.g., Sheets 1975), and the specific behavioral typologies for these industries are described elsewhere (e.g., Braswell 2000).

In addition to typological analysis, certain metric attributes (length, width, thickness, mass, and for blades and blade-derived types, total cutting edge) and nonmetric attributes (the presence of cortex, unifacial and bifacial retouch, grinding, and platform preparation technique) were noted. Curiously, not a single artifact in the Pook's Hill collection was retouched. That is, there were no bifaces or even unifacial scrapers in the sample. Moreover, not one artifact retained traces of cortex, the natural outer covering of an obsidian nodule. Although polyhedral blade cores are well trimmed and prepared in their proximal and medial regions, it is common to note a bit of cortex near the distal tip of cores or on the distal tips of a few polyhedral blades. The fact that no cortex was found at all in the Pook's Hill collection suggests that polyhedral blade cores reached the site in a significantly reduced state.

# **Prismatic Blade and Retouch Industries**

The prismatic blade industry is the most complex. The key diagnostic feature of its final stage is that a pressure crutch is used to remove long, parallel sided ribbons of obsidian from (in most cases) a bullet-shaped polyhedral core. The retouch industry entails removing small flakes by hard hammer percussion, soft hammer percussion, or pressure (and often more than one of these techniques) from a preform or blank in order to thin, shape, or strengthen a particular tool. The most easily recognizable retouched tools from the Maya area are bifacially worked knives and projectile points. These were most often made using percussion blades or even pressure blades as blanks. Unifacially retouched scrapers, often made on percussion flakes, are at least as common as bifaces.

# **Casual and Bipolar Percussion Industries**

Both the casual percussion and bipolar percussion industries are much less complex and were practiced to create simple, *ad hoc* tools. In the Maya lowlands, obsidian tools and byproducts resulting from another industry were often recycled using either of these expedient methods. The difference between the two industries lies is how flakes are produced. In the casual percussion industry, a hard hammer is used to strike flakes from a hand-held core. In the bipolar industry, a small core is placed on an anvil and smashed.

# **Type Assignments**

Each of the four lithic industries has diagnostic types, but some types crosscut all industries. These are often non-diagnostic artifacts, unless scars representing particular activities are noted. One example of this is the common debitage taxon "chunk" or "shatter." Some chunks have morphological characteristics that make it possible to assign them to a particular industry, but others do not.

In ceramic analysis, pottery sherds are assigned to a single type because they represent one, and only one, final product. Chipped-stone lithics, however, often were recycled and morphologically altered, and the products and byproducts of one particular lithic industry frequently became the preforms for another. A percussion blade (perhaps a byproduct of core shaping for prismatic blade manufacture) can serve as a blank for making a projectile point in the retouch industry. Later, the projectile point may break and be reused as a core for producing bipolar flakes. Because of lithic recycling, it often is necessary to ascribe an artifact to two or more types and even to two or more lithic industries.

The 496 analyzed artifacts from Pook's Hill were assigned to five fundamental morphological types, several of which have subtypes. The basic types noted in the collection include flakes (with distinct subtypes pertaining to the casual percussion, retouch, and bipolar percussion industries), large percussion blades, prismatic blades, exhausted polyhedral cores, and chunks. Typological data are summarized in Table 3.

Lithic Industry/Type	2	Ν	Unadjusted	Adjusted
			Percent <sup>a</sup>	Percent <sup>b</sup>
Prismatic Blade Indu	istrv	454	91.5	80.4
Large percussion blade	es	5	1.0	0.9
	Whole	1	0.2	0.2
	Proximal fragments	2	0.4	0.4
	Medial fragments	2	0.4	0.4
Prismatic Blades		374	75.4	66.2
	Whole	9	1.8	1.6
	Proximal fragments	114	23.0	20.2
	Medial fragments	198	39.9	35.0
	Distal fragments	53	10.7	9.4
Exhausted polyhedral	cores	6	1.2	1.1
	Whole	2	0.4	0.4
	Proximal fragment	1	0.2	0.2
	Medial fragment	1	0.2	0.2
	Distal fragment	2	0.4	0.4
Bipolar flakes from ex	. polyhedral cores	21	4.2	3.7
	Whole	17	3.4	3.0
	Proximal fragments	2	0.4	0.4
	Distal fragments	2	0.4	0.4
Casual perc. flakes fro	m ex. polyhedral cores	20	4.0	3.5
	Whole Described for a second	12	2.4	2.1
	Proximal fragments	3	0.6	0.5
	Distal fragments	3	0.6	0.5
Chunks from av nolul	Distai fragments	2	0.4	0.4
Chunks nom ex. pory	ieurar cores	20	5.0	5.0
<b>Bipolar Percussion I</b>	ndustry	53	10.7	9.4
Bipolar flakes		28	5.6	5.0
	Whole <sup>h</sup>	22	4.4	3.9
	Proximal <sup>1</sup>	3	0.6	0.5
	Distal <sup>J</sup>	3	0.6	0.5
Bipolar cores <sup>k</sup>		25	5.0	4.4
<b>Casual Percussion In</b>	dustry	44	8.9	7.8
Casual percussion flak	tes	43	8.7	7.6
	Whole <sup>c</sup>	30	6.0	5.3
	Proximal fragments <sup>d</sup>	6	1.2	1.1
	Medial fragments <sup>e</sup>	3	0.6	0.5
	Distal fragments <sup>1</sup>	4	0.8	0.7
Percussion core chunk	g	1	0.2	0.2
<b>Retouch Industry</b>		2	0.4	0.4
Thinning flakes		2	0.4	0.4
Unidentified Percussio	on Industry	12	2.4	2.1
Chunks		12	2.4	2.1

Notes: Totals for each lithic industry are presented in bold. **a:** Based on dividing by 496, the total number of artifacts. The sum is greater than 100% because 69 artifacts are each given two typological assignments. **b:** Based on dividing by 565, the total number of artifact assignments. **c:** Includes 12 artifacts also classified as casual percussion flakes from ex. polyhedral cores (whole). **d:** Includes three artifacts also classified as casual percussion flakes from ex. polyhedral cores (proximal). **e:** Includes three artifacts also classified as casual percussion flakes from ex. polyhedral cores (medial). **f:** Includes two artifacts also classified as casual percussion flakes from ex. polyhedral cores (proximal). **g:** Also classified as a chunk from exhausted polyhedral core. **h:** Includes 17 artifacts also classified as bipolar flakes from ex. polyhedral cores (proximal). **j:** Includes two artifacts also classified as bipolar flakes from ex. polyhedral cores (distal). **k:** Includes 20 artifacts also classified as chunks from ex. polyhedral core. **l:** Includes seven artifacts also classified as a whole ex. polyhedral core. **l:** Includes seven artifacts also classified as chunks from ex. polyhedral core and one artifact also classified as a whole ex. polyhedral core. **l:** Includes seven artifacts also classified as chunks from ex. polyhedral core and one artifact also classified as a whole ex. polyhedral core. **l:** Includes seven artifacts also classified as chunks from ex. polyhedral core and one artifact also classified as a whole ex. polyhedral core. **l:** Includes seven artifacts also classified as chunks from ex. polyhedral core and one artifact also classified as a whole ex. polyhedral core. **l:** Includes seven artifacts also classified as chunks from ex. polyhedral core.

**Table 3.** Typological classification of the Pook's Hill obsidian (N=496).

As can be seen, the number of artifacts assigned to each industry (including a fifth category called "unidentified percussion industry," which includes pieces that cannot be unambiguously assigned to either the casual or bipolar percussion industry) sums to 565. This is because 69 artifacts are given multiple assignments, first to the prismatic blade industry and then to one of the percussion industries. The adjusted percentages in the final column of Table 3 reflect these double assignments. In short, these 69 artifacts (some 13.9 % of the entire sample of 496 artifacts) are clear examples of recycling. In many cases they represent core smashing, that is, the use of exhausted polyhedral cores as (first) casual percussion cores and (then, as they become too small to hold in the hand) as bipolar percussion cores.

Table 3 reveals that the most common lithic industry represented at Pook's Hill was the prismatic blade industry. Fully 91.5 % (unadjusted in Table 3) of all artifacts were either prismatic blades or byproducts of prismatic blade production. This is typical, or perhaps just a little low, for most Maya sites dating to a time after the Middle Preclassic period. When double assignments are taken into account (adjusted percentages in Table 3), just 80.4 % of the type assignments pertain to the prismatic industry. This value is guite low for a Classic period site. Again, the reason for this discrepancy is that many prismatic blade related artifacts at Pook's Hill were recycled in either the bipolar or casual percussion industry. Exhausted polyhedral cores and core fragments are relatively common at Pook's Hill. This suggests that, during the Classic period, prismatic blades were locally produced using imported polyhedral cores. What is more, the frequency of exhausted cores (when compared to blade fragments) is high enough to suggest: (1) Pook's Hill produced more blades than were consumed at the site, that is, some were made for export to other sites; or (2) polyhedral cores reached Pook's Hill in a significantly reduced state. Both the total lack of cortex in the sample and the location of Pook's Hill in the extreme eastern periphery of the Maya world certainly make the second possibility highly likely, but without further investigations at nearby smaller sites it is not possible to definitively answer this question.

The second most common industry represented in the sample is bipolar percussion. Fully 10.7 % of the artifacts in the sample can be assigned to this flake industry. This is an extremely high level for a Classic assemblage. It is generally the

case that, after the Middle Preclassic period, no more than 1 % of obsidian artifacts found at Maya sites pertain to this simple, *ad hoc* flake industry. At least 41 of the 53 bipolar artifacts (i.e., 77 %) are pieces of recycled exhausted prismatic blade cores. That is, the "raw material" of choice for making bipolar flakes was the exhausted prismatic blade core.

The third most common is the casual percussion industry (8.9 %, 7.8 % adjusted for total assignments). This, too, is high for a Classic Maya collection. At least 21 of the 44 casual percussion artifacts are derived from exhausted polyhedral cores, again implying that core recycling was a common practice.

Finally, artifacts pertaining to the retouch industry are extremely rare. Just two thinning flakes, the result either of making a new obsidian biface or of re-sharpening an old one, were recovered. The larger of these two flakes was used as a side scraper. The smaller comes from a percussion blade, a common blank or preform used to make obsidian bifaces. Again, no bifaces were found in the collection. This is extremely odd for a site with a significant Terminal Classic occupation. In nearly all Maya centers, the quantity of bifacial projectile points grew substantially during the early Terminal Classic period. Bifacial projectile points are also a relatively common artifact type during the Postclassic period. The lack of such points at Pook's Hill suggests three possibilities: (1) very little obsidian reached the site after the end of the Late Classic period; (2) another material, such as chert, may have been used to make projectile points during the Terminal Classic; or (3) there were few or no lithic specialists at Pook's Hill who knew how to manufacture bifaces during the Terminal Classic period.

# Synchronic Interpretation

A synchronic interpretation of the obsidian artifacts from Pook's Hill suggests that obsidian reached the state in a well-prepared and significantly reduced state (demonstrated both by the lack of pieces with cortex and by a high core to blade ratio). The most commonly imported form was probably the polyhedral blade core. Prismatic blades were made locally from these cores (evinced by the presence of exhausted cores and core fragments). I suspect that the cores were small and typically nearly exhausted when they reached the site (because of the high core to blade ratio), but it is also possible that lithic specialists at Pook's Hill made blades that were used at other sites. The few percussion blades in the collection may represent the rejuvenation of damaged polyhedral cores; at least one comes from a core that was nearly exhausted. No obsidian bifaces were found at the site, but two thinning flakes suggest that someone occasionally manufactured or re-sharpened bifaces. The complete lack of obsidian bifaces at the site, particularly from Terminal Classic contexts, is anomalous, and may represent a shift to chert, a lack of access to suitable imported preforms, or a breakdown in economic specialization. Both the production of prismatic blades and bifaces are skilled tasks that are often associated with at least a modest level of specialization.

Exhausted polyhedral cores were later reused as cores in two industries that require no skill or specialization whatsoever: the casual percussion and bipolar percussion industries. This recycling was almost certainly sequential. Exhausted polyhedral cores were first held in the hand and broken using direct hard hammer percussion, resulting chunks and shatter were then placed on an anvil and smashed using bipolar percussion. Fully 109 of the 496 obsidian artifacts, or roughly 22 %, are classified as flakes or percussion cores of one sort or another. When we consider that 374 of the obsidian artifacts from Pook's Hill are prismatic blades or prismatic blade fragments, artifacts generally too small for further reduction by either percussion technique, this means that most only 13 other artifacts were not somehow recycled. Obsidian recycling, therefore, was very common at Pook's Hill, and the artifact type of choice to be recycled was the exhausted polyhedral core. What remains to be answered is if this practice was common throughout the occupation of the site or occurred primarily during the Terminal Classic, a period when very little new obsidian was brought to the site.

## **Diachronic Analysis**

Table 4 presents diachronic data regarding the lithic industries represented at Pook's Hill during different periods of occupation. The artifacts and contexts presented in this table are precisely those shown in Table 2. In the case of Table 4, typological data are summarized according to lithic industry rather than particular type, that is, each entry in the table is comparable to the total tallies shown in bold face in Table 3. The total number of artifacts pertaining to each period or ceramic phase is displayed in the first column. Entries in the top three rows (that is, data for the latest three periods) sum to a total greater than the number of artifacts for those phases. As in Table 3, the reason for this is that some artifacts were assigned to two lithic industries; footnotes to the table elucidate these double assignments. Unlike in Table 3, adjusted percentages, reflecting double assignments, are not presented.

Period	Prismatic Blade	Retouch	Bipolar Percussion	Casual Percussion	Unidentified Percussion
A.D. 950+ (N=205)	184 (89.8%)	1 (0.5%)	31 (15.1%) <sup>a</sup>	18 (8.8%) <sup>b</sup>	$8(3.9\%)^{c}$
(secondary, mixed contexts)					
A.D. 830-950 (N=61)	56 (91.8%)		$5(8.2\%)^{d}$	$10(16.4\%)^{e}$	1 (1.6%)
(primary, unmixed contexts)	· · · ·		· · · ·	· · · · ·	. ,
A.D. 700-830 (N=15)	14 (93.3%)		2 (13.3%) <sup>f</sup>		
(primary, unmixed contexts)					
A.D. 550+ (N=48)	48 (100.0%)				
(Cache 4A-2, primary, unmixed)					
A.D. 350-550 (?) (N=5)	5 (100.0%)				
(Secondary, mixed context)					

*Notes:* **a:** Includes 25 artifacts also classified as exhausted polyhedral core fragments. **b:** Includes seven artifacts also classified as exhausted polyhedral core fragments. **c:** Includes five artifacts also classified as exhausted polyhedral core fragments. **d:** Includes four artifacts also classified as exhausted polyhedral core fragments. **e:** Includes seven artifacts also classified as exhausted polyhedral core fragments. **f:** Includes one artifacts also classified as an exhausted polyhedral core fragment.

**Table 4.** Obsidian industries represented at Pook's Hill, Belize, by period (data presented as counts and percentages, some lines sum to more than assignments than artifacts because of multiple assignments).

During all periods, the dominant lithic industry represented in the collection was the prismatic blade industry. For contexts dating to a time before A.D. 700, the sample is not robust, consisting of at most 53 artifacts (Table 4, bottom two lines). All are assigned to the prismatic blade industry. More importantly, however, none can be assigned to either of the two percussion flake industries.

The sample for the second half of the Late Classic (A.D. 700-830) is woefully small, consisting of just 15 artifacts. Fourteen clearly pertain to the prismatic blade industry. The fifteenth artifact, a very small bipolar flake with a mass of just 0.5 g, may have been removed from an exhausted polyhedral core but is too small and lacks the clear attributes needed to make this assignment. This small flake and one more (which clearly does come from an exhausted polyhedral core) are assigned to the bipolar industry; together they account for 13.3 % of the artifacts dating to this period. Thus, the practice of reducing exhausted polyhedral cores using bipolar percussion may have emerged during the last century or so of the Late Classic period, perhaps even during the early 9<sup>th</sup> century.

The early Terminal Classic (A.D. 830-950) collection is more robust and consists of 61 artifacts. Sixteen of these (i.e., 26% of the sample) can be assigned to the two percussion flake industries. Although neither sample is particularly large, this may indicate a doubling in the importance of flake industries from the previous period. About two thirds (11 of 16) of these flakes and percussion cores are clearly derived from exhausted polyhedral cores. It is interesting to note that during the early Terminal Classic, the casual percussion industry (N=10) may have been more common than the bipolar percussion industry (N=5). The samples, though, are so small in number that this must be considered a hypothesis.

The sample that may date to the late Terminal Classic (A.D. 950+) is considerably larger, consisting of 205 artifacts. Again, it must be cautioned that none of these artifacts were recovered from unmixed primary contexts. Instead, they were found on or near the surface and above terminal architecture. Fully 57 of these artifacts (28 % of the sample) pertain to the two percussion flake industries. This is about the same percentage as for the early Terminal Classic sample. Thirty seven of these 57 artifacts (i.e., 65 %) are clearly derived from exhausted polyhedral cores. It is fascinating to note that the proportion of casual and bipolar percussion artifacts is reversed from that of the previous period. In the case of the late Terminal Classic, the quantity of bipolar percussion artifacts is approximately twice that of casual percussion flakes and cores. Bipolar cores and flakes are generally much smaller than casual percussion flakes and cores. A plausible interpretation is that, over the years, it became increasingly difficult to scavenge obsidian artifacts of a size sufficient for use as cores in free hand percussion. That is, as the Terminal Classic proceeded, the bipolar industry may have become more important because there were fewer and fewer unreduced exhausted polyhedral cores at the site.

The only artifact in Table 4 assigned to the retouch industry comes from a late Terminal Classic secondary context. This is a large (10.3 g) flake that has many of the attributes of a thinning flake on its ventral face. The thinning flake (initially a form of debitage) was recycled and used as a side scraper. Given the fact that the flake was recovered from a secondary context, its production cannot be dated. It may have been made and discarded sometime during the Early or Late Classic period, only to be

scavenged and used as an *ad hoc* tool during the late Terminal Classic. In any event, this single artifact from a secondary context should not be considered as proof of the local manufacture of obsidian bifaces during the late Terminal Classic period.

Obsidian artifacts from datable contexts form only a small portion of the total collected from Pook's Hill. Nonetheless, it seems quite significant that of the 109 artifacts assigned to the percussion flake industries (see Table 3), fully 73 (i.e., 67%) come from contexts that appear to date to the Terminal Classic (Table 4, top two rows). It is quite reasonable to suppose that many of the 34 percussion flakes and cores that were recovered from secondary or mixed contexts might also date to the Terminal Classic period. In contrast, there is very little evidence (in fact, just two bipolar flakes) for the practice of these industries before the Terminal Classic.

The majority of the bipolar flakes, casual percussion flakes, bipolar cores, casual percussion cores, and miscellaneous percussion chunks are clearly derived from exhausted polyhedral cores. A conclusion, therefore, is that a significant quantity of the obsidian artifacts recovered from Terminal Classic artifacts represent *ad hoc* flake tools and debitage produced from scavenged obsidian discarded during the Classic period. This conclusion is consistent with the observation that the vast majority of the obsidian used at Pook's Hill during the Terminal Classic period comes from the El Chayal, rather than Ixtepeque, source.

# CONCLUSIONS

This report began with two questions that can now be answered: (1) From where was obsidian found at Pook's Hill procured?; and (2) What sorts of obsidian tools were produced and consumed at Pook's Hill?

During much of the Classic period, the obsidian consumed at Pook's Hill came from the source of El Chayal, Guatemala. The most common imported form was the polyhedral core. Prismatic blades were made at the site of Pook's Hill itself. The facts that no obsidian artifacts have traces of cortex and that the ratio of exhausted prismatic blade cores to prismatic blades is high together suggest that cores may have reached the site in a significantly reduced state. There is no unambiguous evidence that obsidian bifaces were produced at Pook's Hill during the Early and Late Classic periods (one small thinning flake comes from an undated context, a second larger thinning flake was found in humus above terminal architecture), and the production of *ad hoc* flake tools was also, at best, an uncommon activity during most of the Early and Late Classic.

To speculate quite a bit, it might have been that during the Early and Late Classic periods, obsidian blades were made by itinerant producers who brought already reduced cores to the site, manufactured blades at Pook's Hill, and then left behind exhausted polyhedral cores as waste. An alternative scenario is that polyhedral blade cores may have been traded in a down-the-line fashion across the Peten and eventually into the Belize Valley. At each exchange, several rings of blades may have been removed. In either case, Pook's Hill appears to have been at or near the end of an exchange network, a suggestion bolstered by both its peripheral location and relatively small size. A final possibility, one that seems somewhat less likely but that cannot be ruled out without investigations at nearby smaller sites, is that Pook's Hill produced many more blades than

it consumed. The exchange of blades out of the site to outlying hamlets might explain the high ratio of exhausted polyhedral cores to prismatic blades. These three possibilities are not mutually exclusive.

Very little obsidian was brought to Pook's Hill during the Terminal Classic period. In the early facet of the Terminal Classic, Ixtepeque obsidian became quite common at Xunantunich. Fully 15.5 % of the obsidian artifacts from Xunantunich Group D, a location with a very strong Late Classic 2 and a somewhat weaker Late Classic 3 (i.e., early Terminal Classic) component comes from this source. Yet only about 5 % (Table 2, top two rows) of the obsidian recovered from Terminal Classic contexts at Pook's Hill can be attributed to this source. In other words, the edge of the overland (and downstream) exchange system that brought Guatemalan obsidian to western Belize was further to the west in the Terminal Classic than in the Late Classic period. That is, Pook's Hill was even more peripheral (when viewed from a Peten perspective) after A.D. 830 than it was during the Early and Late Classic periods.

Scavenging for obsidian became an important procurement strategy in the early facet of the Terminal Classic. The most commonly scavenged artifact was probably the Very few prismatic blade fragments recovered from prismatic blade fragment. archaeological contexts in the central and eastern Maya lowlands are truly exhausted. Although many lack the fine and exceedingly sharp cutting edge of a newly made blade, nearly all can be used for some cutting, sawing, or scraping activities. It can be difficult for a lithic analyst to identify prismatic blades that were produced, used, and discarded during the Late Classic, and then scavenged and reused at a later time. One attribute, platform preparation, can be used to identify Terminal Classic and Postclassic production. Beginning in the Terminal Classic, the platforms of polyhedral blade cores often were pecked-and-ground; by the Postclassic period, this technique became quite dominant. In contrast, blades produced during earlier periods often have scratched or plain platforms and pecked-and-ground platforms are completely absent. Of the 93 whole blades or proximal blade fragments from Pook's Hill that maintain enough of the platform to analyze, 75 (81%) have scratched platforms, 10 (11%) have simple facet or plain platforms, six (6%) have lightly abraded platforms (probably from the removal of platform overhang during reduction; light abrasion makes it impossible to differentiate between scratched and simple facet platforms, but does not make it difficult to identify pecked-and-ground platforms), and just two have pecked-and-ground platforms. These two prismatic blades with pecked-and-ground platforms, which were certainly made some time after A.D. 800, come from the Pachuca and Ixtepeque sources, also consistent with a very late date. Thus, only about 2 % of the prismatic blades found at Pook's Hill can, on technological grounds, be dated to the Terminal Classic or later periods. To summarize, the vast majority of prismatic blades recovered from both early and late Terminal Classic contexts probably were produced and discarded during the Classic period only to be scavenged and reused during the Terminal Classic. Not even one exhausted polyhedral core or chunk from a polyhedral core shows evidence of a peckedand-ground platform. In other words, there is no evidence supporting the production of prismatic blades at Pook's Hill during the Terminal Classic period.

During the late phase of the Terminal Classic period, a few prismatic blades were brought to the site as finished artifacts. These include all five pieces of Mexican "black" obsidian that most likely come from the Ucareo source. This exotic obsidian (which probably also includes the Pachuca blade fragment with the pecked-and-ground platform) reached Pook's Hill from the coast of Belize. Mexican source obsidian is quite common at coastal sites dating to this period. Moreover, the proportion of Mexican obsidian at Pook's Hill is greater than that at Xunantunich, suggesting a fall-off pattern as distance from the cayes increased. Pook's Hill may have thrived for a time during the Terminal Classic because of its greater involvement with coastal trade routes than that enjoyed by sites further upstream. Nonetheless, it seems likely that very little obsidian came up the Belize River as far as Pook's Hill during this period.

In addition to scavenging for still usable prismatic blades, exhausted polyhedral cores discarded during the Classic period were also sought after by the Terminal Classic inhabitants of Pook's Hill. These exhausted polyhedral cores, almost all of which are made of El Chayal obsidian, were reduced by free-hand casual percussion or by bipolar percussion. There is intriguing evidence that bipolar reduction became more common overtime, suggesting that pieces of a size sufficient for free-hand percussion became harder and harder to find. Neither of these reduction strategies requires skill or training; they are simple core smashing techniques. The lack of clear evidence for both prismatic blade and obsidian biface production during the Terminal Classic period is consistent with the loss of specialization that is characteristic of this period.

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## CONTINUED PALEOETHNOBOTANICAL RESEARCH AT POOK'S HILL, BELIZE

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### **INTRODUCTION**

This chapter presents the results of ongoing paleoethnobotanical investigations at Pook's Hill, presenting a continuation of research since 2000 (Morehart 2001). The 2001 report focused on the identification and interpretation of archaeobotanical remains from only 16 flotation samples. Since then, 52 additional flotation and 20 macrofossil samples have been processed for a total of 90 analyzed samples. With the exception of some limited quantitative analysis and generalizations, most of this report will concentrate on samples analyzed since 2001.

#### **METHODS**

Archaeobotanical remains were recovered as either one liter flotation samples or as macrofossil samples (charred remains recovered during excavation). Flotation samples were manually floated in the field by project staff. Light fractions were separated from heavy fractions. Both macrofossil samples and light fractions were exported to the United States where they were analyzed at the Chicago Botanic Garden and at Northwestern University. Samples were rough sorted at low magnification, and botanical remains were separated into taxonomically distinct groups based upon anatomical characteristics. Unknown items were compared to modern material as well as with information contained in reference texts. Table 1 presented at the end of this paper provides a comprehensive list of all the samples that have been analyzed to date. Samples 30001-30069 are flotation samples, and 30070-30090 are macrofossil samples. As just mentioned, samples 30001-30016 have been discussed in a previous report (Morehart 2001). Unless stated otherwise, any quantification of the archaeobotanical data presented below are based solely on the flotation samples as their standardized size enhances comparability (see Miller 1988; Popper 1988).

### **BOTANICAL REMAINS**

Although more samples have been processed since the initial report, a wider variety of economic species (tree fruit remains and domesticates) were identified in the first 16 samples, including maize (*Zea mays*), squash (*Cucurbita* sp.), chile (*Capsicum annuum*), hog plum (*Spondius* sp.), coyol palm (*Acrocomia aculeata*), and calabash

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(*Crescentia cujete*). Few additional remains of tree fruits were identified. The only possibility was a carbonized Fabaceae cotyledon from Burial 4A-3 (30053-001). The cotyledon is not a species of bean (*Phaseolus* sp.) and likely is from a leguminous tree, even though it was not identified beyond the family level. Also, a partial palm (Arecaceae) endocarp was recovered from a macrofossil sample (30080-001). The endocarp is too fragmentary to identify to the genus or the species level, but it is either coyol (*Acrocomia aculeata*) or cocoyol (*Bactris* sp.).

Maize (*Zea mays*) remains represent the dominant botanical food item recovered, and it is the only domesticate identified since the initial report. Sixteen percent of flotation samples contained maize remains (n=69). No macrofossil samples contained maize. Maize remains consist of kernel fragments and cupules (a durable component of the cob). No glumes were recovered, which may suggest that some degree of processing occurred elsewhere. On the other hand, the small glumes are less likely to be recovered or to preserve for long periods of time. Consequently, it would be somewhat misleading to draw specific conclusions as to the nature of the production sequence based on such limited data. The unspecific contextual nature of the maize finds does little to remedy this situation. Maize remains were found in a diversity of contexts, including within architectural fill and collapse, over floors, associated with artifact clusters, and in midden deposits.

The majority of botanical material consists of charcoal, the carbonized woody structures of plants. At the grossest level, charcoal was identified as hardwood, pine, or palm (Arecaceae). Some charcoal specimens were simply identified as dicot; most of these represent charred roots.

Pine (*Pinus* sp.) was by far the dominant taxa of wood charcoal recovered. Eighty-eight percent of all flotation samples from Pook's Hill contained pine charcoal, whereas 25 percent contained hardwood taxa and 3 percent contained charred palm (Figure 1). A wider diversity of contexts contained pine remains, including in midden deposits, on floors, in architectural collapse, in caches, and in burials (Figure 2). Interestingly, a considerable number of flotation samples (29 %) containing pine were from burial samples, whereas only 1 % of samples containing hardwoods were from burials. No hardwood specimens from macrofossil samples were from burials, whereas one macrofossil sample from a burial context yielded pine remains (30082-001). This specimen is fragmentary but has the general long and narrow form that suggests it may have been fashioned into a splint to be used as a torch.

The use of pine by the ancient Maya reveals the sociality encircling plant resources. Although pine most certainly was widely used for utilitarian purposes, Morehart et al. (2005) have explored possible symbolism that surrounded burning pine during rituals in caves and at surface sites. Burning pine torches provided necessary illumination for cave rituals and for rites undertaken at surface sites, particularly if they occurred at night. Moreover, burning pine may have been similar to the modern day burning of candles by Maya groups. The ritual use of pine possibly was embedded within a complex of concepts surrounding the offering of food to deities or to ancestral figures. The wide distribution of pine in ceremonial contexts at surface sites and in caves may indicate that burning pine was a basic, essential act common to many types of rites. Lentz et al. (2005; see also Morehart 2002; Thompson 1970:146) have argued that pine in



Figure 1. Distribution of wood charcoal from Pook's Hill measured by ubiquity.



Figure 2. Distribution of pine and hardwood charcoal at Pook's Hill according to context.

the Belize River valley was a trade item to which local elites had greater access than commoners. Morehart and Helmke (in press) have suggested that the structure of the political economy influenced the nature of environmental knowledge between elites and commoners by studying the use of pine and hardwoods.

Although speculative, these economic and religious aspects of pine use potentially were integrated. If access to pine was restricted based upon one's position within the political economic milieu and if burning pine constituted a fundamental ritual act, powerful groups may have attempted to mediate community rituals. Mediation could have occurred by excluding commoner households from acquiring basic ritual paraphernalia or by offering pine products as gifts, thereby creating conditions of enduring indebtedness. Conversely, it may be possible to avoid equating absence with reduced access and, hence, agency with power. Undertaking rituals without using pine could have represented an act of strategic resistance by commoner households.

Many of the hardwood taxa identified to more specific taxonomic levels reinforce the data on economic tree species discussed above. Avocado (Persea sp.) charcoal was recovered in the first set of samples analyzed (Morehart 2001). Most wood species, however, are represented by the family Sapotaceae, and both chicozapote (Manilkara sp.) and mamey (Pouteria sp.) were identified in both flotation and in macrofossil samples. Sapotaceae wood is generally easy to identify, with distinctive narrow apotracheal bands of axial parenchyma and vessels in long radial chains. Specimens only were identified to the family Sapotaceae when preservation inhibited greater specificity. Both mamey and chicozapote have many economic uses as food, medicine, and construction materials. Chicozapote even appears on Pakal's sarcophagus at Palenque (Robertson 1983). This tree and other species are associated with Pakal's ancestors. McAnany (1995) has argued that the iconography suggests a widespread pattern that linked orchards and land as transgenerational and inheritable sources of power (see also Morehart 2005; Schele and Mathews 1998). It is certainly possible that the affluent residents of Pook's Hill similarly maintained orchards of economically important trees.

Two macrofossil samples (30081-001, 30090-001) yielded the same taxa of wood charcoal identified tentatively as members of the family Leguminosae. Sample 30090-001 was recovered from a sweatbath (Structure 1B), and the charcoal sample contained considerable ash. The wood was poorly preserved and fractured easily along the rays, making it difficult to obtain a good cross-section. Consequently, it was not possible to identify the material to a more specific taxonomic level nor to specify the specific legume sub-family, though the specimens' large, vasicentric to aliform paratracheal axial parenchyma is similar to the Mimosaceae.

Other items identified consist of uncarbonized seeds that are likely intrusive. These include amaranth seeds (*Amaranthus* sp.), trumpet tree seeds (*Cecropia peltata*), and unidentified grass seeds (Poaceae). Both trumpet tree seeds and nightshade seeds (*Solanum* sp.) seeds were discussed in the initial report (Morehart 2001). These items were only found in flotation samples. The presence of these seeds reinforces the importance of flotation for the recovery of small botanical remains. However, they also reveal the taphonomic and formation processes influencing the archaeobotanical record (see Minnis 1981). Trumpet tree and nightshade seeds are common intrusive seeds in archaeobotanical samples from Neotropical sites (Morehart 2002, 2003). They represent a considerable portion of the natural seed rain distributed by birds and, particularly, bats. Consequently, archaeobotanists should use caution when interpreting such remains. Even if one can securely determine their antiquity it remains possible that they are evidence of prehistoric seed dispersal mechanisms and not of socio-cultural practices.

# CONCLUSIONS

The systematic recovery and interpretation of archaeobotanical remains from sites in the Maya region continues to be rare. There are a number of reasons for this condition: the relatively limited number of individuals trained to identify plant remains, the particular research goals of archaeological projects, and the poor preservation of organic materials in the Neotropical environment. Of all these, the last issue is the most pressing and inherently difficult to overcome, particularly for the analyst of macrofloral remains. It is challenging and often impossible to analyze patterns in archaeobotanical assemblages from a limited dataset, whether quantitative, spatial, or temporal. Many archaeobotanists have been criticized for simply providing laundry lists of identified remains and a few ethnobotanical uses drawn from the ethnographic record (Pearsall 2000). Nevertheless, paleoethnobotanists in the Maya Lowlands have made strides in expanding the potential of archaeobotanical data for understanding ecological, economic, and social processes across time and space (Lentz 1991; Lentz et al. 2005; Miksicek 1991; Morehart 2002, 2005; Morehart and Helmke in press; Morehart et al. 2005).

The multi-year, intensive research at Pook's Hill offers the opportunity to understand human-plant interactions among the rural elite in the Maya Lowlands. Pook's Hill's residents appear to have subsisted on a diversity of domesticated plants and tree fruits (Morehart 2001; Morehart and Helmke in press). Household members possibly practiced intensive arboriculture and may have maintained orchards of particular species, such as avocado, chicozapote, mamey, hog plum, and palms. The high relative importance of pine compared to species of hardwood is particularly interesting. Given that pine is not an immediately available resource, these data indicate residents participated in networks of extra-local interaction (Morehart and Helmke in press). The relative affluence of the site suggests that the scale of one's social relationships was conditioned by the one's position within a broader political economy. It is indeed exciting to be able to approach such inherently interesting topics from a paleoethnobotanical perspective.

As research at Pook's Hill continues, certain suggestions can be made concerning methodology and research design. Collecting both flotation samples and macrofossil samples is an effective strategy. Macrofossil samples typically contain larger and better preserved material. Floating soil samples often can have a destructive impact on plant remains; the immersion in water can cause botanical specimens to fracture or to disintegrate. However, flotation samples are more standardized, which is important when quantifying relative importance. Moreover, collecting soil samples for flotation increases the likelihood of finding small seeds, as discussed above, and of recovering a wider diversity of taxa, as macrofossil samples typically contain few items that are seen with the unaided eye during excavations. However, given the poor preservation in the Neotropics the volume of soil collected per flotation sample should be increased from 1 liter to 10. Using a mechanical flotation tank rather than a manual system should reduce the labor involved in processing samples and may enhance the recovery rate.

A final suggestion concerns research design in terms of placing botanical data in a more spatially and temporally comparative framework. Spatially, botanical data are from a single site, which was likely a single household in the past, albeit an elite one. Currently caves are the only other type of sites in the Roaring Creek valley with recorded botanical data (Morehart 2002, 2005). Helmke (2006) has suggested that Pook's Hill was a low-order organizational node in the Roaring Creek valley during the Late Classic period. Obtaining archaeobotanical data from a wider diversity of households or sites in the valley would increase socio-spatial comparisons, offering an opportunity to understand how the sphere of human-plant interactions varied across the landscape. Lastly, deep trench stratigraphic excavations at Pook's Hill or a similar site may yield data on changes in plant exploitation strategies over time, either due to transformations in the environment, in cultural practices, or in both.

ID Number	Plant Name	Plant Part	Weight	Quantity	/ Str/Area	Operation	EU	Level	SU	Feature/Context	Analysis Year
10001			-		-	~	ר ני	ć	- L3	5 • 7 I	1000
	ruus sp.	Cliarcoal	11.1		4A	44	n//a/	54	<b>BCC</b>	Durrat 4A-5	1007
30001-002	Unknown	Residue	0.06	ł	4A	4A	7e/7d	2a	53a	Burial 4A-3	2001
30001-003	Hardwood	Charcoal	0.03		4A	4A	7e/7d	2a	53a	Burial 4A-3	2001
30002-001	Pinus sp.	Charcoal	0.38		4A / Plaza	4A	7c	ю	43	Core of Floor 2	2001
30003-001	Manilkara sp.	Charcoal	0.55		2A / Plaza	6A	14	1b	46	Collapse	2001
30003-002	Pinus sp.	Charcoal	0.15		2A / Plaza	6A	14	1b	46	Collapse	2001
30003-003	Zea mays	Kernels	0.05	7	2A / Plaza	6A	14	1b	46	Collapse	2001
30003-004	Cucurbita sp.	Rind	0.03	1	2A / Plaza	6A	14	lb	46	Collapse	2001
30004-001	Pinus sp.	Charcoal	0.12		4A / Plaza	4A	7b/7c	5	41	Burial 4A-1	2001
30004-002	Poaceae	Disseminules	< 0.01	5	4A / Plaza	4A	7b/7c	5	41	Burial 4A-1	2001
30004-003	Solanum sp.*	Seeds	< 0.01	с	4A / Plaza	4A	7b/7c	5	41	Burial 4A-1	2001
30004-004	Cecropia sp.*	Seeds	< 0.01	7	4A / Plaza	4A	7b/7c	5	41	Burial 4A-1	2001
30004-005	Unknown	Residue	< 0.01	ł	4A / Plaza	4A	7b/7c	5	41	Burial 4A-1	2001
30005-001	Pinus sp.	Charcoal	0.51		4A	4A	7e/7d	4	54a	Burial 4A-4	2001
30005-002	Poaceae	Disseminules	< 0.01	б	4A	4A	7e/7d	4	54a	Burial 4A-4	2001
30006-001	Pinus sp.	Charcoal	0.21		2A / Plaza	6A	10	1c	36e	Cluster 4	2001
30006-002	Zea mays	Kernels	0.01	б	2A / Plaza	6A	10	1c	36e	Cluster 4	2001
30006-003	Zea mays	Cupule	< 0.01	-	2A / Plaza	6A	10	1c	36e	Cluster 4	2001
30006-004	Hardwood	Charcoal	0.24	1	2A / Plaza	6A	10	lc	36e	Cluster 4	2001
30006-005	Crescentia cujete	Rind	0.13		2A / Plaza	6A	10	1c	36e	Cluster 4	2001
30006-006	Spondias sp.	Pits	0.48	$\overline{\ }$	2A / Plaza	6A	10	lc	36e	Cluster 4	2001
30006-007	Capsicum annuum	Seeds	< 0.01	2	2A / Plaza	6A	10	1c	36e	Cluster 4	2001
30007-001	Pinus sp.	Charcoal	0.03		2A / Plaza	6A	10	1b-1c	23 + 36	Collapse / Cluster 4	2001
30007-002	Crescentia cujete	Rind	0.02	ł	2A / Plaza	6A	10	1b-1c	23+36	Collapse / Cluster 4	2001
30007-003	Arecaceae	Charcoal	0.05		2A / Plaza	6A	10	1b-1c	23+36	Collapse / Cluster 4	2001

ID Number	Plant Name	Plant Part	Weight	Quantity	r Str/Area	Operation	EU	Level	SU	Feature/Context	Analysis Year
30008-001	Pinus sp.	Charcoal	0.04		2A / Plaza	6A	13	1b	33	Collapse	2001
30008-002	Crescentia cujete	Rind	0.05		2A / Plaza	6A	13	1b	33	Collapse	2001
30008-003	Zea mays	Kernels	0.02	4	2A / Plaza	6A	13	1b	33	Collapse	2001
30009-001	Pinus sp.	Charcoal	0.17	l	2A / Plaza	6A	17	lc	61	Content of Vase 61/1	2001
30009-002	Hardwood	Charcoal	0.02	1	2A / Plaza	6A	17	1c	61	Content of Vase 61/1	2001
30010-001	Pinus sp.	Charcoal	0.04	1	2A	6A	18	1	35	Collapse	2001
30010-002	Crescentia cujete	Rind	0.03	I	2A	6A	18	1	35	Collapse	2001
30011-001	Pinus sp.	Charcoal	0.09	I	4A / Plaza	4A	7b	4	40	Core of Floor 3	2001
30012-001	Pinus sp.	Charcoal	0.21	l	4A / Plaza	4A	Дþ	S	62	Burial 4A-2	2001
30013-001	Pinus sp.	Charcoal	0.02	ł	2A	6A	17	1	39	Collapse	2001
30013-002	Zea mays	Kernel	< 0.01	1	2A	6A	17	1	39	Collapse	2001
30013-003	Crescentia cujete	Rind	0.03	1	2A	6A	17	1	39	Collapse	2001
30014-001	Pinus sp.	Charcoal	0.11	ł	4A / Plaza	4A	7b/7c	4-5	41+47	Burial 4A-1	2001
30014-002	Poaceae	Disseminules	< 0.01	б	4A / Plaza	4A	7b/7c	4-5	41+47	Burial 4A-1	2001
30014-003	Acrocomia aculeata	Endocarp	0.04	l	4A / Plaza	4A	7b/7c	4-5	41+47	Burial 4A-1	2001
30015-001	Pinus sp.	Charcoal	0.19	l	4A / Plaza	4A	7c	2	47a	Fill of SU 55	2001
30015-002	Crescentia cujete	Rind	0.02	ł	4A / Plaza	4A	7c	2	47a	Fill of SU 55	2001
30016-001	Pinus sp.	Charcoal	0.10	l	2A / Plaza	6A	14	1	32	Collapse	2001
30016-002	Persea sp.	Charcoal	0.21	I	2A / Plaza	6A	14	1	32	Collapse	2001
30016-003	Curcurbita sp.	Seed frag.	0.01	1	2A / Plaza	6A	14	1	32	Collapse	2001
30017-001	Pinus sp.	Charcoal	0.07	I	1B / Plaza	6B	22	1c	121c	Cluster 4	2004
30017-002	Unknown	Parenchymatous Tissue	> 0.01	ł	1B / Plaza	6B	22	lc	121c	Cluster 4	2004
30018-001	Zea mays	Cupules	> 0.01	Э	1B / Plaza	6B	22	1c	121b	Cluster 4	2004
30018-002	Zea mays	Kernels	0.05	I	1B / Plaza	6B	22	1c	121b	Cluster 4	2004
30018-003	Sapotaceae	Charcoal	> 0.01	I	1B / Plaza	6B	22	1c	121b	Cluster 4	2004

ID Number	Plant Name	Plant Part	Weight	Quantity	Str/Area	Operation	ı EU	Level	ns	Feature/Context	Analysis Year
30018-004	Dimic cn	Charcoal	0.04		1R / Dlaza	Ч	ćć	<u>-</u>	1215	Chietar A	POOC
	· de com	Cliat Coal	10.0		1701 T		1	2	0171	- Imenio	1007
30018-005	Dicot	Charcoal	0.10	-	1B / Plaza	6B	22	lc	121b	Cluster 4	2004
30019-001	Pinus sp.	Charcoal	> 0.01	-	1B / Plaza	6B	22	1c	121a	Cluster 4	2004
30019-002	Dicot	Charcoal	0.01		1B / Plaza	6B	22	lc	121a	Cluster 4	2004
30019-003	Pinus sp.	Charcoal	0.01		1B / Plaza	6B	22	lc	121a	Cluster 4	2004
30019-004	Dicot	Rind	0.01		1B / Plaza	6B	22	lc	121a	Cluster 4	2004
30020-001	Pinus sp.	Charcoal	0.06		4A / Plaza	4A	7e	4	144	Burial 4A-5	2004
30021-001	Pinus sp.	Charcoal	0.06		4A / Plaza	4A	7e	4	144	Burial 4A-5	2004
30022-001	Pinus sp.	Charcoal	0.03		2A / Plaza	6C	24	2	149	Core of Floor 1	2004
30022-002	Dicot	Charcoal	0.03	-	2A / Plaza	6C	24	7	149	Core of Floor 1	2004
30023-001	Pinus sp.	Charcoal	0.05		2A / Plaza	6C	24	1c	117a	Cluster 7	2004
30024-001	Pinus sp.	Charcoal	0.08		2A / Plaza	6C	24	lc	117g	Cluster 7	2004
30025-001	Pinus sp.	Charcoal	> 0.01		2A / Plaza	6C	24	lc	117h	Cluster 7	2004
30026-001	Pinus sp.	Charcoal	0.02		2A / Plaza	6C	23	lc	116a	Cluster 7	2004
30026-002	Dicot	Charcoal	0.02		2A / Plaza	6C	23	lc	116a	Cluster 7	2004
30026-003	Sapotaceae	Charcoal	0.04		2A / Plaza	6C	23	lc	116a	Cluster 7	2004
30026-004	Hardwood	Charcoal	0.02		2A / Plaza	6C	23	lc	116a	Cluster 7	2004
30027-001	Zea mays	Cupules	> 0.01	7	2A / Plaza	6C	23	lc	116b	Cluster 7	2004
30027-002	Poaceae	Seed	> 0.01	1	2A / Plaza	6C	23	lc	116b	Cluster 7	2004
30027-003	Pinus sp.	Charcoal	0.05		2A / Plaza	6C	23	lc	116b	Cluster 7	2004
30027-004	Dicot	Rind	> 0.01		2A / Plaza	6C	23	1c	116b	Cluster 7	2004
30027-005	Hardwood	Charcoal	0.03		2A / Plaza	6C	23	lc	116b	Cluster 7	2004
30028-001	Pinus sp.	Charcoal	0.05		2A / Plaza	6C	23	1c	116c	Cluster 7	2004
30029-001	Pinus sp.	Charcoal	0.04	-	4A / Plaza	4A	7e	4	144	Burial 4A-5	2004
30030-001	Pinus sp.	Charcoal	0.28		4A / Plaza	4A	7e	4	144	Burial 4A-5	2004

ID Number	Plant Name	Plant Part	Weight	Quantity	Str/Area	Operation	EU	Level	ns	Feature/Context	Analysis Year
		- 5					ť		ç		2000
100-16006	Finus sp.	Charcoal	00.0	-	4A / Plaza	4A	/e	4	124	Core of Floor 3	2004
30032-001	Pinus sp.	Charcoal	0.10	-	2A	6D	42a	2a	152	Stair 1	2004
30032-002	Sapotaceae	Charcoal	0.04	-	2A	6D	42a	2a	152	Stair 1	2004
30033-001	Pinus sp.	Charcoal	> 0.01	1	4A / Plaza	4A	7e	4	154	Burial 4A-6	2004
30034-001	Pinus sp.	Charcoal	0.03	-	2A / Plaza	6C	24	lc	117b	Cluster 7	2004
30034-002	Zea mays	Cupule	> 0.01	1	2A / Plaza	6C	24	lc	117b	Cluster 7	2004
30034-003	Hardwood	Charcoal	0.02	-	2A / Plaza	6C	24	lc	117b	Cluster 7	2004
30035-001	Pinus sp.	Charcoal	0.03	1	2A	6D	42a	ю	158	Core of Floor 1	2004
30035-002	Unknown	Charred Residue	0.04		2A	6D	42a	б	158	Core of Floor 1	2004
30036-001	Pinus sp.	Charcoal	0.01	-	4A / Plaza	4A	7e	4	161	Burial 4A-7	2004
30037-000	Sterile	-	ł	-	2A	6D	42a/42]	b 3	179	Burial 2A-2	2004
30038-000	Sterile		1	-	2A / Plaza	6D	42c	ю	187	Burial 2A-3	2004
30039-000	Sterile		ł	-	2A / Plaza	6D	42c	б	187	Burial 2A-3	2004
30040-000	Sterile	-	ł	-	2A / Plaza	6D	42a/42]	b 3	162	Burial 2A-1	2004
30041-001	Pinus sp.	Charcoal	0.04		4A / Plaza	4A	7e	4	161	Burial 4A-7	2004
30042-001	Pinus sp.	Charcoal	1.09		1B / Plaza	6B	43	2	163	Core of Stair B	2004
30042-002	Hardwood	Charcoal	0.07		1B / Plaza	6B	43	7	163	Core of Stair B	2004
30042-003	Zea mays	Kernel	0.05	frags	1B / Plaza	6B	43	2	163	Core of Stair B	2004
30042-004	Zea mays	Cupules	0.02	7	1B / Plaza	6B	43	7	163	Core of Stair B	2004
30043-001	Pinus sp.	Charcoal	0.08		1B / Plaza	6B	22	1b-1c	101 + 121	Collapse / Cluster 4	2004
30044-001	Pinus sp.	Charcoal	> 0.01		4A / Plaza	4C	55	lc	214	Cluster 10	2004
30045-001	Pinus sp.	Charcoal	0.02		4A / Plaza	4D	49	2a	210	Core of Stair 1	2004
30045-002	Zea mays	Kernel	> 0.01	frags	4A / Plaza	4D	49	2a	210	Core of Stair 1	2004
30045-003	Dicot	Rind	0.02	-	4A / Plaza	4D	49	2a	210	Core of Stair 1	2004
30045-004	Hardwood	Charcoal	0.01	1	4A / Plaza	4D	49	2a	210	Core of Stair 1	2004

ID Number	Plant Name	Plant Part	Weight	Quantity	Str/Area	Operatio	n EU	Level	SU	Feature/Context	Analysis Year
20016-001	7		100 /	ç		U,	13	-			1000
100-04000	zea mays	Cuputes	10.01	7	4A / FIaza	+ ر	40	10	117	Collapse	2004
30046-002	Dicot	Rind	0.02	2	4A / Plaza	4C	54	1b	211	Collapse	2004
30047-000	Sterile	-	I		4A / Plaza	3'	5	lb	204	Collapse	2004
30048-001	Amaranthus sp.	Seeds	> 0.01	11	4A / Plaza	4A	Τf	la-b	200	Humus / Collapse	2004
30048-002	Angiosperm	Seeds	0.01	с	4A / Plaza	4A	JΓ	1a-b	200	Humus / Collapse	2004
30048-003	Cecropia peltata	Seeds	> 0.01	7	4A / Plaza	4A	Τf	la-b	200	Humus / Collapse	2004
30049-001	Pinus sp.	Charcoal	> 0.01	1	4A / Plaza	3'	5'	1c	212	Cluster 11	2004
30049-002	Dicot	Rind	0.01		4A / Plaza	3'	S	lc	212	Cluster 11	2004
30050-001	Pinus sp.	Charcoal	0.08		4A / Plaza	4A	Τf	2a	53c	Burial 4A-3	2004
30051-001	Pinus sp.	Charcoal	0.73		4A / Plaza	4A	Τf	2a	53c	Burial 4A-3	2004
30052-001	Pinus sp.	Charcoal	> 0.01		2A / Plaza	6D	42c	2	187	Burial 2A-3	2004
30053-001	Pinus sp.	Charcoal	1.57		4A / Plaza	4A	Τf	2a	53c	Burial 4A-3	2004
30053-002	Fabaceae	Cotyledon	0.03	-	4A / Plaza	4A	7f	2a	53c	Burial 4A-3	2004
30054-001	Pinus sp.	Charcoal	14.97	1	4A / Plaza	4A	Τf	2a	53c	Burial 4A-3	2004
30055-001	Pinus sp.	Charcoal	5.28	1	4A / Plaza	4A	Τf	2a	53c	Burial 4A-3	2004
30056-001	Pinus sp.	Charcoal	1.50	1	4A / Plaza	4A	Τf	2a	53c	Burial 4A-3	2004
30057-001	Pinus sp.	Charcoal	0.11	1	1A / Plaza	9B	59-61	2a	250	Core of Terrace 1	2004
30058-000	Sterile	1	I	1	4A / Plaza	4C	50	1b	203	Collapse	2004
30059-001	Pinus sp.	Charcoal	0.02	-	Plaza	5B	63	2a	232	Core of Floor 1	2004
30060-001	Pinus sp.	Charcoal	0.10	1	4B / Plaza	4E	56	lc	234	Cluster 10	2004
30061-001	Pinus sp.	Charcoal	0.08	1	1A / Plaza	9B	59	ld	236	Terrace 1 Collapse	2004
30061-002	Manilkara sp.	Charcoal	> 0.01	1	1A / Plaza	9B	59	ld	236	Terrace 1 Collapse	2004
30061-003	Arecaceae	Charcoal	0.01	1	1A / Plaza	9B	59	ld	236	Terrace 1 Collapse	2004
30062-001	Pinus sp.	Charcoal	> 0.01	1	1A / Plaza	9B	60	ld	237	Terrace 1 Collapse	2004
30062-002	Zea mays	Cupule	> 0.01	1	1A / Plaza	9B	60	1d	237	Terrace 1 Collapse	2004

ID Number	Plant Name	Plant Part	Weight	Quantity	· Str/Area	Operation	EU	Level	SU	Feature/Context	Analysis Year
30062-003	Zea mays	Kernel	> 0.01	1	1A / Plaza	9B	60	1d	237	Terrace 1 Collapse	2004
30063-001	Pinus sp.	Charcoal	> 0.01	-	1A / Plaza	9B	61	1d	238	Terrace 1 Collapse	2004
30064-001	Pinus sp.	Charcoal	0.04	1	1A / Plaza	9B	62	1d	239	Terrace 1 Collapse	2004
30065-001	Pinus sp.	Charcoal	1.49		4A / Plaza	4A	7f	4	244	Cache 4A-2	2004
30066-001	Pinus sp.	Charcoal	0.04	1	4A / Plaza	4A	7f	5	247b	Burial 4A-8	2004
30067-001	Pinus sp.	Charcoal	0.02		1A / Plaza	9B	62b	1b	246	Collapse	2004
30067-002	Manilkara sp.	Charcoal	0.05	1	1A / Plaza	9B	62b	1b	246	Collapse	2004
30068-001	Pinus sp.	Charcoal	0.06	1	1A / Plaza	9B	62b	1b	246	Collapse	2004
30068-002	Hardwood	Charcoal	0.01	1	1A / Plaza	9B	62b	1b	246	Collapse	2004
30069-001	Pinus sp.	Charcoal	0.06	1	4A / Plaza	3'	5'	2a	249	Architecural Unit 3	2004
30070-001	Hardwood	Charcoal	4.92	1	1B	9D	75	4	283	Collapsed Vault	2006
30071-001	Dicot	Charcoal	2.11	1	2B / Plaza	6E	62	la-lb	276	Humus / Collapse	2006
30072-001	Apocynaceae	Charcoal	0.18		1C / Plaza	9C	71	la	271	Humus	2006
30073-001	Pinus sp.	Charcoal	0.05	-	1B	9D	75	4a	277b	Collapsed Vault	2006
30073-002	Sapotaceae	Charcoal	0.78	1	1B	9D	75	4a	277b	Collapsed Vault	2006
30073-003	Dicot	Charcoal	6.63		1B	9D	75	4a	277b	Collapsed Vault	2006
30074-001	Dicot	Charcoal	1.35	-	1C / Plaza	9C	70	1b	278	Collapse	2006
30075-001	Pinus sp.	Charcoal	0.51	1	1A / 1B / Plaza	9E	77	la-lb	274	Humus / Collapse	2006
30075-002	Pouteria sp.	Charcoal	0.18		1A / 1B / Plaza	9E	77	la-lb	274	Humus / Collapse	2006
30075-003	Dicot	Charcoal	5.05	-	1A / 1B / Plaza	9E	77	la-lb	274	Humus / Collapse	2006
30076-001	Hardwood	Charcoal	0.86	-	1C / Plaza	9C	72	1b	280	Collapse	2006
30077-001	Dicot	Charcoal	1.85		1B	9D	75	4b	283	Collapse	2006
30078-001	Dicot	Charcoal	0.26	-	1B	9D	75	4b	283	Collapse	2006
30079-001	Sapotaceae	Charcoal	0.91	-	1B	9D	75	5	288c	Cluster 4	2006
30080-001	Arecaceae	Endocarp	0.36	1	1C / Plaza	9C	70	lb	278	Collapse	2006

ID Number	Plant Name	Plant Part	Weight	Quantity	/ Str/Area	Operation	EU	Level	SU	Feature/Context	Analysis Year
30080-002	Hardwood	Charcoal	1.90		1C / Plaza	9C	70	1b	278	Collapse	2006
30081-001	Unknown	Charcoal	10.31		1B	9D	75	9	291	Terminal Infill	2006
30082-001	Pinus sp.	Charcoal	0.91		1B / Plaza	6B	22	1b-1c	101 + 10	2 Collapse / Cluster 4	2006
30083-001	Hardwood	Charcoal	1.63		1B / Plaza	6B	43	7	163	Core of Stair B	2006
30084-001	Dicot	Charcoal	0.70		1B / Plaza	6B	43	2	163	Core of Stair B	2006
30085-001	Pinus sp.	Charcoal	0.40		2A / Plaza	6D	42a	2a	152	Core of Stair 1	2006
30086-001	Dicot	Charcoal	0.34		2A / Plaza	6D	42a/42	b 3	179	Burial 2A-2	2006
30087-001	Pinus sp.	Charcoal	1.92	1	4A	4A	49	2a	210	Core of Stair 1	2006
30088-001	Hardwood	Charcoal	3.35		1A / Plaza	9A	41	1b-1c	159	Collapse of Terrace 1	2006
30088-002	Dicot	Charcoal	10.93		1A / Plaza	9A	41	1b-1c	159	Collapse of Terrace 1	2006
30089-001	Arecaceae	Charcoal	10.78		1B / Plaza	6B	22	1b-1c	101 + 10	2 Collapse / Cluster 4	2006
30089-002	Hardwood	Charcoal	13.59		1B / Plaza	6B	22	1b-1c	101 + 10	2 Collapse / Cluster 4	2006
30090-001	Unknown	Charcoal	0.25	ł	4A / Plaza	4A	Τf	5	247	Burial 4A-8	2006

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#### CHARACTERIZATION OF LIME PLASTERS AND LITHOLOGICAL FACIES FROM POOK'S HILL

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#### INTRODUCTION

This paper presents the results of material analyses conducted upon limestone and lime plaster samples from the ancient Maya site of Pook's Hill. Optical reflected-light microscopy, petrography, scanning electron microscopy with energy dispersive spectrometry (SEM/EDS), X-ray fluorescence (XRF) and Raman spectroscopy were employed as analytical techniques. Limestone samples were analysed together with lime plasters, as the former ones constitute the likely raw materials for lime production. Different types of limestones were observed, including fossiliferous limestones, micrites and a crystalline limestone. Plaster samples showed variation in the use of raw materials, both in the binding and in the aggregate materials. Coloured layers were also characterised, with the presence of hematite and graphite, the latter related to the ancient usage of Structure 1B.

Lime is produced when limestone or another calcium carbonate-rich material is burned at temperatures over 900° C, after which this compound transforms into calcium oxide. This material is then slaked with water or moist air, forming a white powder or paste depending on the amount of water, and transforming into calcium hydroxide. The slaked product is sometimes stored for several months to promote hydration and to improve plasticity and other working properties of the lime. The paste is then mixed with aggregate material to produce plasters or mortars, which are applied over architectural surfaces. During setting and following exposure to air, calcium hydroxide reacts with carbon dioxide to once more form calcium carbonate (Boynton 1980).

It is well known that lime-based materials were widely used by Mesoamerican cultures for both decorative and structural purposes in architecture. However, the Lowland Maya developed lime pyrotechnology and lime plaster manufacturing to the highest degree; partly because raw materials were easily obtained in the calcitic limestone lowlands of the Yucatan peninsula (see Espinosa et al. 1996).

Despite the abundance of lime-based materials in Maya architecture, few studies on the characterisation of these materials have been undertaken (Villegas et al. 1995, Hansen et al. 1997, Magaloni 1995, Goodall et al. 2007), since pioneering research by Edwin Littman (1957, 1958, 1959a, 1959b, 1960a, 1960b, 1962, 1967).

In addition to characterisation studies, some of the most illuminating sources with regards to ancient Maya lime production are provided by ethnographic research.

Schreiner (2002) has described the rich modern Maya knowledge pertaining to lime production, which is accomplished in complex arrangements of wet wood pyres, embedded in male-specific, ritually-laden technology. These open pyres have also been described by Morris et al. (1931) as well as Redfield and Villa (1934) and the use of such expedient pyres in antiquity accounts for scarcity of clear archaeological evidence associated with lime production, since few, if any, permanent structures were built to burn the limestone (see Abrams and Freter 1996).

This report presents, in the first part, the petrographic characterization and elemental composition of limestone samples from Pook's Hill, since they represent likely raw materials for lime production. Following this, results and discussions of microscopic observations and elemental analyses of plasters from various masonry structures at this site are presented. Finally, analyses of pigments and coloured surfaces observed in the plasters are reported.

## EXPERIMENTAL PROCEDURES

Optical reflected-light microscopy, petrography, scanning electron microscopy with energy dispersive spectrometry (SEM/EDS), Raman spectroscopy and X-ray fluorescence (XRF) were selected as analytical techniques in order to study textural and compositional properties of the samples.

Reflected-light microscopy was carried out with a Leica DMLM polarizing microscope, at magnifications ranging from 50X to 200X. In preparation for reflected microscopy samples were vacuum-impregnated with EpoThin® resin, and subsequently sectioned and polished to 15  $\mu$ m grit size.

Petrographic observations were carried out with a Leica CMLP microscope, at magnifications ranging from 40X to 400X. Photomicrographs of both plane polarized and crossed polarized light were secured with a Nikon-Coolpix digital camera attached to the microscopes. Thin sections for petrography were obtained by adhering the polished blocks previously prepared for optical microscopy onto glass slides, grinding them down to ca. 30  $\mu$ m thickness and polishing them with 5  $\mu$ m aluminium powder.

SEM-EDS analyses were carried out with a Hitachi S-570 with Link Analytical Equipment. Thin sections to be processed by SEM-EDS were carbon-coated in order to avoid charging. Photomicrographs of both secondary and backscattered electron modes were obtained at magnifications spanning from 50X to 1000X with an accelerating voltage of 20kV. Elements identified by EDS were combined with oxygen by stoichiometry and results are therefore presented as oxides. Carbon was excluded, as samples were carbon-coated. Data were normalized to 100 %.

X-ray fluorescence (XRF) equipment consisted in a Spectro X-lab 2000. XRF analyses were also made by normalized oxides, combining oxygen by stoichiometry. Samples were ground in an agate mill, oven-dried at 100° C for 24 hours and prepared as pressed pellets. Limestone BCS 393 was employed as standard material to report accuracy for both XRF and SEM/EDS equipments.

A Renishaw spectrometer was employed for Raman spectrometry analyses, and was operated with a wavelength of 875 nm. No sample preparation was required.

Sample	Structure	Context	Optical reflected- light microscopy	Petrography	SEM/EDS	Raman spectroscopy	X-ray fluorescence
PKH-Li-1	Structure 2B	Core (SU 319)		*			*
PKH-Li-2	Structure 2B	Core (SU 319)		*			*
PKH-Li-3	Structure 2B	Core (SU 319)		*			*
PKH-Li-4	Structure 2B	Core (SU 319)		*			*
PKH-Li-5	Structure 2B	Core (SU 319)		*			*
PKH-Li-6	Structure 2B	Core (SU 319)		*			*
PKH-Pl-001	Structure 2A / Plaza	Floor 1 (SU 158)	*	*			
PKH-Pl-003	Structure 4A	Collapse (SU 204)	*	*		*	
PKH-P1-004	Structure 4A	Looter backdirt (SU 6)				*	
PKH-Pl-006	Structure 4A	Looter backdirt (SU 6)	*	*			
PKH-Pl-007	Structure 4A	Looter backdirt (SU 7)	*	*	*		
PKH-Pl-008	Structure 4A	Core – Phase A (SU 19)	*	*		*	
PKH-Pl-009	Structure 4A	Looter backdirt (SU 5)	*				
PKH-Pl-010	Structure 4A	Looter backdirt (SU 5)	*		*		
PKH-Pl-011	Structure 4A	Looter backdirt (SU 9)	*		*		
PKH-Pl-012	Structure 2A / Plaza	Floor 1 (SU 45)	*		*		
PKH-Pl-013	Structure 1B	Humus (SU 263)	*	*		*	
PKH-Pl-014	Structure 1B	Humus (SU 263)	*		*	*	
PKH-Pl-015	Structure 1B	Humic infill (SU 268b)	*	*		*	
PKH-Pl-016	Structure 1B	Eastern bench (SU 302)	*		*		
PKH-Pl-018	Structure 1A / Plaza	Floor 1 (SU 311)		*			
PKH-Pl-021	Structure 1B	Core (SU 318)	*		*	*	
PKH-Pl-022	Plaza Platform	Floor 1 – AU1 (SU 148)	*	*	*		

 Table 1. Samples and analyses carried out.

#### CHARACTERISATION OF LITHOLOGICAL FACIES

All limestone samples were recovered from core of Structure 2B, during backcutting operations as part of consolidation and architectural curation efforts, conducted at the end of the 2005 field season (see Helmke 2006: 50). The set of six samples represents the six macroscopically-defined types of limestone encountered at Pook's Hill as elements of ancient masonry. The macroscopic typology has been developed by Helmke in collaboration with foremen Oscar Chi and José Puc where various properties, including coloration, hardness/friability, porosity/impermeability, and liability to erosion and weathering were taken into account (see Figure 1 and Table 2). As different types of stones were more or less suitable to particular architectural elements and purposes it was essential to document these limestone types and their properties during the excavation and consolidation of the site conducted between 1999 and 2005.

As part of the processing of samples these were cut and polished in order to observe their colour and texture (see Figure 1). They were subsequently analysed by

petrography and X-ray fluorescence analysis, as explained below. Classification of lithological facies is based on Sholle and Ulmer-Scholle (2003), after Folk (1959).



Figure 1. Macroscopic aspect of limestone samples from Pook's Hill. Scale bars: 5 cm.

Coloration	Hard	Friable	Porous	Impermeable	Liable to erosion?
Beige	PKH-Li-1			PKH-Li-1	no
	PKH-Li-2			PKH-Li-2	
White		PKH-Li-3	PKH-Li-3		yes
		PKH-Li-4	PKH-Li-4		
Red	PKH-Li-6	PKH-Li-5		PKH-Li-5	no
				PKH-Li-6	

Table 2: Basic macroscopic typology established prior to characterisation and elemental analyses.

To better cross-reference the results of the present analyses with references made to these various types of limestone in foregoing excavation reports, the designations that were attributed to the major types are provided: "dolostone" or "dolomitic limestone" (PKH-Li-1 and PKH-Li-2), "limestone" (PKH-Li-3 and PKH-Li-4), and "red limestone" or "ferric oxide-tinted limestone" (PKH-Li-5 and PKH-Li-6).<sup>1</sup> In light of the present findings the earlier provisional terminology is now known to be inadequate, and is superseded by the designations employed here. Notably the use of 'dolostone' and 'dolomitic limestone' should be abandoned as a reference to limestones at Pook's Hill since by definition the term refers to magnesian limestones, with concentrations ranging between 35 % and 50 % of magnesium carbonate.

<sup>&</sup>lt;sup>1</sup> For reference: the foremen Oscar Chi and José Puc also independently recognised these three basic types. What was termed 'dolostone' in the field they called *piedra fuego*, "fire stone" since on contact with picks and excavation equipment bright sparks are emitted. Thus this dense and fine-textured limestone was conceptually grouped with cherts. What was simply termed 'limestone' they referred to as *piedra cal*; exact congruities of one another. The third type, 'red limestone' was variable in its designation, but mostly referred to simply as *piedra roja* "red stone".

# PKH-Li-1

- Macroscopic observations: Dense and homogeneous. Munsell colour: dry: 7.5 YR 8/2 (pinkish white), wet: 10 YR 8/3 (very pale brown).
- Petrographic observations: uniserial, biserial and miliolid foraminifers cemented in a microspar matrix. Fractures and voids filled with pseudospar. No visible porosity.
- Characterization: Fossiliferous limestone (packed biomicrite; see Figure 2).





## PKH-Li-2

- Macroscopic observations: dense and homogeneous. Munsell colour: dry: 5 YR 8/1 (white), wet: 10 YR 6/3 (pale brown).
- Petrographic observations: sparite cement with low proportion of fossils. No visible porosity.
- Characterization: biosparite (see Figure 3).



minimimimimimimimi 0.5mm

Figure 3. Sample PKH-Li-2. Biosparite. Crossed polars, scale bar: 0.5 mm.

# PKH-Li-3

- Macroscopic observations: Light weight, powdery, with visible red inclusions. Munsell colour: dry: 10 YR 7/3 (very pale brown), wet: 10 YR 7/3 (very pale brown).
- Petrographic observations: high porosity; high proportion of intraclasts in a micritic cement.
- Characterization: intramicrite (see Figure 4).



Figure 4. Sample PKH-Li-3. Intramicrite. Crossed polars, scale bar: 1 mm.

# PKH-Li-4

- Macroscopic observations: porous and powdery. Munsell colour: dry: 2.5 Y 8/3 (pale yellow), wet: 2.5 Y 8/3 (pale yellow).
- Petrographic observations: some porosity. Pellets of faecal origin in micritic cement.
- Characterization: Pelmicrite (see Figure 5).



Figure 5. PKH-Li-4. Pelmicrite. Crossed polars, scale bar: 1 mm.

# PKH-Li-5

- Macroscopic observations: porous and powdery. Munsell colour: dry: 10 YR 8/1 (white), wet: 7.5 YR 8/2 (pinkish white).
- Petrographic observations: uniserial, biserial and miliolid foraminifers cemented in a microspar matrix. Fractures and voids filled with pseudospar. No visible porosity.
- Characterization: Fossiliferous limestone (sorted biosparite; see Figure 6).



Figure 6. PKH-Li-5. Fossiliferous limestone (sorted biosparite). Crossed polars, scale bar: 1 mm, 40X.

## PKH-Li-6

- Dense and heavy. Munsell colour: dry: 10 R 5/3 (weak red), wet: 10 R 4/6 (red).
- Petrographic observations: equidimensional crystals of calcite between 100 and 200 µm. Inclusions of pyroxenes. Iron oxides deposited in grain boundaries.
- Characterization: crystalline limestone with pyroxene inclusions.



Figure 7. PKH-Li-6. Crystalline limestone. Left: Plane polarized light. Note the iron oxides in grain boundaries, scale bar: 1mm. Right: Crossed polars, scale bar: 1mm.

All stone samples, except PKH-Li-6, have a sedimentary origin, corresponding with the Palaeozoic and Cenozoic formation of the Yucatan limestone shelf. Samples PKH-Li-1 and PKH-Li-5, despite their differences in macroscopic porosity, have the same textural characteristics, as well as very similar chemistries (see Table 3 below). These samples, together with sample PKH-Li-2, correspond to the description made by Ower (1928:503) regarding the soft foraminiferal limestone that weathers easily, white to cream in colour, which is abundant in Belize.

Sample PKH-Li-3 showed intraclasts, that is, fragments of carbonate sediments that have been eroded and re-deposited, suggesting a setting with intermittently highenergy conditions, whereas sample PKH-Li-4 showed the presence of faecal pellets, indicating a rapid sedimentation in a low energy setting (Scholle and Ulmer-Scholle 2003: 254).

Sample PKH-Li-6, on the contrary, is a crystalline limestone rich in iron, and may have been subjected to slight metamorphism, which is most likely related to the formation of the adjoining Maya Mountains (Rommey 1959).

Regarding elemental composition, XRF analyses showed that all six samples are highly calcitic. PKH-Li-6 is the most different in comparison with the rest, with higher contents in silicon, iron, aluminium and magnesium (see Table 3).

Sample	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	CaO	Fe <sub>2</sub> O <sub>3</sub>	SnO <sub>2</sub>	Sum
PKH-Li-1	0.30	0.45	0.97	98.19	0.09	0.00	100
PKH-Li-2	0.62	0.43	1.21	97.66	0.08	0.00	100
PKH-Li-3	0.15	0.97	1.78	96.05	0.27	0.77	100
PKH-Li-4	0.18	0.35	0.65	98.75	0.08	0.00	100
PKH-Li-5	0.30	0.32	0.81	98.16	0.07	0.35	100
PKH-Li-6	1.07	2.76	7.04	87.74	1.40	0.00	100
BCS 393	0.00	0.54	1.35	97.98	0.13	0.00	100

Table 3. Stone samples. Normalized results of X-ray fluorescence (wt %).

Although it is not possible to know with certainty how the ancient Maya conceived, classified and used these stone types, some inferences can be made based on the way modern Maya approach these materials, as recent ethnographic research has documented. It is known that a soft high-calcium type of limestone abundant in the Peten region, known by modern Yukatekan Maya as *tzaal*, is used to produce lime. In the same way, limestones are classified according to hardness and porosity in the Yucatan peninsula; from soft to hard and from porous to dense, they are known as *sah cab tunich*, *hel bach*, *toc tunich* and *taman tunich*,<sup>2</sup> from which only the first two types are employed as raw material to produce lime (Schreiner 2002: 52-53). It is also known that hard crystalline limestones are avoided, since they require higher burning temperatures

<sup>&</sup>lt;sup>2</sup> The colonial orthography is employed in the rendition of these entries, in keeping with the original source (Schreiner 1980). In modern orthography the corresponding terms are: *sah kab' tunich* ("white-earth-stone"), *jel b'ach, tok tunich* ("fire-stone") ~ *tok' tunich* ("flint"), and *taman tunich*.

(Schreiner 2002:53, Boynton 1980:172). Based on this, it is likely that stone types PKH-Li-3, PKH-Li-4 and PKH-Li-5 were employed for lime production in the plaster, stucco and mortar from Pook's Hill, and that the crystalline limestone represented by PKH-Li-6 would have been particularly avoided.

### ANALYSIS OF LIME PLASTERS

All lime plaster samples were analysed by optical reflected microscopy. Some of them were selected for petrography and SEM-EDS, and only those with paint layers were analysed by Raman spectroscopy.

#### **Petrographic observations**

## Re-plastering

Different periods of plastering, corresponding to architectural renovations are frequently visible. Examples of more than one layer of plaster brought about by renovations and other refurbishments were observed in samples PKH-Pl-003, PKH-Pl-010, PKH-Pl-011, PKH-Pl-012, PKH-Pl-013, PKH-Pl-014 and PKH-Pl-021 (see Figure 8).



Figure 8. PKH-Pl-013. General scanned view with two different layers of plaster. Scale bar: 0.5 cm.

Multiple layers are sometimes clearly divided by paint layers, as in sample PKH-Pl-010. In addition, this sample shows another plaster layer underlying the upper plasters, which can only be seen in a magnified view (see Figure 9).

As observed by optical and textural characteristics of the plasters, it is clear that they constitute two different episodes (re-plastering), instead of graded layers of the same period of application.

Architectural renovations in the form of re-plastering are frequently seen in Maya architecture, and they indicate maintenance and prolonged use. However, it is also well known that renovations and re-plastering events are sometimes associated with dedication and termination rituals of structures (Garber et al. 1998; Tozzer 1966). Furthermore, recent ethnographic research has documented that modern Maya associate lime and even

marl with birth, transformation and fertility (Schreiner 2002:104-116; Wagner 2002), which provides additional evidence to the ritual connotations of re-plastering.



**Figure 9.** Sample PKH-Pl-010. Left: general scanned view of the sample, where superposition of plasters is marked by a red paint layer. Scale bar: 0.5 cm. Right: interface between plaster layers. Note the different characteristics and optical properties of the two layers. Crossed polars, scale bar: 1 mm.

#### Limewash applications

Thin limewash layers were observed over the surfaces of samples PKH-Pl-007 PKH-Pl-008, PKH-Pl-010, PKH-Pl-012 and PKH-Pl-018, applied as finishing layers in order to obtains a smooth appearance. These thin layers range between 100-300 µm thick and have few and very fine calcareous aggregates, very likely sieved *sascab*.<sup>3</sup> Although most of these layers were applied by burnishing to obtain a white smooth surface, it is clear that in some cases they serve as a preparation for the application of paint layers, as in samples PKH-Pl-001, PKH-Pl-007, PKH-Pl-018. However, in sample PKH-Pl-008 limewashes were applied over the red paint layer, in order to cover the red colour with a white surface (see Figure 10).

## Use of aggregates

Most of the aggregates observed in the samples from Pook's Hill proved to be calcareous, in most of the cases with rounded and subrounded edges, suggesting the use of sascab as aggregate material. This material is a subrounded sediment that is abundant in the Maya lowlands. It is obtained from dissolution pits of the karstic terrain, or easily quarried in tunnels and wells between the limestone hardpan and the limestone bedrock (Espinosa et al. 1996, Folan 1982).

<sup>&</sup>lt;sup>3</sup> The word *sascab* (in Colonial orthography) corresponds to the *saskab*' (in modern orthography) and is the Yukatek Maya term that for the most part is equivalent of the English "marl" or Spanish "caliche". The descriptive term *saskab*' is a compound noun of "white" *sak* and "earth" *kab*' as *sak-kab*'. With the gemination of  $\langle k \rangle$  the morphemic boundary has shifted phonologically to the spirant  $\langle s \rangle$ , *sakkab*' > *saskab*'. A more archaic intermediate reflex is attested in Colonial Yukatek (in the Motul Dictionary) as *sahkab*', which in turn allows the following reconstruction: *sakkab*' > *saskab*'.



**Figure 10.** Sample PKH-Pl-008. Two layers of limewash applied over the red paint layer. Crossed polars. Scale bar: 1 mm.

Although sascab from Pook's Hill was not available for analysis since the ancient quarries utilised by the Pook's Hilleños have not been relocated, modern sascab from the village of Indian Church, in Lamanai, was analysed. This material consists of micritic calcite sediments with subrounded edges, corresponding with the characteristics observed in the aggregate materials from the Pook's Hill plasters (see Figure 11). The use of sascab was observed in samples PKH-PI-007, PKH-PI-009, PKH-PI-010, PKH-PI-013 and PKH-PI-018.



**Figure 11.** Left: Sascab (small rounded aggregates) in upper plaster of sample PKH-Pl-010. Crossed polars, scale bar: 1 mm. Right: Sascab grains from Lamanai (modern material). Crossed polars. Scale bar: 0.5 mm.

However, other samples showed very different aggregates with angular edges and composed of polycrystalline grains of calcite, very likely corresponding to the crystalline limestone represented by sample PKH-Li-6. It is also possible to see iron oxides in the grain boundaries, corresponding to the crystalline limestone described above (see Figure 12). These aggregates were also observed in samples PKH-PI-009, PKH-PI-013 and PKH-PI-022.

Moreover, ethnographic and experimental research have documented that stone fragments generated as waste as part of quarrying and the dressing of facing stones are sometimes incorporated in the plasters by modern Maya masons (Abrams 1984: 46, Morris et al. 1931: 215, Schreiner 2002). Furthermore, angular aggregates may have been added as a way of providing the plasters with higher mechanical strength.



**Figure 12.** PKH-PI-012. Angular aggregates, crushed fragments of crystalline limestone. Note the iron oxides in grain boundaries at the lower right corner. Scale bar: 0.5 mm.

## Use of gypsum

As will be explored further below, SEM-EDS analyses have shown a high sulphur content in sample PKH-Pl-022. As seen by petrography, these phases show a light yellow colour under plane polarized light and a dark grey colour with specks of calcite under crossed polars (see Figure 13). The high sulphur content, and the ease with which these phases were dissolved during sample preparation, suggest they are partly composed of gypsum, which is relatively soluble in water. Similar phases were observed in samples PKH-Pl-003, PKH-Pl-007, PKH-Pl-008, and PKH-Pl-010.



**Figure 13.** Sample PKH-Pl-022. Left: lump of binding material high in sulphur (likely gypsum). Plane polarized light. Scale bar: 1mm. Right: Dark grey matrix rich in sulphur, light grey aggregates rich in calcium (see Table 4). Backscattered electron image. Scale bar: 1 mm.

The reasons for using gypsum instead of lime may be related to the energy that is required to calcine these materials. Whereas lime is produced after burning limestones above 900° C, gypsum only requires 150-200 °C (Kingery et al. 1988) and it is therefore a less energy-demanding alternative that requires smaller amounts of fuel. Another reason may be related to the hardening process, since adding some gypsum to the lime mixture, a practice known as "gauging" speeds up the setting times (Radcliff 1997). Although gypsum is relatively soluble in water, it can be employed over architectural surfaces protected from the rain.

#### Fossils

Occasionally it is possible to discern fragments of fossils (foraminifera) within the lime matrix, indicating that lime was produced with fossiliferous limestones. This evidence also shows that the burning temperature was not sufficiently elevated to burn the fossils, which char at a slightly higher temperature than the micritic cement which they are embedded. The observation of unburnt fossils in lime plasters has also been reported by Goren et al. (1991). Fragments of fossils were observed in samples PKH-Pl-001, PKH-Pl-007, PKH-Pl-009, PKH-Pl-010 and PKH-Pl-013 (see Figure 14).

The presence of fossils in the plasters suggests that fossiliferous limestones were favoured over other types to produce lime. However, it is also possible that other porous micritic types of limestone were also used, such as the type represented by PKH-Li-4, although these limestones would not exhibit residual and diagnostic characteristic features, as they burn easily given their micritic texture, losing their morphological characteristics.



Figure 14. PKH-Pl-010. Fossil within the lime matrix. Scale bar: 0.5 mm. Crossed polars, scale bar: 0.5 mm

# Substrate of plasters

In some cases, underlying stone fragments that constitute architectural surfaces were observed in cross section views of the samples. These substrates were seen in samples PKH-Pl-015 and PKH-Pl-022, the former with a fragment of crystalline limestone, and the latter with a fossiliferous limestone, corresponding to the stone types previously described, and which supports that such stone types were selected for a variety of architectural purposes (see Figure 15).



**Figure 15.** Left: Sample PKH-Pl-015. Plaster applied over crystalline limestone. Crossed polars. Scale bar: 1 mm. Right: Sample PKH-Pl-022. Plaster applied over a fossiliferous limestone. Crossed polars. Scale bar: 1 mm.

#### Elemental analysis of plasters (EDS)

Eight plaster samples were analysed by means of energy dispersive spectrometry (EDS) attached to the scanning electron microscope. Elemental analyses show that the plasters are highly calcitic, reflecting the composition of local limestones. Silicon content is sometimes considerably high, as in sample PKH-Pl-012. This is likely related to quartz grains observed by petrography, as well as impurities in the lime mixtures, such as clays. It is also worth noticing the high content in sulphur of the matrix in sample PKH-Pl-022, which may indicate the presence of gypsum, as discussed above.

Sample	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	SO <sub>3</sub>	CaO	Fe <sub>2</sub> O <sub>3</sub>	SnO <sub>2</sub>	Sum
PKH-Pl-007 <sup>A</sup>	0.0	1.9	6.7	0.0	0.4	91.1	0.0	100.0
РКН-РІ-007 <sup>в</sup>	1.3	0.0	1.4	0.0	97.3	0.0	0.0	100.0
PKH-Pl-010 <sup>B&amp;D</sup>	0.0	0.0	2.7	0.0	96.4	0.8	0.0	100.0
PKH-Pl-010 C&D	3.1	0.3	6.5	0.0	88.4	0.0	1.8	100.0
PKH-Pl-012 <sup>E</sup>	0.9	1.7	6.6	0.0	90.8	0.0	0.0	100.0
PKH-Pl-012 <sup>F</sup>	0.0	0.0	15.2	0.0	84.8	0.0	0.0	100.0
PKH-Pl-012 D	0.0	1.2	6.4	0.0	91.5	0.9	0.0	100.0
PKH-Pl-011 <sup>B</sup>	0.0	0.0	6.1	0.0	92.4	0.0	1.5	100.0
PKH-Pl-014 <sup>B</sup>	0.4	0.5	1.8	0.3	97.0	0.0	0.0	100.0
PKH-Pl-014 <sup>G</sup>	0.0	0.0	2.1	0.0	95.8	0.0	2.0	100.0
PKH-Pl-014 <sup>H</sup>	0.6	0.0	0.0	0.0	99.4	0.0	0.0	100.0
PKH-Pl-016 <sup>B&amp;D</sup>	0.0	0.0	8.0	0.0	89.9	0.0	2.1	100.0
PKH-Pl-021 <sup>B</sup>	0.0	0.0	5.3	0.0	94.7	0.0	0.0	100.0
PKH-Pl-022 <sup>G</sup>	0.0	1.4	2.1	56.1	40.4	0.0	0.0	100.0
РКН-РІ-022 <sup>н</sup>	0.0	0.3	0.0	0.0	99.7	0.0	0.0	100.0
Standard material (BCS 393)	0.0	0.0	0.0	0.0	100.0	0.0	0.0	100.0

Table 4. Normalized results of semi quantitative elemental analyses, as shown by EDS (%). A: Red particle in red pigment layer; B: bulk analysis; C: lime lump; D: upper layer; E: lower layer; F: middle layer; G: matrix; H: aggregate.

#### ANALYSIS OF PIGMENTS AND COLOURED SURFACES

Red paint pigment layers were observed in samples PKH-Pl-003, PKH-Pl-004, PKH-Pl-005, PKH-Pl-006, PKH-Pl-007, PKH-Pl-008 and PKH-Pl-010, their thickness varying between 100 and 500  $\mu$ m. Multiple applications of coloured layers were also seen, as in sample PKH-Pl-007, where a reddish layer with big lime inclusions is overlain by a thinner red layer (see Figure 16).

As mentioned above, sample PKH-Pl-010 also shows two thin red paint layers, but in this case clearly divided by the application of a lime plaster. The lime plaster shows a pink colour, with visible inclusions of hematite, very likely representing a coloured preparation substrate for the red paint layer (see Figure 17).



Figure 16. PKH-Pl-007. Red pigment layers. Reflected polarized light. Scale bar: 1 mm.



**Figure 17.** PKH-Pl-010. Application of paint layers, clearly divided by plasters. Note the pinkish colour of the plaster layers and the inclusions of hematite. Reflected polarized light. Scale bar: 1 mm.

Raman Spectroscopy was employed for the characterization of pigments. The pigment in the red paint layers of samples PKH-PI-003, PKH-PI-004 and PKH-PI-008 proved to be hematite, since the red layers show characteristic peaks at 226, 249 and 411 cm-1, which corresponds with peaks previously reported for hematite (see Sendova et al. 2005), (see Figure 18). Additionally, SEM-EDS showed that the red pigment of sample PKH-PI-007 is high in iron, also indicating hematite (see Table 4).



Figure 18. PKH-Pl-008. Raman spectrum of red pigment with characteristic peaks of hematite.

Hematite was a widely used pigment in the Maya area that was employed to decorate architectural surfaces. It occurs abundantly in the numerous faults of southern Belize, where large-scale exploitation of this mineral might have taken place (Graham 1987:756).

Calcite was also identified with Raman Spectroscopy by the presence of a peak in 712 and 1086, which can represent that the painting technique made use of lime as a means of binding the pigments, although it can also be related with the lime from the underlying plaster.

Regarding the blackened surfaces in samples PKH-Pl-013 and PKH-Pl-014, PKH-Pl-015 and PKH-Pl-021, the presence of graphite was confirmed by the identification of a peak in 1580 (cm-1), which is the disordered arrangement of carbon. However, the other characteristic line of graphite, which is reported around 1360 (Vidano and Fischbach 1978, Ferrari and Robertson 2006, Tamor and Vessell 1994, Tunistra and Koening 1970), is visible at 1335.

No cellular structure is visible when the blackened plaster is scraped off and subsequently observed under petrography, which indicates that it is very likely soot material instead of black carbon pigment (see Eastaugh et al. 2004:88). Furthermore, as can be seen in Figure 19, there is no clear evidence of a paint layer over the surface. Instead, a blackened area is observed across the plaster's strata, suggesting that the material was subjected to exposures of soot, and that the plaster has been blackened by very fine particles of graphite that are not possible to detect with optical microscopy (see Figure 19).



Figure 19. PKH-Pl-013, Cross section of blackened plaster with no clear presence of paint layer, suggesting the presence of soot material. Scale bar: 0.5 mm.

The fact that the plasters are blackened by soot, without the clear presence of paint layers is related to the use Structure 1B as sweatbath. This structure has been documented by Helmke and Awe (2005), who have described charred plaster and cracking of the hearth as a consequence of fire exposures. In turn the presence of soot-blackened plaster surfaces and fire-cracked hearth stones inside the sweatbath demonstrate that fires were used to heat the sweatbath, rather than heating stones outside and subsequently carrying them, as has been suggested by replicative experiments at Piedras Negras (Houston et al. 1998: 45-46).

#### CONCLUSIONS

Characterisation of stones from Pook's Hill revealed the presence of different types of facies, including fossiliferous, intramicritic and pelmicritic limestones, as well as a red crystalline limestone.

Fragments of fossils were observed in many of the samples, which indicate that fossiliferous limestones were employed for the production of lime, and that the burning temperature was not high enough to calcine them completely. However, other porous micritic types of limestone may have also been used, although they would not have left any characteristic features behind.

Underlying substrates of plasters were also observed, with the identification of crystalline limestone and fossiliferous limestones, which stands for the selection of stone types for architectural purposes.

Re-plastering events as a consequence of architectural renovations were frequently seen in the samples, sometimes clearly divided by the presence of paint layers. Limewashes were also documented, in some cases as finishing layers, and in some others as preparation substrates for paint applications.

Sascab was widely observed as aggregate materials in the samples, although crushed fragments of crystalline limestone and limestone were also seen. The use of sascab denotes the abundance of this material, and the ease which it is obtained with, whereas the presence of crushed stone samples may represent waste materials from other construction activities and crafts, or an attempt to provide the plasters with higher mechanical properties.

The high content of sulphur in sample PKH-Pl-022, and similar phases observed by optical microscopy in other samples, likely represents the use of gypsum, which may have been employed as less energy-demanding alternative to lime.

Red paint layers proved to be in all cases composed of iron oxides, indicating the use of hematite. This pigment was also mixed in the plasters, in order to obtain a pinkish colour.

The identification of graphite without the clear observation of paint layers suggests the presence of soot material, deposited as a consequence of firing activities inside Structure 1B, likely related to the primary function and use of the structure as a sweatbath.

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