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Excavations and Interpretation of Two Ancient Maya Salt-Work Mounds, Paynes Creek National Park, Toledo District, Belize

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EXCAVATIONS AND INTERPRETATION OF TWO ANCIENT MAYA SALT-
WORK MOUNDS, PAYNES CREEK NATIONAL PARK, TOLEDO DISTRICT,
BELIZE

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Geography and Anthropology

by

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ABSTRACT

In 2012, excavations were conducted at Witz Nabb' and Killer Bee the last remaining above sea level features Paynes Creek National Park, Belize. Salt is a basic biological necessity that was in limited supply at inland Maya cities. The ancient Maya of coastal Belize produced by fire enhanced evaporation of salt enriched brine. Survey and excavation at inundated salt works in a shallow lagoon in Paynes Creek National Park provide extensive evidence of this technique in the form of briquetage, the remains of pots used in the fire evaporation. Lacking is any evidence that the salinity of seawater was enriched by leaching brine through salty soil or by solar evaporation – virtually universal in ethnographic and historic case studies.

Discussions of the excavation, stratigraphy, and artifacts helped to determine the function of the mounds and demonstrate how production scales changed over time. Ethnographic examples indicate that salt making is often a periodic activity. The excavation at Witz Naab' supports evidence that salt production was not a continuous activity. Detailed soil analysis developed a baseline of data to compare to ongoing research at the surrounding inundated sites. Furthermore, the use and function of these mounds will aid in our understanding of resources exploitation and trade interaction between the coastal Maya and the inland Maya centers of the Late Classic (A.D. 600-900). This research will expand the understanding of techniques of salt production associated with the ancient Maya and the interaction between the coastal and interior settlements.

CHAPTER 1: INTRODUCTION

Salt, a basic biological necessity in limited supply at inland Maya cities, was produced along the coast of Belize by evaporating brine by heating over fires (MacKinnon and Kepecs 1989; McKillop 2002; Mock 1994). Survey and excavation at inundated salt works in a shallow lagoon in Paynes Creek National Park, southern Belize, provide extensive evidence of this technique in the form of briquetage, the remains of pots used in the fire evaporation process (McKillop 1995, 2002, 2005a, 2005b, 2005c, 2008; McKillop et al. 2010; Sills and McKillop 2010). Killer Bee is interpreted as a slag heap from the salt making process in which brine was enriched by pouring salt water through soil to enhance salinity (McKillop 2002:49). A process virtually universal in ethnographic and historical case studies (Andrews 1983; Reina and Monaghan 1981).

Numerous field seasons have revealed important data concerning the surrounding inundated salt works. The focus of this dissertation is to understand the internal structure and function of the earthen mounds at Witz Naab' and Killer Bee, within Paynes Creek salt works. The purpose of the research is to expand the understanding of techniques of salt production associated with the ancient Maya and explore the role of the Paynes Creek salt works in the larger Maya world. The mounds at Killer Bee and Witz Naab' (Figure 1) are situated in an estuarine system characterized by *Rhizophora mangle* (red mangrove) ringing the edge of the lagoon and occasionally found in small concentrations within the lagoon. The land becomes drier inland, and *Avicennia germinans* (black mangrove) and *Languncularia racemosa* (white mangrove) dominate the landscape. The lagoon floor is composed of mangrove peat. The peat environment has preserved the wooden architectural remains of the Paynes Creek salt works. The

red mangrove ecosystem has dominated the landscape through the Holocene as indicated by pollen and peat fiber analysis from sediment cores (McKillop et al. 2010).

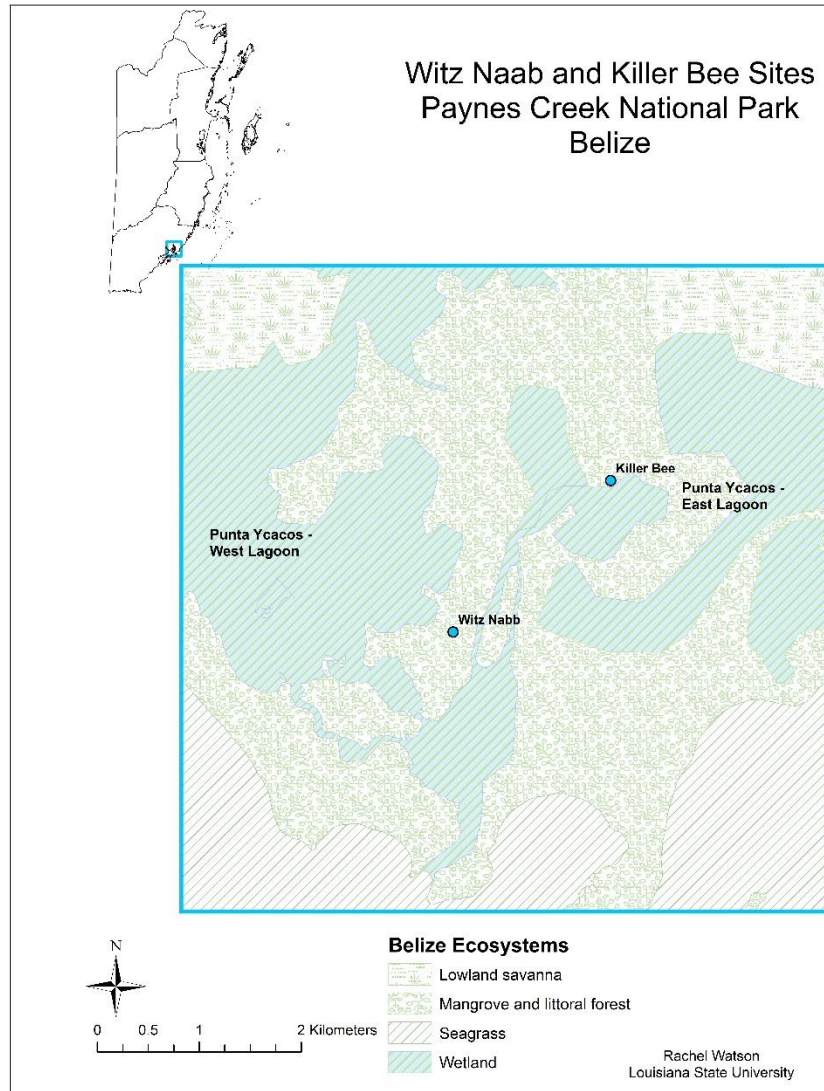


Figure 1: Ecosystems Map of Paynes Creek National Park.

History of the Project

The research is part of the larger, long-term project in southern coastal Belize designed to further the understanding of how the coastal Maya of the region participated in the larger Classic and Postclassic Maya cultural sphere. Research interest began with the investigation of the Maya

settlement of Wild Cane Cay (McKillop 1996), and how the island functioned as a trading port. Wild Cane Cay was a major Late Classic trading port located some 1.5 km east of the Paynes Creek salt works (McKillop 2005b). Systematic shovel testing indicated that the island inhabitants occupied an area of roughly 10 acres; however, the current dry land consists of approximately 3 acres (McKillop 1996, 2005b). Excavations of the mounds and the surrounding area illustrate that sea level rise has inundated much of the Late Classic deposits. The mound construction began in the Late Classic and extended into the Postclassic period. The mounds were constructed of layers of boulder coral as a base material and finger coral used as a leveling agent. A red clay floor was laid atop the finger coral and a perishable structure constructed on the surface. No structural remains were identified except thatch-impressed clay within the deposits (McKillop 1996, 2005b). Evidence of sandstone walls and tombs were encountered during excavations. The sandstone was imported from mainland sources and was used to face the exterior of the platforms simulating a mainland architectural aesthetic. Abundant trade goods tie the island to coastal-inland trade and the Late Classic deposits within the Paynes Creek salt works (McKillop 1996, 2005b).

Frenchman's Cay is an offshore trading port nearby. Shovel testing conducted in 1994 establishes that the settlement once covered a 300 x 100m area of the island (McKillop et al. 2004). My thesis research (Watson 1999) was designed to evaluate the architectural similarities of Spondylus Mound to the architecture of Wild Cane Cay. The South Coastal Archaeology of Belize project excavations in two other mounds indicated all three mounds are similar to the mound construction noted at Wild Cane Cay (McKillop et al. 2004). A three to four-course high sandstone wall was identified in situ surrounding three sides of the largest mound. Sandstone was noted on the surface ringing the base of Spondylus mound but excavation was not carried

out to determine if the wall was intact. Excavations at Green Vine Snake indicated similar coral rock foundations (McKillop 2005b).

The Paynes Creek salt works were discovered by survey in 1988 during a visit to Killer Bee, with underwater salt works discovered in 1991 and excavated in 1999 (McKillop 1995, 2002). More sites were found in 2003, with wooden architecture discovered in 2004 (McKillop 2005a). The sites were inundated by sea level rise during the Late Classic or early Postclassic, a process that helped preserve the remnants of posts from the structures in the mangrove peat of the lagoon floor (McKillop 2005a-c, 2006, 2008; McKillop et al. 2011). Extensive briquetage concentrations exist on the undisturbed surfaces. McKillop (2005a, 2008, 2009a) developed an innovated method for identifying these sites using flotation devices to conduct systematic surveys without disturbing the loose soil layer that rests on a firm peat layer. Pin flags were placed at the location of posts. Spatial analysis has helped to recreate the shape and size of buildings (Sills and McKillop 2010).

Survey and mapping have revealed the presence of 105 inundated sites (McKillop 2009 a&b; Sills 2007; Somers 2007) with evidence of wooden structures. Furthermore, ceramics associated with salt production are embedded and buried in the peat, and illustrate the larger scale salt production. Earthen mound at two sites are located in the eastern portion of the lagoon. These features are the only obvious human-constructed features on the landscape. The mounds' presence gives us an opportunity to assess their archaeological importance to the coastal landscape of the Punta Ycacos lagoon.

Hypotheses and Models Discussion

Excavation, detailed stratigraphic descriptions and comparison, artifact analysis, loss-on ignition, inductively coupled plasma-mass spectrometry (ICP-MS) of soil samples, and

ethnographic comparison will be utilized to understand the function of both mounds, interpret Maya trade models, scales of production, social organization, and coastal and interior site interaction. Research at Witz Naab' and Killer Bee was designed to test several hypotheses. The first hypothesis tested was to determine the function of the earthen mounds. The four possible functions for the mounds at the Paynes Creek National Park salt works include: (1) leaching mounds; (2) residential structures for the salt laborers; (3) administrative structures for the adjacent salt works; or (4) a combination of leaching by-product, residential, and administrative functions.

Leaching Mounds

If the mounds at Witz Naab' and Killer Bee are leached spoil piles of soil left over from concentrating salt in the brine, then we would expect to find leached soils, charcoal, artifacts associated with the fire evaporation method, and no evidence of domestic deposits. Pottery would be restricted to briquetage, thick walled jars, sockets, and spacers, and clay cylinder supports used in the fire evaporation of brine. McKillop (2002) has identified ceramics as Punta Ycacos Unslipped.

The Guzman mound is an example of such a mound in coastal Guatemala. The mound was excavated by C. Roger Nance (1992) as part of salvage project. The site is located within the boundaries of a modern salt operation. Guzman dated to the Late Preclassic, and the mound's matrix contained leached soils, charcoal, and daub. The charcoal was identified as part of linear trenches in the mound. Nance believed this to be evidence of fire evaporation to produce salt. The ceramics are thick wares that were consistent with ceramics noted at other salt production sites in the Yucatan (Andrews 1983). Cylinders associated with the fire evaporation method at southern Belizean sites were not found at Guzman. There are ethnographic examples from

Sacapulas (Renia and Monaghan 1981) of stones being used for vessel elevation. Nance believes that rim fragments could have served a similar purpose at Guzman.

MacKinnon and Kepecs (1989) reported mounds at salt making sites on the shores of Placencia lagoon. The mounds are described as low lying, amorphous in shape ranging from a meter to a meter and half in height. These mounds were interpreted as the remains of leached soils resulting from the fire evaporation method and the artifacts associated with production. Little domestic evidence was found within the mounds.

McKillop (2002:46-50) excavated a low-lying earthen mound at Killer Bee site within Paynes Creek National Park. The low mound is surrounded by a mix of broadleaf and mangrove forest. A shovel test was conducted 12m west of the mound in an area where artifacts were noted upon the surface. The shovel test was excavated in 20cm levels. The previous layers contained small fragments of ceramics. The water table was encountered at 40cm. Artifacts were noted on the surface of the mound. A 1x1 m unit was excavated to locate diagnostic ceramics, to determine the function of the mounds, and garner information concerning sea-level rise. Few diagnostic ceramics were recovered from the unit that was interpreted as a slag heap for brine enrichment.

Residential Platforms

If the earthen mounds at Paynes Creek are residential platforms, we would expect to find evidence of house floors distinct from the surrounding soils matrices and deposits associated with domestic activities, a variety of ceramic styles, obsidian, chert, hearths, and faunal/flora remains associated with subsistence.

The platform mound is a common architectural style in the Maya regions. Until recently, most excavations have focused on the temples or monumental architecture of the larger urban

Maya centers. The simplest form of Maya architecture is the platform or mound. Simple does not imply that some of these building endeavors were not labor intensive. Transportation of building material for large platforms would have been labor-intensive work. Such archaeologists as Abrams (1994) and Haviland (Haviland et al. 1985) have studied labor investment. Separate material was sometimes used as a floor for a perishable structure. At many sites, compressed clay or marl indicates living surfaces (Awe and Healy 1994; Freidel 1979; Haviland et al. 1985; Healy 1990; McKillop 1996). Successive construction layers develop over time as the perishable structure was torn down and a new construction layer was added.

The use of stone for platforms enhanced mound construction. Cut stone blocks faced or formed the outline of the structure. The remaining platform was made of a rubble and earthen fill. This stone platform would then support a perishable structure. The shape of the platform varied from oval to rectangular (Wauchope 1938). Platforms at such sites as Pacbitun (Healy 1990) and Lubaantun (Hammond 1975) supported perishable structures on stone platforms. The construction of the perishable structures that sat atop these platforms has remained unchanged for centuries. Wauchope's (1938) early ethnographic work on Maya house construction has supported this hypothesis. Maya houses were constructed using a pole and thatch construction technique.

Evidence of perishable structures has been recorded at several sites throughout the Maya area. Remnants of postholes have been noted at Tikal (Haviland et al. 1985), Cerros (Freidel 1979; Robertson and Freidel 1986), Cuello (Hammond et al. 1995), and San Juan (Guderjan 1988). Roofs were constructed of tightly interwoven, native palms. Roofs were supported by single or multiple wooden upright poles and wooden crossbeams or lintels. According to

Wauchope's (1938) observation; the Maya cooked outside their homes so chimneys and windows were not necessary.

Administrative\Ritual Structure

If the Paynes Creek earthen mounds had a ritual role in salt production, the material cultural should be similar to the ritual paraphnaelia at other Maya salt sites. Andrews (1983) states that the salt sites of San Mateo Ixtatán and Sacapulas in Guatemala are still considered sacred by the modern Maya, and Emal in the Yucatan contains a prehispanic temple platform, colonial and modern shrines, as well as large wooden crosses. Indigenous religion and Catholicism merge at some salt works. A Catholic church with a shrine to the Virgin del Rosario is located at the Salinas Atzam in Chiapas. Virgin del Rosario is the patron saint that protects the sacred salts used by the local communities (Andrew 1983). Salt is used to subvert the power of witches and for exorcisms (Redfield and Villa Rojas 1934).

Multi-Function Platform

Mound function may have changed over time. The mound could have started as a leached spoil pile and become more important toward the end of the Late Classic as population and salt production increased in southern Belize. If the use of the mound did change over time, the stratigraphic trench should expose not only the construction episodes, but the function differences as well. We would expect that the leached soils with little domestic refuse would be the deepest deposits. If the mound then became a domestic/scared space, excavations should reveal evidence of floors and structures.

Overview of Maya Trade Models

The presence of local and non-local goods at Maya households is well documented from the Preclassic through the Postclassic suggesting that the Maya participated in multiple

sophisticated trade network systems (Fowler et al. 1989; Freidel 1979; Graham 1987; Lucero 2002; McKillop 1989; McKillop 2005; Rathje 1971). How these networks were organized and controlled continues to be the focus of much debate among Maya archaeologists. The Classic Maya appear to have employed a variety of trade strategies to procure goods.

Economy as a term for prehistoric society goes beyond the twenty-first century understanding of markets, capitalism, and production. Economy includes an understanding how a society procured food, shelter, clothing and the other essentials for existence. This includes the social control of procurement or political economy. The Classic Maya were clearly a stratified society based on evidence of their material culture but how did the elite participate in trade networks?

Rarely does an individual leader hold sole power. Restrictive geography, economic autonomy, entrepreneurship, and weak government control (Lucero 2002; McAnany 1995; Rathje 1971) were all factors leading to a rise in minor elites during the Classic. Furthermore, by the Late Classic, a population increase in the southern lowlands had led to an expansion of minor Classic Maya centers. To maintain the urban centers new elite rulers were necessary. Many of these rulers had connections to larger centers through direct kinship or marriage. In southern Belize, this includes the sites of Lubaantun, Nim Li Punit, and Uxbenka.

McKillop (2009) discussed three models of trade for the Classic Maya useful for interpreting the interaction between the inland Maya and the coastal Maya. The models include the “household production model”, “tribute model”, and the “alliance model” (McKillop 2009). Household in this context is not the Western understanding of an immediate family. Wilk and Rathje (1982) defined households as groups of individuals bound by some notion of kinship and/or a shared identity. These groups cooperate in the production and reproduction necessary

for survival. Maya “households” were independent and self-sufficient. The household produced all that was needed for the community. This model does not preclude that households were not specialist such as the case at Colha (Shafer and Hester 1991). Nor does the model discount that elites themselves were craft specialist and producers [e.g. Aguateca: (Inomata 2001) and Inomata and Stiver (1998)]. The household model would require evidence of domestic settlements. The tribute model is similar to the organization of the Aztec and Inca civilizations. Military forces compel outlying communities to send tribute to a centralized elite controlled government. The alliance model is described as a system of powerful inland center elites that created trading and other alliances with coastal populations. These alliances were reinforced through ritual and feasting to procure goods.

Salt Specific Trade Models

Understanding how salt was traded is important to interpreting how the Paynes Creek salt works fit into the larger discussion of trade models. Four types of salt trade models have been proposed that would affect the southern Maya lowlands (Andrews 1983; McKillop 2002; MacKinnon and Kepecs 1989; Valdez and Mock 1991). Andrews (1983) engaged in a large-scale study of salt production to test a model purposed by Rathje (1971) that long distance salt trade was integral to complex social-political development of the Lowland Maya. Andrews utilized both archaeological and ethnographic evidence to support his hypothesis that the salt beds in the northern Yucatan were the main producer of salt for the Classic Maya. Solar evaporation was employed in the northern Yucatan. The salt beds of the northern Yucatan produce salt via the solar evaporation method and have been utilized by the pre-historic and current Maya. Management of these salt beds led to the rise of centers in the northern Yucatan.

Additional archaeological investigations of the northern Yucatan salt beds continue to illustrate the importance of salt to the Maya. The Isla Cerritos Archaeological Project investigated the relationship between the island port complex and Chichén Itzá's control of the salt trade in the northern Yucatan during the Itzá period (A.D. 700-1200). Long-distance trade items recovered support the notion that Isla Cerritos played an integral role in the coastal peninsula trade network (Andrews et al. 1988).

The coastal site of Canbalán may have been a port for the inland site of Chunchumil (Arden 2000). The salt works of Celestún were a basic component of the Chunchumil's economy. Trade goods that include Fine Orange and Fine Grey ceramics as well as obsidian from Mexico and Guatemala reinforce Canbalán's role in long-distance trade networks in the Terminal Classic period. Clearly, the salt works of the northern Yucatan were important sources of salt for the Maya and subsequently the Spaniards. Andrews (1983) argued that the pure white salt of the northern Yucatan would have been preferred by the elites of the southern Maya Lowlands and that trade benefited the local Maya centers that controlled the salt beds. After twenty plus years of research by other researchers, Andrews (Andrews and Mock 2002) acknowledged that his early model was too simplistic.

Other researchers have argued that salt was locally available to the Maya of the southern Lowlands. Salt can be obtained by burning palms or eating meat (Andrews 1983; Gann 1918; Marcus 1984; McKillop 1994a, 1996; Pohl 1976). Furthermore, inland salt springs at Salinas de los Nueve Cerros (Dillon 1977; Dillon et al. 1988) were utilized by the inland Maya and were certainly closer than the salt beds of the northern Yucatan. Marcus (1984, 1991) and Dillon (1977) state that the salt produced by burning palms or from salt springs was sufficient to supply

salt to the southern Maya Lowlands. This model supports the utilization of “local” resources so long distance trade was not necessary.

Was this enough salt to support the inland Maya? Andrews (1983) estimated that Maya would need between 8 to 10 grams per day based upon the tropical environment that they inhabited. A milpa farmer could require as much as 30 grams per day. These numbers are supported by Redfield and Villa Rojas’ (1934) ethnographic evidence. Gibson (1964:338) noted that during the Colonial period

Indians, whatever their location, seem to have regarded salt as a necessity, and they consumed it in prodigious quantities. Food rations in *desagüe* labor, reflecting native tastes, included three standard items, maize, chile, and salt, all others being described as extraordinary rations.

Given this evidence, Andrews (1983) suggested that 131.4 tons of salt would be required to support the population of Tikal. Furthermore, Andrews (1983) believed that only a small amount of salt can be obtained from eating meat.

Joyce Marcus (1984) argues that Andrew’s estimates of salt consumption were too high. Burning palms produces a minimal amount of salt and palms were utilized for building materials and foods sources (McKillop 1996) for the Maya. Large scale destruction of a valuable resource seems unlikely. Furthermore, the average Maya is not believed to have consumed large amounts of meat, but rather maintained a diet of corn and other plants. Producing salt from the salt springs would have required a large amount of fuel for the fire evaporation method to support the large population of the Classic Maya southern Lowlands. Mock (1994) has posited that fuel may have been limited due to large-scale forest clearing for agricultural proposes.

An alternate model to Andrews’ Yucatan centric model has been offered by Jefferson MacKinnon and Susan Kepecs (1989). The discovery of salt production sites in and around Placencia Lagoon revealed that salt production was taking place on the coast of Belize during the

Classic. The artifacts included spacers and sockets associated with the fire evaporation method. The investigators proposed that local salt consumption was sated with locally produced salt and that the elites would have had access to the more desirable salt from the Yucatan. This assumption is based upon the visual appearance of the salt. The salt from the Yucatan is a pure white variety. Fire evaporation technique produces salt that is tinted from the soil matrix through which the brine is leached to concentrate the salinity. This assumption is based on upon early western sensibilities. Ethnographic studies illustrate that the darker salts produced in the highlands of Guatemala were preferred by the local population (Andrews 1983; Renia and Monaghan 1981). In addition, modern salt sensibilities have changed: Grey-tinged Fleur de sel, pink salt from the Himalayas, or Kala Namak a purplish salt from India are expensive and in demand by modern consumers.

A fourth model was proposed based upon research from the New River Lagoon in northern Belize. Valdez and Mock (1981) proposed that fish were salted at coastal sites for trade to interior sites. Minimal evidence has been found at inland sites to support the idea that seafood was a significant part of the inland diet (Emery 1999; Graham 1991; McKillop 1984, 1985; Wing 1975, 1977). There is evidence of marine resources at Tikal (Rice 1978) and other mainland sites but the majority of faunal assemblages indicate that populations relied on local protein sources (Emery 1999; McKillop 1984, 1985; Pohl 1976). Archaeological evidence at inland sites indicates that white-tailed deer and peccary were consumed at interior sites (Emery 2004; White 1999). McKillop's (1984, 1985, 2005a, 2005b) work on the coast of southern Belize has revealed a reliance on seafood at offshore and coastal sites.

Almost thirty years have passed since Andrews published Maya Salt Production and Trade in which he argued that salt from the northern Yucatan provided salt for the southern

Maya lowlands. Much new evidence of salt production in Belize and Guatemala has led Andrews (Andrews and Mock 2002) to agree that salt production and trade was more complex than his original model. Andrews believes that the model holds true for the Postclassic period.

McKillop (2005a; 2009b) suggests another view of ancient Maya salt production and trade based upon the discovery of 105 salt works in Paynes Creek National Park, southern Belize. McKillop (2009b) states that the coastal Maya inhabitants of the offshore cays and mainland sites participated in larger trade networks independent of city/state control to provide the inland Maya centers with resources from the coast. In turn, the inland communities strengthen their connection to coastal communities through marriage and supplying ritual paraphernalia. This entrepreneurial system of coastal production salt production does not fit the household or tribute models. However, the large-scale production and lack of domestic deposits does support the alliance model.

Ancient Maya Strategies for Salt

Salt played an important role in the lives of the ancient Maya. Salt was utilized by both the Maya elite and commoners. At Calakmul, a temple was discovered covered with murals depicting the lives of the common Maya (Vargas, et al. 2009). A salt glyph was identified on the mural in association with a figure of man with a basket and spoon. Aj atz' aan is translated as "Salt Man". Since glyphs were used to denote importance aspects of Maya culture (i.e. royal lineages), the discovery of glyph for salt demonstrates the importance of the mineral to the lives of the ancient Maya.

Evidence of salt production has been identified on the coast of Guatemala as early as the Late Preclassic(Coe and Flannery 1967). Subsequent studies identified salt making sites in the

Yucatan (Eaton 1978) and the southern Maya lowlands (Dillon 1977) that also date to the Late Preclassic. The Maya's interest in salt began early in antiquity. Salt was still being produced for trade when the Spaniards arrived. Salt production increased after European contact when salt became an essential part of silver mining industry.

Solar Evaporation

Solar evaporation was exploited by the both the prehistoric and modern Maya. Utilizing sunlight to evaporate highly concentrated brine into salt that can be harvested is still employed in the northern Yucatan. Large salt beds are found along the northern and northwestern shore of the Yucatan. The Classic Maya exploited these natural salt works (Andrews 1983). Salt water from estuaries evaporates in shallow pans to concentrate the salt. The salt harvest begins in May when most of the water has evaporated. Salt is simply raked up with hoes and stored in piles on the lakeshore. Hester (1953) reports salt that was difficult to collect was gathered by hand or shell scrapers.

Williams (1999, 2004, and 2010) examined the solar evaporation salt making sites in the Lake Cuitzeo Basin, Michoacán, Mexico. Like Andrews, Williams used a combination of ethnographic information and archaeological investigations. Some early accounts from the 16th century indicate that the area used for salt production. The tool assemblages for modern salt production include hoes, shovels, pick axes, buckets and wheelbarrows. In the past, a fiber sack was used to carry the soil and locally produced ceramic vessels were used to carry the water. Each salt production site has a funnel shaped wooden structure to filter water through salty earth. The saline enriched brine then is concentrated in wooden containers such as old canoes. In the past, these structures, similar to canoe construction were made from trees (Williams 1999, 2004). The finished salt is harvested from the apparatus once solar evaporation has removed most of the

water. Williams (1999, 2004) discusses several indicators that may be visible in the archaeological record for their method of salt production. These include large mounds of leached soils containing broken ceramics, evaporation pans and canals for moving water from salt springs, wells, supports for canoas, and scraping tools. Modern salt funnel structures are mostly concrete.

Fire Evaporation

Evaporating salt water over fire to concentrate salinity is another method that was widely used by the ancient Maya. Juan de Estrada (Coe and Flannery 1967) described the fire evaporation method on the Pacific Coast of Guatemala in 1579. Canoas were filled with salty soils. Estuary water was filtered through the soil. Cane mats were placed inside the canoe beneath the soil to filter out soil particles. Brine was collected in vessels placed beneath the canoe. This brine was concentrated in pots over fires to produce salt.

Late Classic Maya salt production sites have been identified on the coast of Belize. Earlier assumptions (Andrews 1983) were that there were no local sources of salt for the Maya lowlands although Gann (1918) had reported salt production in Belize.

The salt making tool assemblage identified at Placencia Lagoon included sockets and spacers (MacKinnon and Kepecs 1989). Sockets are attached to either end of the cylinder to stabilize the pot on the ground and help suspend the pot. Spacers were used in between pots when multiple brine pots were utilized. Twenty-two mounds were identified during the Placencia Lagoon survey with a mixture of broken thick-walled vessels, cylinders, sockets, spacers and soil (MacKinnon and Kepecs 1989).

Numerous salt making sites were identified (McKillop 1995, 2002, 2005a) in Punta Ycacos Lagoon, Paynes Creek National Park, Belize. Initially, four sites were reported and

investigated (McKillop 1995, 2002). Artifacts were seen on the lagoon floor during the dry season when turbidity is absent or reduced. The artifact assemblages resembled those identified at Placencia Lagoon. The Paynes Creek sites were inundated except for the Killer Bee site. A low earthen mound, discovered at the Killer Bee site (McKillop 2002) was interpreted as a soil leach mound associated salt production. Subsequent surveys (McKillop 2008) identified 105 underwater locations with briquetage. Witz Naab' provides an opportunity to investigate and compare the leaching methods at two salt workshops.

Identified Maya Sites in Research Area

The major Late Classic Maya centers Lubaantun, Uxbenka, Nim li Punit, and Pusilha are located inland within the foothills of the Maya Mountains from the coastal settlements of Belize. Recent research (Braswell et al. 2004; 2008 and 2011; Braswell and Gibbs 2006; Prufer et al. 2008 and 2011) in southern Belize indicates complex interaction and identity among these four sites with shifting political alliances but where each center was ruled by an autonomous local aristocracy.

The site of Lubaantun is a Late Classic period (AD 600 - 900) Maya center. The site is 32 km inland on a high ridge close to the modern village of San Pedro Colombia, Belize. Lubaantun consists of eleven major structures and five plazas. The Maya at Lubaantun altered the ridge through a system of terraces that supported the structures. Large stone platforms were constructed without the use of mortar. Lubaantun-style figurine ocarinas have been found at salt production sites. T.A. Joyce (1933) discussed the mold made whistles and their styles and noted the remnants of blue slip. McKillop (personal communication 2011) noted a blue slip on an ocarina recovered at the Eleanor Betty site. The slip faded as the artifact was being filmed almost

immediately upon removal from the peat. The unit stamped pottery found within the deposits of the salt making sites includes decorations similar to those at Lubaantun (McKillop 2002).

Earthen Mounds

There are several earthen mounds in the coastal region that may be similar to the Paynes Creek salt works mounds – Arvin’s Landing, Tiger Mound, and Seven Hills Creek (McKillop 2002, 2005b). Excavations of the earthen mound at Arivn’s Landing, recorded a low lying cobble platform with no evident floors and appears to be a single construction episode (Steiner 1994). Shovel testing in the non-mound area indicated extensive “invisible” settlement (Somers and McKillop 2005).

How does the architecture of the mounds at the Paynes Creek salt works relate to other architecture in the area? As illustrated by the discussion above, for all the similarities that we recognize as Maya, each site will have independent characteristics. As we project our understanding of the past, archaeological excavations continually illustrate that we must re-evaluate our ideas of social complexity and identity. The excavation of the only remaining above ground architecture at the Paynes Creek salt works will add to our understanding of the lives of the coastal Maya of southern Belize.

The Paynes Creek Salt Works

The Paynes Creek salt works have architecture unlike other ancient Maya sites previously discussed. The sites were inundated by sea level rise during the Late Classic or early Postclassic, a process that helped preserve the remnants of posts from the structures in the mangrove peat of the lagoon floor (McKillop 2002, 2005a-c; 2006, 2008; McKillop et al. 2011). Extensive briquetage concentrations are identified on the surface as long as this soil layer is not disturbed. McKillop (2005a, 2008, 2009a) developed an innovated method for identifying these sites using

flotation devices to conducted systematic survey without disturbing the loose soil layer that rests atop a firm peat layer. Pin flags were placed at the location of posts. Spatial analysis has helped to recreate the shape and size of buildings (Sills and McKillop 2010).

Excavations have been carried out at several sites within the lagoon to determine the function and spatial layout of the sites. During the 2011 field season, I participated in transect excavations at the Eleanor Betty site. The excavations yielded abundant briquetage resulting from the fire evaporation method.

Overview of Fieldwork and Analysis

I conducted my dissertation fieldwork under my advisor's permit from the Belize Institute of Archaeology in the spring 2012. NSF funding "Ancient Maya Wooden Architecture and the Salt Industry" project, under the auspice of my advisor, provided student assistance, equipment and supplies, and the opportunity to participate in the field project. Mound A at Witz Naab' was selected for excavation. The tidal flats are dense with mangroves and we felt that we would have the least impact to the surround environment. Mound A was closer to the team's entry point from the lagoon. I established a 1x4 meter trench from the base to the top of the mound. I choose not to conduct excavations off the mound due to the inundated conditions. I excavated the units in 20 cm deep levels in order to reveal the stratigraphy. A screening station was set up on the mound. All material was dry screened, trowel/hand sorted or water screened. I labeled the units 0-1m starting at the base of the mound, with 3-4m at the top. Units 0-1m and 1-2m were excavated to a depth of 40cm. Unit 2-3m was excavated to a depth of 100cm. Unit 3-4m was excavated to a depth of 205cm. I collected soil and charcoal samples. Samples were exported under permit from the Belize Fisheries Department to LSU for further analyses.

The first 0-20 centimeters consisted of top sediments and roots. The palmetto palm has a dense root system and is difficult to excavate even with a sharp shovel. Minimal cultural material was recovered in this layer compared to the other levels. We did recover briquetage (Figure 2) that was mostly amorphous clay lumps (ACL). ACLs are the remnants of salt making ceramics that are unrecognizable by form. I recovered an occasional salt making cylinder.

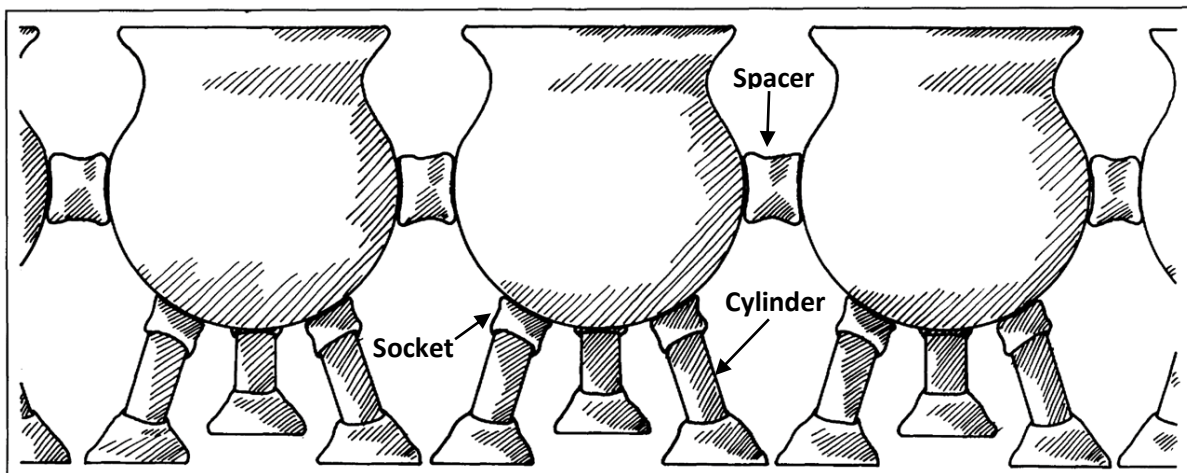


Figure 2: Salt Making Assemblage from McKillop 1995: Figure 10.

Levels 20-40cm and 40-60cm consisted primarily of ACLs and cylinder fragments. These levels are densely packed with discarded briquetage. Little or no charcoal was noted within these units. Below 60 cm, several distinct lenses of charcoal and clay are apparent within the wall profile. The clay is difficult to excavate. These layers were hand sorted by placing the material in the screen. We continued to recover ACLs, with the addition of a few recognizable vessel sherds. We encountered the water table at approximately 128cm depth. Alternating charcoal and clay layers continue to a depth of 185 cm. Below 185 cm, the levels are almost exclusively charcoal. Shovel testing deeper revealed a hard cemented lens of grey clay about 205 cm depth. We had anticipated finding the mangrove peat that surrounds the mound.

Visible lenses of charcoal on the eastern wall of the trench suggest that there were two separate earthen mounds. At some point in the Late Classic period when salt production reached its peak at the Paynes Creek Salt Works, the discard of briquetage and leaching sediment intensified, resulting in a single large mound. The wall profiles were cleaned, photographed, videotaped, and drawn. We collected a sediment column sample from the top to the base of the mound from the eastern wall of the trench. We also collected a set of 99 samples for magnetic susceptibility testing from the same wall, as well as samples of charcoal and other distinctive lenses.

The second mound site we excavated is the Killer Bee site. Killer Bee site is a low-lying earthen mound situated on the northern channel of Punta Ycacos Lagoon. The site consists of briquetage on the surface in a black mangrove tidal flat as well as an earthen mound. Excavations in the tidal flat from previous fieldwork reported in McKillop's Salt book indicated a Late Classic age of the site, with abundant briquetage. Previous excavations in the earthen mound suggested it was a slag heap from leaching water through salty soil to enrich the salt content before the fire evaporation process.

After a hike through the mangroves and finding an area that was not completely covered with ping wing, a prickly native pineapple, we set up a 1x3 m trench. Units were excavated in 20 cm levels. The Killer Bee mound is lower than the mound at Witz Naab' and we encountered the water table at 50 cm. All the sediment was hand sorted for artifacts. Like Witz Naab', the mound consisted of sediment mixed with briquetage. Although the artifacts were eroded at the Killer Bee site, there was still a larger amount of recognizable forms of the salt making assemblage including vessel supports, spacers, sockets, and vessels. Unlike Witz Naab', no layers of charcoal were noted in the mound.

Ceramic Analysis

We analyzed all the ceramics collected during the 2012 and 2013 field season. The volume of ceramics was determined for each unit and level. All rims and select other recognizable forms were retained for future analysis. Upon visual inspection, I noted that the ceramics recovered from Killer Bee were more eroded than those found at Witz Naab'. The volume of discarded ceramics is larger at both sites within the top two levels of excavation. Within Killer Bee, the volume of recovered material is twice in Unit 1 Level 0-20 cm than that of the other two levels. Ceramic volumes at Witz Naab' indicate a similar pattern. There is a substantial increase of ceramic volume within the 20-40 cm level within all units. This pattern could indicate an increase in the volume of salt produce at both sites during the time-period associated with these deposits.

Loss-on ignition

Loss-on Ignition testing is complete on six soil samples from Killer Bee and fourteen soils samples from Witz Naab'. I gathered these samples from the exported soil column samples in LSU coastal geomorphology lab. I determined the organic content of selected samples following the procedure used previously (McKillop et al. 2010a). Loss-on Ignition can illustrate buried horizons that are difficult to detect. Soils are weighed and then fired at high temperature to burn off the organic contents. Then the sample is weighed again. The percentage of organic content within a sample is used to interpret the presence of buried highly organic deposits. A leaching mound should not contain large amounts of organic material unlike a mound platform with house floors. Food preparation and discard would increase the organic content within domestic deposits. Furthermore, if these soils were selected for the increased salt content, they would not be suitable for agricultural purposes.

Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS) Analysis of Soils

I was awarded a Sigma Xi Grants-in-Aid of Research Award during the March 2014 grant cycle to conduct chemical analysis of soil samples. We hypothesize that inductively coupled plasma- mass spectroscopy (ICP-MS) will produce elemental signatures demonstrating whether or not there is evidence of residential habitation. Cation exchange is the process through which anions (negative ions) of soils attract the cations (positive ions). Cations associated with human activity include carbon, nitrogen, sodium, phosphorus, and calcium. This process makes these compounds stable and resistant to migration through the soil column. According to Holiday and Gartner (2007), common chemical elements affected by human activity include carbon, nitrogen, sodium, phosphorus, and calcium. Phosphate is the least likely to be affected by natural processes. Previous research by Wells (2004) and others (Wells et al. 2007; Wells and Terry 2007) established particular chemical elements were associated with human activity at archaeological sites (sodium, phosphorus, barium, magnesium, and calcium). Dr. Christian Wells at the University of South Florida Laboratory for Archaeological Soils Research will test the samples utilizing ICP-MS to produce a chemical profile of the elements in each soil sample.

Detailed soil analysis of Killer Bee and Witz Naab' will develop a base line of data to compare to ongoing research at the surrounding inundated sites. Furthermore, the use and function of these mounds could add to our overall understanding of the interaction between the coastal Maya and the inland Maya centers of the Late Classic.

Through analysis of materials and chemical testing, I will discuss models of trade, social complexity, and periodicity of resource exploitation. Furthermore, by comparing excavation results to ethnographic data from historic and modern salt works I will contribute the growing literature on salt production and further the understanding of the coastal Maya populations of

southern Belize. As more research is conducted along the coast, Maya archaeologists have begun to understand that the social organization and complexity of the coastal people is vastly different from those of the inland dwellers.

Conclusions

A few salt making mounds have been studied archaeologically. The excavations at Witz Naab' and Killer Bee are important to understanding the practice and development of salt production. Furthermore, understanding the construction of these features add to our interpretation and understanding of economic organization during the Late Classic. The excavated data, when used in conjunction with ethnographic information, helps us understand the subtle complexity of salt production.

The excavations revealed that the mounds are not the remains of domestic structures where the salt workers lived. The earthen mounds at Witz Naab' and Killer Bee are the result of brine enrichment for salt production. Artifacts associated with salt production were the only material recovered at both sites. The lack of variation in the artifact assemblage demonstrates that these mounds were not used for domestic occupation.

For comparison, domestic structures at nearby Wild Cane and Frenchman's Cay contained a variety of artifacts including different types of ceramic styles and forms, obsidian, chert, manos and other mainland stone artifacts. Multiple construction episodes have been noted at nearby Wild Cane Cay and Frenchman's as evidenced by multiple floors identified within the architecture. Burials were encountered below the floors at Wild Cane Cay. The mounds at Wild Cane and Frenchman's Cay are similar to other Maya domestic mounds except for the building material. The mounds on the cays were constructed with coral rather local stone.

There is no evidence that the mounds at the Paynes Creek salt works served as administrative structures. Although artifact evidence, such as Warrie Red unit-stamped jars, Moho Red bowls, and ocarinas, suggest a connection with the inland classic Maya centers there is no evidence that the salt works were controlled, or managed by these centers. Unit-stamped jars has been recorded at other sites including but not limited to Altar de Sacrificios (Adams 1971), Seibal (Sabloff 1975), Tikal (Culbert 1993), Las Cuevas (Kosakowsky et al. 2013), and Lubaantun (Hammond 1975). There are stylistic variations among the sites. Hammond (1975:305) proposed that the Pasion region of Seibal and Altar de Sacrificios and the Belize Valley to Lubaantun were two areas associated with production and distribution of unit-stamped vessels. These wares and whistles would have been used during ceremonies performed before the salt production began, reinforcing the connection between producer and consumer. The spatial distribution of the workshops implies that the coastal Maya of the region were producing amounts of salt beyond the need of a household level. The expansion of the population during the Classic period presented an opportunity to the coastal Maya to participate in an entrepreneurial system of salt production.

The specialty function of the mounds at Witz Naab' and Killer Bee support the idea that coastal Maya participated in alliance trade with the interior Maya. The spatial patterning of the salt workshops do not indicate a formalized design but rather appear to follow the now submerged shoreline (McKillop et al. 2010). The alliance between the coastal and inland Maya was based upon the desire for access to goods. The island sites of Wild Cane Cay and Frenchman's Cay were occupied from the Classic through the Postclassic and have coral platform mounds that mimic mainland style architecture. The elites on the coastal sites would

have wanted access to the goods provided by the interior Maya and conversely the interior Maya would have desired the access to salt and other ritual coastal paraphernalia (McKillop 2009).

Descriptions of excavations at Guzman Mound, Guatemala, and Wits Cah Ak'al, Belize were used for comparison to interpret the mounds at Witz Naab' and Killer Bee. The mounds at Cah Ak'al, Witz Naab', and Killer Bee have some commonalities. Briquetage was recovered at all three sites. In-situ hearths were noted at Cah Ak'al. However, some of the mounds at Cah Ak'al were not associated with salt production.

The leaching mound at the salvage excavation site of Guzman was different from either of the mounds at the Paynes Creek salt works. In situ hearths were identified at Guzman. The artifact assemblage lacked the clay cylinders identified at Witz Naab' and Wits Cah Ak'al. This difference could be due to the fact the Guzman is associated with Preclassic Period and the salt assemblage at Witz Naab', Killer Bee, and Wits Cah Ak'al are identified as Late Classic Period deposits exemplifying temporal differences in salt-making assemblages.

The loss-on ignition indicates that there was little organic material within the mound at Witz Naab' and Killer Bee. The presence of food refuse would have a higher organic content. No midden deposits were identified at Witz Naab' or Killer Bee.

The mounds at Witz Naab' are approximately 1.5m in height and .5m high at Killer Bee. This could indicate a change in the scale of production that occurred within the Paynes Creek National Park salt sites. The stratigraphy at Witz Naab' is interpreted as evidence of periodicity and shifts in the scale of production. We do not have the evidence to discuss seasonality, but we can discuss the potential with the evidence of periodic construction at Witz Naab'. Multiple construction episodes were noted at Witz Naab'. Specifically the three lower construction episodes indicate multiple depositional events. The charcoal layers indicate multiple burning

events. multiple evaporation episodes are supported by the presence of charcoal layers are interspersed by layers of leached soil and briquetage. The uppermost layer at Witz Nabb is the result of a massive shift in production to meet increased consumer demand as the population expanded in the southern Maya lowlands. Refuse appears to be quickly collected and dumped to make way for the next evaporation session.

The excavation in combination with chemical analysis at Witz Naab' and Killer adds to the evidence that the Paynes Creek Salt Works were workshops for specialized production. The wooden posts at the inundated workshop locations are the remains of buildings for salt production. This explains the lack of hearths in the Witz Naab' mound. Rainfall in southern Belize would have made outdoor evaporation risky. The evaporation process would have occurred indoors to protect the commodity. The excavated inundated buildings indicate that the workshops were kept clean and large amounts of charcoal and briquetage have been recovered outside of the structures. We believe this to be the remnants of mounds similar to those at Witz Naab' and Killer Bee.

The chemical analysis produced low phosphorus levels. Low phosphorus levels are further evidence that the mounds are not domestic in nature. Elevated levels sodium and magnesium, low levels of phosphorus, and the charcoal layers indicated these are the remnants of hearths utilized in the evaporation of brine in pots over fires to make salt. Hearths utilized for food production have elevated levels of potassium, magnesium, and phosphorus. Elevated levels of sodium, potassium, magnesium, and phosphorus are associated with wood ash. In addition, we did not observe fired surface within the mounds that would be associated with a hearth.

Soil chemistry evidence from Witz Naab' and Killer Bee confirm their use as brine enrichment and salt production discard. Patterns noted at Witz Naab' and Killer will be used as a

model for the 105 underwater salt works nearby. Mounds would have been common features of the landscape prior to sea level rise.

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CHAPTER 2: BRINE ENRICHING SLAG HEAPS OR MOUNDED REMAINS OF SALT MAKERS HOMES? EARTHEN MOUNDS IN THE MANGROVES AT THE PAYNES CREEK SALT WORKS

Introduction

Ongoing research within Paynes Creek National Park of the ancient Maya submerged salt works continues to reveal intriguing information concerning the ancient Classic Maya economy. Salt, a basic biological necessity in limited supply at inland Maya cities, was produced along the coast of Belize by evaporating brine by heating over fires (Graham 1994; MacKinnon & Kepecs 1989; Andrews & Mock 2004; McKillop 2002). Survey and excavation at inundated salt works in a shallow lagoon in Paynes Creek Nation Park, southern Belize, provide extensive evidence of this technique in the form of briquetage, the remains of pots used in the fire evaporation process (McKillop 1995, 2002, 2005a-c, 2008; McKillop et al. 2010 a-b, 2011; Sills 2007; Sills and McKillop 2010; Somers 2007). However, until this field season, the focus of excavation has been the submerged archaeological sites. As part of the larger project and the focus of the senior author's dissertation research, we excavated two earthen mounds located within Paynes Creek National Park (Figure 1) to understand their relationship to the surrounding salt works. In this paper, we report the findings of the 2012 field season. The field work was carried out under permit from the Belize Institute of Archaeology and the participation of undergraduate and graduate field team members from Louisiana State University.

Leaching Mounds for Concentrating Brine

Several hypotheses were developed with test implications in advance of the field excavations.

The mounds could be leached spoil piles of soil left over from concentrating salt in the brine.

The Guzman mound is an example of such a mound in coastal Guatemala.

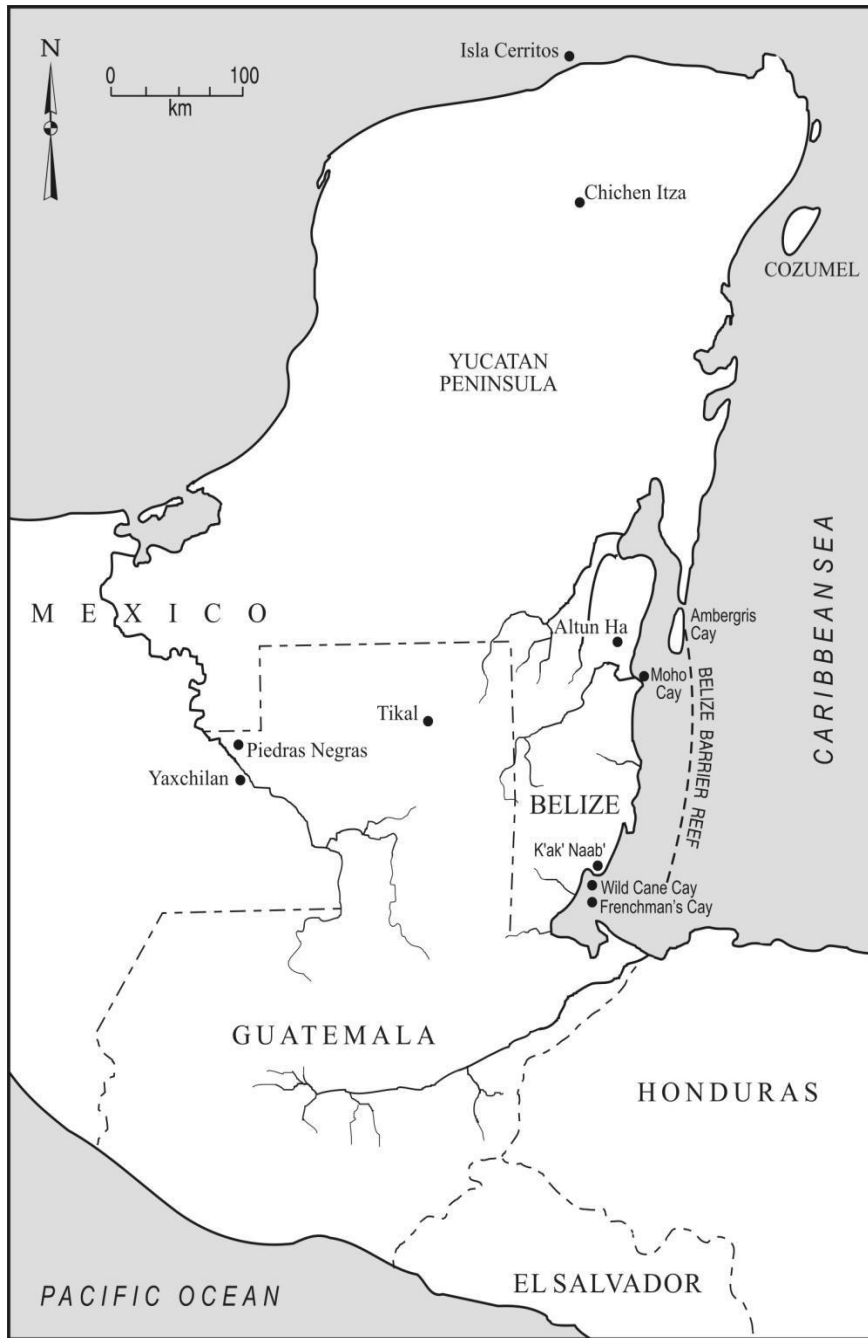


Figure 1: Location of Paynes Creek National Park, Toledo District, Belize courtesy McKillop 2005: Figure1.

The mound was excavated by C. Roger Nance (1992) as part of salvage project. The site is located within the boundaries of a modern salt operation dates to the Late Preclassic. The mound's matrix contained leached soils, charcoal, and daub. The charcoal was identified as part

of linear trenches in the mound. Nance believed this to be evidence of boiling brine to produce salt. The ceramics were thick wares that were consistent with ceramics noted at other salt production sites in the Yucatan (Andrews 1983) and coastal Belize (Graham 1994; MacKinnon and Kepecs 1989; Mock 1994; McKillop 2002).

However, cylinders associated with the brine boiling method at southern Belizean sites were not found at Guzman. There are ethnographic examples from Sacapulas (Reina and Monaghan 1981) of stones being used for vessel elevation; Nance believes that rim fragments could have served a similar purpose at Guzman. In that case, we would expect to find leached soils, charcoal, artifacts associated with the brine boiling method, and very little evidence of domestic deposits. Pottery would be restricted to briquetage, thick walled jars, sockets and spacers, and solid clay cylinder supports used in the fire evaporation of brine method. McKillop (2002) has identified ceramics as Punta Ycacos Unslipped.

MacKinnon and Kepecs (1989) reported mounds at all the salt making sites in the Placencia lagoon area. The mounds are described as low-lying amorphous in shape ranging from a meter to a meter and half in height. These mounds consist of the leached soils resulting from the boiling brine method and artifacts associated with production. Little domestic evidence was found within the mounds. MacKinnon and Kepecs believe that these mounds were used for seasonal salt production.

McKillop (2002) excavated a low-lying earthen mound at Killer Bee site (Figure 2) within the Punta Ycacos Lagoon. The low mound is situated on the northern channel of the Punta Ycacos Lagoon and is surrounded by a mix of broadleaf and mangrove forest. A shovel test was conducted 12m west of the mound in an area where artifacts were noted upon the surface. The shovel test was excavated in 20cm levels. The previous layers contained small fragments of

ceramics. The water table was encountered at 40cm. Artifacts were noted on the surface of the mound. A 1x1 m unit was excavated to locate diagnostic ceramics, to determine the function of the mounds, and garner information concerning sea-level rise. Few diagnostic ceramics were recovered from the unit.



Figure 2: Clearing low-lying mound at Killer Bee site. Photo by H. McKillop.

Murata's (2011) recent work at Wits Cah Ak'al has added to the growing volume of research into Maya salt production. Wits Cah Ak'al is located 12 miles outside of Belize City and is situated on the coastal plain. The site consists of 28 mounds, clustered in groups of 2 or 3 mounds, along the edge of a mangrove swamp system associated with Straight Lagoon. Murata identified ceramic assemblages or briquetage commonly associated with salt production both on the surface and within the mounds of Cah Ak'al. Furthermore, no domestic artifact assemblages were identified at the site. Cah Ak'al's environmental setting and artifact assemblage, allows us to make a comparison with the low earthen mounds at Witz Naab and the Killer Bee site.

Residential Platforms

The earthen mounds at Paynes Creek may have been residential platforms. In that case, we would expect to find evidence of house floors distinct from the surrounding soils matrices and deposits associated with domestic activities, a variety of ceramic styles, obsidian, chert, hearths, and faunal/flora remains associated with subsistence.

The platform mound is a common architectural style in the Maya regions. Early research focused on the temples or monumental architecture of the larger urban Maya centers and overlooked the lower lying platform mounds. However, simplest does not imply that some of these endeavors were not labor intensive. Labor investment has been studied by such archaeologists as Abrams (1994) and Haviland (Haviland et al. 1985). Separate material was sometimes used as a floor for a perishable structure. Compressed clay or marl has been identified as living surfaces at many sites (Awe and Healy 1994; Freidel 1979; Haviland et al. 1985; Healy 1990; McKillop 1996). Successive construction layers developed over time as the perishable structure was torn down, and a new construction layer was added.

Evidence of perishable structures has been recorded at several sites throughout the Maya area. Remnants of postholes have been noted at Tikal (Haviland et al. 1985), Cerros (Freidel 1979; Robertson and Freidel 1986), Cuello (Hammond et al. 1995), and San Juan (Guderjan 1988). Roofs were constructed of tightly interwoven, native palms. Roofs were supported by single or multiple wooden upright poles and wooden crossbeams or lintels. According to Wauchope's (1938) observations, the Maya cooked outside their homes, so chimneys and windows were not necessary.

Administrative Structure

The Paynes Creek earthen mounds may have had a ritual role in salt production. Andrews (1983) states that San Mateo Ixtatán and Sacapulas in Guatemala are still considered sacred by the modern Maya. Emal in the Yucatan contains a prehispanic temple platform, colonial and modern shrines, as well as large wooden crosses. Indigenous religion and Catholicism have been combined at some salinas. A Catholic church with a shrine to the Virgin del Rosario is located at the Salinas Atzam in Chiapas. Virgin del Rosario is the patron saint that protects the sacred salts used by the local communities (Andrew 1983). Salt is used to subvert the power of witches and for exorcisms (Redfield and Villa Rojas 1934).

The presence of a manos and metates cache could indicate a ritual or household function of the mounds. There are four sets of mano and metates made from material to represent different colors. Four is a significant number in Maya cosmology and color and direction were associated with four deities: east-red, north-white, west-black, and south-yellow (Thompson 1934). Tedlock (1996:220) noted in his translation of the Popol Vuh that four divisions referred to the gods that measured the surface of the Earth. This is believed to be associated with a corn field being laid out for cultivation. Furthermore, the Maya cosmogram is represented by four roads radiating from the center, and colors are associated with the sun's daily cycle (Bassie-Sweet 2008).

Multi-Function Platform

Mound function may have changed over time. The mound may have started as a leached spoil pile and become more important toward the end of the Late Classic as population and salt production increased in southern Belize. If the use of the mound did change over time, the stratigraphic trench should expose not only the construction episodes, but the function

differences as well. We would expect that the leached soils with little domestic refuse would be the deepest deposits. If the mound then became a domestic/scared space, excavations should reveal evidence of floors and structures.

Witz Naab Excavation

Excavations were carried out at two sites during the 2012 field season, Witz Naab and the Killer Bee site, both located near salt works in Paynes Creek National Park. Witz Naab (Figure 3) is located in the western portion of the lagoon system and consists of two earthen mounds that are covered with palmetto palms. The mounds are surrounded by black mangrove tidal flats with abundant briquetage. The both mounds are impacted by tidal changes. A surface inspection prior to excavations revealed that briquetage and charcoal is eroding from the mound. During low tide, the surrounding mangrove tidal flats were dry. High tide fluctuations inundated the surrounding tidal flats surface with anywhere from an inch to five inches of water. These daily tidal fluctuations are hastening the erosion of Witz Naab (Figure 4).



Figure 3: Mounds A & B, Witz Naab, Paynes Creek National Park, Belize. Photo by H. McKillop.



Figure 4: Witz Naab – briquetage and charcoal eroding from the mound. Photo by H. McKillop.

We selected Mound A for excavation. The tidal flats are dense with mangroves and we felt that we would have the least impact to the area if we selected Mound A. This mound was closer to our teams enter point from the lagoon. We laid out a 1x4 meter trench (Figure 5) from the base to the top of the mound. We choose not to conduct excavations off the mound due to the inundated conditions. Units were excavated in 20 cm levels to discover the stratigraphy. A screening station was set up on the mound. All material was dry screened, trowel/hand sorted or water screened. The units were labeled 0-1m starting at the base of the mound, with 3-4m at the top. Units 0-1m and 1-2m were excavated to a depth of 40cm. Unit 2-3m was excavated to a depth of 100cm. Unit 3-4m was excavated to a depth of 205cm. For this paper, we will focus on discussion of units 2-3m and 3-4m, which revealed a complex stratigraphy.



Figure 5: View of Trench 1, Witz Naab facing south.

The first 0-20 centimeters consisted of top sediments and roots. The palmetto palm has a dense root system and is difficult to excavate even with a sharp shovel. Little cultural material was recovered in this layer compared to the other levels. However, we did recover briquetage that was mostly amorphous clay lumps (ACL) which are the remnants of salt making ceramics that are unrecognizable by form. We did recover the occasional salt making cylinder.

Levels 20-40cm and 40-60cm consisted primarily of ACLs and cylinder fragments. These levels were densely packed with discarded briquetage. Little or no charcoal was noted within these units. Below 60 cm there are several distinct lenses of charcoal and clay that are apparent within the wall profile. The clay is difficult to excavate. These layers were hand sorted by placing the material in the screen. We continued to recover ACLs, with the addition of a few recognizable vessel sherds. We encountered the water table at approximately 128cm depth. Alternating charcoal and clay layers continue to a depth of 185cm. Below 185cm, the levels are almost exclusively charcoal. Shovel testing deeper revealed a hard cemented lens of grey clay about 205cm depth. We had anticipated finding the mangrove peat that surrounds the mound.

Visible lenses of charcoal on the eastern wall of the trench suggest that there were two separate earthen mounds. At some point in the Late Classic period when salt production reached its peak at the Paynes Creek Salt Works, the discard of briquetage and leaching sediment intensified, resulting in a single large mound. The wall profiles were cleaned, photographed, videotaped, and drawn. We collected a sediment column sample from the top to the base of the mound from the eastern wall of the trench. We also collected a set of 99 samples for magnetic susceptibility testing (Figure 6) from the same wall, as well as samples of charcoal and other distinctive lenses. The analyses of the marine sediment will be part of the senior author's dissertation research at LSU.

Killer Bee Excavation

The second mound site we excavated this season is the Killer Bee site. Killer Bee site is a low lying earthen mound situated on the northern channel of Punta Ycacos Lagoon. The site consists of briquetage on the surface in a black mangrove tidal flat as well as an earthen mound.

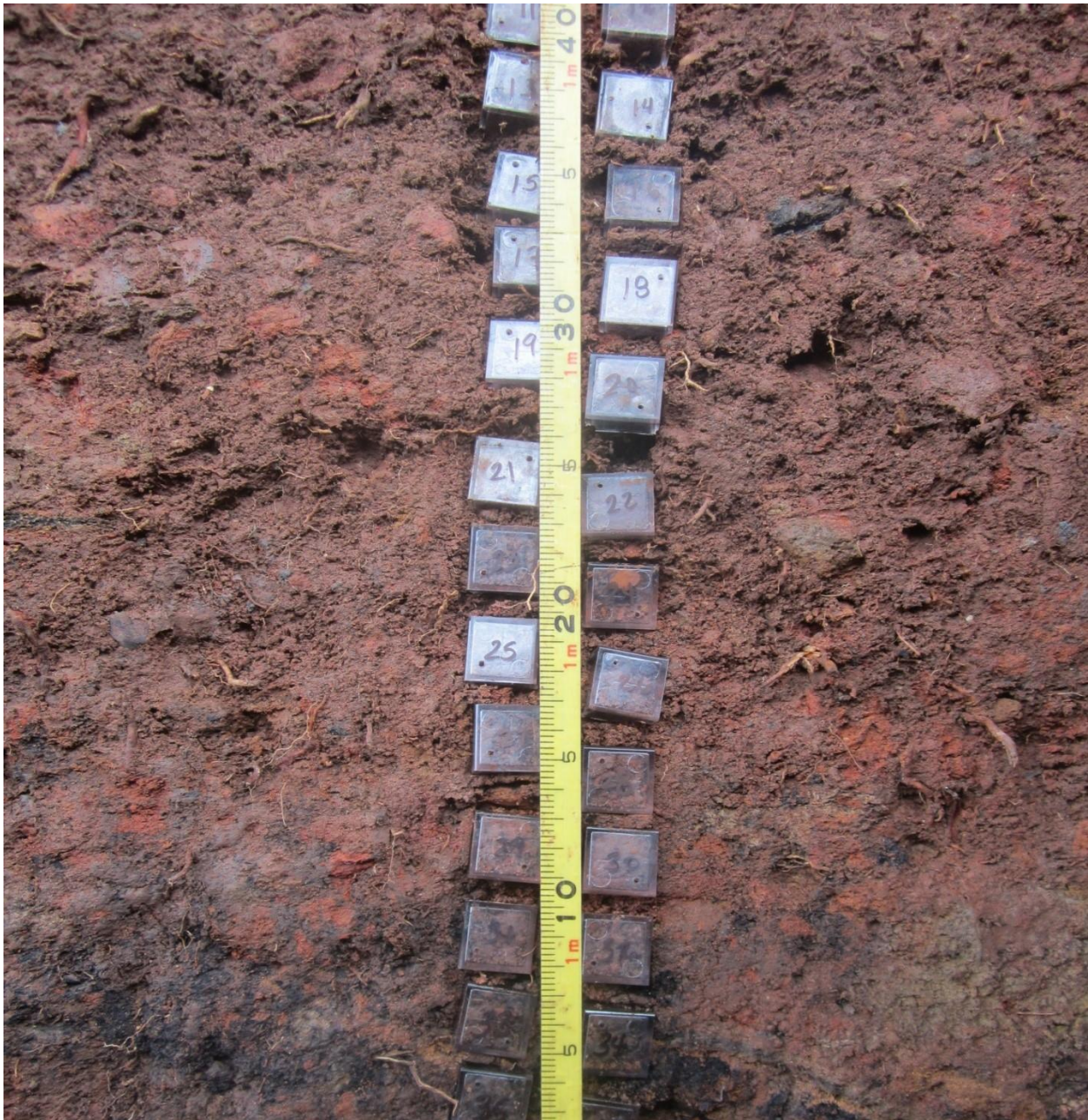


Figure 6: Sediment collection for magnetic susceptibility. Photo by H. McKillop.

Excavations in the tidal flat from previous fieldwork reported in McKillop’s Salt book indicated a Late Classic age of the site, with abundant briquetage. Previous excavations in the earthen mound suggested it was a slag heap from leaching water through salty soil to enrich the salt content before the boiling process.

After a hike through the mangroves and finding an area that was not completely covered with ping wing, a prickly native pineapple, we set up a 1x3 m trench. Units were excavated in 20 cm levels. The Killer Bee mound (Figure 7) is lower than the mound at Witz Naab and we encountered the water table at 50 cm. All the sediment was hand sorted for artifacts. Like Witz Naab, the mound consisted of sediment mixed with briquetage. Although the artifacts were eroded at the Killer Bee site, there was still a larger amount of recognizable forms of the salt making assemblage including vessel supports, spacers, sockets, and vessels. Unlike Witz Naab, no substantial amounts of clay or charcoal were found at the site.



Figure 7: Test unit at Killer Bee site. Photo by H. McKillop.

Conclusions

Excavations at Witz Naab and Killer Bee indicate that the earthen mounds are not the remains of domestic structures where the salt workers lived. The excavations at Witz Naab revealed only artifacts associated with salt production and not the type of household assemblage

that is typically associated with domestic occupation. Excavations within the mound at Killer Bee revealed a similar artifact assemblage as that of Witz Naab. The lack of variety among the artifact assemblage strengthens the evidence that these mounds were not used for domestic occupation.

Furthermore, the mounds are not similar to other domestic mounds within the area, such as the coral foundations of pole and thatch buildings at nearby Wild Cane Cay and Frenchman's Cay. No floors were encountered during excavation to indicate that there was once a living surface at either site. No evidence of multiple reconstruction episodes was identified either. Multiple construction episodes have been noted at nearby Wild Cane Cay and Frenchman's Cay. Multiple floors were identified within the architecture of the mounds at Wild Cane Cay.

No evidence of any ritual or administrative function could be discerned through excavation. No artifacts associated with ritual practices have been recovered at either Witz Naab or the Killer Bee site. Figuring whistles and fine ware ceramics have been recovered at other salt production sites within Paynes Creek National Park.

The strongest case can be made that the earthen mounds at Witz Naab and Killer Bee are in fact slag heaps that were produced as a result of brine enrichment for salt production. Any brine- enriching mounds beside the majority of the Paynes Creek salt works would have been washed away by water since all other salt works are underwater in the lagoon system. The mounds within Paynes Creek National Park share some characteristics with some of the mounds described at Cah Ak'al. The presence of briquetage at Cah Ak'al indicates some level of salt production. However, not all the mounds at Cah Ak'al are associated with salt production. Furthermore, Murata (2011) description of various other ceramic, artifact, and faunal assemblage have not been noted at other salt sites and indicate that Cah Ak'al has a complex history.

Although the mounds served a similar function at both sites, there are some differences between the two sites. The mounds at Witz Naab are substantially taller than the mound at Killer Bee. The mounds at Witz Naab are approximately 1.5m in height. The single mound at Killer Bee is a little over .5m high. This difference in size may have implications for the scale of production that occurred within the Paynes Creek National Park salt sites.

Soil and charcoal samples for Witz Naab and Killer Bee will be submitted for standard C-14 and Accelerated Mass Spectrometry (AMS) dating to establish the chronology of the site. Are these sites contemporaneous? If so, why are there differences in the size and internal structure of the mounds at the two sites? As previously stated, the artifacts at Killer Bee appear eroded more than the assemblage at Witz Naab. However, the vessel form and function was still recognizable in most of the assemblage at Killer Bee. The majority of the assemblage at Mound A, Witz Naab is what we have identified as ACL. Is the mound at Killer Bee older than Mound A, Witz Naab? If the mounds are not contemporaneous, then interpretations concerning the scale of production through time can be made for the salt production sites within the Paynes Creek National Park.

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CHAPTER 3: A FILTERED PAST: INTERPRETING THE TECHNOLOGY OF ANCIENT MAYA SALT PRODUCTION AND TRADE FROM TWO REMNANT BRINE ENRICHMENT MOUNDS AT THE PAYNES CREEK SALT WORKS, BELIZE.

Introduction

Earthen mounds at Witz Naab and Killer Bee are the only remaining above-ground evidence of an ancient Maya salt industry in Punta Ycacos Lagoon, a large salt-water system in Paynes Creek National Park, Belize. The Classic period (A.D. 300-900) salt works were submerged by a sea-level rise that occurred after the Late Classic (A.D. 700-900; McKillop 2002, 2005). The salt works are associated with large-scale workshop production using the technique of evaporating brine in pots over fires, resulting in briquetage – the broken salt-making pottery. Wooden structures were used for production and storage of salt (McKillop 1995, 2002, 2005a, 2005c, 2008; Sills and McKillop 2010; Somers 2007). The buildings were preserved in the anaerobic red mangrove (*Rhizophora mangle*) peat below the sea floor. The southern Maya lowland has too much precipitation to produce significant amounts of salt via solar evaporation. The coastal Maya of Belize utilized an alternative method, boiling enriched brine, to meet the demand for salt. The wooden buildings at the Paynes Creek salt works would have allowed for salt production to be protected from the rain similar to the process Reina and Monaghan (1981) observed at an inland salt spring at Sacapulas, Guatemala.

Excavations of one of the Paynes Creek mound at Witz Naab in 2012 revealed that the mound was the remnants of the brine enrichment process to produce salt (Watson *et al.* 2012). The mound fill consisted of briquetage, charcoal, and soil. This type of brine enrichment has been documented at other salt-making sites both archaeologically and ethnographically (Reihm 1961; Charlton 1969; Williams 2002; Valdez et al. 1996; Santley 2004). Noticeably absent is the domestic artifact assemblage commonly associated with households elsewhere on the southern

Belize coast (McKillop 1995; 2002; 2005c). Furthermore, no evidence of food production and consumption expected with settlements such as serving dishes and faunal/flora remains was recovered. However, the complex stratigraphy of the mound indicated that discard leached soil from the brine enrichment was not the only activity.

The mound at Killer Bee is the remnants of brine enrichment as evidenced by excavation. McKillop's (2002:49) previous excavations established the presence of salt-making artifacts and suggested the earthen mound was a remnant of the brine enrichment process before evaporating it in pots over fires. To understand the stratigraphy and how this mound's internal structure compared to the Witz Naab, additional excavations were conducted in 2012. Interpretations of the data from the excavations indicated that Witz Nabb and Killer Bee were not permanently occupied. Rather, the sites are part of large specialized salt-production workshop that increased the volume of production over time to meet the growing demand for salt due to population expansion.

The southern Maya lowlands underwent a population expansion in the Classic period (A.D. 250 – 900). New dynastic city centers were founded at inland locations in southern Belize. Uxbenka transitioned from a hamlet to a small urban center during the Early Classic (A.D. 250 – 500) (Prufer et al. 2008, 2011). Other dynastic centers include Lubaantun (Braswell et al. 2004; Hammond 1975), Pulsiha (Braswell et al. 2004, 2008), and Nim li Punit (Braswell and Prufer 2008; Fauvelle et al. 2012; Wanyerka 2009) founded during the Classic period. The inland Maya cities of southern Belize were abandoned during the social and political upheaval of the Terminal Classic period (A.D. 700 – 900). Elsewhere, the inland settlements of Belize have longer occupational chronologies. The island sites of Wild Cane Cay and Frenchman's Cay were continually occupied into the Postclassic period (A.D. 900-1500). In fact, Wild Cane Cay

expanded its role as a trading port for the transportation of goods along coastal trade routes (McKillop 1996, 1989).

The Importance of Salt to the Ancient Maya

Salt is a biological necessity but has other important uses to the Maya including food preservation, tanning hides, medicinal, and ritual uses (Andrews 1983:10-11). Both the Maya elite and commoners utilized salt. At Calakmul, a temple was discovered covered with murals depicting the lives of the common Maya (Vargas et al. 2009). A salt glyph has been identified on the mural in association with a scene of a man with a basket and spoon (Vargas et al. 2009: Figure 6B). The glyph characters, Aj atz' aan, is translated as "Salt-person". Since glyphs were used to denote important aspects of Maya culture (i.e., royal lineages), the discovery of a glyph for salt demonstrates the importance of the mineral to the lives of the ancient Maya.

Consumption of meat can meet the dietary need for salt (Andrews 1983; Marcus 1984). Archaeological evidence at inland sites indicates that white-tailed deer and peccary were consumed at interior sites (Emery 2004; White 1999). McKillop's (1984; 1985; 2005a; 2005b) research on the coast of southern Belize has revealed a reliance on seafood, another natural source of salt, at offshore and coastal sites.

The Maya's interest in salt began early in antiquity. Salt was still being produced, but production sites were taken over for commercial purposes when the Spaniards arrived (Andrews 1988:130-131). Evidence of salt production has been identified on the coast of Guatemala as early as the Late Formative/Late Preclassic (300 B.C. – A.D 100; Coe and Flannery 1967), on the Yucatan (Eaton 1978), and the southern Maya lowlands (Dillon 1977). Salt production increased after European contact when salt became an essential part of the silver mining industry (Andrews 1988:14-15; Ewald 1985; 12-13) and sustaining cattle ranches (Andrews 1988:15).

Methods of Salt Production

Solar evaporation was exploited by both the prehistoric and modern Maya by utilizing sunlight to evaporate a highly-concentrated brine into salt that can be harvested. Large salinas or salt bed/flats are found along the northern and northwestern shore of the Yucatan. The Classic Maya exploited these natural salinas (Andrews 1983). Salt water from estuaries evaporates in shallow constructed pans to concentrate the salt. The salt harvest begins in May when most of the water has evaporated. Salt is gathered with hoes and stored in piles on the lakeshore (Andrews 1983).

Eduardo Williams (1999, 2004) examines the solar evaporation method of salt-making sites in the Lake Cuitzeo Basin, Michoacán, Mexico. Williams used a combination of ethnographic information and archaeological investigations. Early accounts from the 16th century indicate that the area was used for salt production. The tool assemblages for modern salt production include hoes, shovels, pick axes, buckets, and wheelbarrows. Each salt-production site has a funnel-shaped wooden structure to filter water through the salty earth. The saline-enriched brine is concentrated in wooden containers such as old canoes. In the past, the structures were made out of trees similar to canoe construction (Williams 1999:404). The salt is harvested from the containers after solar evaporation has removed most of the water. Visible remains of brine enrichment in solar evaporation pans in the archaeological record would include the large mounds of leached soils containing broken ceramics, evaporation pans, and canals for moving water from salt springs, wells, supports for containers, and scraping tools (Williams 1999, 2004).

Evaporating brine in pots over fires to concentrate salinity is another method that was widely used by the ancient Maya. Juan de Estrada (Coe and Flannery 1967:92) described the

brine-evaporation method on the Pacific coast of Guatemala in 1579: canoes were filled with salty soils. Estuary water was filtered through the soil. Cane mats were placed in the canoe beneath the soil to filter out soil particles. Brine was collected in vessels placed beneath the canoe. This brine was evaporated in pots over fires to produce salt.

Late Classic Maya salt-production sites have been identified on the coast of Belize. Early assumptions (Andrews 1983) were that there were no local sources of salt for the southern Maya lowlands, although Gann (1918:22) had reported coastal salt production in Belize. Graham (1994:155-156) recovered ceramics at Watson Island that she thought could be associated with salt production. They were similar to salt-making vessels from the modern city of Sacapulas, Guatemala (Reina and Monaghan 1981). The sites along the coast date to Middle to Late/Terminal Classic (A.D. 600-1000) and provided numerous trade goods, including salt, to support the interior Maya centers that developed in the southern Maya lowlands (Andrew and Mock 2002:319). Graham (1994:316) believes that some of these sites, particularly Watson's Island, were established earlier. However, the northern Belize sites do not contain the solid clay cylinder vessel supports found at the southern Belize salt-making sites or mounds from brine enrichment.

The briquetage identified at Placencia Lagoon include sockets and spacers (MacKinnon and Kepecs 1989). Sockets are attached to either end of the cylinder to stabilize the pot on the ground and help suspend the pot over a fire. Spacers were used in between pots when multiple brine-evaporation pots were utilized. Twenty-two mounds were identified during the Placencia Lagoon survey. The mounds had a mixture of broken thick-walled vessels, cylinders, sockets, spacers and soil (MacKinnon and Kepecs 1989).

Few examples of brine enrichment mounds have been described in detail. A Late Preclassic mound, Guzman, is one example of thoroughly described stratigraphy. Guzman mound was excavated by C. Rogers Nance (1992) as part of an archaeological salvage operation in Guatemala. The mound had already been impacted by the expansion of the existing modern salt operation on the property. A bulldozer cut was cleaned. The exposed wall profile was described. Two units were excavated in the undisturbed portion of the mound to understand the internal structure. Nance (1992:29) noted that the original mound was 1.3m high. Subsequent layers were developed by clearing refuse from the surface of the slopes of the original mound. Several layers of gray loam with daub identified throughout the mound were interpreted as tailings deposits from the salt-making process. Other layers were described as pinkish gray loams containing charcoal and sherds. Nance (1992:29) indicated that the sherds of the upper layers were highly eroded and that no features were encountered above 60cm depth. Nance (1992) interpreted this as a change in function over time and that the deposits associated with salt production were below 60cm. He believed that the mound was used for cultivation possibly during the Postclassic. Six features identified as hearths contained a mixture of ash, sherds, and charcoal. One is described as being a clay-lined hearth.

Porvenir Coarse pottery is described as a necked jar with a thickened rim. The vessel rim shape changed slightly over time, from a sharply necked jar to an in-sloping necked jar, based on analysis of 181 large rims sherds (Nance 1992:34). The rim thickness remained the same. Nance speculated that this change could have been evidence of a technological advance to increase the efficacy of the brine evaporation process. The constricted necked jar could have impeded evaporation and required a larger amount of fuel (Nance 1992:35). Destruction of Guzman and other mounds at the location precluded any further analysis to test this hypothesis. No clay

cylinders vessel supports were recovered at Guzman. Clay cylinder have been identified at other salt-making sites on the Pacific coast (Coe and Flannery 1967; Sisson 1973; Riehm 1961) and have been attributed to supporting the brine vessels over fire during the evaporation process. However, other strategies for supporting pots over a fire have been noted, including using stones and large ceramic rims like at Sacapulas (Reina and Monaghan 1981). The large rims recovered within the Guzman mound could have served to elevate the brine pots. Fine ware and charcoal were used to refine the Preclassic date for Guzman mound.

MacKinnon and Kepecs (1989) report mounds at all the salt-making sites on the shores of the Placencia lagoon area. The mounds are described as low-lying amorphous in shapes ranging from a meter to a meter and half in height. The mounds consist of the leached soils resulting from the brine evaporation method and artifacts associated with salt production. Little domestic evidence was found within the mounds. MacKinnon and Kepecs (1989) believe that these mounds were used for seasonal salt production.

Wits Cah Ak'al is a salt-making site located 12 miles inland from Belize City on the coastal plain within the zone of salt-water mangroves. The twenty-eight mounds, were clustered in groups of two or three, along the edge of a mangrove swamp associated with Straight Lagoon. Murata (2011) excavated four test units into four mounds recovering briquetage. Three of the mounds contained layers of baked clay material (BCM; Murata 2011:73) which are the equivalent of the ACLs found within the mound at Witz Naab. Murata used clay from the site to create a salt-making assemblage of vessels, sockets, spacers, and cylinders. He noted that when he removed the briquetage from the hearth, the bases and sockets fractured and created BCM (Murata 2011:192).

Wits Cah Ak'al was a settlement for salt and ceramic production. Murata (2011:283) states that Wits Cah Ak'al was built because the geographic setting that provided clay, water, and fuel that was needed for both ceramic and salt production. The mounds were used as work surfaces for both activities. The stratigraphy of each mound varied. Hearths identified within the mounds and were interpreted as used for firing ceramics and producing salt.

Salt-making sites were identified in Punta Ycacos Lagoon, Paynes Creek National Park, Belize (McKillop 1995, 2002, 2005a). Initially, four sites were discovered and excavated between 1988 and 1994 (McKillop 1995; 2002). Artifacts were seen on the lagoon floor and in the mangroves. The Paynes Creek sites were inundated except the Killer Bee site. A low earthen mound discovered at the Killer Bee site (McKillop 2002) was interpreted as a brine leaching mound associated with salt production. The subsequent surveys identified 105 underwater salt workshops with briquetage (McKillop 2008). The Witz Naab mounds provide an opportunity to investigate the leaching method since the site is above water in a tidal flat.

Models of Maya Salt Trade in Southern Belize

Salt was an important commodity throughout Mesoamerica and beyond. For the purposes of this discussion, we will focus on the specific geographic region of southern Belize and role salt played in regional trade. McKillop (2009) discusses three models of trade for the Classic Maya period, including the "household production" model, the "tribute model", and the "alliance" model. Excavations at Witz Naab were designed to discover whether salt production at the Paynes Creek salt works fit into one of these models. Wilk and Rathje (1982) defined households as groups of individuals bound by kinship and/or a shared identity. Householders cooperate in production and reproduction necessary for survival. In the household production model, Maya householders were independent and self-sufficient and produced all that was

needed for the community. Households could have been specialist such as the case at Colha (Shafer and Hester 1991). Elites were also craft specialists and producers as at Aguateca (Inomata and Stiver 1998; Inomata et al. 2002). However, this model requires evidence of domestic settlements.

The tribute model is similar to the organization of the Aztec and Inca civilizations. Military forces compel outlying communities to send tribute to a central elite-controlled government. The alliance model is described as a system of powerful inland center elites who created trading and other alliances with outlying populations. The alliances were reinforced through ritual and feasting to procure goods.

Evidence from McKillop's long-term research in southern Belize and other identified salt production sites on the coast has altered the idea that the interior Maya traded for salt from the beds of the northern Yucatan (Andrews 1983; Andrews and Mock 2002). Salt has played an important role in the lives of the Maya, both elite and commoners. Four types of salt trade have been discussed for the southern Maya lowlands. Andrews (1983) engaged in a large-scale study of salt production to test a model purposed by Rathje (1971) that long distance salt trade was integral to the complex social-political development of the lowland Maya. Andrews utilized both archaeological and ethnographic evidence to support his hypothesis that the salt beds in the northern Yucatan were the main producer of salt for the Classic Maya. Management of these salt beds led to the rise of centers in the northern Yucatan. The Isla Cerritos Archaeological Project investigated the relationship between the island port complex and Chichén Itzá control of the salt trade in the Northern Yucatan during the Itzá period (A.D. 700-1200). Long-distance trade items recovered support that Isla Cerritos played an integral role in the coastal peninsula trade network

(Andrews et al. 1988). However, after years of research Andrews and Mock (2002) agree that his early model was too simplistic.

Others have argued that salt was locally available to the Maya of the southern lowlands. Salt can be obtained by burning palms or eating meat (Andrews 1983; Gann 1918; Marcus 1984; McKillop 1994, 1996, 2002). Furthermore, local salt spring (Dillon 1977) were utilized by the inland Maya and were certainly closer than the salt beds of the Northern Yucatan. Marcus (1984) and Dillon (1977) believe that the salt produced by burning palms or salt springs was sufficient to supply salt to the southern Maya lowlands. This model supports that local resources were utilized, and long distance trade was not necessary-- supporting the household model.

A third type of trade, proposed by MacKinnon and Kepecs (1989). The discovery of salt production sites in and around the Placencia Lagoon revealed that salt production was taking place on the coast of Belize during the Classic period. The investigators proposed that local salt consumption was sated with locally-produced salt and that the elites would have had access to the more desirable salt from the Yucatan. This assumption is based on the visual appearance of the salt itself. However, ethnographic studies illustrate that the darker salt produced in the highlands of Guatemala were preferred by the local population (Andrews 1983; Reina and Monaghan 1981).

A fourth trade strategy was proposed based on research from the New River Lagoon. Valdez and Mock (1911) proposed that fish were salted at coastal sites for inland trade to interior sites. This view could represent either tribute or alliance models. However, little evidence has been found at inland sites to support the idea that seafood was a significant part of the inland diet (Carr 1986; McKillop 1984, 1985, and 1996).

McKillop (2009) proposed an alternate model for salt production and trade in southern Belize. She has proposed that the coastal Maya were somewhat autonomous from the inland elite Maya and participated in “entrepreneurship” to provide much-desired salt to inland centers. The coastal production sites do not fit the household or tribute models. However, the large-scale production and lack of domestic deposits does support the alliance model.



Figure 1: Map of Paynes Creek National Park, Belize with inset site locations.

Stratigraphy of Witz Naab and Killer Bee

Witz Naab

The mounds at Witz Naab and Killer Bee are located on a tidal flat in the western portion of Punta Yacaos lagoon, Paynes Creek National Park, Toledo District, Belize (Figure 1). The lagoon is now an estuarine system with *Rhizophora mangle* (red mangrove) ringing the edge of the lagoon and in small concentrations within the lagoon. With drier land inland, *Avicennia germinans* (black mangrove) and *Languncularia racemosa* (white mangrove) dominate the landscape. The mound is covered in *Accelora wrightii* (palmetto palms). The area around the mound is surrounded by red mangrove and is inundated during high tide.

A 1x4 m trench from the top of the mound was excavated to reveal the stratigraphy of Mound A at Witz Naab. The trench was excavated in 20 cm increments. The water table fluctuated between 128 -140cm depth based on the tides. The soils were wet starting at 60-70cm. The wet conditions made excavation and screening difficult. Furthermore, the presence of clay obscured subtle stratigraphic changes during excavation. Units 0-1m and 1-2m were not excavated to the water level. Unit 0-1m is located on the edge of the mound that would have allowed additional lagoon water to inundate the excavations during high tide events. Units 0-1m and 1-2m are not excavated below 75-80cm. Excavations in Unit 1-2m were terminated to focus on Units 2-3m and 3-4m. Unit 3-4m was bailed regularly. However, we were able to excavate a quarter of the unit to 205cm depth. The shovel test revealed a solid layer of charcoal. The mound is a mixture of brown/red clay (7.5YR2.5/2), briquetage, and charcoal. Most of the briquetage consists of ACLs (Amorphous Clay Lumps; Figure 2). Layer A, is differentiated from lower levels due to the presence of heavy root mat. Layer A varied in depth from 0-20cm in the four units. This level was easily screened.

West Wall Profile

Layer A, consists of a dense root mat that varies in depth from 0-20cm in depth. Layer B consists of brown/red clay (7.5YR2.5/2), ceramic, charcoal, and briquetage from the 20-60cm depth that varies in thickness from 20-40 cm. Layer B tapers off toward the terminus of the mound in units 1-2m and 0-1m. Charcoal layers, layers C-I (7.5YR2.5/1) are visible in the west wall and the north wall (Figure 3).



Figure 2: Amorphous Clay Lumps from Level 20-40 cm depth Unit 3-4, Witz Naab.

The charcoal layers were not easily clearly visible during excavation due to the wet clay soil. The top charcoal layer varies 2-3cm in thickness. Layer C begins in unit 1-2m, extends through unit 3-4m, and is visible on the north wall of unit 3-4m. Layer C is obscured at the junction of units 2-3m and 3-4m. Distinct charcoal layers C-I was identified in unit 2-3m. The distinct charcoal layers were noted interspersed throughout the Layer B, which the majority of the mound fill is comprised. These additional charcoal layers ranged from 105 to 175cm depth. The smaller .25 X .25 excavation below the water table in unit 3-4m revealed charcoal fill.

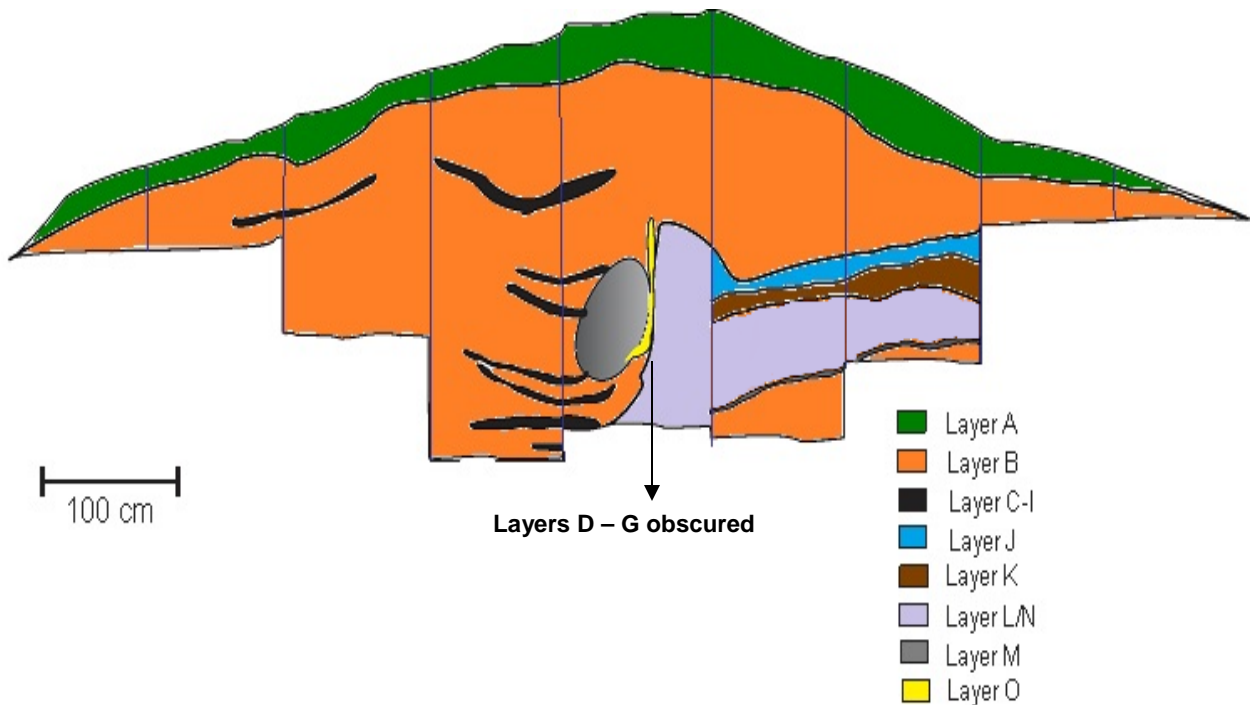


Figure 3: Witz Naab – Panoramic Profile. Layer A is soil mixed with heavy root mat and briquetage. Layer B is a mixture soil, ceramic, charcoal, and briquetage. Layers C-I are charcoal. Layer L/N is gray clay. Layer O is a lens of yellow clay.

North Wall Profile

The charcoal layers C-I detected in the west wall are visible the north wall profile (Figure 3). Layer C-I are only visible in part of the unit. The charcoal layers slope upward towards the eastern wall. A discrete reddish yellow clay layer, layer O (7.5YR7/8), is noted starting at 85cm depth to 140cm sloping to left at approximately 130cm depth. This layer is 2 cm thick. A gray clay (7.5YR6) layer, Layer L/N is located in the lower northeast corner of the unit. This layer is visible in the north wall, extends in from the east wall, and continues below the water level.

East Wall Profile

The east wall stratigraphy differs from the west wall at the lower layers. The same top Layer A, consists of a dense root mat that varies from 0-20cm in depth. Layer B consists of clay, ceramic, charcoal, and briquetage from 20-100cm depth. Layer B tapers off toward the terminus of the mound in units 1-2m and 0-1m (Figure 3).

A charcoal layer, layer J (7.5YR2.5/1), was noted at approximately 100-110cm. This layer varies 7-10cm in thickness. A layer of black clay (7.5YR2.5/1), layer K, was detected at 111cm and varies 5-15cm in thickness. Layer L a mixture of grey clay (7.5YR6) continues to varying depths of 120-150cm below the water level. A thin surface of very dark silt (7.5YR3/1), Layer M, 2cm thick was noted at in unit 3-4m at 150 cm depth and sloped upward through unit 2-3m. Unit 1-2m was not excavated to the depth, but the surface appears to continue to the unit.

The stratigraphy with Mound A at Witz Naab indicates that the mound underwent a minimum of three deposition episodes. Two lower mounds appear to have combined to form a larger mound. Layers J-N in the east wall profile is evidence of multiple surfaces in a mound. Layers C-I interspersed throughout Layer B is evidence of a second mound. The two mounds intersect at in the north wall. Layer A and B were then deposited covering the two separate mounds to form a single feature on the landscape.

Killer Bee

The stratigraphy of Killer Bee differs from that of Witz Naab. A 1X3 m trench was laid out on the low-lying mound at Killer. This unit was excavated in 20cm levels. All material was screened or hand sorted. The water table was encountered at 50 cm depth. There were no visible stratigraphic differences at Killer Bee. The soil is dark gray or black clay/silt (7.5YR3/1) mixed with briquetage and charcoal (Figure 4). The top 20cm consists of thick root material from ping wing, a native pineapple, which covers the mound.

Ceramic Analysis of Witz Naab and Killer Bee

The artifact assemblage from Witz Naab Mound A consists of briquetage associated with the production of salt. Sockets, spacers, and cylinders were recovered in the excavated levels. The overwhelming quantities of artifacts are amorphous clay lumps (ALCs). ACLs



Figure 4: Uniform Stratigraphy at Killer Bee. Photo by H. McKillop.

include fragmentary pottery vessels, sockets, spacers, and cylinder vessel support that are broken beyond recognition of form. Cultural material was recovered from every level by either screening through ¼” mesh or using a trowel/hand. Artifacts were sorted in the field and assigned to the Punta Ycacos Unslipped type (McKillop 2002). Pottery rims, body sherds and cylinders were counted. ACLs were weighed to determine the volume by layer and unit. No other artifact types were recovered from the excavations. The ceramic assemblage at Killer Bee consists of briquetage as well. The artifacts within Killer Bee were eroded compared to those from Witz Naab.

Determining the organic content of Witz Naab and Killer Bee Soil

A column sample collected from the west wall of Witz Nabb and south wall of Killer Bee was subjected to loss-on ignition to determine the amount of organic matter in the soil. The surrounding sites within the Paynes Creek Salt Works are in a mangrove peat environment.

Excavations of the inundated salt-work deposits in the lagoon indicate the sediment was highly organic. When examined under a microscope, the organic content of the sediment was virtually all red mangrove. The mangrove peat resulted from the red mangroves keeping pace with sea-level rise. The peat deposits lead to preservation of wooden building determined to be associated with large-scale, salt-production activity (McKillop et. al 2010). We wanted to determine if the mounds contained any mangrove peat or any other highly organic soil that could indicate a multifunctional purpose for these mounds. We utilized the protocols developed previously for analysis of the lagoon deposits to test the sediment of Mound A at Witz Naab and Killer Bee mound.

A portion of the soil was sampled for each of the 10cm column sediment samples collected from the excavation units. Crucibles and lids were washed with an HCL acid solution and dried in an oven at 105°C for 24-hours. All crucibles were labeled and weighed before adding sediment samples. The sediment samples were dried in an oven at 60°C for 24 hours prior to analysis. The dried samples were ground using a mortar and pestle, both of which were cleaned between uses to prevent cross-contamination. Sediment samples were weighed in the crucible and then placed into a pre-heated 105°C muffle furnace for 4 hours without the crucible lid. The samples were then removed to a desiccator and allowed to cool for 10 minutes. While samples were cooling, the muffle furnace was heated to 400°C. The sample weight was recorded. Samples, with the lid, were placed back into the muffle furnace. The samples were burned for an additional 8 hours. The muffle furnace was then ramped down to 105°C and the crucibles cooled until they were safe to remove by hand, wearing heat-proof gloves. The crucibles were cooled for an additional 10 minutes in the desiccator. Final weights of the sediments were recorded

without the lid. The percentage of organic matter (OM) was calculated using the following formula:

$$\% \text{OM} = [(W_{105} - W_{400}) / W_{105}] \times 100$$

W_{105} = weight of soil at 105°C
 W_{400} = weight of soil at 400°C

High final percentages would indicate that the sediment has a high organic content.

High percentages would be unlikely if the mounds do not contain mangrove peat or other organic soils.

Discussion

Compelling evidence for periodicity and shifts in the scale of production is demonstrated by the presence of the layer of clay, ceramic, charcoal, and ACL, (Layer A) that caps the mound (Figure 3). This layer is interpreted as the result of a massive shift in production to meet increased consumer demand as the population expanded in the southern Maya lowlands. Careful cleaning and disposal associated with brine evaporation appears to have been abandoned. Refuse was not disposed of in detectable basket loads into the mound. Rather, refuse was quickly collected and dumped to make way for the next evaporation session. This rapid deposition obscures the discreet layers evidenced in the lower levels of the mound.

The stratigraphy at Witz Naab indicates there were three building episodes at Mound A. The north wall of the trench at Witz Naab shows the interface between the two mounds (Figure 3). A deposit of yellow clay and several charcoal layers were visible in the wall profile. These layers were deposited on the edge of the original surface. The charcoal layers have been interpreted as discarded after an evaporation episode. The multiple charcoal layers could indicate either multiple boiling sessions or a potential seasonal aspect of salt production. The intermediate layers of charcoal could have been deposited during multiple seasons of salt production. The

yellow clay could be evidence of raw clay that was not used for ceramic production. We collected samples of all these layers for further analysis.

Within the west wall profile, the multiple charcoal layers continue into Unit 3-4 m. However, only the uppermost layer of charcoal extends into Units 2-3m and 1-2m. The grey clay layers were noted within units 2-3m and 3-4m. The lower two mounds are completely covered in Layers A and B. Unlike the mounds at Guzman and Wits Cah Ak'al, we did not detect any hearths within the excavation. Furthermore, we did not recover any obsidian, chert, or food remains within the deposits. Obsidian and chert have been recovered from the offshore deposits. Obsidian and chert were recovered from the deposits at Guzman and Wits Cah Ak'al. This layer of ACL is confirmed by the artifact analysis. The ACL data was plotted (Figures 5-8) by weight level. The ACL volume increased significantly in levels 20-40cm levels in all units gradual decreasing until another peak at in Unit 3-4, 120-140cm and below the water table. The other units were not excavated to 120-140 depth we cannot make any interpretations concerning this concentration. We did recover the recognizable forms of ceramic associated with the salt production assemblage.

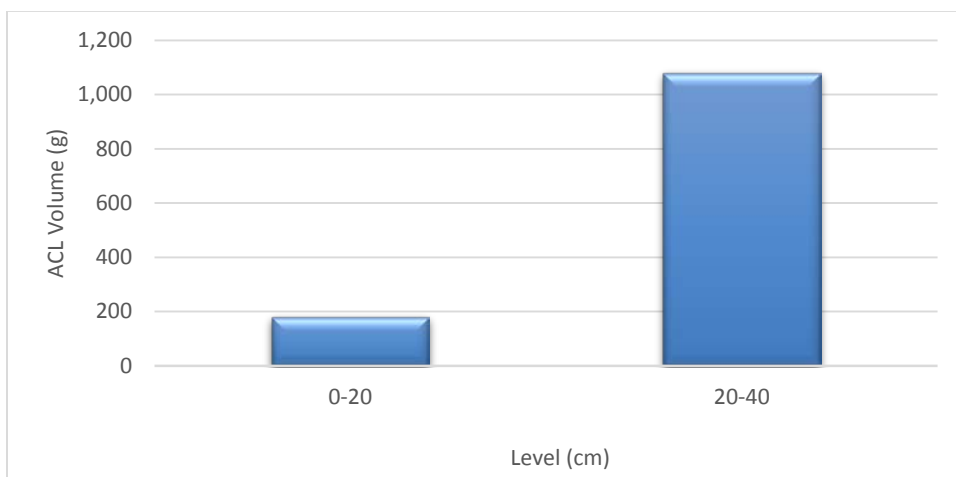


Figure 5: Weight (g) of Amorphous Clay Lumps (ACL) at Witz Naab, Unit 0-1m.

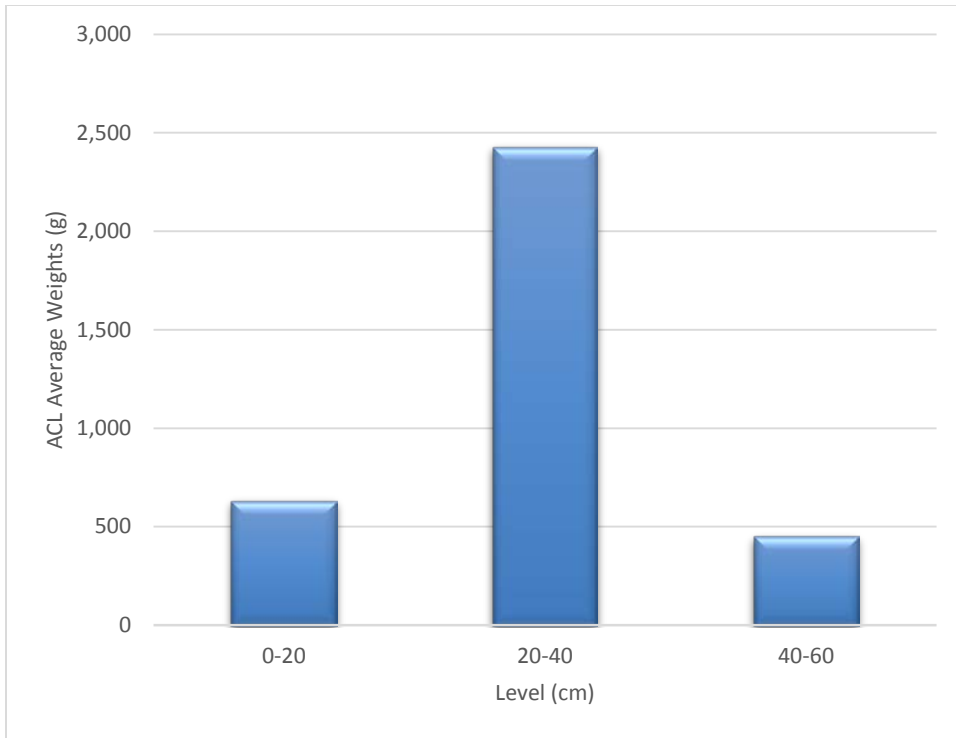


Figure 6: Weight (g) of Amorphous Clay Lumps (ACL) at Witz Naab, Unit 1-2m.

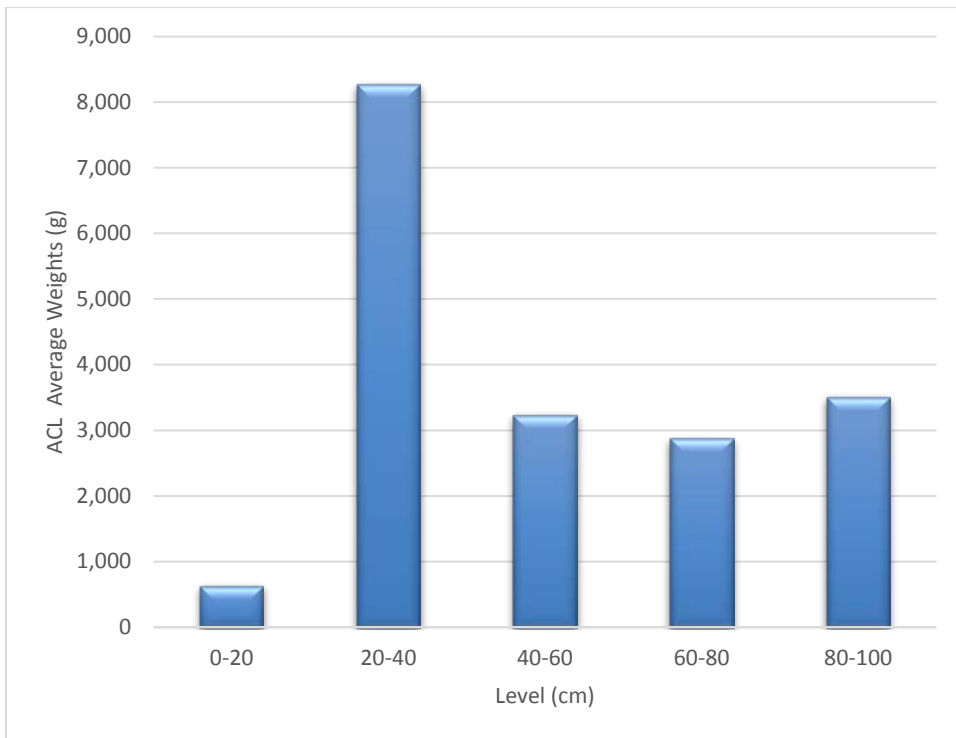


Figure 7: Weight (g) of Amorphous Clay Lumps (ACL) at Witz Naab, Unit 2-3m.

The stratigraphy within Killer Bee is uniform. The site is a leached soil discard pile; however, the depositional process differs at this salt production location. The difference in stratigraphy could be a result of different scales of production over time. Without c-14 dates to establish chronology, we can only speculate. As we noted, the artifacts at Killer Bee were more eroded than those at Witz Naab. The erosion could be the results of the environmental setting. The low-lying mound could be affected by the fluctuation of tidal movement more than the mounds at Witz Naab causing the salt artifact assemblage to erode at a faster rate. Alternatively, the artifacts in Killer Bee could have been deposited in an earlier time period than the artifacts at Witz Naab. The ACL counts at Killer Bee were almost double in the uppermost level as compared to the counts in levels 20-40cm and 40-60cm (Figure 9). The increase in discarded ceramics could demonstrate an increase in production in this area prior to abandonment.

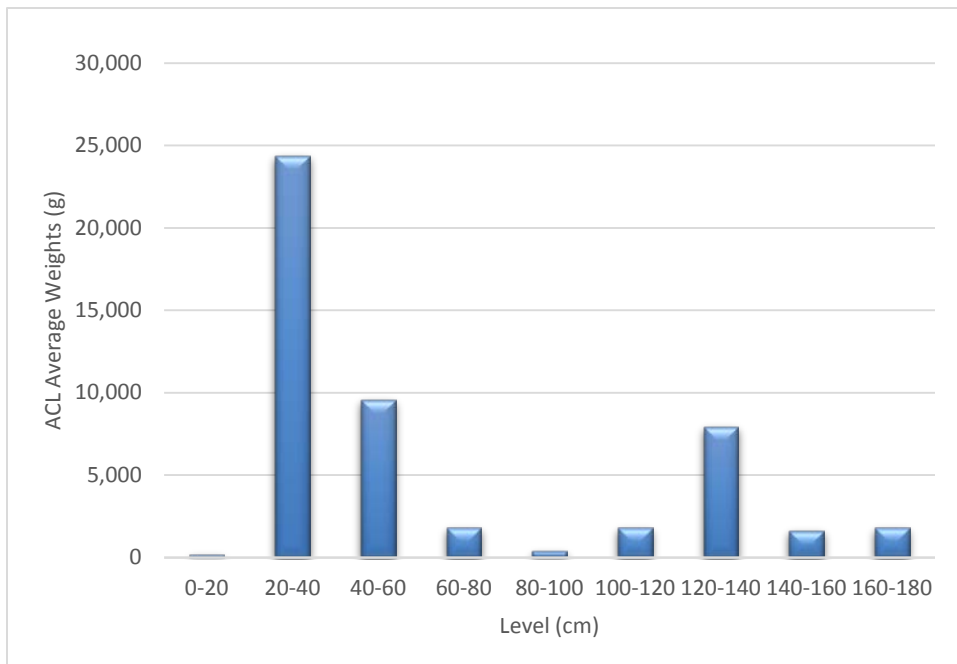


Figure 8: Weight (g) of Amorphous Clay Lumps (ACL) at Witz Naab, Unit 3-4m.

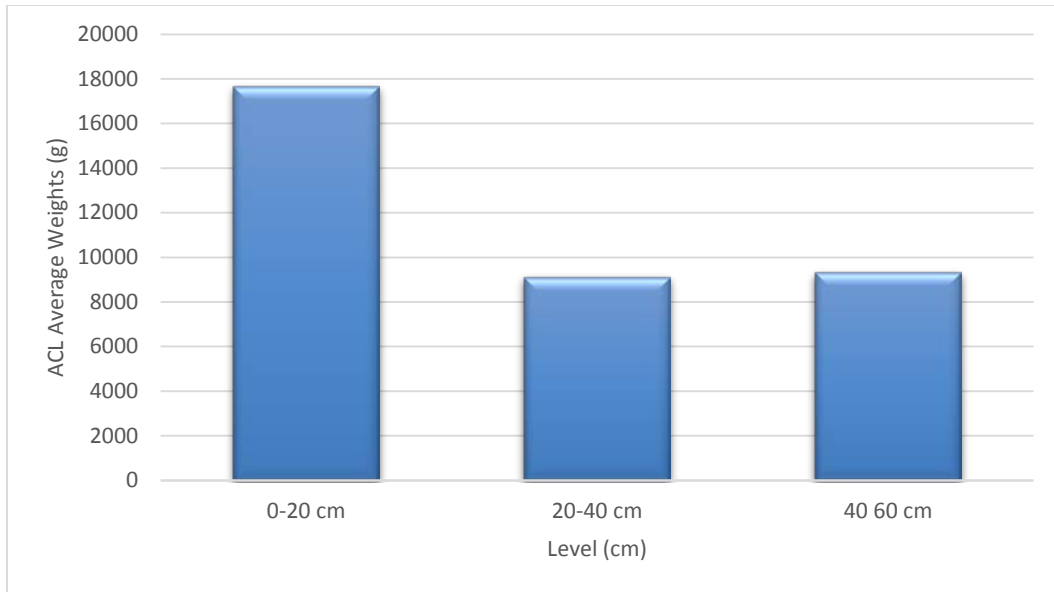


Figure 9: Weight (g) of Amorphous Clay Lumps (ACL) Unit 0-1m at Killer Bee.

To determine the organic nature of the mounds a soil column was collected to conduct loss-on ignition at both Witz Naab and Killer Bee. A leaching mound should not contain large amounts of organic material unlike a mound platform with house floors. Food preparation and discard would increase the organic content within domestic deposits. Furthermore, if these soils were selected for the increase salt content, they would not be suitable for agricultural purposes. Agricultural soils would require a higher organic content to be productive. The results of the loss-on ignition were what we anticipated. There was very little loss of organic material after the soils were burned at Witz Naab and Killer Bee.

The results at Witz Naab (Figure 10) demonstrated that the levels 0-10cm, 10-20cm, and 20-30cm had a slightly higher organic material than the subsequent nine levels. The increase is attributed to the presence of roots for the vegetation covering the mound surface. Levels 30-40cm – 110-120cm had a small percentage of change from the original samples. The lower two levels 120-130cm and 130-140cm had similar results to the upper three levels. The increase is attributed to the more charcoal in these two layers.

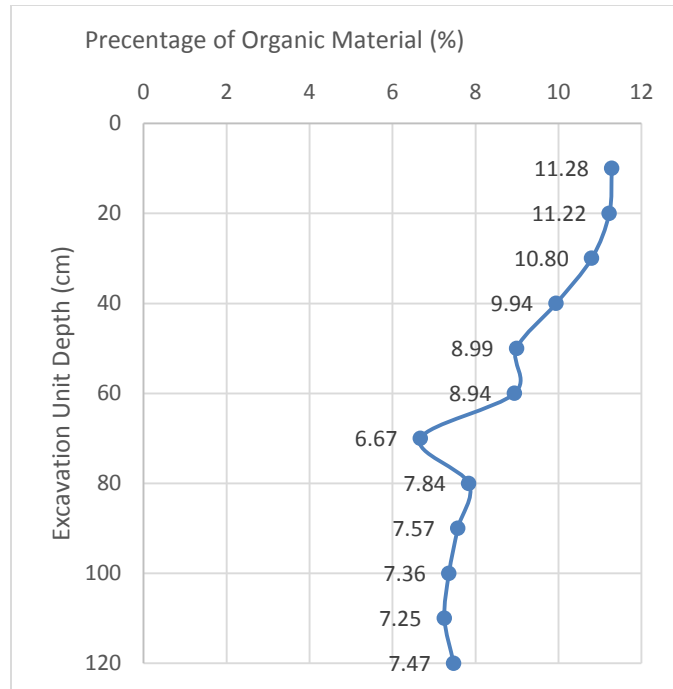


Figure 10: Witz Naab Loss on Ignition Data

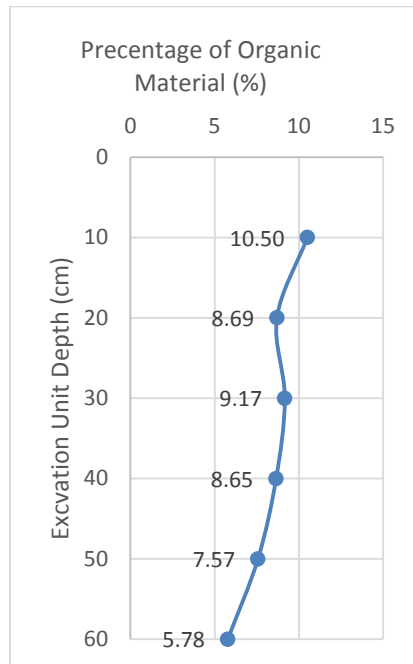


Figure 11: Killer Bee Loss on Ignition Data

There was very little loss of organic material from the samples within Killer Bee (Figure 11). Killer Bee did not contain the concentrated layers on charcoal that were found at Witz Naab.

The results of loss-on ignition results are interesting when compared to the results of testing conducted at K'ak Naab, an inundated site within the eastern lagoon. The average percentage of organic matter at K'ak Naab is 65% (McKillop et al. 2009:248, Figure 4). The loss-on results indicated the development of mangrove peat at K'ak Naab resulting from sea-level rise.

The mound at Witz Naab is unlike the leaching mound at Guzman. Two of the mounds at Wits Cah Ak'al contained evidence that suggests they were utilized as a disposal site for leached soils. However, hearths associated with the evaporation process were identified. The Wits Cah Ak'al mounds were similar to the description of the mound at Guzman. However, the Guzman mound lacked the clay cylinders identified at Witz Naab and Wits Cah Ak'al. Differences could be due to the fact the Guzman is associated with Preclassic Period and Witz Naab, and the salt assemblage at Wits Cah Ak'al are Late/Terminal Classic Period illustrating the temporal differences in salt-making assemblages.

The mounds identified at Placencia lagoon appear to be leaching remnants. Unfortunately, there is simply not enough published description of the stratigraphy to confirm or refute this hypothesis. The artifact assemblage is that of ancient Maya salt production. The coarse thick-walled vessels, cylinders, spacers, and sockets are the same artifact assemblage identified at the Paynes Creek Salt Works. Most other coastal sites in northern Belize lack spacers and sockets, which suggests differences in technological production.

The excavation at Witz Naab further strengthens the argument that the Paynes Creek Salt Works were workshops for specialized production. The discoveries of wooden posts that are the remains buildings for salt production (McKillop 1995, 2002, 2005a, 2005c, 2008; Sills and McKillop 2007), explain the lack of hearths in the Witz Naab mound; the amount of rainfall in southern Belize would have made evaporation outdoors difficult and risky endeavor. Sudden rain

showers during the “dry season” are common. The evaporation process would have occurred indoors to protect the commodity. Unlike the mounds at other sites, the mound at Witz Naab is a specialized disposal space for the refuse associated with evaporating brine. The excavated inundated buildings indicate that the workshops were kept clean (McKillop 2007). Large amounts of charcoal and briquetage have been recovered outside of the structures (McKillop 2008).

The Paynes Creek salt workers functioned autonomously from the inland Classic Maya. Artifact evidence such as Warrie Red unit-stamped jars, Moho Red bowls, and ocarinas, suggest a connection with ceramic styles at inland sites that were likely redistributed by the trading port at Wild Cane Cay (McKillop 2002:177). These wares and whistles would have been used during ceremonies performed before the salt production began, reinforcing the connection between producer and consumer. The large volume of briquetage and the spatial distribution of the workshops implies that the coastal Maya of the region were producing amounts of salt beyond the need of a household level or village level (McKillop 2009). Inland population expansion during the Classic period presented an opportunity to the coastal Maya to start an entrepreneurial endeavor of salt production. The salt workshops were inundated sometime after the inland sites were abandoned during the Terminal Classic. The Maya of the coastal region continued their occupation and participation in circum-Caribbean trade during the Postclassic. They shifted commodities to address the needs of the new consumers. McKillop (1989) has documented this shift by the presence of large amounts of obsidian recovered at Wild Cane Cay, as well as stone architecture and exotic pottery of the Postclassic (McKillop 2005c).

The loss-on ignition results, ceramic analysis, and stratigraphic descriptions indicate that salt production at the Paynes Creek salt works is a periodic activity. The loss-on ignition

indicates that there was little organic material within the mound at Witz Naab unlike the mangrove peat deposits at K'ak Naab (McKillop et al. 2010). If the mounds had contained domestic refuse or midden material, we would have expected soil that is more organic at Witz Naab. Furthermore, no midden deposits were identified within the mound. We did not recover faunal material within the mound. Residential use would have created deposits associated with food preparation.

The majority of the ceramics recovered were associated with salt production as at the inundated sites. The ceramic assemblage does not contain the diversity of pottery associated with Maya settlements.

The stratigraphy at Witz Naab provides evidence of both periodicity and shifts in the scale of production. The multiple construction episodes, in particular, the three lower construction episodes, indicate a gradual deposition until they merged into a single mound. The charcoal layers indicate periodic burning followed by disposal of waste products. The fact that the charcoal layers are interspersed by layers of leached soil and briquetage supports evidence of multiple evaporation episodes.

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CHAPTER 4: TRACES OF THE PAST: ANALYSIS OF CHEMICAL SIGNATURES FROM TWO MOUNDS AT THE ANCIENT MAYA SALT WORKS, PAYNES CREEK NATIONAL PARK, BELIZE

Introduction

The analysis of soil chemistry at archaeological sites is established as an effective method for detection, reconstructing landscape use for agriculture, and determining activity areas.

The chemistry of samples from two Maya salt works within Paynes Creek National Park were analyzed to determine the function of the mounds at Witz Naab and Killer Bee. We have proposed that these mounds are the by-product of brine enrichments techniques of leaching sea water through salty soils to concentrate the sodium levels. Sodium levels should be elevated within the discarded sediment since leaching would not remove all salts. Low phosphorus levels are expected if these are not platforms for domestic activities. Other studies (e.g., Middleton and Price 1996; Parnell et al. 2002; Wells et al. 2000) have explored the spatial relationship of chemical signature and structures.

Following the end of the Late Classic period, a large salt making complex in Punta Ycacos Lagoon, Paynes Creek National Park, Toledo District, Belize was inundated due to sea-level rise (McKillop et al. 2010). Salt—a basic biological necessity—was sought by the ancient Maya, like people worldwide from antiquity to the present. The sites were first identified due to large amounts of briquetage – the remains of pots used for evaporating brine over fires – that were visible on the lagoon floor. Additional research uncovered the wooden architectural remains of the structures associated with salt production during the Late Classic period (McKillop 2005 a-c, 2007, 2008, 2009; Sills and McKillop 2010; Somers 2007).

Studies of soil chemistry for interpreting activity areas are promising in Mesoamerica. The soils are conducive to phosphorus and other elements; such as barium, calcium, iron, magnesium, and manganese, that readily fix to the clay. Arrhenius (1931) noted a correlation between elevated phosphorus levels and archaeological sites. Phosphorus studies as an archaeological indicator have increased over time (e.g. Proudfoot 1976; Eidt 1973, 1977; Holliday and Gartner 2007). Technological improvements led to the use of multi-element analysis (e.g. Middleton 2004; Middleton and Price 1996; Entwistle and Abrahams 1997; Entwistle et al. 1998, 2000, 2007).

Soil chemistry will aid in the interpretation of the inundated deposits and help us to identify activity areas associated with the salt works. As with other recent studies in Mesoamerica (Dahlin 2009; Dahlin et al. 2012; Inomata and Stiver 1998; Huston and Terry 2006; Huston et al. 2009; Parnell et al. 2002; Parnell et al. 2002; Wells 2004; Wells et al. 2000; Terry et al. 2004), the spatial distribution of soil chemistry across a site can help to develop a picture of site development and activity areas, especially when the analysis is used in conjunction with data collected from ethnographic examples of soil studies (Barba 2007; Dore and Varela 2010; Fernandez et al. 2002; Middleton and Price 1996). This approach is exemplified by Dahlin's (2009) work at the Early Classic site of Chunchucmil. He identified a plaza that was utilized as a market for the exchange of food goods based on the soil phosphorus signatures associated with low stone architectural features that served to delineate a space or essentially a stall. This interpretation was further supported by soil chemistry data gathered from the modern Maya market at Antigua, Guatemala which demonstrated a similar spatial pattern to the market at Chunchucmil (Dahlin et al. 2007; Dahlin 2009).

Brine evaporation over fires is conducted in buildings due to the wet climate in southern Belize. The area has an average rainfall of 300cm. June through September are the wettest months of the year with rainfall totals between 400 – 700 mm (Heyman and Kjerve 1999). February, March, and April are the driest months with monthly rainfall between 40 – 70 mm (Heyman and Kjerve 1999). Andrews (1980:28) describes the salt-making practice on the Pacific Coast of Guatemala of leaching salts out of marsh soils utilizing a dugout canoe. A palm tree trunk drains the brine to an indoor kitchen for cooking. This process, which began in the Late Preclassic period (300 B.C. – A.D. 300), produces large mounds of soils as a by-product. Coe and Flannery (1967:92) discuss the brine-enrichment process noted by Juan de Estrada in 1579 on the Pacific Coast of Guatemala. Canoes are filled with salty soils. Cane mats are placed in the canoe beneath the soil to filter out soil particles as estuary water is poured into the container. Brine is collected in vessels placed below the canoe. The brine is concentrated in pots over fires to produce salt. Good (1995), Parsons (2001), Eduardo Williams (1999, 2004) and have researched historic salt production from leached soils in Mexico. Good describes the that the leached brine looks like cola before solar evaporation but produces a granular white salt (Good 1995:2) Parson discusses three types of salt that were produced at Nexquipayac, Mexico. These include sal blanca, sal negra, and sal amarilla. Sal blanca is ordinary table salt, sal negra is used for carnitas preparation, and sal amarilla used for curing meats (Parsons 2001:15-17). Sal amarilla is the by-product of a failed batch of sal blanca (Parsons 2001:17).

Interpretations of stratigraphy and artifact assemblage demonstrated that the Paynes Creek mounds at Witz Naab and Killer Bee were in fact evidence of brine enrichment spoil piles (Watson et al. 2013). Chemical testing of soil is used to identify the functions of the mounds including the interpretation that the mounds are brine enrichment spoil piles. Habitation would

produce chemical signatures typical of household debris, notably phosphorus, barium, and magnesium. In contrast, if the area were used for salt production, chemical signatures would not include high levels of these elements. Chemical analysis in conjunction with stratigraphic and artifactual evidence will increase our understanding of how the mounds were constructed over time.

Salt production has been thought of as a household level of production (Good 1995; Reina and Monaghan 1981). The workshops at El Salado in Veracruz were interpreted as the household level of production even though they were not directly associated with domestic deposits (Santley 2004). Evidence of continued household salt production into the Postclassic was found at Wild Cane Cay located near the Paynes Creek salt works (McKillop 2002:173). McKillop (2012; 2005a; 2008) has identified the Paynes Creek salt works as a specialized non-domestic workshop. This specialization beyond the household level of production was noted at the site of Colha. Colha, located in northern Belize, was identified as a chert production workshop (Shafer and Hester 1983; Shafer and Hester 1986). No domestic refuse was found associated with the workshop deposits. However, unlike the Paynes Creek salt workshops, Colha's workshops are associated with permanent settlement. Understanding the development and organization of the Paynes Creek salt works will help interpret the complex trade strategies of the Maya beyond the traditional interpretations of household and elite controlled economies.

Site Description and Physical Environment

Geological studies in southern Belize have focused on the Maya mountains (e.g. Ower 1928; Dixon 1956). The exception, Land in British Honduras (Wright et. al 1959), includes discussion of soil development in the study area. Wright, Romney, Arbuckle, and Vial (1959) identified this area as the east central development region. This area is described as a coastal

strip comprised of pine ridge, forest-covered foothills, and river valley systems that drain the eastern flank of the Maya Mountains (Wright et. al 1959:148). The soils are noted to have low fertility and poor drainage, although large tracts of Puletan soils can support pine plantation (Wright et. al 1959:149). Puletan sub-soils are described as a mottled red and white sandy clay or clay. The topsoil is described as a coarse yellow loam and white sand. Phosphorus and Calcium levels are low (Baillie et al. 1993)

The mounds at Killer Bee and Witz Naab (Figure 1) are situated in an estuarine system with *Rhizophora mangle* (red mangrove) ringing the edge of the lagoon and occasionally in small concentrations within the lagoon. The land becomes drier moving inland, with *Avicennia germinans* (black mangrove) and *Languncularia racemosa* (white mangrove) dominating the landscape. The lagoon floor is comprised of mangrove peat. The peat environment has preserved the wooden architectural remains of the Paynes Creek salt works. The red mangrove ecosystem has dominated the landscape through the Holocene based on pollen and peat fiber analysis from sediment cores (McKillop et al. 2010).

Methods

Sediment samples were collected from the excavations at Killer Bee and Witz Naab. A sediment column sample was collected by cutting 10cm³ section (Figure 2) from the northern wall of the excavation unit at Killer Bee. A trowel was covered in a new plastic bag to prevent cross contamination for each sample collected. Each sample was wrapped in plastic, labeled to indicate orientation, and put into a ziplock bag. Six samples were collected from Killer Bee. Fourteen samples were collected from the west wall of Witz Naab utilizing the same technique except these samples were small enough to place in whirl pack bags. Individual soil samples were collected from the west, east, and north wall profiles from distinct layers. The samples

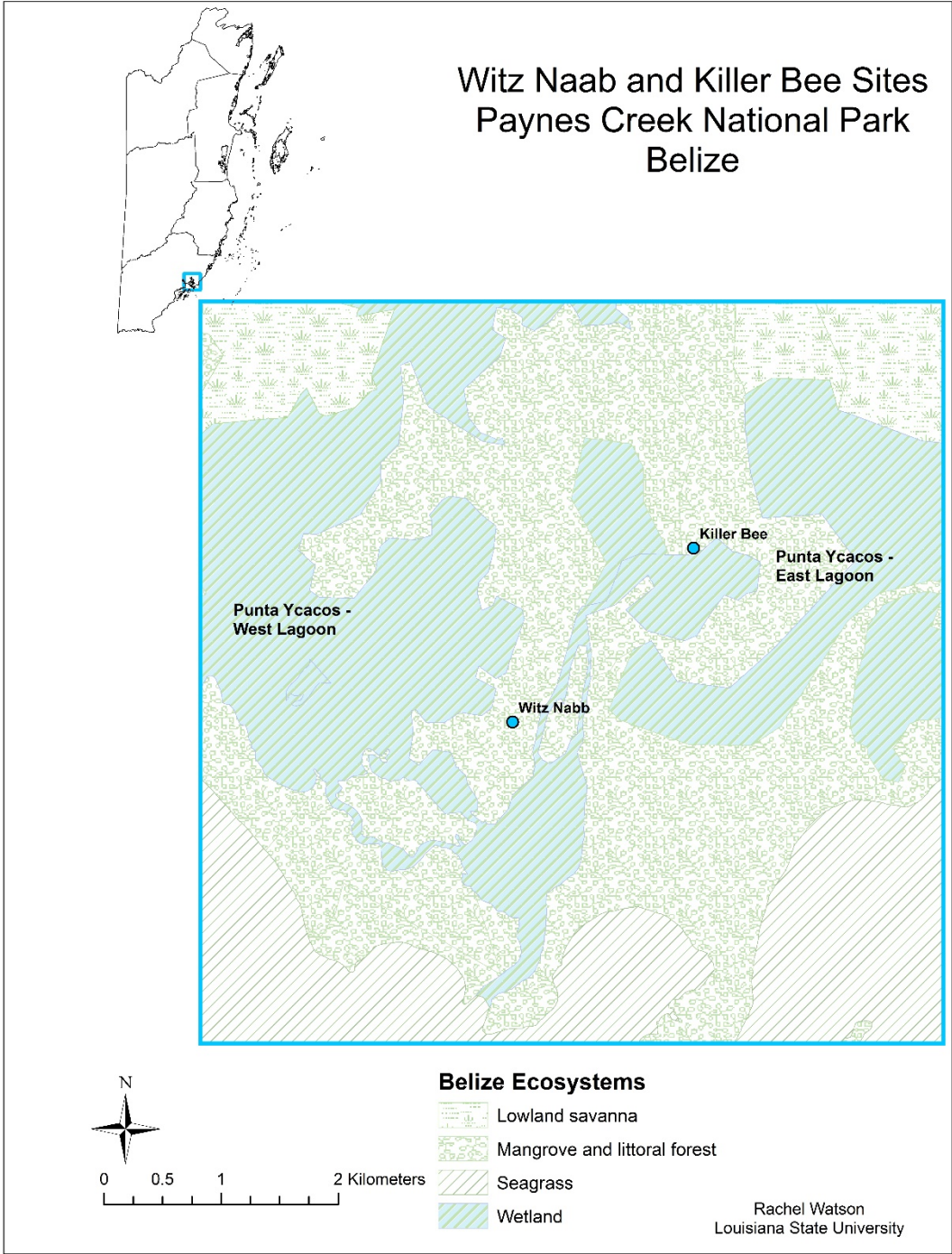


Figure 1: Ecosystems Map of Paynes Creek National Park.

(Figures 2-3) were labeled alphabetically (Soil Sample [SS] A-O). SS-O was taken from below the water table and does not appear on the figure. All the samples were reduced and placed in whirl pak bags. Sampling instruments were washed, between sampling, to prevent cross contamination.

Sample preparation was performed at the Laboratory for Anthropogenic Soils Research at the University of South Florida and an explanation of the procedure was provided by E Christian Wells (personal communication 2014). For this study, a ca. 2.00 g portion was taken from each sample using an Ohaus ExplorerPro electronic balance (Model EP114C, d = 0.1 mg), pulverized with a Coors porcelain mortar, mixed with 10 ml of .60-molar hydrochloric acid (trace metal grade) with .16- molar nitric acid (trace metal grade) in a phosphate-free polyethylene scintillation vial, and shaken vigorously on an electronic shaker at 220 rpm for 30 minutes. For each sample, the solution was filtered using Whatman quantitative-grade ashless (.007 percent) filter paper and an acetone-rinsed glass funnel, and then decanted into clean polyethylene vials. The extracts were then diluted with ultrapure deionized water (type I reagent grade 18 Megaohm*cm-1 resistance) to bring the concentrations of the elements in the optimal measurement range of the instrument.

All samples were analyzed using a Perkin Elmer Elan II DRC quadrupole inductively coupled plasma-mass spectrometer (ICP-MS) (with background correction techniques facilitated by the WinLab 32 software providing detection limits close to 1 ppb for most elements; reported detection limits for the ICP-MS range from 0.1 ppt [0.1 ng/L] to 1 ppb [ug/L] for most elements) at the Center for Geochemical Analysis at the University of South Florida. For this analysis, each liquid sample was drawn into the ICP where a flow of argon gas converted it into a fine aerosol.

A portion of the sample aerosol was then directed through the center of an argon plasma torch, where the temperature is near 10,000 °K. The energy of the plasma caused the sample ions to

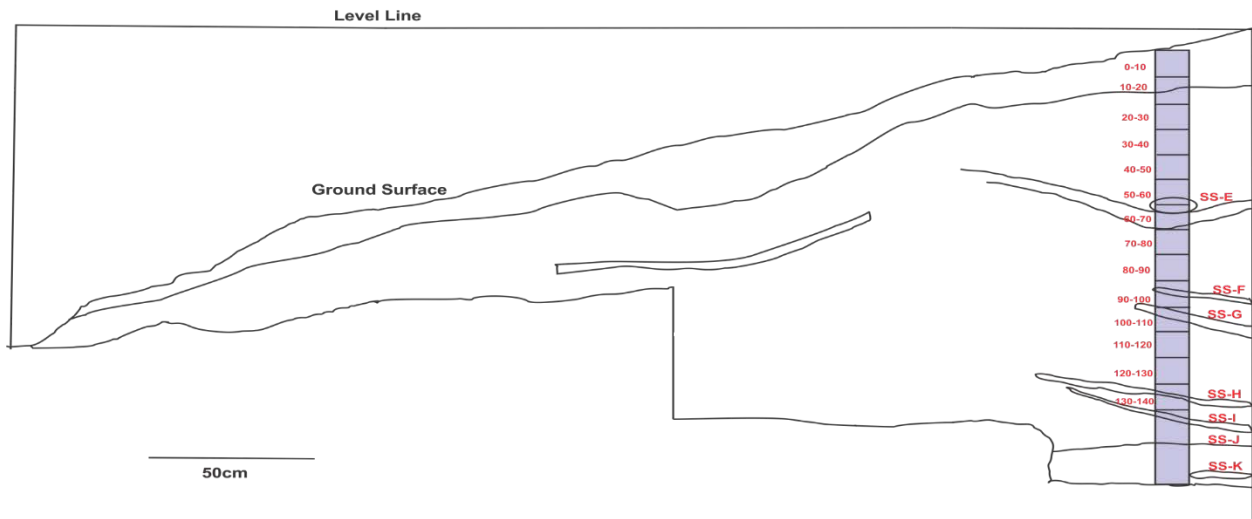


Figure 2: West Wall Profile Witz Naab including sediment samples by 10cm depth column and individual soil samples (SS-E through K).

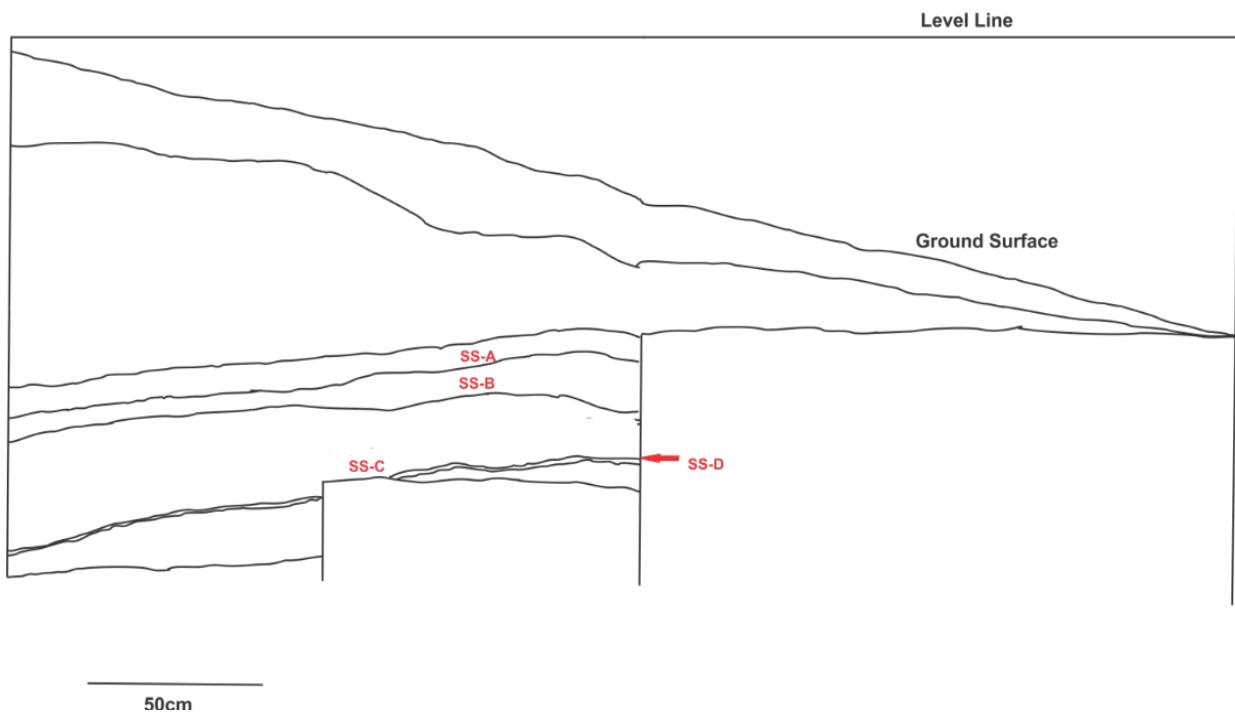


Figure 3: East Wall Profile Witz Naab individual soil samples locations (SS - A through D).

lose an electron and reach an “excited” state. As the excited ions relaxed to their base states, they gave off energy in the form of light. The spectrum of light frequencies emitted from each element is unique and can be used to identify the presence of that element in a sample. The emitted light was separated by wavelength using a mass spectrometer equipped with a solid-state detector, which identified each wavelength and its relative intensity. The intensity of the emitted light is analogous to the concentration of an element in the sample solution. This information was then compared to calibration data for quantification.

For calibration, known solution standards containing the elements of interest in concentrations bracketing the expected concentrations of the sample were run during the analysis. By running several standards of different concentrations, calibration “curves” were generated equilibrating instrument response with known concentration. The unknown data were then plotted on these curves and the amount of each element of interest was calculated. The data show 5-10 percent variation on the NIST CRM for all standards and samples and 5-10 percent error on internal quality control (blanks).

The calibrated concentrations of 20 elements were determined: aluminum (Al), barium (Ba), iron (Fe), calcium (Ca), copper (Cu), magnesium (Mg), manganese (Mn), mercury (Hg), lead (Pb), nickel (Ni), sodium (Na), phosphorus (P), strontium (Sr), titanium (Ti), zinc (Zn), vanadium (V), chromium (Cr), cobalt (Co), yttrium (Y), and uranium (U). The results were converted to mg element/kg sediment (mg/kg) by dividing the ppm value by the mass (g).

Results and Discussion

The stratigraphy of Witz Naab is complex. The mound consists of a topsoil layer that varies in depth between 0-20cm that consists of ceramics sherds, soil, and a thick root mat. Below the 0-20cm depth, the mound consists of soil mixed with ceramics and charcoal. This fill

is interrupted by layers of distinct charcoal layers that do not extend across the surface of the layer. Multiple charcoal layers were noted within the west wall of the excavation of Witz Naab (Figure 2). We chose to collect the column sample from the west wall. Individual samples were taken from the east and north wall, as well. The north wall sample was collected from a distinct yellow clay layer (Figure 4). East wall samples (Figure 3) were collected from three distinct soil layers and one possible work surface/floor area.

The stratigraphy at Killer Bee was uniform throughout the excavation as opposed to the stratigraphy at Witz Naab. The mound is a mixture of sediments, ceramics, and charcoal. The artifacts assemblage consisted entirely of briquetage. The column sample was collected from the north wall and no individual samples were collected.



Figure 4: Witz Naab North Wall Photo of SS-L.

Phosphorus

The phosphorus levels for all the samples (N=33) were low for a cultural context (Tables 1-3). The mean phosphorus level for Witz Naab and Killer Bee is 1.149 mg/kg. Phosphorus values at Piedras Negras ranged between 20-30 mg/kg (Wells et al. 2000:458) and 50 – 5 mg/kg at Ceren (Parnell et al. 2002:336). The lowest phosphorus values at Ceren are attributed to areas that were regularly swept which prohibited the chemical reaction to stabilize phosphorus levels within the deposits (Parnell et al. 2010).

Table 1: Phosphorus values (mg/kg) for the Column Samples at Witz Naab Site.

Site	Depth (cm)	Phosphorus (mg/kg)
Witz Naab	0-10	0.07675
Witz Naab	10-20	0.016945
Witz Naab	20-30	0.065324
Witz Naab	30-40	0.016444
Witz Naab	40-50	0.069393
Witz Naab	50-60	0.054263
Witz Naab	60-70	0.104276
Witz Naab	70-80	0.058694
Witz Naab	80-90	0.117468
Witz Naab	90-100	0.082934
Witz Naab	100-110	0.140291
Witz Naab	110-120	0.069576
Witz Naab	120-130	2.946285
Witz Naab	130-140	9.037583

Table 2: Phosphorus values (mg/kg) for the Individual Sediment Samples at Witz Naab Site.

Site	Depth (cm)	Phosphorus (mg/kg)
Witz Naab	Sample A	0.116097
Witz Naab	Sample B	0.238484
Witz Naab	Sample C	0.07994
Witz Naab	Sample D	3.854521
Witz Naab	Sample E	0.097606
Witz Naab	Sample F	0.061192
Witz Naab	Sample G	0.105768
Witz Naab	Sample H	0.249658
Witz Naab	Sample I	0.043661
Witz Naab	Sample J	9.789475
Witz Naab	Sample K	8.220207
Witz Naab	Sample L	0.188653
Witz Naab	Sample O	1.191036

Table 3: Phosphorus values (mg/kg) for the Individual Sediment Samples at Killer Bee Site.

Site	Depth (cm)	Phosphorus (mg/kg)
Killer Bee	0-10	0.183157
Killer Bee	10-20	0.237131
Killer Bee	20-30	0.271999
Killer Bee	30-40	0.032866
Killer Bee	40-50	0.120168
Killer Bee	50-60	0.004721

Ethnographic examples of phosphorus values at two Q'eqchi households in Las Pozas, Guatemala (Fernandez et al. 2002) varied across the collection site. Kitchen samples were as high as 240 mg/kg and 250 mg/kg at the respective households. The living room in the dwelling yielded phosphorus levels were greater than 100 mg/kg. Pathways and roofline areas around the house yield values of 8-50 mg/kg. Dore and Varela (2010) compared two households in Cuentepec, Morelos, Mexico. Phosphorus levels ranged from 109-25 represented ten household activity areas. The highest levels were associated with food preparation/production areas. The lowest numbers were associated with walkways.

Three samples from Witz Naab returned values between 8-9 mg/kg. These levels are deposits associated with areas that would be swept regularly. Artifacts recovered from the units were all associated with the production of salt. These included cylinder vessel supports, sherd from thick-walled pots, spacers, sockets, and the fragments of these broken from identified as ACLs (amorphous clay lumps). No faunal remains were recovered. The low phosphorus levels in conjunction with artifacts assemblage supports our argument that these were leaching mounds associated with concentrating the salinity of brine before evaporation in pots over the fire.

Other Element Concentrations

Concentrations of sodium, magnesium, aluminum, calcium, iron, and strontium were noted within the samples from Killer Bee and Witz Naab. The sodium levels increase in both soil columns the closer the samples were taken to the water table. Considering that both sites are within a saltwater lagoon system, this find is not unexpected. Killer Bee sodium (Figure 5) levels range between 7 – 21mg/kg. Witz Naab levels range between 6 – 187mg/kg (Figure 6).

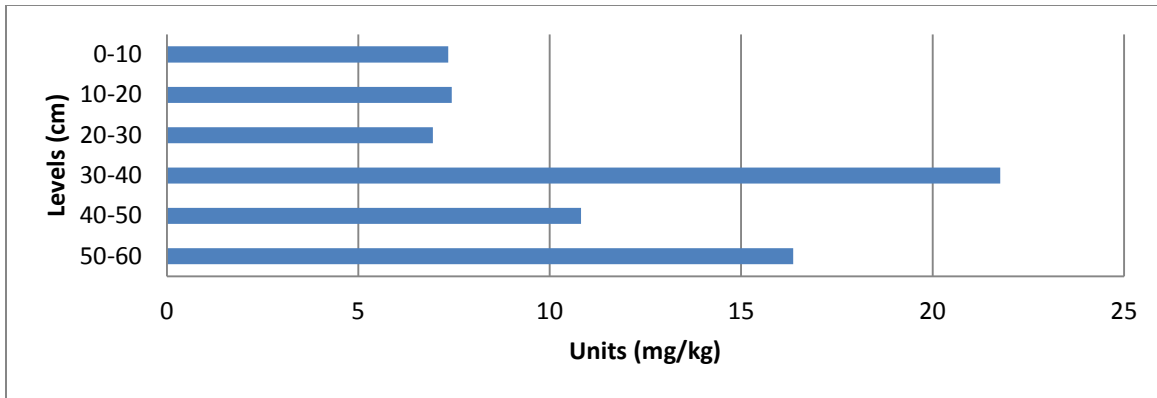


Figure 5: Sodium Levels from column sample at Killer Bee.

Killer Bee is located further inland from open water and tidal fluctuations. Witz Naab is actively eroding due to tidal fluctuations. Witz Naab’s geographic setting could account for the increased sodium levels for the deeper stratigraphic levels. The individual samples indicate the same pattern of increased sodium levels within the deeper levels. The sodium levels ranged between 11 – 258mg/kg. Samples C and D from the east wall profile and H, I, J, and K from the west wall profile were collected below ~130 cmbs (Figures 2-3).

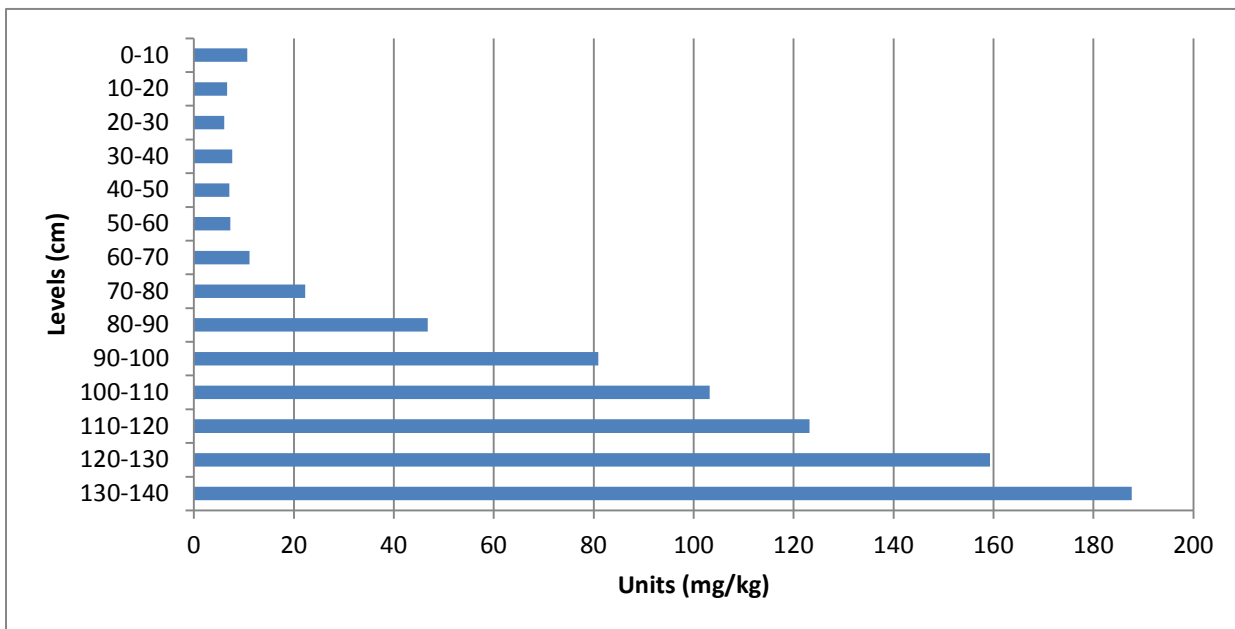


Figure 6: Sodium Levels from column sample at Witz Naab.

Magnesium levels for the column samples varied between 7 – 21 mg/kg within Killer Bee (Figure 7) and 10 – 117 mg/kg within Witz Naab (Figure 8). The magnesium levels for the individual samples ranged from 14 -101 mg/kg.

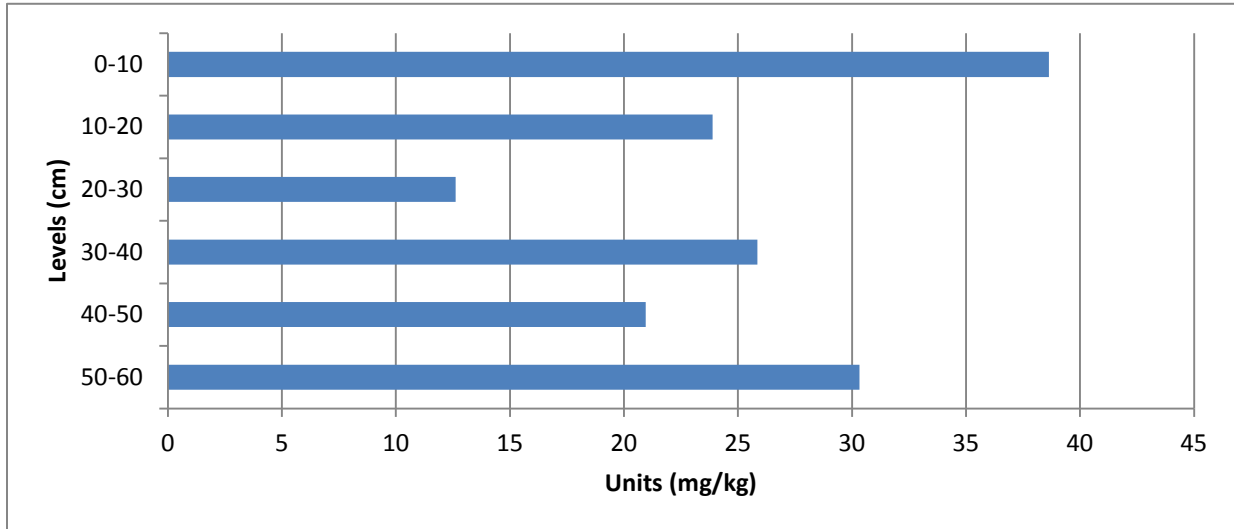


Figure 7: Magnesium Levels from column samples at Killer Bee.

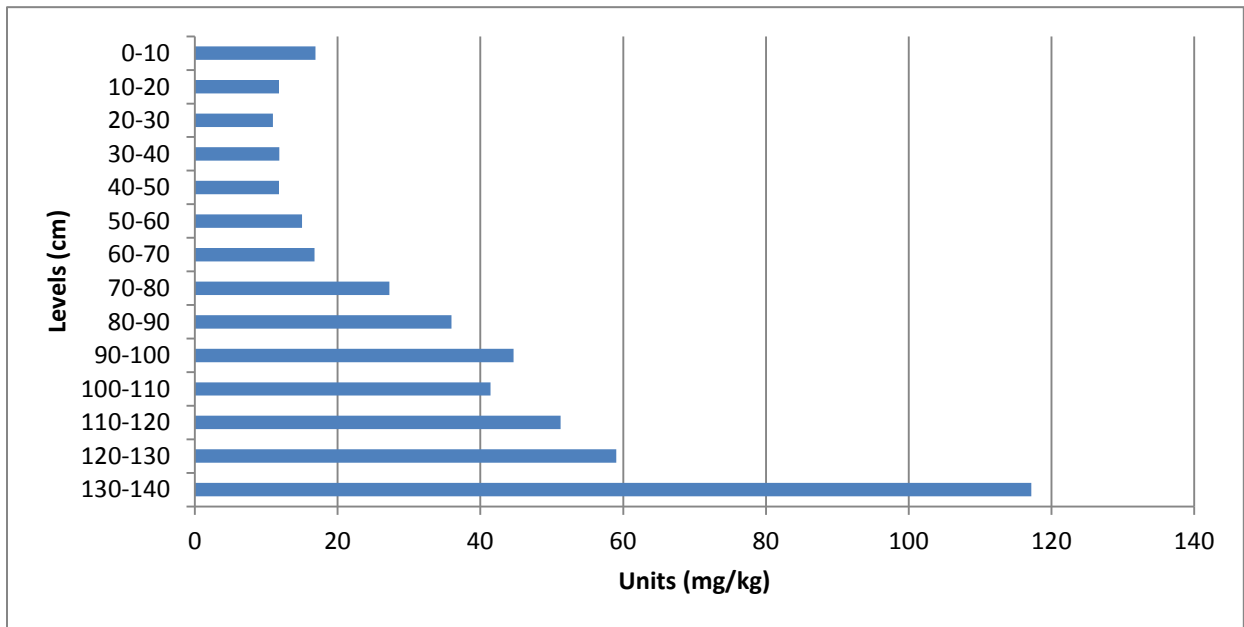


Figure 8: Magnesium Levels from column sample at Witz Naab.

Aluminum levels for the column samples ranged from 24 – 124 mg/kg at Killer Bee (Figure 9) and 28 – 127 mg/kg (Figure 10) at Witz Naab. Individual sample aluminum levels ranged from 19 – 170 mg/kg. Killer Bee calcium levels varied 24 – 124 mg/kg (Figure 11) whereas Witz Naab levels are between 40 – 228 mg/kg (Figure 12). Calcium levels for the individual samples ranged from 48 – 219mg/kg.

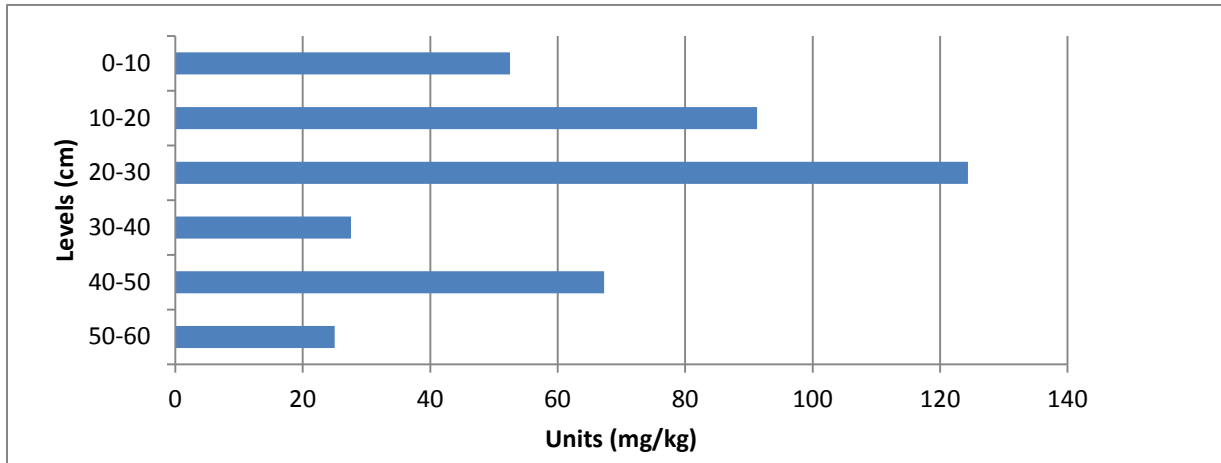


Figure 9: Aluminum Levels from column sample at Killer Bee.

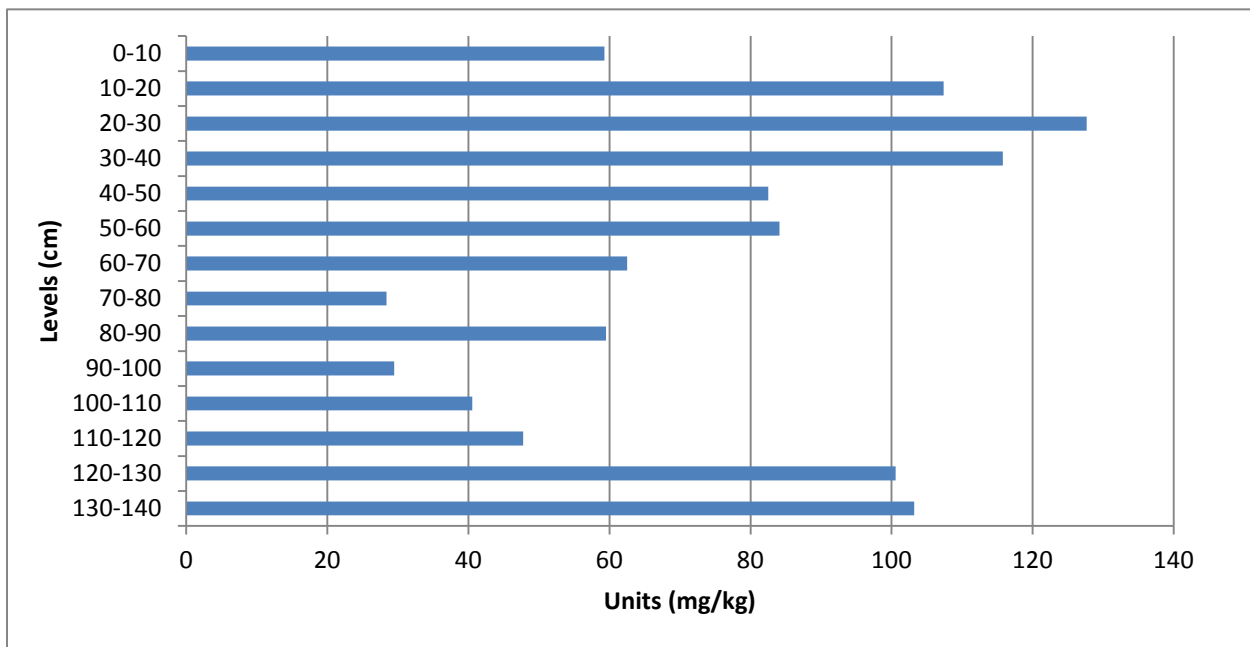


Figure 10: Aluminum Levels from column sample at Witz Naab.

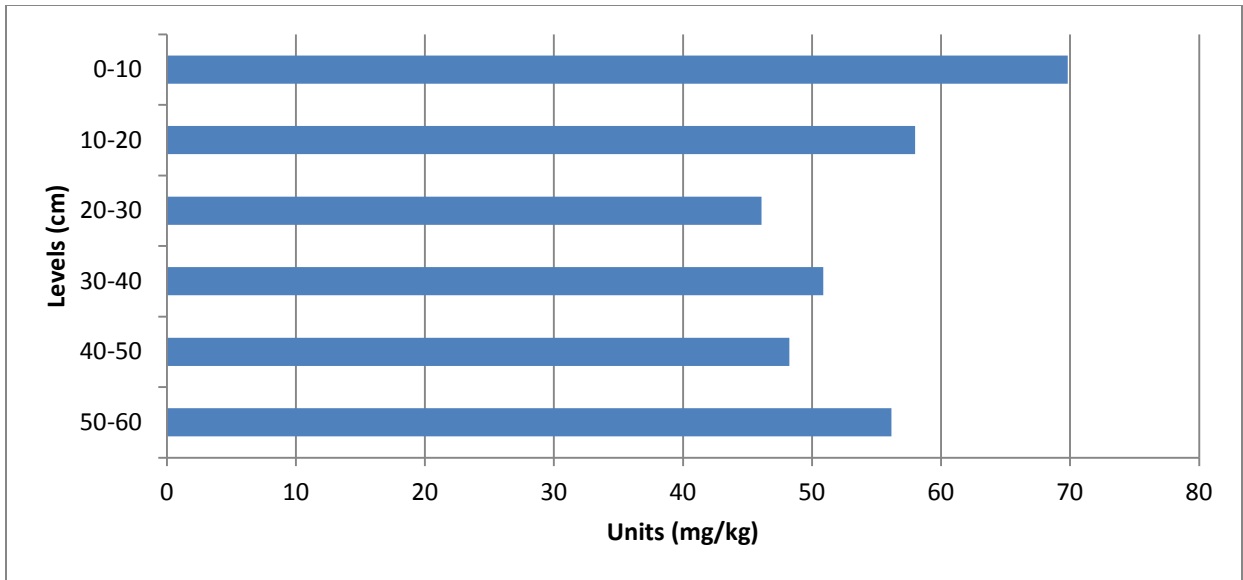


Figure 11: Calcium Levels from column sample at Killer Bee.

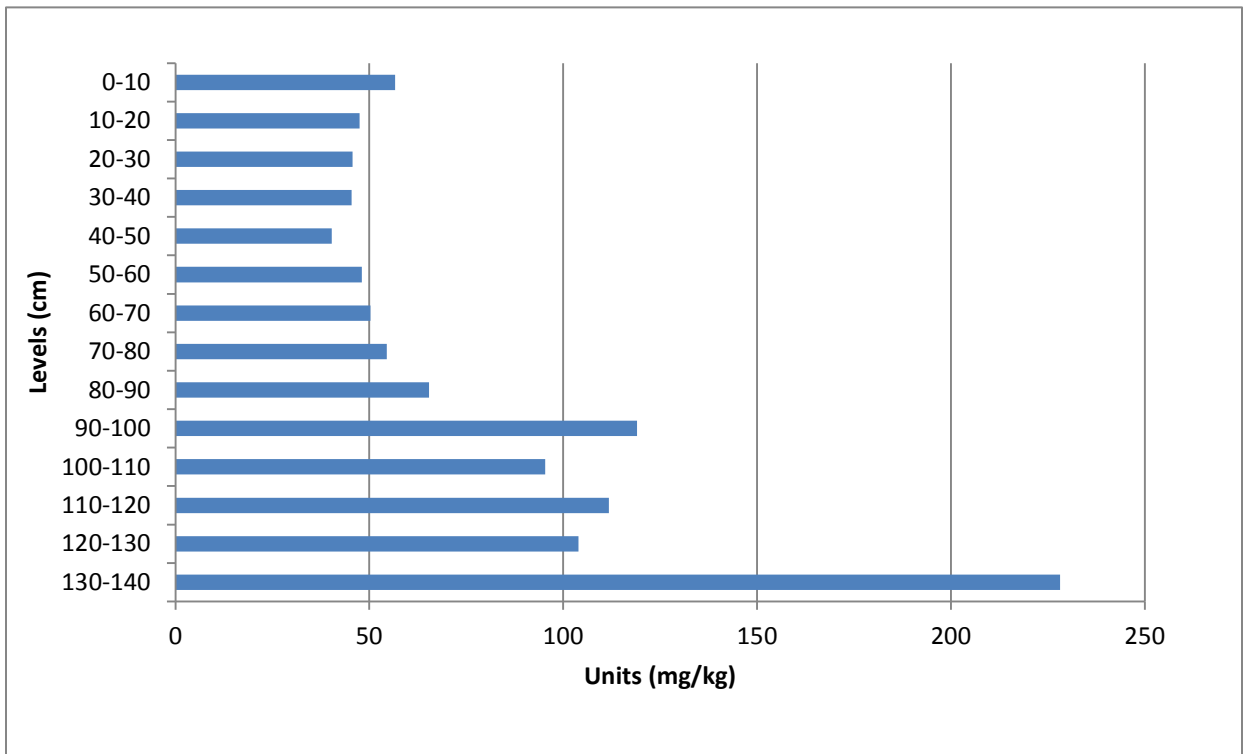


Figure 12: Calcium Levels from column sample at Witz Naab.

The iron levels were between 2 – 45mg/kg at Killer Bee (Figure 13) and 2 – 11mg/kg at Witz Naab (Figure 14) within the column samples. The individual samples iron levels ranged between 6 – 77mg/kg. The variation in Fe levels could indicate further evidence of burning.

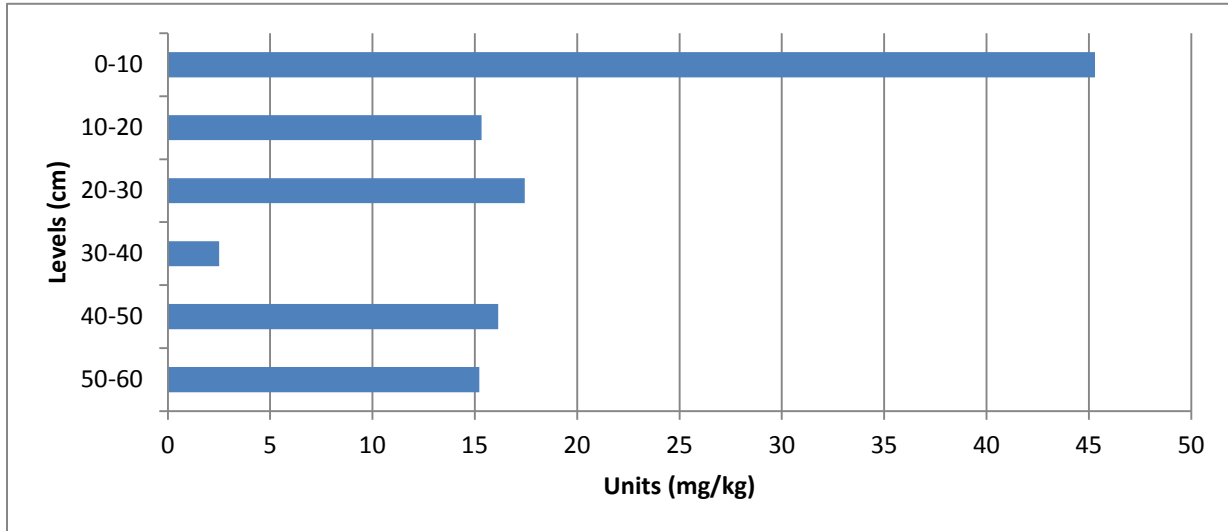


Figure 13: Iron Levels from column sample at Killer Bee.

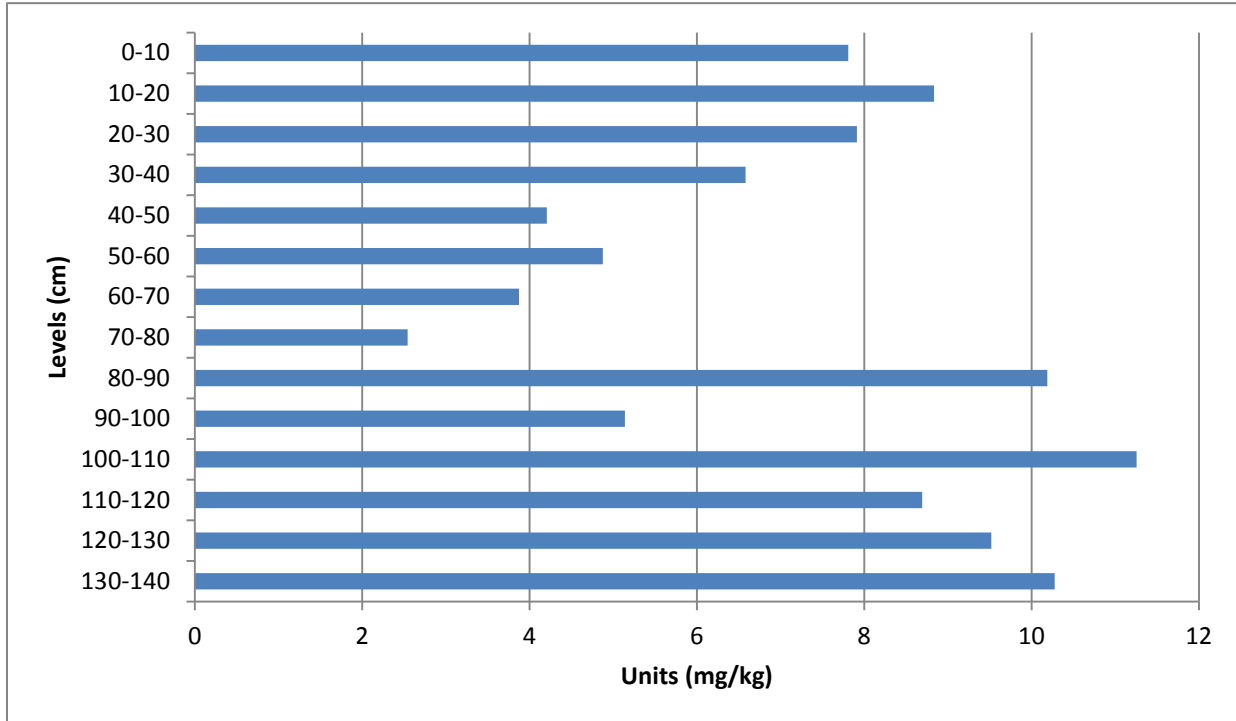


Figure 14: Iron Levels from column sample at Witz Naab.

Individual samples were collected from several charcoal layers SS- E-K (Figures 15-20), which were present in the excavation of Witz Naab. Once again, sodium levels increased in the deposits that were closer to the water table with a mean of 226mg/kg. Calcium, magnesium, aluminum, iron, and strontium have a mean of 269mg/kg, 120mg/kg, 194mg/kg, 24mg/kg, and 5mg/kg. We identified a potential work surface/floor within the east wall of Witz Naab. The surface (SS-D) is approximately 2 cm thick and unlike any of the other layers within the mounds. The chemical analysis indicated an elevated level of sodium and calcium (Figure 21). The remaining elements were present at such small levels they do not appear to indicate significant human activity and occur naturally at these levels in the soil (Table 4).

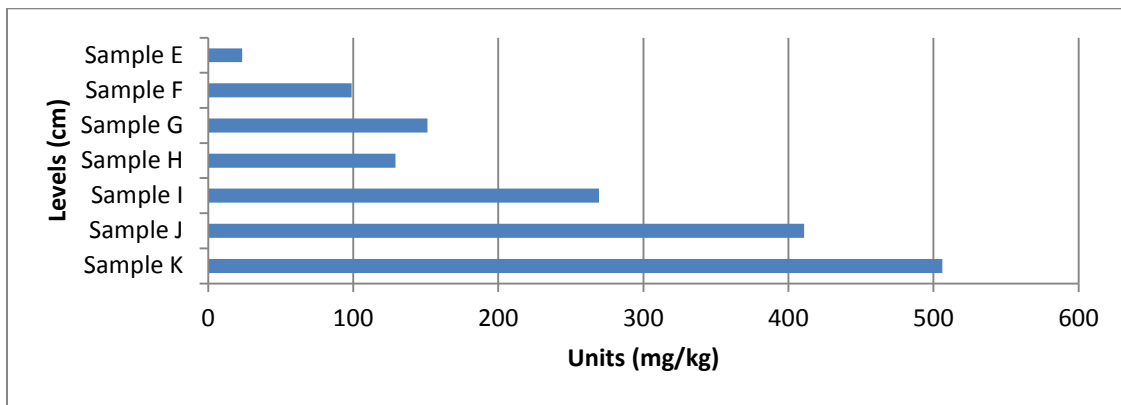


Figure 15: Sodium Levels SS E-K

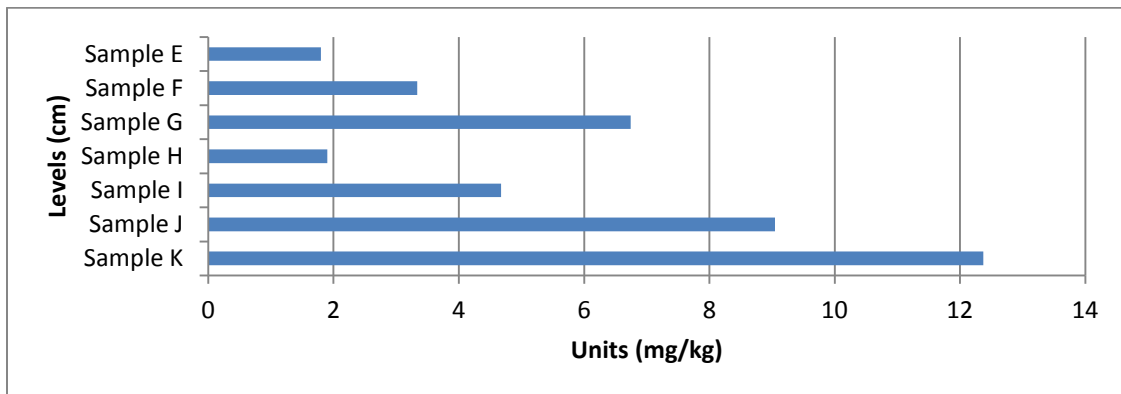


Figure 16: Strontium Levels SS E-K.

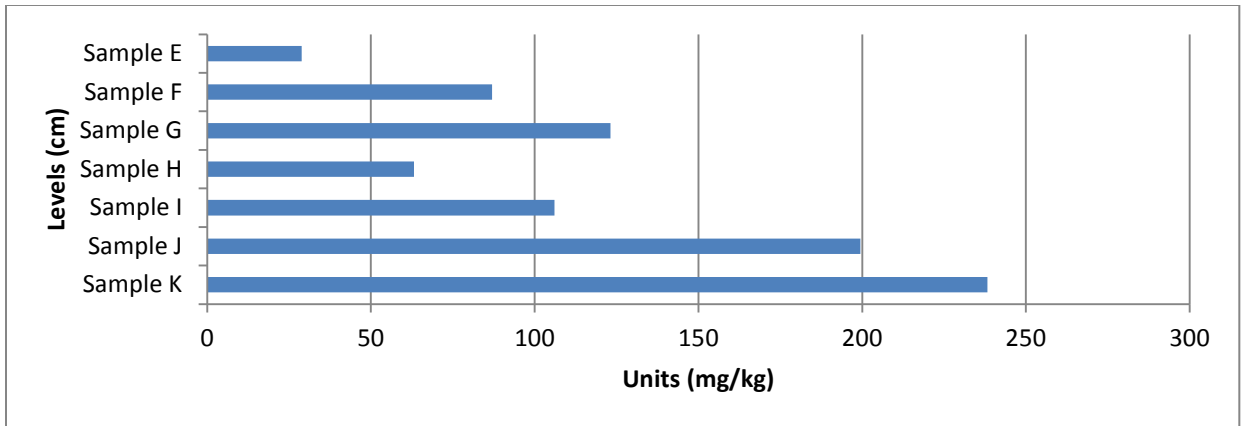


Figure 17: Magnesium Levels SS E-K.

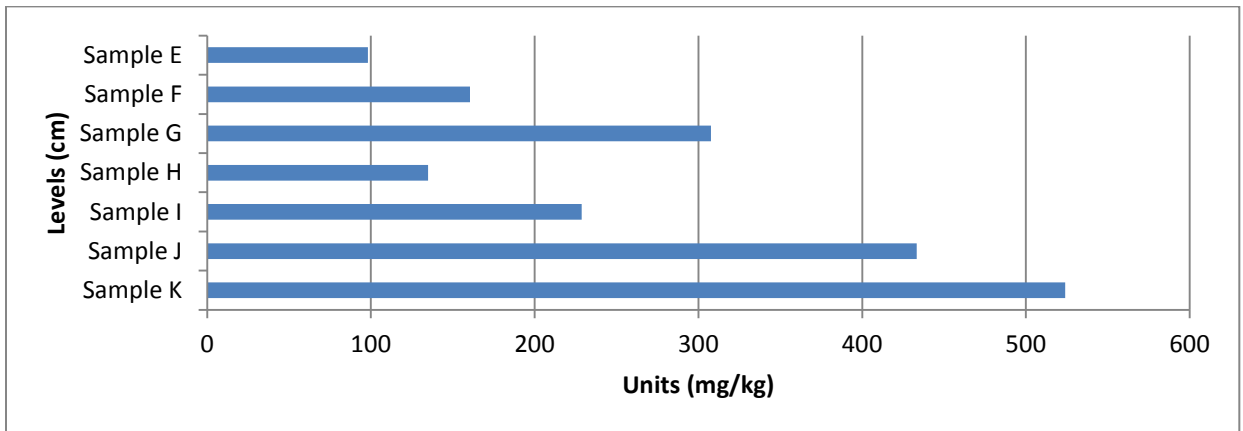


Figure 18: Calcium Levels SS E-K.

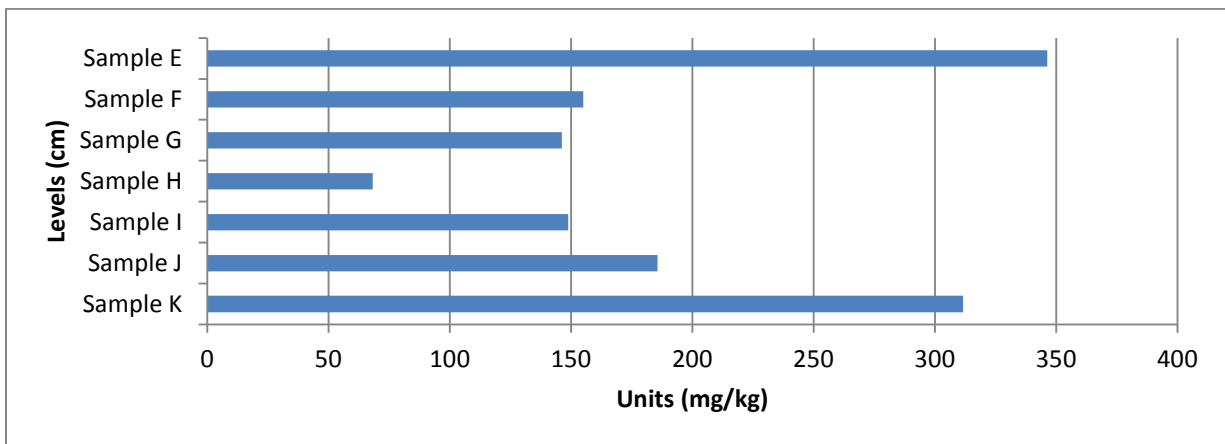


Figure 19: Aluminum Levels SS E-K.

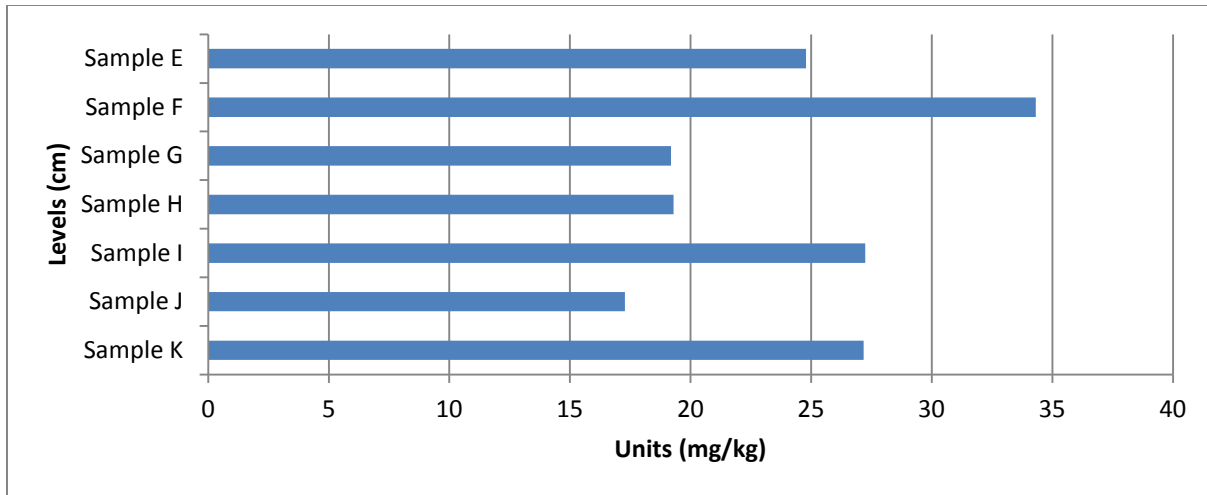


Figure 20: Iron Levels SS E-K.

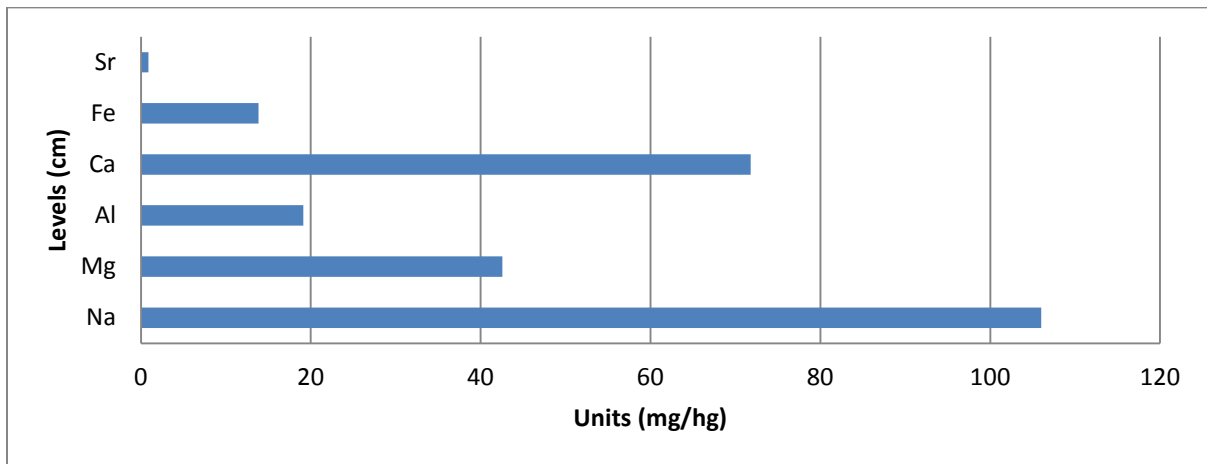


Figure 21: Chemical Levels for SS-D at Witz Naab.

Table 4: Average of Elements for Killer Bee and Witz Naab.

Barium (Ba)	2.186	Strontium (Sr)	1.578	Chromium (Cr)	0.025
Copper (Cu)	0.492	Zinc (Zn)	0.302	Cobalt (Co)	0.025
Lead (Pb)	0.128	Titanium (Ti)	0.088	Yttrium (Y)	0.319
Mercury (Hg)	0.003	Vanadium (V)	0.339	Uranium (U)	0.021
Nickel (Ni)	0.041				

Discussion

All of these elements occur naturally in both the soil and seawater to varying levels. Elevated levels of calcium and magnesium at salt production sites in China are believed to be part of the natural mineral concentration in the brine (Flad et al.2005:12620). Calcium, magnesium, and sodium are positively charged cations common in water. Positively charged cations will adhere to negatively charged silt and clay particles (Pearson 1960). The presence of clay accounts for elevated levels of calcium, magnesium, and calcium selected for brine enrichment. Elevated levels of sodium would make the soils unsuitable for agriculture.

Ethnoarchaeological examples have illustrated some interesting patterns of chemical signatures for identifying activities areas. According to the Middleton's research at sites in Mexico, Canada, and Europe food production hearths have elevated levels of potassium, magnesium, and phosphorus (Middleton and Price 1996; Middleton et al.2010). Sodium, potassium, magnesium, and phosphorus were elevated in areas where wood ash is found (Middleton and Price1996; Middleton et al.2010:5). In-situ burning enhances the amount of detectable iron and aluminum (Middleton et al.2010:5).

The Witz Naab and Killer Bee mounds were not used as living surfaces. They are the discard evidence of both brine enrichment and cleaning refuse from indoor structures after the evaporation process. No artifacts associated with domestic activities were recovered at either site. The ceramics recovered were used for salt production. This evidence coupled with the extremely low phosphorus levels supports our argument that these spoil features. Elevated levels of calcium and magnesium may have been desirable elements within the soils selected for brine enrichment. The low levels of phosphorus in combination with the elevated levels sodium and magnesium within the charcoal layers indicated these are the remnants of hearths utilized in the

evaporation of brine in pots over fires to make salt. The charcoal layers were re-deposited in the mound when the salt workshop was cleaned after evaporation event. Phosphorus would not have had to bind to the soil/charcoal refuse before the floor was swept clean for the next burning. Furthermore, we do not see a fired surface within the mounds that would be associated with a hearth. Sample D could have been the remnants of an original work surface. The sample had a phosphorus level of 3mg/kg that is low when compared to other examples from food preparation areas. Charcoal layers J and K had elevated phosphorus levels when compared to other samples, 9 and 8 mg/kg respectively. Perhaps the two charcoal levels were not cleaned and re-deposited as quickly as other layers.

The soil chemistry of the column samples from earthen mounds at Witz Naab and Killer Bee underscore their use as a discard area from the brine enrichment process at the Paynes Creek Salt Works. The results provide a model for the 103 underwater salt works nearby where earthen mounds would have been leveled by waves and storms. At Witz Naab and Killer Bee, the soil chemistry supports non-domestic use with low phosphorus, magnesium, and sodium, except in the inundated deposits. The abundance of these elements in the inundated deposits may reflect the natural levels that are found in the lagoons brackish water. These elements are among the most common.

The soil chemistry supports the interpretation of salt production at the Paynes Creek Salt Works is similar to ethnographic and historical production elsewhere, including the Maya highland salt works at Sacapulas, Guatemala and Nexquipayac, Mexico. From historical and ethnographic accounts, salt production is seasonal and was organized at the household level but that a more complex strategy may have been employed in the distant past (Parsons 2001:191). Salt workers at lagoon sites constructed ephemeral, temporary structures for production and

occupation while the permanent settlement was further inland (Parson 2001:192). This pattern has been noted at the Paynes Creek salt works except the wooden structures are preserved due sea level rise and mangrove peat formation (McKillop 2002, 2005, 2008; McKillop et al. 2010).

The coastal Maya of the Paynes Creek salt works were producing more salt than could have been used by the local populations. Trade goods from the interior Classic centers of have been found at the salt works. However, there is no evidence of over-site or control from Maya elites. To date, there does not appear to be a formalized organization to the workshop alignment that would be expected with single over-site. The Paynes Creek salt works appear to demonstrate a market driven response to a commodity need, similar to the market space at Chunchucmil.

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CHAPTER 5: SUMMARY

The excavations at Witz Naab and Killer Bee are important to understanding the practice and development of salt production. Furthermore, understanding the construction of these features add to the interpretation and understanding of economic and social organization of the coastal Maya in the Port Honduras region during the Late Classic. The excavated data, when used in conjunction with ethnographic information, demonstrates the subtle complexities of salt production within the Punta Ycacos lagoon.

Four possible functions for the mounds were hypothesized; that the mounds were leaching mounds, or the mounds were residences for the salt workers, or the mounds served as an administrative structure, or the mounds were a combination or one of the functions mentioned above. Excavation, ceramic analysis, soil chemistry analysis, and ethnographic comparison were used to determine the function on the mounds. These analytical techniques were used to interpret how the Paynes Creek salt works function within three trade models: household, tribute, or alliance trade. Furthermore, interpretation of the stratigraphy and artifacts were used to interpret scales of production, social organization, and coastal/inland interactions.

The mounds are not the remains of domestic structures where the salt workers lived based on the interpretation of the stratigraphy and artifact analysis. The mounds at Witz Naab and Killer Bee are the result of brine enrichment for salt production. The majority of artifacts recovered at Witz Naab were associated with salt production. Some ceramics not associated with salt production were recovered from the deposits below the water table in Unit 3-4m in Witz Naab. The ceramic assemblage at Killer Bee was exclusively salt making ceramics. The minimal variation in the artifact assemblage demonstrates that these mounds were not used for domestic occupation. The deeper deposits at Witz Naab could have another function; however, further excavation and analysis would be needed to interpret these deposits.

Wild Cane and Frenchman's Cay contained a variety of artifacts including different types of ceramic styles and forms, obsidian, chert, manos and other mainland stone artifacts in the identified domestic deposits. Multiple floors identified within the architecture indicated multiple construction episodes at nearby Wild Cane Cay and Frenchman's Cay. Burials were encountered at Wild Cane Cay. The mounds at Wild Cane and Frenchman's Cay are similar to other Maya domestic mounds except for the building material. Coral rock and finger coral were used to construct the platforms instead of soil or stone.

There is no evidence that the mounds at the Paynes Creek salt works served as administrative structures. Warrie Red unit-stamped jars, Moho Red bowls, and ocarinas, suggest a connection with the inland Classic Maya centers there is no evidence that the salt works were controlled or managed by these centers. The coastal Maya traded salt and possibly other coastal commodities for these trade goods. Status items such as these would have been used during ceremonies performed before the salt production began, reinforcing the connection between producer and consumer. The coastal Maya of the region were producing amounts of salt beyond the need of a household level. The expansion of the population during the Classic period presented an opportunity to the coastal Maya to participate in an entrepreneurial system of salt production.

The specialty function of the mounds at Witz Naab and Killer Bee support the idea that coastal Maya participated in alliance trade with the interior Maya. The spatial patterning of the salt workshops does not indicate a formalized layout. The alliance between the coastal and inland Maya was based upon the desire for access to goods. The island sites of Wild Cane Cay and Frenchman's Cay were occupied from the Classic through the Postclassic and had coral platform mounds that mimic mainland style architecture. The elites on the coastal sites would have

wanted access to the goods provided by the interior Maya. Conversely, the interior Maya would have desired the access to salt and other ritual coastal goods.

Descriptions of excavations at Guzman Mound, Guatemala, and Wits Cah Ak'al, Belize were used for comparison to interpret the mounds at Witz Naab and Killer Bee. The mounds at Cah Ak'al, Witz Naab, and Killer Bee have some commonalities. Briquetage was recovered at all three sites. In-situ hearths were noted at Cah Ak'al. However, some of the mounds at Cah Ak'al were not associated with salt production.

The salvage excavation at Guzman indicated that the stratigraphy was different from either of the mounds at the Paynes Creek salt works. In situ hearths were identified at Guzman. However, clay cylinders were not identified as part of the artifact assemblage at Guzman. Cylinders were recovered at Witz Naab and Cah Ak'al. This difference could be due to the fact the Guzman is associated with Preclassic Period. The salt assemblage at Witz Naab, Killer Bee, and Wits Cah Ak'al are identified as Late Classic Period deposits exemplifying temporal differences

The stratigraphy at Witz Naab indicate there was a possible shift in the scale of production. The seasonal aspect of salt production has been established through ethnographic accounts. We do not have the evidence to discuss seasonality, but there is evidence of periodic construction at Witz Naab. Multiple construction episodes were noted at Witz Naab. Specifically, the lower construction episodes indicate multiple depositional events. Multiple charcoal layers indicate multiple burning events. The uppermost layer at Witz Nabb is the result of a massive shift in production to meet increased consumer demand as the population expanded in the southern Maya lowlands. Discard of briquetage appears to be quickly collected and dumped to make way for the next evaporation session

Domestic deposits would contain midden deposits associated with food preparation. The presence of food refuse would have a higher organic content. No midden deposits were identified at Witz Naab or Killer Bee. The loss-on ignition results indicate that there was little organic material within the mound at Witz Naab and Killer Bee.

Chemical analysis at Witz Naab and Killer Bee strengthens the evidence that the Paynes Creek Salt Works were workshops for specialized production. The wooden posts at the inundated workshop locations are the remains of buildings for salt production. Rainfall in southern Belize would have made outdoor evaporation risky. The evaporation process would have occurred indoors to protect the commodity. We believe this to be the remnants of mounds similar to those at Witz Naab and Killer Bee. Indoor brine evaporation explains the lack of hearths in the Witz Naab mound.

The chemical analysis produced low phosphorus levels. Domestic deposits would produce higher phosphorus levels based upon published accounts from other sites. Elevated levels of sodium and magnesium, low levels of phosphorus, and the charcoal layers indicated these are the remnants of evaporation of brine by fire utilized to produce salt. Activity areas utilized for food production have elevated levels of potassium, magnesium, and phosphorus. Elevated levels of sodium, potassium, magnesium, and phosphorus are associated with wood ash. Also, we did not observe fired surface within the mounds that would be associated with a hearth. Hearth surfaces have been identified at other sites at the Paynes Creek salt works. Soil chemistry evidence from Witz Naab and Killer Bee confirm their use as brine enrichment and salt production discard. Patterns noted at Witz Naab and Killer will be used as a model for the interpreting future excavations.

APPENDIX: CONSENT LETTERS



July 10, 2015

Dr. John Morris,
Director,
Institute of Archaeology,
National Institute of Culture and History
Culvert Road,
Belmopan, Belize, C.A.

Dear Dr. Morris:

I am writing to request permission to use a reprint of the following article for use within the dissertation of Rachel Watson, Ph.D. candidate in the Department of Geography and Anthropology, Louisiana State University. This reprint will be available via the web on the Electronic Thesis and Dissertation Library.

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2012 Brine Enriching Slag Heaps or Mounded Remains of Salt Makers Homes? Earthen Mounds in the Mangroves at the Paynes Creek Salt Works. *Research Reports in Belizean Archaeology* 10:297-304.

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Sincerely,

Heather McKillop, Ph.D.
Doris Z. Stone Professor of Latin American Studies
Chair, LSU Graduate Council



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15th July 2015

Dr. Heather McKillop
Doris Z. Stone Professor of Latin American Studies
Chair, Louisiana State University Graduate Council

Dear Dr. McKillop:

I hope this letter finds you well.

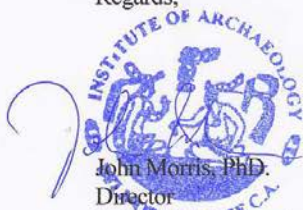
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If there are any concerns kindly contact the Institute of Archaeology, NICH at ia@nichbelize.com or 822-2106/2227.

Regards,



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VITA

Rachel Mariah Watson, a Louisiana native, received her bachelor's degree in Anthropology at Louisiana State University in 1996. She received her master's degree in Anthropology at Louisiana State University in 1999. Her MA thesis explored the function of an ancient Maya coral mound on Frenchman's Cay, Belize. In 1992, she went to work as student employee at the Louisiana Division of Archaeology. As a student, she assisted the Section 106 reviewer and was trained in implementation of the National Historic Preservation Act and National Environmental Policy Act within the State Historic Preservation Office. Upon completion of her MA, she went to work as a full time permanent employee as the Section 106 reviewer. She helped develop and manage a comprehensive statewide geographic information system and was promoted to an Archaeologist Manager position. She will receive her doctorate in August of 2015 and plans to transition from a government archaeology position to a tenure-track academic position.