Part VI: Biological and Geomorphological Analyses
Chapter 19
The Burial Interments of Pakal Na

Rebecca Storey

Editors’ note: Although the massive mortuary pit cut into Structure 130 of Pakal Na was excavated during the 1999 and 2001 seasons, an in-depth osteological analysis was not undertaken until 2002. Since the deposit is significantly large and complex—and the identity of the individuals interred within of considerable importance for understanding the Terminal Classic period within the Sibun Valley—the results of Rebecca Storey’s osteological and paleopathological analysis are reported upon here. For additional details relating to the burial feature, stratigraphic relationships, and the construction history of Structure 130, please consult Harrison (2002) and Harrison and Acone (2003).

As has recently become apparent, Maya interments can be characterized by prolonged and elaborate treatment of bodies and revisitation of corpses some time after death. While such treatment seems widespread during the Preclassic, at K’axob for example (McAnany et al. 1999), it is apparently more restricted, as well as much more elaborate, during the Classic period at such sites as Copan (Storey n.d.), Piedras Negras (Fitzsimmons 1998), and Caracol (Chase and Chase 1996). At these sites, only high-ranking individuals or members of royal families were recipients of extended mortuary rituals and processing of bodies, however, and this exclusive pattern seems to represent a departure from the more widespread Preclassic pattern of complex mortuary practices. For example, the sample of Late Classic high-ranking individuals from the Bacab’s Palace of Copan is overwhelmingly primary interments that were not disturbed or later reinterred. In general, males seem to have been accorded more elaborate burials during the Classic Period (Haviland 1997).

The Pakal Na Structure 130 Burials

The characteristics of the burials discussed here indicate high rank by both the quality and nature of the grave offerings coupled with evidence of an extended period over which the mortuary ritual occurred. All of the identifiable individuals in this sample are males and all were interred within Structure 130, the largest platform structure of Pakal Na, which occupies the western side of an open plaza arrangement and exhibits a pronounced north-side orientation. The mortuary features were encountered during the excavation of an axial trench that originated on the eastern side of the structure. The most conspicuous characteristic of the mortuary activities at Structure 130 is the presence of a large pit that contained multiples individuals grouped around a focal male (Burial 1 deposit). Construction of this pit disturbed the earlier interment of Burial 2 who had been placed within the construction fill. The large burial pit is 3 m in length with a maximum width of 130 cm. The remains of probably four individuals plus a skull mask were found within this large facility (see Figure 19.1). In my opinion, there are at least three separate interment episodes present. Only two of the individuals are true interments while the other two individuals, and certainly the skull mask, are probably best interpreted as accompaniments or furnishings for one of the primary interments. Below, each of the skeletal individuals is discussed separately—beginning with the basal interment of Burial 2—and then the whole mortuary sequence is tentatively reconstructed. Further analysis will make it possible to confirm some of the interpretations suggested below.
Figure 19.1. Plan of Burial 1 interment (drawing by S. Morandi and inking by K. Acone).
**Burial 2.** This individual was placed in an earlier earthen structure that predated expansion of the platform into the present surface manifestation of Structure 130. Burial 2 was possibly a dedicatory interment for this structure. This primary interment was placed as an articulated skeleton on his back with feet crossed and head to the south. Accompaniments included a drilled fish vertebra bead and possibly a cylindrical pottery vessel. The individual was later disturbed by the preparation of the large burial pit; thus, only the left humerus and the body from the pelvis to the feet were found in situ. A smashed ceramic vessel was found just to the west of where the head would have rested. Preservation of bone and skeletal elements is only fair, as the ends of long bones and many delicate bones are missing. Parts of the skull and upper torso were found in the fill of the large, intrusive burial pit. These formed a clear but somewhat scattered deposit and some care was taken to collect the scattered bones during excavation of the pit.

Because of the state of preservation, only two morphological indicators of sex were present, while the pelvis—the preferred bone for sexing a skeleton—was ambiguous. A cranial trait indicated male and so an estimation of male was made preliminarily and later confirmed by comparing the robusticity of the femur and humerus to other Maya populations. These comparisons are accomplished through the calculation of discriminant functions (DF) based on individuals whose sex has been securely established on morphological grounds. I compared Burial 2 to the Copan rural sample from the Late Classic period, because of similarity of measurements taken. In all measures, Burial 2 was classified as strongly male (over 95% probability given the DF) and comparable to Burial 1A/1C (see below). Wrobel et al. (2002) have calculated discriminant functions to use for Maya samples. These are based onTipu but also tested on other Belize skeletal samples, so these would be very appropriate for the Pakal Na skeletons. For Burial 2, only one DF could be employed—that based upon the robusticity of the humerus. Results also indicated a strong male classification; thus, this individual is probably a male.

Aging is more problematic. The best adult age estimators are located on the pelvis, but these were not preserved in Burial 2. Teeth wear, from four teeth, and a few sutures of the cranium are available, but these are not particularly accurate indicators. The sutures are fully closed, which indicates an older individual. The teeth are only moderately worn; this condition might agree with the suture estimation if this individual had lost many of his teeth already and the four teeth present were all that were left. However, no mandible or maxilla was preserved to verify antemortem tooth loss. Also, the head of the skeleton was not in its original position, so one cannot be sure that some teeth had not been lost in repositioning the skeletal elements. Thus, at best, this individual is middle to older in age, probably older than 40 at time of death.

Other indications of health and lifestyle from the skeleton point to ill health during childhood that, nevertheless, the individual did survive. There is a clear systemic linear enamel hypoplasia on canines and one premolar. This condition indicates a period of growth arrest as a very young child in response to a serious disease or disease/malnutrition interaction. A more definite diagnosis of cause for this health indicator is not possible. He also exhibits healed cribra orbitalia in at least one orbit, which is usually an indicator of significant anemia during childhood (Goodman and Martin 2002), although it may be reflective of other conditions as well. For indications of health closer to the time of death, there is a carie in one of the four teeth and evidence of an extensive healed infection on lower legs and cranium. The cranial infection is both on the ectocranial and endocranial surfaces. Although healed, the infection most likely occurred during the final ten years of his life because the bone has not been remodeled. There is moderate arthritis of the hip and knee (more so than observed within the Burial 1 sample of individuals) which, coupled with pronounced muscle markings, indicate an active life. His phalanges bear the marks of habitual gripping, not unlike those of scribes. The teeth also have moderate amounts of calculus, which is considered an indicator of an acidic diet with a good proportion of protein (Hillson 1996).
The cranium was too fragmentary to judge whether there had been any modification, but the upper canine was drilled for an inlay, which is missing. There were no other upper anterior teeth, so the pattern of modification cannot be determined. The modified tooth further reinforces the impression that this individual enjoyed high status during his lifetime.

Interments of the Burial 1 Mortuary Pit

**Burial 1A/1C.** This primary interment is a focal individual who was placed at the base of the large burial pit located immediately to the east of Burial 2. Burial 1A was placed extended on his back with feet crossed and hands folded over pelvis. The top of the skeleton was placed to the north—the opposite orientation of Burial 2. All of the other individuals and the evidence of extended mortuary ritual are linked to this initial primary interment. Sometime after burial, parts of both arms and the head were removed, and ceramic vessel no. 5 placed where the head should have been. To the east and northeast of this individual, there were three other bone clusters. The easternmost cluster (Burial 1C) contained missing elements of Burial 1A: specifically cranial and arm fragments. This was verified by matching the left humerus of Burial 1C to the right humerus of Burial 1A, which had not been disturbed. As the skeletal elements did not overlap with any of the *in situ* bones, they are considered to belong to the 1A individual. Three ceramic vessels were placed on top of the body of 1A, along the N-S centerline of the mortuary pit. A portion of a smashed vessel was positioned under the area of the lower leg bones. There was also a vessel in a niche on west side of burial pit near the right shoulder. The bone cluster of 1C reveals a scatter of skeletal elements rather than a bundle, although some of the cranial fragments were stacked. A conch shell core, four perforated dog canines, and an elaborately carved skull mask accompanied this cluster.

Burial 1A/1C was relatively complete and well preserved. The pelvis and cranium both proclaimed that he was a male. Age indicators suggest that he was a fairly old individual at time of death, probably over 60 years. A very robust individual, slightly more so than Burial 2, Burial 1A/1C exhibited pronounced muscle markings on the shoulder girdle and a prominent linea aspera of the femur. An active lifestyle is indicated. There was no skull modification, but both upper anterior teeth present had been drilled for inlays, now missing (see Figure 19.2).

For health indicators, there were two clearly from childhood. Like Burial 2, this individual had one systemic linear enamel hypoplasia episode as a young child and evidence of slight, but healed, porotic hyperostosis on the vault. This also indicates an episode of anemia. He has no caries, but had already lost at least three teeth. Interestingly, this individual also bears scars of infection on both his legs and cranium, especially the endocranial surface (this is comparable to Burial 2). The difference is that this infection is only partially healed, and thus was active at time of death. There is only slight arthritic involvement in major joints of the shoulder, knee, and thoracic vertebrae, although the other vertebrae are poorly preserved and may have shown more involvement. Interestingly, the posterior right humerus and proximal ulna seem to show the effects of a dislocation, which happened some time before death (see Figure 19.3). The distal articulation of the humerus is partially obliterated on the posterior surface and replaced with a roughened, porous surface (pseudo-articulation?), while the ulna has a depression in the inferior semilunar notch with a facet on the coronoid process that is not normally there. Unfortunately, the proximal radius and the olecranon process of the proximal ulna are not preserved, so it is not possible to reconstruct accurately all changes to the joint. It appears as though the individual was probably able to retain movement in the elbow.
Figure 19.2. Empty inlays in teeth of Burial 1A/1C.

**Burial 1B.** Placed just east of the 1A body, this deposit included a bundled head with atlas vertebrae and pieces of the left shoulder. Drilled jaguar teeth and a deposit of cinnabar (20 cm across by 5-10 cm thick) were arrayed next to this bundle. The morphological features of the skull indicate male but this is only an estimate. Cranial measurements indicate that Burial 1B was gracile compared to the Copan rural male sample and the other two individuals already discussed. No comparable measures or discriminant functions are available from Wrobel et al. (2002). Teeth wear and closure of some sutures point towards an older adult, probably the oldest in this sample.

The individual bears a few indicators of pathology, including some healed porosis from anemia and enamel hypoplasia during childhood. There is also evidence of healed infection on the shoulder bones, so Burial 1B also suffered from a systemic infection, although there are no indications on the cranium. The shape of the cranium had not been modified but one canine was drilled for an inlay, which is absent here as well. This individual shows heavy calculus on many teeth, which indicates a very acidic diet.

**Burial 1D.** Consisting mostly of arm and leg long bones with few other skeletal elements, this individual appears to have been scattered rather than bundled. Located north of Burial 1B, these remains probably were placed in the pit at the same time as was Burial 1B. In fact, these subcranial skeletal elements could comprise the missing part of Burial 1B although there is a clear spatial separation between the two clusters. On the other hand, no age indicators on the bones of Burial 1D indicate an older individual as is Burial 1B. At this point, Burial 1D is treated as a probable different individual. No obvious offerings
accompanied this interment, although a large smashed serving bowl (Vessel 1) had been positioned above part of this bone cluster. From the size of the bones, this individual is a male. Most of the long bones bear traces of a healed infection, so he also survived a systemic infection.

Burial 1E. Identified only by teeth found within the Burial 1C cluster, these remains included no identifiable cranium fragments and may consist of only a deposit of teeth. The teeth indicate a probable middle to older individual and sex cannot be determined. No enamel hypoplasias were noted, but the most susceptible teeth for this health indicator during childhood were not present. There were no caries, but again many of the teeth were practically encased in calculus.

Skull Mask. Within the Burial 1C bone cluster were pieces of a skull mask that had been cut so that only the frontal and face bones were present (not all elements of the face were present in the deposit). Based on the morphology of the forehead and mandible, this modified trophy had been a male. The only age indicator is tooth wear, which indicates young to middle-aged, probably younger than the 1A/1C individual. One cannot score for porotic hyperostosis on the elements present, but there is definite reactive, healed bone mass in the maxilla sinuses, possibly indicating some chronic sinusitis for this individual during his life. A couple of teeth contain cavities from caries and, as is common in these individuals, the lower anterior teeth are covered in calculus. Defleshing marks from creation of the mask are very clear; these are the only such marks in this sample (see Figure 19.4). The clarity of the marks indicates that the skull was processed soon after death, likely for a trophy mask. The incision work is quite elaborate with a mat design and drilled holes on the central frontal section and fragmentary cartouches with probable zoomorphic designs were around the edges of the mat design. The hieroglyph for smoke or fire (k’ak’) is carved into the glabella (between the brow ridges). The mandible (in two pieces) contains carved cartouches of bird and feline/
canine designs (see Figure 19.5). Incisions also are present on the infraorbital area, so all of face probably was decorated. The mandible was drilled in several places along the inferior margin, probably so that feathers or other decorative elements could be attached to the mask. The bone literally is “smoked”; i.e., there are areas of scorching mainly on the interior surface but some on exterior surfaces as well. The style and content of the animal cartouches bear similarities to those of northern Yucatán/Chichén Itzá (see Harrison and Acone 2003 for more detail).
Summary of Individuals

There are at least three, and probably four, individuals in this sample. All are clearly adults, and probably older than 35 years at time of death. All are clearly male, except for the individual who is only represented by teeth, which is presently undetermined. (In my experience, teeth are not strongly dimorphic in Maya samples.) Three individuals had teeth drilled for inlay although the inlays are missing (perhaps all were jade). None bears clear evidence of cranial modification. All remains exhibit clear evidence of health
problems and some had occurred during childhood; the commonality of systemic infections among these adults is notable. Such infections are indicative of poor hygiene and perhaps also poor nutritional status in the years preceding death although, in two cases, the infections had healed. Health indicators such as these are common among Late/Terminal Classic Maya skeletons at Copan. Three of the individuals have significant calculus deposits on their teeth, an indicator not only of poor dental hygiene but also of a very acidic diet, which could be reflective of high protein intake (Hillson 1996). In summary, indicators of sex, age, dental modification, and diet suggest that these individuals were of high rank. Evidence of childhood stress does not preclude an ascribed high status, but these individuals also could have achieved high status as adults.

Reconstruction of the Mortuary Ritual

While Structure 130 was either under initial construction or undergoing an early stage of renovation, Burial 2, plus another ritual cache, was placed in the fill. The male likely was intended to be a dedicatory burial for this structure. Placed in an articulated position with a cylindrical vessel near the head, the individual’s death may have provided the impetus to construct the earthen phase of this mound. While careful wrapping or shrouding of a corpse can preserve proper articulation for some time after death, this individual probably was not curated for long because the bones were well articulated when discovered.

After a century or so had passed, this individual was disturbed when a large burial pit was excavated to inter Burial 1A/1C. This activity disturbed Burial 2 from his pelvis to his cranium. It is not clear whether the smashed vessel to the west of the head of Burial 2 was moved at this time. The disturbed parts of Burial 2 were scattered within the fill of the large burial pit above the inhumation of Burial 1A. It makes sense that disturbed skeletal elements would be re-interred in the burial fill just above the original elevation of Burial 2. Burial 1A was placed with a series of vessels, but the only one sure to have been present at the initial interment is the large jar that was broken and placed under the legs. Burning occurred at this time, as evidenced by the copious charcoal, a layer 10-15 cm thick lens under the legs and above the sherds of the broken vessel. The bones bear evidence of smudging and scorching from smoke, although the good condition of the bones—smoked rather than charred—indicates that the intent of the ritual was not cremation.

The body of Burial 1A could have remained at the base of the open mortuary pit for some time before the left arm and cranium were removed. There are no cutmarks, so this was probably done after the body was skeletonized. It could also be that the burning and smoking served to reduce the body to a more skeletonized condition. In that case, the time between initial placement of the body and the removal of skeletal elements may not have been very long. After the head was removed, a vessel was placed in its position and it is possible that the line of vessels on the centerline of body were placed at the same time. Further evidence of the manipulation of a skeletonized body is provided by traces of red and yellow ochre paint on the bones, some in places that could only be accessed if bones were exposed, such as the promontory of the sacrum. Eleanor Harrison-Buck who excavated the mortuary pit suggests that the individual may have been placed already dismembered and decapitated. If so, those conducting the interment ritual were able to preserve very good articulation from the right torso to the feet.

The depth of the Individual 1A body is about 40-50 cm below the other bone clusters in this pit. Thus, I think that the pit around this body was excavated first, and the extension of the pit to the east and placement of the other bone clusters came later, as part of the termination of this burial pit. This is somewhat controversial as the excavators reconstruct the whole pit as one episode, an interpretation
bolstered by the fact that the fill of the pit is similar throughout, both texturally and compositionally. Thus, a later excavation/expansion of the pit is not easily proven, although it is possible. It seems most logical that the deeper pit was dug for the body and then covered up after the skeletal elements were removed. Because the original body was no longer easily accessible, the pit was extended, and Burial IC and the other burial clusters placed as the final termination ritual.

These three other individuals had been curated in some way and placed to the northeast and east of the Burial 1A body. Most were scattered within a delimited area although the cranial fragments of Burial 1C and the head of Burial 1A appear to have been stacked and might have been bundled. Excavators indicate that the Burial 1B cranium was smashed. The skull mask also appears to have been broken, and in fact, much of the face is missing (and probably not placed in the pit or preserved). Thus, the mortuary rite involved deliberate breakage of crania in addition to deliberate breakage of ceramics. Such breakage was probably important to the ritual. In the end, the broken bones were primarily scattered within a bounded area (rather than closely bundled). They were placed with offerings and a deposit of cinnabar. Above the main interment and between Burials 1B and 1D, a large vessel was smashed. At the very top of the burial pit there was a fire pit, which could represent a final burning of the deposit. Then the top of the pit was roughly capped with a cobbled and pebble surface, so that the building could still be used. It is most probable that the final re-terracing of the structure occurred soon after the capping. The structure then functioned for some time after this event.

Importance of the Pakal Na Burials

From early on, this structure was intended partly as the burial place of important individuals/ancestors for the probable leading family of a place now called Pakal Na. The first interment, Burial 2, was fairly simple and this simplicity may reflect the modest position of the family at that time. By the time of the Burial 1 interment, however, the structure had been fashioned into a large and impressive platform with several terraces. Burial 1A/1C is definitely the focus of the mortuary ritual and wealth disposal within the large pit; his interment indicates a protracted rite. The identity of this individual is therefore of some interest. There are indications from the ceramic offerings and markings on the skull mask of connections with northern Yucatán, perhaps from Chichén Itzá itself. The possible migration of this individual from the north will be tested by isotope analysis of the bone.

The presence of a skull mask (probably worn as a pectoral in life), a second cranium, and the symbolism of the animal cartouches on the mask seem to indicate a militaristic theme, as if the individual was a successful warrior. Possibly, he was interred with the remains of various war trophies, although it is not clear exactly what the relation of the Individuals 1B, 1D, and 1E are to the main interment. None carries any marks of perimortem violence and they are just as likely to be honored relatives curated and allowed to accompany the main interment. Skeletal robusticity supports the notion that Burial 1A/1C was a warrior; he bore strong muscle markings on the arms and legs. However, he and the other individuals had clear evidence of systemic infection. This could be a reflection of the pursuits of these individuals, as infection might very well be the result of non-lethal cuts received in warfare—an occupational hazard perhaps. It is probably a tribute to the generally good lifestyle and prestige accorded warriors that these individuals generally survived the infection. The main individual also appears to have suffered a probable dislocation of his right elbow during life, which healed fairly well. It is tempting to designate this a battle injury. Perhaps he was recovering from a battle—living with the probable attendant prestige plus the infection as one might expect within Terminal Classic Maya society—when he died. After all, he was not a young man.
With the evidence of foreign connections and military honors, it is no surprise that this individual was treated very elaborately at death. Mortuary ritual involved the removal of some elements when the individual had probably been mostly skeletonized, perhaps for use in other rituals or just for more immediate commemoration of this individual. A ceramic vessel was substituted for the head. After some time, however, the elements were placed back in the pit along with offerings and the skull mask pectoral in a separate cluster of bones, along with the remains of probably three other individuals. Termination involved breakage, perhaps to blunt the power of these bones and vessels, and final burning, as the original interment of Burial 1A also involved burning. The closure of the pit and rebuilding of the structure removed the skeletons from any more manipulation or active use in rituals for the living, but I’ll bet Structure 130 served as a monument to this individual or individuals for the rest of the occupation of the site.

This particular burial context is evidence of the elaborate rituals involved in the interment of important ancestors during the Late/Terminal Classic period and not just in the larger, well-known Maya centers. To place this burial in the wider context of Maya mortuary practices, such treatment generally was reserved only for very few individuals of the highest rank. For example, at the House of the Bacabs (Compound 9N-8) in Copan, none of the elite individuals in this prominent residence had evidence of such treatment, rather it is present only among members of the ruling family. The Burial 1A/1C individual at Pakal Na was very important indeed.

References Cited

Chase, Diane, and Arlen Chase

Fitzsimmons, James L.

Goodman, Alan, and Debra Martin

Harrison, Eleanor
Harrison, Eleanor, and Kevin Acone

Haviland, W. A.

Hillson, Simon

McAnany, Patricia A., Rebecca Storey, and Angela Lockard

Storey, Rebecca
n.d. Lifestyles (Before and After Death) of the Rich and Famous at Copan. In Rise and Fall of a Classic Maya Kingdom, SAR Press, in press.

Wrobel, Gabriel D., Marie E. Danforth, and Carl Armstrong
Chapter 20
Mollusca from Midden and Ritual Contexts

Katherine Belzowski

Within Maya society, some shells were symbols of the gods and of elite status, while others were used in architectural construction, as food, and as personal adornment. During the 2003 XARP season, a large sample of shell was recovered from excavations at the sites of Hershey (HS), Augustine Obispo (AOS), and Cedar Bank (CB). All of these sites represent different time periods in Maya history: the Late-Terminal Classic, Terminal-Postclassic, and the Postclassic-Colonial periods, respectively. In addition, each of these sites is located at a different point along the Sibun River, with AOS being closest to the coast, CB upriver at the entrance to the karstic region, and Hershey at the top of the valley near the base of the Sibun Gorge. Each site contained a distinctive sample of shell. Through the examination of shell from each site, a more complete picture of Maya life in the Sibun River Valley emerges.

According to Hammond (1975:384), “Shells may be classified and archaeological significance assessed on the basis of the habitat of their former occupants”. The Xibun Maya utilized both freshwater shells from the Sibun River and marine shells from various sources. The use of marine shells at inland sites illustrates the effort put in to their acquisition—the ancient Maya would have acquired them through trade between the inland sites and coastal regions or by traveling to the coast to gather it. On the other hand, not every shell in the archaeological record is the result of human activity. In addition to marine and freshwater shell, terrestrial snail shells also were collected from the sites. Such molluscs were frequently encountered inhabitants of the soils of ruined buildings.

The types of shell recovered and their respective archaeological contexts reveal not only their use in a technological sense but also may help to determine their ideological significance. For example, shells have been found in caves and as grave goods, building ornaments, and instruments. As Harrigan (2004:399) notes in reference to the shells from the site of K’axob in northern Belize: “Comparison of the various amounts and types of species found in the varied deposits around K’axob allows for an understanding of how Maya incorporated mollusca into subsistence, ritual, and architecture.” Thus, by comparing the different archaeological deposits of shells one can determine the significance of different species in the Maya world.

In Maya society, shells were seen as symbols of water, life, and fertility (Isaza 2004:335). They could serve as religious symbols, often associated with certain gods. One of the most interesting examples of the architectural use of shell occurred at San Gervasio on Cozumel Island where marine shells were used to decorate a circular structure (Taube 2000). The Maya god of rain Chak was known to be associated with conch shells. Shells are also very prominent as jewelry items and were fabricated into necklaces, tinklers, and earrings. The use of large conch shells as trumpets is well noted. All of these items can be considered illustrative of a person’s status and often were associated with elites.

Shells also could serve secular functions as well. *Jute*, which is still eaten today, was a common source of food for the ancient Maya. The shells of this species often are found with their spires lopped off from the processing used to remove the snails. Crushed shell was used as temper for pottery, as seen in countless thin-sections from archaeological samples. Furthermore, shells could be used as construction
materials as well. In reference to the Stann Creek District, Elizabeth Graham (1994:254) notes that “shells are found everywhere, probably because they were used as [construction] fill.”

Shell Types

Due to its particular location and period of occupation, each site yielded a slightly different collection of shells. However, there were certain types of shells that were commonly found within excavations. These shell types can be divided into three categories based on habitat: marine, freshwater, and terrestrial.

Most of the shells came from the class *gastropoda*. This class includes snails and slugs and is the largest class of mollusks. There are about 30,000 existing species of gastropods, most of which have an asymmetrical spiral shell which functions as a portable retreat (Oliver 1975). There were fragments of shells from the class *bivalvia* but I was unable to positively identify the specimens down to genus, but it is certain that more than one genus is present.

Eight different genera of gastropods were identified: *Pomacea, Orthalicus, Euglandina, Melongena, Strombus, Pachychilus, Oliva*, and *Jenneria* (Table 20.1). In addition, unknown land snails were also found and recorded. For some genera, individual species could be positively identified. Of the three habitats represented, the marine category includes *Strombus pugilis* (West Indian Fighting Conch), *Strombus gigas* (Queen Conch), *Melongena melongena* (Indian Crown Conch), *Oliva*, and *Jenneria pustulata*. The freshwater invertebrates include *Pomacea flagellata* (apple snail) and *Pachychilus sp.* (jute). Finally, the terrestrial invertebrates include *Orthalicus princeps* (Florida tree snail), *Euglandina cylindracea* (a land snail), and other unidentified land snails. Below each type of gastropod is discussed by its habitat characteristics.

<table>
<thead>
<tr>
<th>Gastropoda</th>
<th>Common Name</th>
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<tbody>
<tr>
<td><em>Pomacea flagellata</em></td>
<td>Applesnail</td>
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<tr>
<td><em>Orthalicus princeps</em></td>
<td>Florida Tree Snail</td>
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<td><em>Euglandina cylindracea</em></td>
<td>Landsnail</td>
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<tr>
<td><em>Melongena Melongena</em></td>
<td>Indian Crown Conch</td>
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<tr>
<td><em>Strombus sp.</em></td>
<td>Conch</td>
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<tr>
<td><em>Strombus gigas</em></td>
<td>Queen Conch</td>
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<tr>
<td><em>Strombus pugilis</em></td>
<td>West Indian Fighting Conch</td>
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Table 20.1. Gastropods and Bivalves within the XARP 2003 Sample.

*Marine gastropods*
Strombus. Strombus was the most common species of marine gastropod found at the three sites. The Strombus genus, more commonly known as conch shells, is found throughout the tropics. Its members vary in size, but are characterized by “an expanded body whorl, narrow aperture, thickened outer lip, and short siphonal canal” (Oliver 1975:65). A particularly distinctive characteristic of Strombus shells is the ‘stromboid notch’, an indentation near the bottom of the outer lip. Strombus shells generally are solidly constructed and typically live in shallow water marine habitats on sand or sandy-mud.

Two different Strombus species were identified, S. pugilis (West Indian Fighting Conch; see Figure 20.1) and S. gigas (Queen Conch; see Figure 20.2). S. pugilis can be found in estuarine conditions although it often occurs in waters of oceanic salinity. It prefers oceanic waters with a touch of freshwater influence and slightly muddy bottoms in waters that are not crystal clear. “Therefore it is very likely that S.pugilis was found not far from the shore in ancient times” (Graham 1994:253-254). S. gigas, conversely, is commonly found in reefs and in true coral waters. Conch beds are usually found in the Barrier Reef off the coast of Belize. This likely made conch collection relatively easy for coastal Maya.

Figure 20.1. Conch shell: top row is Strombus pugilis; bottom row is Melongena melongena.
Melongena. Among the species that were identified, another that is often mistaken for a conch is *Melongena melongena* (Figure 20.1). *M. melongena* displays physical characteristics of either two spiral rows of short sharp spines or none at all. “It has a short spire and a channeled suture, an inflated body whorl and short open siphonal” (Oliver 1975:58). *M. melongena* is a marine species, found in archaeological deposits, shallow lagoons, and some creeks. It is commonly known as the Indian Crown Conch, mud conch or the fiber conch, even though it is not in the same order as other conchs. Because of its similar appearance, it can be confused with the genus *Strombus*.

*Oliva*. The *Oliva* genus, part of the *Olividae* family, is generally cylindrical, with short spire, a siphonal notch, a columella that folds away from the apex, and a fasciole. They dwell in the sand in tropical and warm seas. The shells are usually very hard, shiny, brightly colored and variously-patterned with
numerous fine wrinkles. The *Oliva* sp. was commonly worked and used for decorations, ornaments, and pendants (Oliver 1975).

*Ovulidae.* The family *Ovulidae* was represented by a single specimen in the deposits excavated during the 2003 field season, but it was very significant, as is discussed below. *Ovulidae* are strikingly colorful, with a patterned mantle. The mantle is normally drawn entirely over the shell, preserving the shell’s highly polished appearance. *Ovula* live in tropical waters. The highly-colored mantle and sharply contrasting spots result from accumulation of otherwise noxious chemicals that are retained in the mantle. *Jenneria pustulata* is the only recovered species from the *Ovulidae* family. A marine species from west Central America, the base of *J. pustulata* has coarse ribs from aperture to margin and bright orange pustules ringed with dark brown (Oliver 1975).

*Freshwater gastropods*

Freshwater shells were represented by either *Pomacea flagellata* or *Pachychilus* sp., the latter is commonly called *jute.* While *Pachychilus* is common to the swift-flowing waters of the Sibun River, *Pomacea* prefers the still or slow-moving waters of oxbows and wetlands. *P. flagellata* features a pinkish round shell with a single spiral apex while *Pachychilus* species are long with a pointed spire, many whorls, a simple lip, and a surface that is either smooth or ribbed. *Pachychilus* sp. (Figure 20.3) was the most prevalent shell found during the 2003 field season.

![Figure 20.3. Freshwater shells indentified from left to right as unknown black/white and two jute shells.](image-url)
Terrestrial gastropods

Terrestrial shells *Orthalicus princeps*, *Euglandina cylindracea*, and unidentified land snails were also collected from the sites (Figure 20.4). *O. princeps* is considered an arboreal species that inhabits the forests of South and Central America (Harrigan 2004:402) and features a short spiraled, swirled shell with purple and orange strips running lengthwise. Though similar in color to *O. princeps*, *E. cylindracea* (Figure 20.4) has a longer, tubular shell. An unknown land snail species (Figure 20.4) was found primarily at CB. Its shell was small, circular and brown and it was also found living in the soil. Live examples of these snails were found during excavation.

![Image of land snails](image)

Figure 20.4. Land snails identified from left to right as unknown, *Euglandia cylindracea*, and *Orthalicus princeps*.

Terrestrial shells are hard to interpret due to the ambiguity that surrounds their significance. As Graham (2002:252) notes: “Aquatic faunal sample shows that exploitation of marine and estuarine resources was clearly related in some way to the choice and utilization of sites, whereas the presence of terrestrial fauna is only indirectly related to the utilization of the site”. Terrestrial shells may hold information regarding current and past ecological conditions in the immediate environs of a site.
Protocol for Analysis

The project protocol included examination of each bag of shell collected from AOS, CB, and HS and selection of all identifiable pieces. Pieces were considered identifiable if the genus could be determined and if the fragment could not be considered part of another individual. For bivalves, when only one half was recovered, then that half was considered an individual. All individuals of the same species were grouped together. The first thing that was recorded was the number of the field collection bag (FCB). In some cases there were several different species of shell in one FCB.

Next, each shell’s archeological context was recorded, which included the following provenience information: site, operation, zone, and square. Within each site there were different operations (excavation units) that were subdivided into squares. In a square, cultural layers were identified by zone number, typically beginning with the surface as Zone 1. After these data were recorded, they were reorganized hierarchically by site, operation and zone.

Once provenience was noted, the shells were identified. Similar shells were placed into the same group. In each group the class, genus, and species of shell were identified when possible. The shells could be from one of two classes: bivalve or gastropod. Next, each identified genus was given a number and the shells were given a number corresponding to their genus. Within the genus, the species name along with the common name was recorded. Most of time the pieces collected were not large enough for an accurate identification of genus or species. In these cases, they were labeled as miscellaneous pieces. All of these pieces were weighed and recorded. In this way, the quantity of shell from each zone was determined even if every piece could not be identified.

The habitat of each species was then recorded. Shells could be from a freshwater, marine, or terrestrial habitat. To determine how many shells were present in a species group, the Minimal Number of Individuals (MNI) of each species was recorded. The MNI calculation reveals how the distribution of species varied among zones. Each species group was then weighed. Afterwards, comments about the specimens were recorded to identify any distinctive characteristics.

Data Analysis

In this section, patterns in the distribution of shell types are presented and discussed on a site-by-site basis. For tallies of unworked shell by site, see Table 20.2.

Augustine Obispo Site

AOS contained two different operations, Operation 32 and Operation 33. Operation 32 investigated a circular structure on the eastern side of a plaza while Operation 33 was placed on the top of a nearby residential mound situated on the northern side of the plaza (see Chapters 3 and 4 of this volume). Operation 33 contained a burial within the mound. It was near this burial that the few shells from Operation 33 were found.
### Table 20.2. Identification of Unworked Shell (Genus and Species) by Site.

<table>
<thead>
<tr>
<th>Identification</th>
<th>Augustine Obispo</th>
<th>Cedar Bank</th>
<th>Hershey</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Melongena melongena</em></td>
<td>21</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><em>Strombus pugilis</em></td>
<td>13</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Orthalis princeps</em></td>
<td>4</td>
<td>miscellaneous pieces</td>
<td>5</td>
</tr>
<tr>
<td><em>Pachychilus sp.</em></td>
<td>43</td>
<td>73</td>
<td>1548</td>
</tr>
<tr>
<td>Unknown Conch</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><em>Oliva sp.</em></td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><em>Euglandina cylindracea</em></td>
<td>3</td>
<td>5</td>
<td>29</td>
</tr>
<tr>
<td><em>Pomacea flagellata</em></td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Strombus gigas</em></td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Strombus sp.</em></td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unknown land snail</td>
<td>1</td>
<td>221</td>
<td>9</td>
</tr>
<tr>
<td>Unknown bivalve</td>
<td>17</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Mother of pearl</td>
<td>miscellaneous pieces</td>
<td>0</td>
<td>miscellaneous pieces</td>
</tr>
<tr>
<td>Black/white shell</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Operation 32 contained more marine shell than any other operation. The presence of several types of conch shells is notable, especially in the uppermost zones. The three different species of conch included *M. melongena, S. pugilis,* and *S. gigas.* Most of the conch remains were evenly balanced between *M. melongena* and *S. pugilis* (Figure 20.1). *S. pugilis* today is a major food source, which may be a reflection of the ancient Maya use of the shell. Only one example of *S. gigas* was found. The shell was a lip fragment that had broken off from the rest of the shell (Figure 20.2). Most often, *S. gigas* is not recovered in one piece, which may be because of “use of *S. gigas* shell in a variety of ways, as trade items or in jewelry manufacture, [which] reduces the likelihood of finding whole Queen Conch shells in the archaeological deposits” (Graham 1994: 254).

Conch remains were consistent throughout the zones with a high concentration of conch as deep as Zone 7. Most of the conch was concentrated near the doorway to the circular structure and also on a floor inside the structure. The close proximity of the conch shells to the doorway may indicate that they were used in the architectural façade of the building. This is highly probable given that almost all the lips were broken off. This finding is consistent with those at sites in the Northern Yucatan such as San Gervasio where conch shells were used for architectural decoration of a circular structure (Taube 2000). The close proximity of this site to the sea would have facilitated the procurement of marine shells such as conch in large numbers.
Operation 32 also yielded one example of an unworked *Oliva sp.* from Zone 3 as well as freshwater and terrestrial shell from several zones. Operation 32 also was the only operation in which a small black and white shell was found (Figure 20.3). The shell was white with black wavy lines running from the center. It is unknown whether the shell is marine or freshwater. A significant number of unidentifiable bivalves found (Figure 20.5). Finally, one piece of worked marine shell was recovered from Operation 32 (Figure 20.6).

![Figure 20.6. Worked Marine Shell: top center artifact from AOS, bottom four from HS.](image)

Operation 33 did not yield nearly as many shells as did Operation 32. Shells were present only between Zones 14 and 19. Two fragments of conch shell were found: *Strombus sp.* and *S. pugilis.* The rest were miscellaneous pieces.

**Cedar Bank**

Several operations were placed on or near the mounds at Cedar Bank (see Chapter 5 in this volume). Operation 40 was located at the base of Structure 351, a large mound located on the north side of the southern plaza. Operation 41 was positioned on top of the same mound. Operations 42 and 43 were placed in a structure that is located on the north side of the north plaza. Operation 42 extended north
to south across the east part of the mound, while Operation 43 also ran north to south but was located several meters to the west, toward the middle section of the mound.

Operation 40 yielded mostly unidentified land snails and *jute*. Large numbers of unidentified land snails were collected in Zones 1 and 2 but were absent from Zone 3. *Jute* is considered to be a Maya food source and was eaten by breaking off the spire and sucking out the mollusca inside. All recovered *jute* were missing their spires.

Four conchs were found in Operation 40, all in the upper Zones 2 and 3. The two conch from Zone 2 were so deteriorated that genus could not be identified. The third “conch” in Zone 2 was identified as *M. melongena*, while the fourth conch (from Zone 3) was *S. pugilis*. All of the conchs were found near the wall of the unit in between long stones that appeared to be part of the structure. Their proximity to these stones is indicative of a midden context. It is also possible, however, that these conch shells were used for architectural decoration as at AOS. Unlike the conch at AOS, the conchs at CB were highly deteriorated. This difference could attributed to soil differences between CB and AOS, or exposure to the elements for a longer period of time than the conchs at AOS. The AOS conch shells were found in a doorway feature while the shells at CB were outside of the building. There also were fewer conch shells found at CB, which could be due to its location farther upriver; in short, conch may not have been as accessible. Also, conch samples could have deteriorated due to intense flooding that CB experiences during the rainy season.

Operation 41 produced only terrestrial shells. The majority of the recovered shells were unidentified land snails that also were present in Operation 40. Over one hundred such shells were found in Zones 1 through 4. Operations 42 and 43 followed the Operation 41 example with shells occupying the top zones. There was only one example of shell below Zone 1. All shells were terrestrial snails or miscellaneous pieces.

**Hershey**

At HS, only two of the operations reported any shell remains. Both operations were located in Group A. Operation 54 was positioned over a passageway between Structures 504 and 503 (see Chapter 9 of this volume). Operation 55 was an axial trench placed across the ballcourt that is located on the southeastern side of Group A (see Chapter 10 of this volume).

The Hershey site, particularly Operation 54, was characterized by large amounts of *jute* shell (Table 20.2). This is consistent with the large quantity of *jute* found at the site during an earlier excavations. Norbert Stanchly (2003) identified two species of *jute* from Hershey, the majority of which are *Pachychilus indiorum*. I was not able to identify the *jute* species but could determine that there are two types of *jute* present at Operation 54. One, which was also found at AOS and CB, was smooth, while the other features longitudinal ridges. The *jute* vary greatly in size and were found in every zone in all squares of Operation 54. In Zone 6 of Square A there were 383 *jute* shells and in Zone 9 (Square A) there were 639 specimens. Most were missing a spire, and, due to the context, it is possible that the consumption of *jute* was ceremonially linked.

Operation 54 also yielded much higher frequencies of *E. cylindracea* than AOS and CB and far fewer unidentified land snails than Cedar Bank. Significantly, no conch remains were found at HS which may have to do with the fact that it is significantly farther from the sea then either AOS or CB. This may
have made conch a more precious shell due to the cost of transport. Conch is also noted as only being used in Maya architecture to decorate circular structures, none of which are present at HS.

On the other hand, Operation 54 contained the most pieces of worked marine shell (Figure 20.6). Most of the shell was so heavily worked that it was impossible to identify the species beyond that of a marine gastropoda. The uppermost worked shell came from Zone 3 and was a tubular bead about 1.5 cm long (Figure 20.6). Two shell pendants also came from Zone 3. One was only a fragment of what seemed to be a larger example of a second smaller complete pendant (Figure 20.6). Worked shell also came from Zone 5—a very thin circular piece of shell with a drill hole through the middle (Figure 20.6). The other three pieces of worked shell came from identifiable shells. Two examples from the Oliva genus were worked into tinklers. There was also one example of a worked Jenneria pustulata. The sole specimen of Jenneria pustulata is very significant because it is only found on the Pacific coast of Central America. This signifies that HS was involved in long distance trade and that goods were being traded across the Maya region from the Pacific to the Caribbean coast. Access to such trade routes would have brought exotic shell to powerful elites.

Operation 55 contained shells only in the first two zones and all were either E. cylindracea or jute. Zone 1 yielded a significant amount of jute (n=46), though it was small relative to the Operation 54 numbers. It also did not appear to have been found in the construction fill.

Conclusions

Based on findings from XARP excavations, shell appears to have played a variety of purposes in Maya societies of the Sibun River Valley. First of all, shell seems to have been a traded commodity. At HS, the tinklers were exactly like those found at Northern Belize sites. “The shells are either of the genus Oliva or Olivella, and are cut medially to exhibit a perforation in the body whorl near the aperture. They served as ornaments, perhaps pendants” (Sidrys 1983:348). The present of tinklers made from Oliva indicates that HS residents maintained connections to the coast and were importing and trading shells over long distances. The presence of Jenneria pustulata, furthermore, indicates trade links that stretched as far away as the Pacific coast, possibly via the southern highlands.

It also appears that Maya living along the Sibun River gathered shells that were within a short distance of their communities. AOS contained a number of conch shells, which reflects its close proximity to the coast. CB also yielded a few conch shells that could have been either gathered from the coast or acquired through trade. The interior site of HS, on the other hand, likely would have traded for marine shell with other sites located near the coast. Interestingly, HS does not contain a lot of marine shell besides those that were worked. “In sum, the three modes of mollusk-gathering—reef, coastal and inland—suggest a pattern of conservative exploitation in which gathers of mollusks, and perhaps fishermen in general, stayed close to resource zones near their own villages” (Sidrys 1983: 346).

HS did contain a lot of jute shell, which is easily gathered in large quantities from the nearby Sibun River. The two varieties of jute are present in the hundreds of jute collected during the XARP 03 field season. Such large collections are not rare to Maya sites. In reference to Lubaantun, Hammond (1975:384) reports the presence of thousands of jute, “many whole except for the tip of the spire, found in all levels of the 1970 excavation, though mainly in midden or mixed fill deposits and rarely in quarried construction fill.” These large numbers indicate their importance to Maya subsistence. Hammond
(1975:385) goes on to suggest that the “constancy and immobility [of jute] may have been a factor in the location of the settlement.” In contrast, marine shell was more likely to be imported for reasons other than subsistence.

In summary, shells were found in a variety of contexts at the three sites examined. At AOS and possibly CB, conch shell appears to have been used for architectural embellishment while worked marine shell at HS comprised artifacts of high status personal adornment for elites. These contrasting examples illustrate the many functions of shell in Maya society and the social symbolism of different shells.

References Cited

Graham, Elizabeth

Hammond, Norman

Harrigan, Ryan

Isaza Aizpurua, Illean

Oliver, A.P.H.

Sidrys, Raymond V., editor

Stanchly, Norbert
Taube, Karl

Field Stay and Goals

Struever’s (1971) crucial treatise on flotation techniques in archaeological excavations opened up a new avenue to interpretation of material plant remains. Today, separation of floral, faunal, and other types of artifacts from soils for identification and analysis is increasingly employed in archaeological excavations. In the Americas, systematic collection methods and rigorous analyses by archaeobotanists have yielded exciting results, including the identification of cultivation, crop processing, production, and consumption trends (Hastorf 1988), of fuel wood use (Piqué 1999), of particular plant taxa as environmental indicators (e.g., Smart and Hoffman 1988; Minnis 1978), of important economic plant species in environments generally considered inhospitable to preservation (e.g., Crane 1996; Lentz 1991; Miksicek 1983), of plant taxa in cave rituals (Morehart 2002), of trade (McKillop 1994), and of the origins of agriculture in the Neotropics (e.g., McClung de Tapia 1992; Piperno and Pearsall 1998; Pope et al. 2001). Numerous other accomplishments exist but are beyond the scope of this paper. In light of the potential contribution of plant remains to the study and interpretation of subsistence, ritual use, and ancient life ways, archaeobotanical study of sediments from the Xibun Archaeological Research Project is underway.

A primary goal of the XARP Archaeoethnobotany Research Project is determining whether cacao (Theobroma cacao, Sterculiaceae) cultivation and/or production played an integral part in the local Sibun economy during the Late Terminal Classic or the Spanish Colonial period. As part of a broader project exploring the political economy of the lowland Maya in Belize, we want to determine if cacao was a prestige good produced in the Sibun Valley, and exchanged to other areas of the Maya lowlands. Political control of such a resource could have lent social distinction to the Sibun Maya communities. The earliest evidence of cacao consumption in Mesoamerica is from Colha (Powis et al. 2002) and cacao pods are depicted on Classic Period polychrome drinking vessels from Belize. Clearly, cacao was important to ritual and social events. Furthermore, good ethnohistoric evidence (Jones 1989) exists that river valleys in Belize were zones of intensive cacao cultivation. Early Colonial records that a small Spanish colonial mission or visita and Spanish-owned encomiendas were located on the Sibun River. It is very likely that cacao was planted and managed, and a critical crop for the local economy, prior to the arrival of Spaniards; cacao cultivation and production in the valley may extend far back into time. The Sibun Valley, particularly the mid- to upper reaches, certainly meets the ecological and edaphic requirements of cacao cultivation. In addition, the excellent transport routes supplied by the river, access to numerous habitats and, presumably, varied economic products, as well as the presence of an early Spanish- Colonial archaeological component (Morandi 2003), make it very likely that the Sibun Valley provided tribute in the form of cacao to Spanish overlords. Given the documentary and archaeological evidence, as well as the ecological conditions, we feel that if cacao is to be located and preserved in Belize, the Sibun is a promising and productive site to investigate. A recent proposal to the National Science Foundation (see Hastorf et al. 2004), proposes to identify and analyze possible cacao remains in the XARP archaeoethnobotanical flotation collections. The project’s larger goal is to investigate cacao cultivation, exchange, and consumption in Belize and Honduras.

Tripplett conducted botanical surveys in 2001 (see Tripplett 2003). In addition to survey of the botanical resources in the Sibun Valley study area, Tripplett initiated a project enumerating and documenting
current cacao varieties planted and managed in the Sibun, collecting modern cacao materials for plant voucher specimens, recording and documenting morphological variability, cultivation and production techniques, and traditional uses of cacao whenever possible. Such data have several applications and are crucial for understanding how ancient Maya may have managed cacao populations within the Sibun landscape and achieved levels of production that could have permitted trade or tribute of cacao. In addition, it is important to determine if native Maya cacao populations still exist in the Sibun today and, if so, to record their morphologies and variability, in order to enhance our identification of cacao in the archaeological record. Tripplett aimed to continue the project in 2003.

Methods

In February, 2003, sediment sample collections for flotation, pollen, and phytolith analysis were initiated in the XARP study area. Flotation continued until late April. Tripplett had the pleasure of training Roderick Burns, a Belizean, in flotation techniques. He was an avid and enthusiastic assistant. Sediment samples were collected from archaeological excavations at the Cedar Bank, Augustine Obispo, Samuel Oshon, and Hershey sites during this period and floated for archaeobotanical remains. A blanket sampling strategy (cf. Lennstrom and Hastorf 1992) was conducted at each of the excavation sites, including the collection of both macro- and microbotanical sediments from identified contexts (Pearsall 2000; Hastorf and Popper 1988). Collections were made from both features and areas not recognized as features to ensure that samples can be compared evenly across and within sites (Hastorf 1999; Lennstrom and Hastorf 1992, 1995; Pearsall 2000; Toll 1988; van der Veen 1985). Phytolith and pollen sediment samples were extracted from samples prior to flotation for later analysis by Ellie Harrison-Buck and Steven Morandi. Sediment samples were then submitted for flotation after being labeled and recorded in a flotation log.

The flotation system was designed to conserve water; the light fraction was captured by the overflow of water from the surface, or by decanting, thus reducing potential damage to carbonized remains through handling and increasing recovery rates (Wagner 1988:20). Trained floaters carefully hand-mixed, or gently agitated, the sediment matrix in the tank and extracted large heavy fraction items in order to reduce breakdown of more delicate materials. The mesh used to capture the light fraction was very fine, close-meshed chiffon, likely to recover tiny seeds from archaeological sediments. The material was securely wrapped around a light-fraction outflow pipe. The heavy fraction mesh was 1/8” screen supported by 1/4” mesh. After flotation of the light fraction was complete, the heavy fraction was popped out to completely expel the heavy fraction remains, and allowed to dry in the shade on 1/8” screen. Light fractions were hung in their chiffon recovery bags on a shaded line and allowed to dry. All labels were rechecked and assigned to their respective fractions. The tank was effective for approximately 4 samples, and then an outflow pipe was opened to allow fine sediments to drain from the bottom of the tank. Once emptied and cleaned, the tank was refilled and the process began anew.

In general, recovery rates for botanical remains are low in tropical soils (Miksicek 1983; Pearsall 1993). Initial flotation samples were therefore 30 liters in volume. Heavy fractions were processed with the same fine chiffon material noted above (resting on a 1/8” screen, which rested, in turn, on 1/4” screening), in order to capture any tiny seeds caught in the soil matrix. This technique proved laborious and impractical: flotation samples required up to two and a half hours per sample because of heavy clay loads. After demonstrating the impracticality of using chiffon for the heavy fraction, 1/8” screening was used. Sample volumes were also reduced because of time and resource constraints. As mentioned, soils in the excavation sites were often heavy with clay; an average flotation period for a 15-liter sample was 45 minutes.
Results

A total of 121 sediment samples were collected from a range of contexts: tumble, midden, construction fill, burials, enigmatic features, earthen layers, pits, and steps/staircases, as well as some comparative surface samples. Numerous samples of carbonized wood were also collected by excavators and catalogued separately from archaeobotanical sediment samples. A subsample of 34 flotation samples has been selected and a full-sorting analysis commenced in the spring of 2004. Future analysis of additional archaeobotanical flotation and charred wood samples will be conducted as resources become available.

A preliminary glance at the light fraction samples indicates that recovery of archaeobotanical artifacts is low, as predicted by preservation conditions in a tropical, moist environment. Wood charcoal represents the bulk of the remains but small, unidentified objects are also present. Heavy fraction contents include turtle carapace fragments, obsidian microdebitage, parrot-fish teeth, ceramic sherds, carbonized wood fragments, baked clay material, fish vertebrae, bone fragments, chert fragments, jute shell, limestone gravel, and cohune palm fragments. In the laboratory, floated light fraction samples are screened through graduated geological screens and separated according to size classes. Each sample is then sorted according to material classes (e.g., wood charcoal, seeds, nutshells, parenchymous lumps, bones, other faunal artifacts). Whenever possible, remains are identified to plant family or genus.

In concert with Tripplett’s dual role as field botanist for XARP and in order to continue the botanical survey of the study area, an application for renewal of our 2001 Scientific Research and Collection Permit, issued by the Forestry Department, Ministry of Natural Resources, Environment and Industry (Ref. No. CD/72/1/01A8) was submitted. The permit allowed Tripplett to assemble numerous leaf, fruit, flowers, and wood collections of local plant taxa for study and preservation in conjunction with botanical survey. Resulting voucher specimens were placed on deposit at the Herbarium of the Forest Department at the end of her work season. Field collections of cacao were also a component of the 2001-2003 field period.

Due, however, to increasingly complex political tensions concerning biopiracy of botanical germplasm in Belize, no extension of the research permit was granted and further collection of cacao in the Sibun during the course of the 2003 field study period was prohibited. Access to a known population of feral cacao in the Maya Mountains of southern Belize (the site of \textit{T. cacao} and/or \textit{T. bicolor} populations, Hector Mai, personal communication to Kirsten Tripplett, 2001; Tripplett, personal observation) was therefore barred, as was collection of cacao specimens from Q’eqchi’ and Mopan Maya communities in the Toledo District. Today, the Toledo District is the foremost producer of cacao in Belize. Despite the current situation, the collections of cacao fruit from the 2001 study period, temporarily deposited in the Herbarium of the Forestry Department in Belmopan, were recovered in 2003 and charred in the field. Botanical surveys of 2001 that were conducted on and near the old Hershey Plantation (also the locale of the archaeological site of Hershey) yielded no evidence of wild or feral populations of cacao; \textit{Theobroma} cultivated on plantations has been replaced with numerous hybrids between \textit{T. cacao} and South American varieties (Tripplett 2003). Recent evidence of possible feral populations in the Sibun provides a promising opportunity for field study in the summer of 2004 (Patricia McAnany, personal communication, 2004). A series of interviews with landowners and residents of nearby Mennonite and Maya communities demonstrated that local knowledge of wild or feral cacao was limited, indicating that such populations may be very rare in the Sibun River watershed. Only a single wild \textit{Theobroma} was encountered in the course of fieldwork in the Sibun, at the very edge of the watershed.
From the view of population genetics, and given the exceedingly low numbers and genetic diversity of “wild” and feral populations (see Motamayor et al. 2003) of cacao encountered in Mexico, the status of observed Maya criollo cacao populations in Belize supports the hypothesis that the ancient species of Mesoamerican Theobroma cacao is threatened or endangered, perhaps even on the verge of extinction. An examination of Theobroma voucher specimens at the Herbarium in Belmopan, yielded only five sterile specimen sheets, without flowers or fruit. The genus is underrepresented, given its role in Belizean culture and economy. Further efforts to collect material for the Herbarium, Forestry Department, Belize, and for the archaeobotanical reference collections of the present project, are necessary and proposed. Trippllett is scheduled to return to Belize in the summer of 2004 for continued study with the Xibun Archaeological Research Project. New dialogues with government officials about the cacao archaeobotany research will be initiated then.

Concluding Remarks

The tropics provide limited conditions for botanical preservation (Miksicek 1983; Pearsall 1993) and recognition of potentially differential preservation is a serious issue for any archaeobotanical analysis. Although initial examinations of XARP flotation samples appear to reflect such reality, a pessimistic view is obstructive to constructive analysis and interpretation. Detailed investigation of charred wood, seeds, and other materials are likely to yield valuable data related to subsistence, fuel, and ritual use of plant taxa in the study area. Comparison to findings elsewhere in Belize and the lowland Maya environs will add to our understanding of resource utilization, crop cultivation and consumption, and ritual plant use in Terminal Postclassic sites in the Sibun. Analysis of the early Spanish Colonial contexts may provide new and unique data as well. Archaeobotanical sorting techniques will be utilized in order to identify charred plant taxa and to provide information on presence/absence, ubiquity, a sense of relative density, and degree of preservation. A table will also present raw data. Trends in plant use as food, in ritual, and in trade will be identified when possible. Insights into issues and influence of taphonomy and site formation processes (Miksicek 1987; Schiffer 1983) as represented by botanical remains will be explored and discussed in the final findings report. Concurrent analysis of phytolith and pollen samples obtained from sediment samples prior to flotation will be the subject of future analysis by Harris on-Buck and Morandi. Comparison of macro- and microbotanicals to other Mesoamerican archaeological sites will contribute to a better understanding of paleoenvironmental conditions (Dunning et al. 1998; Jones 2003; Leyden 2002; Rue 1989; Rue et al. 1998), cultivation, production, consumption, and trade of economically important crops (cf. Crane 1996; Jones 1994; Lentz 1991; McKillop 1994; Miksicek 1979, 1983, 1990, 1991; Wiseman 1983), and cultural and natural transformation processes at the time of deposit (Dunning et al. 1998; Jones 2003; Miksicek 1987; Schiffer 1983; Rue 1989).

References Cited

Crane, C. J.
Dunning, N., D. J. Rue, T. Beach, A. Covich and A. Traverse

Hastorf, C. A.


Hastorf, C. A., R. A. Joyce and K. Tripplett
2004 The Archaeoethnobotany of *Theobroma cacao* in Mesoamerica - Phase II. Proposal submitted to the National Science Foundation. Pending.

Hastorf, C. A. and V. S. Popper, editors

Jones, G.

Jones, J. G.


Joyce, R. A., C. A. Hastorf and K. Tripplett
2001 The archaeoethnobotany of *Theobroma cacao* in Mesoamerica. National Science Foundation. BCS 139214.

Lennstrom, H. A. and C. A. Hastorf

Lennstrom, H. A. and C. A. Hastorf


Morandi, S.

Morehart, C. T.

Motamayor, J. C., A. M. Risterucci, P. A. Lopez, C. F. Ortiz, A. Moreno and C. Lanaud

Pearsall, D. M.

Pearsall, D. M.

Piperno, D. R. and D. M. Pearsall

Piqué, R.


Powis, T. G., Fred Valdez, Jr., Thomas R. Hester, W. Jeffrey Hurst, Stanley M. Tarka, Jr.

Rue, D. J.
Rue, D. J., A. Freter and D. A. Ballinger  

Schiffer, M. B.  

Smart, T. L. and E. S. Hoffman  

Struver, S. (editor)  

Toll, M. S.  

Tripplett, K.  

Van der Veen, M.  

Wagner, G. E.  

Wiseman, F. M.  
In terms of paleo-environmental data, Belize has been fairly well studied in the northern portion of the nation, but studies in the south and central portions of the country are still largely lacking. Archaeological endeavors along the Sibun drainage, however, provide a unique opportunity to address this lack of information; slowly, but surely, we are beginning to amass some paleo-environmental data. Though the results are currently incomplete, what we do see is compelling and significantly different from the pattern known for the northern half of the country.

A large number of paleo-environmental studies have been conducted in northern Belize, and pollen records are known from Cobweb Swamp, Kob Swamp, Douglas, Pulltrouser Swamp, Pat Swamp, Chan Chen, Burrell Boom, Honey Camp Lagoon, Sarteneja, Chetumal Bay and Santa Rosa. While variations occur in all cores based on local cultural events and irregularly distributed plant communities, the general pattern of human activity throughout the region has been similar. The oldest pollen sequence we have for Belize is from Cobweb Swamp, a well-studied lagoon associated with the site of Colha. A vegetative sequence extending back at least to 8000 BP, the core contains a record of a grassland savannah with scattered freshwater ponds and wetlands filled with sedges and cattails in its most basal portion.

Around 6500 BP, the forests begin to develop around Cobweb Swamp, only to be abruptly cut off by the earliest farmers, documented around 2400 BC, but known to have been farming elsewhere in Belize (the Kob Site) at least by 3000 BC. The identity of these early farmers is not fully understood but, based on the type of maize being grown, they may have been affiliated with the Olmec who are known to have been farming in the Gulf lowlands during this period. From Cobweb Swamp, only two crops are documented from this period: maize and manioc.

By 1500 BC, the character of environment surrounding Cobweb Swamp changes again, and we begin to see a more intensive type of agriculture, with raised or ditched fields and a greater variety of crops, including maize, manioc, chili pepper, squash and cotton. These are the cultigens of the earliest recognizable Maya, and the maize that is being grown at this point is identical to modern maize. At this time, forests were further reduced and this trend continues as Maya population levels increase.

Curiously, breadnut appears to have been unimportant to ancient Maya farmers of northern Belize, as these trees are removed along with all other non-economic types. Trees that are favored by Preclassic farmers—including hogplum, sapote and some palms—were clearly spared. With the Postclassic reduction in Maya populations throughout northern Belize, there is some reforestation, but nowhere do the forests return to what they had been before agricultural times.

These data are new and exciting and help to place northern Belize Maya in context. But these events appear to have been specific to the northern wetlands; additional data are needed to understand patterns of colonization and agriculture among central and southern Belizean Maya.
The Xibun Pollen Project

The ancient vegetation communities of central Belize have yet to be established, but we now have collected data suggestive of a distinctively different trajectory for this part of the country. To provide background paleo-environmental data for the Xibun archaeological program, we began an energetic coring project. Initially, we were hoping to collect paleo-environmental records from several portions of the drainage, thereby establishing the past conditions in which Maya farmers had lived. We were also interested in identifying crops grown in the area during the peak period of settlement growth within the valley—the Late-to-Terminal Classic.

Unlike the low-energy hydrology of northern Belize—where marshes, lagoons and wetlands are abundant—permanent, sediment-filled bodies of water are lacking in the Sibun drainage. The upper reaches of the Sibun are dominated by high-energy fluvial events; locations that fill with sediments are periodically scoured clean, leaving no traces for the palynologists to study. Closer to the coast, hurricane events are the dominant landform process. Oxbows are abundant but, generally, are filled with massive deposits of recently derived sediments; material likely to have been introduced to the basins by very recent hurricane events. In the face of this situation, efforts to collect a palynological record focused on the middle portion of the Sibun drainage.

Coring Operations

Areal surveys identified a number of potential coring locations, including a sinkhole-like feature near Pakal Na, a series of oxbows near the end of the Churchyard Road, and another oxbow at Pechtun Ha. The basins at Pechtun Ha and Pakal Na were especially intriguing as they were both located adjacent to significant archaeological sites, and offered potential information on prehistoric human activity in those areas.

Coring was performed at all of the basins. Due to the nature of the sediments—sticky anaerobic clay—conventional coring apparatus was not effective at recovering a sediment record; an alternative, low-tech approach was our only real option. We drove a 2-inch diameter steel pipe into the sediments. After a meter or so of sediment had been collected, the pipe was sealed and extracted and additional drives were made in the same hole in order to complete the record. In 2001, we collected a total of 200 linear centimeters of sediment from the Churchyard oxbow, 127 cm from Pakal Na and 268 cm of deposits from the oxbow at Pechtun Ha.

The sediments from the Churchyard oxbow were unconsolidated and considered to represent a single recent flood event—thus, the core was not analyzed. The sediments from both Pakal Na and Pechtun Ha, however, were composed of dense organic-rich clay. These sediments can best be described as “nightmarish”, as they were foul-smelling, sticky and difficult to extract. In short, they were a palynologist’s dream and contained a plethora of perfectly preserved fossil pollen grains. The abundance of organic traces—including wood, leaves and seeds—provided abundant material for dating purposes.

The sediments at Pechtun Ha were particularly interesting, but the core was abbreviated because we encountered a deeply buried tree at 268 cm below “surface” (BS). The large sample of wood collected at this depth, however, did provide an excellent radiocarbon sample.

In 2003, we returned to these locations and collected additional sediments, this time concentrating on obtaining the deepest sediments. At Pakal Na, we were able to core the entire sedimentary sequence,
collecting sediments to a total of 420 cm BS. At Pechtun Ha, we again cored the oxbow, this time fortunately missing the deeply buried log and collected a total of 288 cm of sediments. At both locations, the sediments “bottomed-out” in coarse gleyed sands that appear to be basal river deposits. Thus, these sequences provide a complete record for each basin.

The Quest for Cacao

A significant component of the Xibun pollen project is the identification of ancient cacao production or cultivation. Currently, cacao is widely cultivated in the project environment, as the environmental conditions for its growth are favorably met. It seems likely that this region would have provided favorable conditions for the growth of cacao in the past, as well. Cacao is notoriously difficult to identify in the fossil record as it does not produce phytoliths and, unless fortuitously carbonized, its macro-remains do not preserve well and have not been documented, thus far, in archaeological contexts. Cacao pollen is diagnostic, but is probably not to be expected in most contexts. The trees produce large numbers of flowers, but each flower produces very few grains, and these grains are poorly dispersed and would not be expected to occur any distance from the source. Even sampling the modern ground surface in a cacao orchard may not produce any cacao pollen.

Modern cacao production takes place in shaded orchards, where emergent trees are allowed to grow producing an ample supply of shade favored by cacao trees. In the past, Maya cacao farmers probably used similar cultivation techniques. Thus, it may be possible to suggest prehistoric cacao production based on the presence of pollen from normally rare emergent or economically significant shade trees coinciding with the absence of medium to small non-economic arboreal types.

The Pollen Record

Pakal Na. To date, Pakal Na sediments collected in 2001 have been analyzed, but not the basal sections collected in 2003. When the sediments from Pakal Na were initially collected, the uppermost portions appeared to have been heavily oxidized and were reddish in color. However, during pollen extraction, it became obvious that pollen was not only present in the sediments, but was both abundant and perfectly preserved.

The coring location was somewhat atypical for the region, occurring some distance from the river, and was more typical of a sinkhole rather than an oxbow and its geomorphic origin is still unclear. Pollen-bearing sediments were sampled throughout the core and identification of the pollen clearly indicates that changes occurring in the local forests (Figure 22.1). From the base, recently dated at 770 + 35 BP, the core shows that the basin itself was open as reflected by the high percentage of aerobic pollen types in the samples, including Pinus, Podocarpus, Quercus and Salix grains. Relatively high percentages of normally scarce forest types, however, indicate that the area surrounding the basin was heavily forested. Towards the base (130 cm BS), these forest types are somewhat reduced, but by 120 cm BS had become well established. Quite probably, this core shows reforestation following Maya abandonment of the area.

Towards the top of the core, there is an increase in some disturbance indicators—mostly Typha, Brassicaceae, Poaceae, Asteraceae and Mimosa and a corresponding decrease in forest types. This change likely marks the introduction of historic farming activities earlier in the 20th century. Currently, a large complex of orange groves surrounds the basin. Orange pollen is rare and might not be expected to occur in the samples, but the weeds associated with its cultivation are abundant. Curiously, there is no evidence of
Figure 22.1. Pollen profile from core at Pakal Na, Belize.
Figure 22.2. Pollen profile from core at Pechtun Ha, Belize.
human activity in this record and it is possible that Postclassic populations did not take advantage of this water source.

While evidence of Maya activity is almost invisible in this core, the composition of the post-Maya forest at the base of the sediment section is curious, and shows elevated percentages of an unknown Salix-like grain, Coccoloba, breadnut, and several other forest types, and especially Unknown A. Several of these types are currently used to provide shade for cacao fields. Although cacao pollen has not been found in our cores, the relative abundance of shade trees such as Acacia-types and breadnut, as well as economically significant species like Coccoloba hint at evidence of ancient Maya forest management.

Pechtun Ha. The core samples collected in 2001 have been analyzed to a maximum depth of 267 cm BS and the basal sediments have been dated to 647 + 32 BP. Pollen preservation was excellent in this core, and a comprehensive record of local vegetation was obtained (Figure 22.2). As in the Pakal Na core, the Pechtun Ha record shows that the lagoon has remained open, but was surrounded by ever-changing forests. The basal section of the core records a heavily forested environment surrounding the oxbow, but slight hints of human activity are present in the lowermost sample where the charcoal concentration is somewhat elevated. All subsequent samples, however, contain very low concentrations of charcoal suggesting that human activity in this area has been minimal in the last 650 years. Through time, it is clear that the species composition of the local forests changed with the addition and loss of various tree species. Arboreal species that at one time or another were common in the vicinity of the oxbow include Alchornea, Orbignya (cohune), Coccoloba, Cassia, Gymnopodium, Mimosa, Pilocarpus and others. As all of these taxa represent distinct episodes, it is likely that we are recording actual individual trees or clusters of these plants.

At 200 cm BS, there is a single Zea mays pollen grain. While it is possible that small-scale milpa operations were carried out in the oxbow area, the absence of notable quantities of charcoal argues against this. Rather, it is more likely that this single grain washed into the oxbow from upstream, and was introduced into the sediments from some past flood. However, very slight increases in Cheno-Ams, a disturbance indicator, might suggest that small-scale milpas were present not too far from the oxbow.

As in the case of the Pakal Na core, any evidence of local human activity is most likely to be found in the deepest, as yet unanalyzed sediments. An estimated 40-50 cm of additional sediments were retrieved in 2003; thus, it seems unlikely—although not impossible—that the unanalyzed material will extend back to the Late Classic period.

At the base of the 2001 core, there is an increase in several arboreal species, including the same Salix-like grain noted in the Pakal Na core, as well as Sapotaceae and Spondias. Percentages of non-economic emergent tree pollen also are elevated slightly at the base of the core, and include Acacia, Alchornea and Cassia-type Fabaceae. Interestingly, it is this type of pollen signature that may be indicative of prehistoric cacao orchards.

Pollen Washes

A series of pollen washes was performed in the field on two separate manos and metates collected from cave contexts. The grinding surfaces of the artifacts were washed with dilute acetic acid and distilled water; the liquid fraction that contained pollen was collected. An effort was made to collect pollen only from the cracks and crevices on the grinding surface, and not from soil or other material adhering to the
artifacts. The ground stone from Actun Chanona was particularly interesting as the metate had been found inverted, thus reducing the chance of contamination. In both caves, the mano and metate had been found together and are thought to have been associated.

Pollen was present in all samples, but in very low concentrations. Full counts were not obtained for these samples; however, the pollen taxa that were present, along with their approximate concentrations, provide a notion of which plants may have been processed with these tools. It is important to remember that these tools contain no context beyond the fact that they were made by humans and come from a cave. Conceivably, they could date to any time period although the bulk of temporally diagnostic artifacts from caves in the Sibun region date to the Late-to-Terminal Classic period.

Metate Cave. Pollen was present in low concentrations on the metate sample and was almost absent from the mano. Cultigens were wholly lacking in the assemblages. Curiously, nearly all pollen identified in the metate sample came from insect-pollinated plants, suggesting that the few grains present in this sample actually may be contaminants from either frugivorous bats or pollen that was present in or on insects consumed by bats. Still, several pollen types stand out and, in fact, may represent ancient foods of the Maya. Economic pollen types identified include *Coccoloba*, a plant in the Polygonaceae family related to sea grape, a single grain from the Sapotaceae family, and several grains from ramon or breadnut. This latter type was the most commonly encountered grain in the assemblage representing 22% of the abbreviated assemblage.

Actun Chanona. The pollen assemblages found on ground stone from Actun Chanona were much more informative. Here, well-preserved fossil pollen was identified in both the mano and metate samples. The fact that the metate was found inverted inspires a higher level of confidence that the pollen assemblages represent human activity rather than contamination from bat feces. The presence of a *Trichuris* (whipworm) egg—presumably from a bat—in the metate sample, however, suggests that some contamination might still be an issue. Overall, the Actun Chanona samples are consonant with a human-derived assemblage and contain low frequencies of pollen consistent with bat foraging. In short, the pollen probably came from plants that were processed with the ground stone either during the course of a ritual within the cave or prior to the transport of the ground stone into the cave chamber.

The mano and metate pollen assemblages are similar suggesting that these two tools truly did “belong together.” The metate contained only a few grains that likely represent economic taxa, and include a single Solanaceae (nightshade family) grain and two grains from *Chrysophyllum* (star apple). The mano, however, contained many more well-preserved pollen grains, and the assemblage was dominated by economic types, including *Chrysophyllum*, *Coccoloba*, ramon, and most surprising – five pollen grains (9.4%) from what is almost certainly *Capsicum* (chili peppers). While the identification of this genus from pollen is difficult, to my knowledge there are no other members of this family in Belize that produce pollen consistent with this type. The finding of *Capsicum* pollen is rare under the best of circumstances, and the presence of such a significant quantity of chili pepper pollen surely represents the economic usage of this plant. This genus is the likely source of the single Solanaceae grain identified on the metate sample.

Finally, a single grain of what may be cacao pollen was noted on this mano sample, although it is also possible that this grain may represent *Guazuma* – a common disturbance tree. The introduction of cacao pollen into the grinding stone sample would not be expected through the preparation of cacao beans, however, if this grain does represent cacao, it might offer the first real evidence that this plant was grown in
the immediate area. For now, this problematic grain must remain a tantalizing hint of insights to come as this study unfolds.

Summary

The fact that pollen is present in this part of Belize is good news but, of course, the search for older core sediments continues. Regardless, this study has shown that pollen can be recovered from oxbow sediments. Upcoming analysis of the basal sediments of the Pakal Na and Pechtun Ha cores will add time depth to the sequences and, hopefully, verify whether or not the pattern of tree species noted above signals selective emergent and economic tree cultivation by Maya farmers.

Another significant finding of this project is that pollen can be recovered from grinding stone surfaces, even in the humid tropics. These pollen analyses are the first ever conducted in Belize on ground stone from cave contexts, and future efforts will expand this database. The fact that significant quantities of unexpected economic pollen types were recovered hints that further efforts along these lines will be most illuminating.
Chapter 23
Fluvial Geomorphology of the Upper Sibun Drainage

Thomas F. Bullard

For the past three millennia, Maya farmers and traders are known to have inhabited riverine environments and utilized rivers for transport and as trade routes. The Xibun Maya of Classic through Colonial times provide a textbook example of the advantages and risks of a riverine lifestyle (McAnany 2002). Questions persist as to the causes of the decline in Xibun Maya settlements during the Postclassic period (after A.D. 1000) and answers continue to retain a certain amount of speculation. But recognition that village sites were located on the banks of abandoned meanders far from the current river channel, coupled with the discovery of Terminal Classic structures buried beneath flood deposits, raise the possibility that changes in the behavior of this dynamic river system could have contributed to the abandonment and possible relocation of many Sibun Valley settlements.

Humans have always maintained a close relationship with water, whether lakes, oceans, rivers, springs, or isolated catchments. More often than not those inhabiting areas adjacent to fluvial systems have contended with the consequences associated with the natural behavior, or misbehavior, of rivers. Rivers can be viewed from a variety of perspectives and commonly engender conflicting images and emotions of beauty, tranquility, resource, danger, fear, and ultimately respect. In a sense, man’s attraction to rivers has been, and continues to be a love-hate relationship.

Given our understanding of fluvial system behavior, principally discharge, we know that every few years most rivers can be expected to overflow their banks and benignly inundate the surrounding floodplain. We are also familiar with the extreme fluvial events known as the hundred and five hundred year floods, which have phenomenal discharges, are commonly damaging to agriculture and habitation sites, and tend to leave a lasting impression on the landscape. In the Americas, the historic flood record reaches back a few hundred years, at best, but in the past few decades the discipline of paleoflood hydrology has emerged and extended the flood record thousands of years (Baker et al. 1983, 1987; O’Connor et al. 1988). This ability to assess the hydrology of rivers deep into the past provides important insight to climate and river behavior over long periods. In parts of Mexico the coastal sedimentary record is yielding paleoclimate data through evidence of hurricane activity extending several thousand years into the past (Goman et al. 2003). Surely, the Xibun Maya who inhabited settlements along the banks of the Sibun and other rivers of the region were accustomed to the periodic ravages of wet season floods and the infrequent extreme event capable of settlement destruction and dramatic reshaping of the river channel and low-lying areas. Thus, we can be assured that the Xibun Maya who lived along the river coped to some degree with the capriciousness of their riverine environment.

The population reduction in the Maya Lowlands at the close of the Classic period is the subject of much debate. Reduction of vegetation through human consumption and agricultural practices is one factor that has received much attention (Goman and Byrne 1998). Climate change has received equal attention (e.g., Leyden 1984; Hodell et al. 1995, 2001; Rosenmeier et al. 2002a; Haug et al. 2003). Recently, Rosenmeier et al. (2002b) have proposed that hydrologic and vegetation responses to change in moisture levels must be factored into an analysis of oxygen isotope content of inland lakes, specifically in Guatemala and Mexico. Ironically, isotope values suggestive of drying periods may be produced by changes in vegetation cover during moister periods with concomitant adjustments in the isotope concentration. Rosenmeier et al. (2002b) demonstrated the presence of pollen from tall canopy forest taxa during times
when the isotope record indicates a dry period. This type of information has great implications for land use, vegetation, hydrologic relationships, and geomorphic responses of the landscape.

This chapter focuses on the final implication noted above—geomorphic responses of a landscape. Based on field activities during the 2003 field season, this chapter addresses the fluvial geomorphic history of the upper Sibun River over the past few thousand years, spanning the time prior to widespread Classic-period occupation in the Sibun Valley to the present. Geomorphic history is developed on the basis of field investigations and mapping of geomorphic and Quaternary geologic units, description and analysis of fluvial stratigraphy, and soil-geomorphic investigations. Changes in the geomorphic system through time, particularly during the Late-Terminal Classic period, are placed in the context of natural system behavior, climate change, and land use. How the Xibun Maya adjusted to the changing geomorphic environment is left to the archaeologists.

Methods

The study included field mapping of Quaternary geologic units, primarily fluvial terraces along the Sibun River. Unit stratigraphy was described in natural exposures and shallow hand-excavated pits, commonly on riverbanks. Bedding, sedimentary structure, grain size, and lithology were described. Topographic profiles were made using tape and level to determine the spatial relationship between terraces along the Sibun River and variation in terrace sequences throughout the system. Soils provide excellent stratigraphic marker horizons and are indispensable correlation tools. Soil chronosequences developed in the tropics (Bullard 1995, 2002) are useful for establishing relative ages and providing age estimates for fluvial terraces. Soil developed on the fluvial deposits in the Sibun River drainage were described following standard pedologic field methods described by the Soil Survey Staff (1999) and Birkeland (1999). Samples of soil horizons were collected and returned to the Desert Research Institute for analysis in the Quaternary Soil Characterization and Pedology Laboratory.

Fluvial geomorphology refers to processes and landforms associated with streams and rivers (Ritter et al. 1995; Knighton 1998). Understanding fluvial processes, such as sediment entrainment, erosion, and deposition allows interpretation of stratigraphy contained in stream deposits. Materials that can be dated by conventional radiometric methods and other indirect indicators of relative time, for example the degree of soil development (e.g., Birkeland 1990, 1999), help to correlate units and provide constraints on temporal and spatial variations in fluvial activity. Crosscutting relationships between fluvial landforms, such as terraces, and cultural features also provide constraints on the timing of changes in fluvial processes. Paleobotanical evidence contained in sediments deposited in abandoned meanders often yield valuable information regarding not only the vegetation of the nearby area, but also important climatic and paleoflood information.

Setting

The Sibun River drainage is situated on the northern flank of the Maya Mountains in southern Belize (Figure 23.1). Precipitation ranges from about 1500 mm near the coast to nearly 3000 mm in the mountainous region. The drainage basin is approximately 1,170 km², most of which is contained in the headwaters area (Boles 1998). About 47% of the area lies between 80 m and 960 m elevation and 40% of the basin is below 40 m (Figure 23.1). The drainage is conveniently divided into four sections: headwaters section, the mid-reaches section, the lower reaches section, and the coastal zone. The principal distinguishing features of these sections are relief, geology, and slope.
Figure 23.1. Components of the Sibun River watershed showing distribution of geologic units and characteristics of the fluvial geomorphology.

Characteristics of the Sibun River

The Sibun River heads in the Maya Mountains, which are comprised of a variety of metasedimentary and igneous rocks. Highest elevations within the watershed are about 960 m. Within about 22 km of the drainage divide, elevations fall below about 100 m for the remaining 65 km of drainage. Streams in the headwaters are steep and have characteristic falls, cascades, and channel morphology that Montgomery and Buffington (1997) refer to as step pool.
North of the headwaters the gradient of the river decreases as it crosses limestone in the mid-reaches section and Tertiary marine and terrestrial rock units. Where the river traverses the limestone units, the channel is generally wide and shallow and has regularly spaced pools and riffles. This is a channel type commonly referred to as plane bed (Montgomery and Buffington, 1997). Sinuosity of the river is low (~1.2). The low sinuosity and high width to depth ratio is typical of rivers having plane bed channel morphology. These channels commonly have high bed shear stress and are capable of transporting large grain-sizes during high discharge events. In the area near Hershey, the focus of most of the geomorphic fieldwork in 2003, large boulder bars are common (Figure 23.2). Some of the boulder bars (lower photo of Figure 23.2) were formed during recent large magnitude discharge associated with hurricanes. These boulder bars create local base level conditions and constrict the flow such that during rising river stage, water is more likely to leave the confines of the channel. Abandoned meanders (oxbows) and meander scrolls (Figure 23.3) are apparent in parts of the mid- and upper reaches sections, although they are shallow and poorly defined. Attempts to retrieve cores of sediment have met with disappointing results. The floors of the oxbows are commonly armored with boulders and coarse gravel. This suggests that high-energy stream conditions in the upper and mid-reaches sections are not conducive to deposition and preservation of fine-grained fluvial sediments. The non-cohesive bank materials and broad valley allow the river channel to migrate with relative ease, particularly under higher discharge and sediment load conditions.

In the lower reaches section of the Sibun, the width to depth ratio of the river decreases and a meandering pattern is dominant. River depths exceed 3 m, channel form is parabolic, and bed shear stress is probably lower than in the upper reach section. The sinuosity of the meandering lower reach section is about 1.8. Abandoned meanders are common in this area (Figure 23.3) and many are filled with sediment during flooding. Based on radiocarbon AMS dates from sediment cores in oxbows, the pollen recovered from the cores in the mid to lower reaches section is thought to record vegetation recovery during the Postclassic period (see Chapter 22, this volume). The radiocarbon dates also indicate that meander cut off and abandonment probably occurred prior to that time, perhaps during the Terminal Classic period.

Fluvial Geomorphology at the Hershey Site

At the Hershey site, the distribution of fluvial terraces was mapped on stereographic aerial photograph pairs obtained during the field season. Map units were distinguished on the aerial photographs primarily on the basis of topographic relationships between terrace remnants and the relative degree of post-depositional erosion. Map units were confirmed in the field by observing and describing the fluvial stratigraphy and soils on each terrace unit and by measuring topographic profiles utilizing a level, stadia rod, and tape. Figure 23.4 shows the surficial geology mapped for the Hershey site and Figure 23.5 is a composite topographic profile of the Hershey site area showing the topographic relationships and stratigraphy of the fluvial terraces.

The Hershey site is situated on a terrace that ranges in height from about 4 to 6 m (T3) above the river. Above this terrace there are two higher terrace remnants situated at about 8 m (T2) and 20 m (T1) above the river. Below the terrace at the Hershey site, there are two additional terraces at about 3 m (T5) and 4 to 5 m (T4) above the river. Each terrace has characteristic geomorphology and each possesses a soil that is distinct from soils on adjacent terraces. The sediment comprising all terraces is predominantly upward fining sequences of fine sand and mud, typically with a basal cobble and boulder unit. With the exception of the highest terraces, sedimentology alone is of limited use in distinguishing the terrace sequence. Evidence of base level and landscape stability is provided by the development of soils. Truncated soils and
Figure 23.2. Boulder deposits in the Sibun River near the Hershey site (top). The recent boulder bar in the lower photo has prograded across and older deposit. The thickness of the recent boulder deposit is about 1 m.

gravel lenses at erosional contacts observed in deposits of T3, T4, and T5 indicate episodes of fluvial activity sufficient to erode and bury previously stable terrace surfaces.

Terrace Soils and Estimated Ages

The morphology of soils formed on terraces was described in road cuts and natural exposures along river cut banks. The exposures were cleared of vegetation and cleaned prior to making field descriptions. Soil morphologic descriptions follow standard techniques and nomenclature of Birkeland (1999) and the
Figure 23.3. Characteristic meanders of the mid and lower reaches of the Sibun near Churchyard and Pechtun Ha. Traces of meander bends are shown with dashed white lines.

<table>
<thead>
<tr>
<th>Terrace</th>
<th>Height above Base Level (m)</th>
<th>Diagnostic Horizon</th>
<th>Horizon Thickness (cm)</th>
<th>Maximum Reddening (hue)</th>
<th>Maximum Soil Structure</th>
<th>Clay Films</th>
</tr>
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<td>0-3</td>
<td>C</td>
<td>120+</td>
<td>10YR</td>
<td>sg</td>
<td>1-2n sil</td>
</tr>
<tr>
<td>Ballcourt</td>
<td>4.0</td>
<td>Bw</td>
<td>60</td>
<td>10YR</td>
<td>1-2msbk</td>
<td>1-2n sil</td>
</tr>
<tr>
<td>T4</td>
<td>4-5</td>
<td>Bt</td>
<td>170+</td>
<td>7.5 – 10YR</td>
<td>2-3msbk</td>
<td>2-3mk</td>
</tr>
<tr>
<td>T3</td>
<td>4-6</td>
<td>Bt</td>
<td>190+</td>
<td>7.5 – 10YR</td>
<td>2-3 msbk</td>
<td>2-3mk</td>
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<tr>
<td>T2</td>
<td>8</td>
<td>Bt</td>
<td>195+</td>
<td>5YR</td>
<td>3csbk – 2-</td>
<td>3k</td>
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<td></td>
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<td></td>
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<td>3mpr</td>
<td></td>
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<tr>
<td>T1</td>
<td>20</td>
<td>Bt</td>
<td>210+</td>
<td>2.5-5YR</td>
<td>3msbk</td>
<td>3-4k</td>
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Notes: Diagnostic horizons and maximum reddening follow nomenclature of the Soil Survey Staff (1999). Colors are from Munsell Soil Color Company. Maximum soil structure refers to naturally occurring structure found in soils. Numerals describe degree of development (1 is weak, 2 is moderate, 3 is strong); m and c refer to the size (medium and coarse), and sbk, pr, and sg denote type of structure: sbk is subangular blocky, pr is prismatic, sg is single grain. Clay films describe the thickness and extent of clay films found in the horizon: numerals refer to the frequency (1 is few, 2 is common, 3 is many, 4 is continuous) and letters refer to thickness (n is thin, mk is moderately thick, k is thick); sil indicates that silt coatings are observed, but no clay films. Structure and clay film nomenclature follows Birkeland (1999).

Table 23.1. Characteristics of Soils in the Hershey Site Area.
Soil Survey Staff (1999). Morphologic characteristics included horizon thickness, color, texture, clay films, roots, pores, and horizon boundaries. Characteristics of soils found on fluvial terraces in the Hershey site area are shown in Table 23.1. Field descriptions are summarized in Table 23.2 and the particle size data are shown in Table 23.3. The soil horizons are identified on the stratigraphic columns shown on Figure 23.5.

**T1 and T2 soils.** In general the stratigraphy of terraces T1 and T2 consists of deeply weathered deposits of fine, silty sand. Both terraces have a thin surface soil overlying thick, buried soils in the subsurface that extend to depths exceeding 2 m. Soils developed on T1 and T2 are the best developed of all soils described in the region. They have extremely well developed Bt horizons, common, thick clay films, clay texture, and are reddened to 2.5YR hues. Red (5YR) and yellow (10YR) mottles consistent with redoxymorphic features characteristic of plinthite are observed in both the T1 and T2 soils. Dark staining, possibly manganese oxide, is also observed on ped faces. The soil on the T1 terrace is more strongly developed and likely much older than T2 soil. Relative to similar soils studied in the tropics of Costa Rica (Bullard 1995, 2002), these soils are mid-to late Pleistocene in age.

**T3 soil.** Two distinct units of upward fining sequences of gravel, rounded pebbles, and coarse sand separated by an erosional contact and evidence of soil development is observed in the T3 deposits. A buried soil is formed on a depositional unit having a basal gravel unit (2 to 5 cm) overlain by sand that fines upward. The top of the buried soil is eroded and overlain by a surface soil formed in about 75 cm of upward fining gravel and sand. The surface soil developed on T3 consists of a thin (~60 cm) profile that has a slightly reddened Bt horizon that overlies the 3 m thick buried soil, which possesses a well-developed Bt horizon. The development of the T3 buried soil relative to soils observed in Costa Rica indicates that it is probably on the order of 7 to 10 thousand years (ky) old. The surface soil has characteristics (Bt horizon, clay films, structure) similar to a tropical soil in the range of 4 to 6 ky old. This indicates that the T3 surface (formerly a floodplain) was probably formed in the latest Pleistocene but received a substantial amount of sediment during the mid Holocene sufficient to bury the original soil formed on T3.

**T4 soil.** Terrace T4 deposits are inset into the T3 terrace and contain a buried soil formed in an upward fining unit consisting of a basal cobble (mean diameter 15 cm, range 5 to 40 cm) at least 2 m thick and rounded gravel, pebbles, and sand. The profile thickness, clay films, structure, and color of the buried soil indicate that it is younger than the soil formed on terrace T3. The uppermost, moderately developed Bt horizon of the buried soil is eroded and overlain by about 60 cm of fine to very fine lithic rich sand that has a weakly developed soil. The relative degree of soil profile development for the buried and surface soils associated with terrace T4 suggest that T4 is likely mid-Holocene in age.

About 60 cm of fine sand and silt is deposited on T3 and buries the ballcourt at the Hershey site (see Chapter 10, this volume, for archaeological description of the ballcourt excavations). The deposits likely represent overbank deposition associated with the formation of T4 and as well as the incorporation of recently deposited flood sediments during large magnitude discharge events. A weak soil with a slightly oxidized and reddened Bw (structural B) horizon has formed in the deposits overlying the ballcourt (Figure 23.6). Because the ballcourt is considered to have been constructed slightly over a thousand years ago (about A.D.830-950), this cultural feature provides an estimate of how rapidly soils form in this environment.

**T5 soil.** Terrace T5 deposits consist of a basal cobble unit (up to 35 cm diameter) and at least 150 cm of alternating graded sand and silty sand beds and. Irregular contacts between T5 depositional units
<table>
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<th>Depth (cm)</th>
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<th>Sand</th>
<th>Coarse</th>
<th>Fine</th>
<th>&lt;3 um</th>
<th>Σfra</th>
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<tbody>
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</tr>
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Table 23.2: Summary of Field Descriptions of Soils in the Hershey Site Area.
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Table 23.3. Summary of Particle Size Data for Sibun River Terrace Soils near Hershey.
Figure 23.4. Preliminary surficial geologic map of the Hershey site area showing the distribution of fluvial terraces and estimates for the age of terraces.
Figure 23.5. Composite topographic profile of the Hershey site area in the upper reaches of the Sibun River. Wavy vertical lines represent soil development. The longer, thicker lines indicate well developed soils. Terraces T1 (oldest) to T5 (youngest) are shown. Dashed lines indicate that units T3, T4, and T5 are likely inset fluvial terraces. Stratigraphic sections are shown for each terrace and soil horizon designations are shown within each section.
coupled with evidence of bioturbation indicate brief periods of surface stability and incipient soil formation separated by discrete depositional events. The lowest buried depositional unit of T5 preserves a weak soil that is slightly oxidized, has massive structure, and displays evidence for the translocation of silt and clay, which contrasts with the overlying deposits, which are comprised of loose sand. At the erosional contacts between the depositional units, there is evidence of bioturbation suggesting that the buried soils had been stable at the surface for brief periods of time prior to burial. Characteristics of the soil on T5 suggest an age of less than 1000 years to the present and that the unit represents multiple recent depositional and erosional phases.
Fluvial Geomorphic History

The terrace sequence, stratigraphy, and presence of multiple buried soils indicate a complex geomorphic history for the Hershey site area. Because the oldest terraces (T1 and T2) are considered to be Pleistocene in age and beyond the age range of archaeological interest, they will not be discussed. Terrace T3 represents the longest period of stability within the inner valley of the Sibun since the Pleistocene. The buried soils found on T3 indicate periods of relative stasis in this part of the fluvial system during which soils formed over a period of several thousand years followed by renewed flooding during the early to mid Holocene. At some time during the mid-Holocene, T3 was buried by perhaps as much as a meter of sediment. It is possible that the Sibun River channel aggraded during the mid Holocene to bury the T3 soil, although the burial of the T3 soil could also occur as a result of repeated inundation and overbank deposition or just a few overbank events. Regardless of the exact nature of the burial, it is clear that final fluvial abandonment of the T3 surface occurred prior to the middle Holocene.

During mid-to-latter part of the Holocene, the T4 terrace was formed either by incision of the T3 surface or by channel aggradation and rapid incision. The T4 terrace was periodically flooded as evidenced by the weakly developed surface soil that buries a moderately developed soil. The surface soil may be less than 2 to 3 thousand years of age. Sediments associated with terrace T5 were deposited within the last several hundred to a thousand years.

Implications of Boulder Deposits

The presence of large deposits of boulders (with b-axis diameters of 20 cm and greater) bears two-fold significance. First, the transport of such large material requires high velocity flow associated with large magnitude discharge, such as is common with hurricanes or other large tropical storms. Currently, the Sibun transports large grain sizes only during intensive storm events. During periods of high discharge, most of the fine-grained material is transported through the system. The implication is that the largest particles (boulders) are transported and deposited only during the infrequent, high-magnitude storm events, whereas the fine-grained deposits that bury the boulders at the base of the T3 and T4 terraces represent smaller, more frequent low-magnitude discharge events. Second, the presence of the boulder deposits, especially notable in the Hershey site area, has the effect of constricting the channel and raising the local base level. The net result is that there may be a greater frequency of local overbank flooding when the mid-channel boulder deposits remain stationary for long periods. That is to say that the presence of the boulder bars may exacerbate the magnitude of flooding of the more frequent small and moderate flood events.

The presence of a recognizable soil on flood deposits overlying the ballcourt at the Hershey Site raises the possibility that despite the relatively high elevation of T3 at the Hershey Site (4 to 6 m), overbank events were common in the last 1000 years or so and may have contributed to abandonment of this site and possibly others along the Sibun. Such overbank events could have resulted from increased frequency of high magnitude flood events, the presence of boulder bars that affect local base level and promote overbank flooding, or both. The cause and timing of changes in flood magnitude and frequency are as yet unknown. There is paleoclimatic evidence (Hodell et al. 1995; Goman et al. 2003; Haug et al. 2003) that could indicate changes in storm type and frequency, which could have affected the Sibun during the latter parts of the Holocene. There is also the suggestion that widespread deforestation could have dramatically altered watershed hydrology (e.g., Goman and Byrne 1998; Rosenmeier et al. 2002a), which also could have had an effect on the behavior of the Sibun River. Currently, we have insufficient data to knit together the
connections among climate, Maya land use practices, and the fluvial behavior of the Sibun River. Radiocarbon dates from oxbows in the middle and lower parts of the Sibun River suggest a loose relation between settlement abandonment and oxbow formation. Future research will be designed to explore the vital connections between the Xibun Maya and their volatile fluvial environment.

References Cited

Baker, V.R., R.C. Kochel, P.C., Patton, and G. Pickup

Baker, V.R., G. Pickup, and R.H. Webb

Birkeland, P.W.

Birkeland, P.W.

Boles, E.

Bullard, T.F.

Bullard, T.F.

Goman, M. and R. Byrne
Goman, M., A. Joyce, and R. Mueller  


Hodell, D.A., J.H. Curtis, and M. Brenner  


Knighton, D.  

Leyden, B.W.  

McAnany, P. A.  

Montgomery, D.R. and J.M. Buffington  

O’Connor, J.E. and R.H. Webb  

Ritter, D.F., C.R. Kochel, and J.R. Miller  


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