Mapping Ancient Maya Wooden Architecture on the Sea Floor, Belize

Heather McKillop
Department of Geography and Anthropology, Louisiana State University, Baton Rouge, LA 70803

The discovery, mapping, and analysis of inundated saltworks in southern Belize between 2004 and 2008 are described and evaluated in terms of the ancient Maya salt industry and trade. The saltworks consist of extensive briquetage, or pottery used to boil brine over fires to make salt, associated with wooden structures preserved in a peat bog below the sea floor. A geographic information system was used to analyze the spatial patterning of wooden posts and artifacts for 103 underwater saltworks. The wooden structures and a canoe paddle underscore the extensive infrastructure of the Late Classic Maya salt industry in Belize.

Introduction

Since wood normally decays in the tropical landscape of Central America, the discovery of submerged wooden structures related to salt production preserved in a peat bog below the sea floor in Belize provides the only known examples of wooden architecture of the Classic Maya civilization (A.D. 300-900). Stone temples and palaces of the dynastic kings and queens are a lasting document of elite architecture (McKillop 2006). In contrast, wooden architecture, which surely dominated the ancient cultural landscape (Haviland 1985), was previously known from modern and historic Maya buildings (Wauchope 1938; Redfield and Villa Rojas 1962; Ochoa-Winemiller 2004), but had not been reported for the ancient Maya.

Mangrove peat created during Holocene sea level rise preserved wooden structures in a shallow saltwater lagoon system in Paynes Creek National Park on the coast of southern Belize (Figure 1). As well as providing baseline information on perishable architecture of the Classic Maya, the Paynes Creek architecture documents wooden structures used in salt production. The discovery suggests that there was a massive salt industry along the coast of Belize capable of supplying a significant portion of the demand for salt of the urban Maya at inland cities during the height of the Late Classic Maya civilization (McKillop 2005a).

Environmental Setting

Paynes Creek National Park consists of a large saltwater lagoon system in southern Belize, with a mangrove ecosystem dominated by red mangroves (*Rhizophora mangle*), with black mangroves (*Avicennia germinans*) and white mangroves (*Laguncularia racemosa*) on marginally dry land. The area is subject to tidal variation of about 50 cm, except in winter when isolated north winds expose large shallow areas of the sea floor for several days. The lagoon system is a Holocene development, resulting from marine transgression that created the Belize Barrier Reef, the offshore cays, and the inshore lagoon (McKillop 2002). A layer of mangrove peat up to 9 m in depth overlying the limestone platform of the southern lagoon reflects a significant rise in sea level during the Holocene.

At some settlements, such as the trading port of Wild Cane Cay, Classic period deposits are submerged, but the extensive Postclassic period settlement (A.D. 900-1500) outpaced sea level rise (McKillop 2005b). Other Classic Maya sites, such as Pelican Cay, were inundated and lie buried beneath mangrove peat, invisible from the modern ground surface of red mangroves (McKillop 2002). Although the timing and rate of submergence of the saltworks at Paynes Creek is unknown, they must have been on dry land when they were in use during the Late Classic period and were subse-

quently drowned by rising sea levels. Since the wooden posts were driven into mangrove peat at the time of construction, sea level rise must also have occurred prior to the establishment of the Late Classic saltworks. Ongoing analysis of sediment cores from the lagoon may clarify the timing and rate of submergence of the saltworks (McKillop et al. 2009).

Previous Investigations of Underwater Maya Saltworks

Previous research included the discovery and excavation of four saltworks in Paynes Creek National Park, including three underwater sites and one site in the adjacent mangrove swamp (McKillop 1995, 2002). The saltworks were marked by briquetage, or broken pottery vessels and supports used to boil brine in pots over fires to make salt. Brine boiling and solar evaporation, in which salt is evaporated in natural and artificial ponds, are widespread historic and prehistoric methods of salt production (Adshead 1992). Until the discovery of briquetage at the Paynes Creek sites and elsewhere on the coast of Belize (McKillop 1995; MacKinnon 1989; Valdez and Mock 1991), Maya archaeologists assumed that salt was imported from the north coast of the Yucatan Peninsula to the southern Maya lowlands of Guatemala and Belize during the Classic period (Andrews 1983). With the discovery of the Belize saltworks, questions about Maya salt making have focused on the energetics of production and transportation of salt. In particular, could enough salt have been produced on the coast of Belize to supply most or all of the inland demand during the Late Classic period?

Standardization of containers used to boil brine at Paynes Creek suggests mass production of salt (McKillop 2002). The salt making vessels and their supports were compared with pottery from household midden deposits at nearby Wild Cane Cay. The average median variation statistic (AMV) was calculated to compare the variation of orifice diameter of the pottery vessels and the diameter of the vessel supports. The AMV provides the variation from a median value, and therefore it is not skewed by outlier measurements or by samples that depart from a normal curve, as can occur when using the coefficient of variation (McKillop 2002). The Paynes Creek salt jars were standardized in their dimensions (AMV = 9.5 for 132 vessels, with a median of 21.9 cm) when compared with the Wild Cane Cay pots (AMV = 20.6 for 245 vessels, with a median of 31.8 cm). Additional comparisons underscored the standardization of the Paynes Creek salt making artifacts, but left lingering questions about the limited amount of salt produced by four saltworks in relation to the high demand for salt that would have been generated by the hundreds of thousands of urban Maya living in adjacent inland areas (McKillop 2002).

The Search for Additional Underwater Saltworks

A comprehensive underwater search began in 2004 in Paynes Creek National Park to locate additional saltworks. A modified form of pedestrian survey was used, with a team walking shoulder to shoulder in lines through shallow water less than 1 m in depth. Saltworks were identified visually by the presence of briquetage on the sea floor. Site mapping and sampling were undertaken by placing a site marker made from 0.5 in. PVC pipe in the sea floor, taking a GPS reading, collecting 30 measurable rims and vessel supports, and recording water depth. Artifacts were sorted into types and dried onboard the research vessel. Measurement of the rims and vessel supports underscored the standardization of dimensions found in the earlier study. The discovery of additional sites indicated that salt production was indeed more extensive than suggested by the four saltworks initially identified.

An unexpected discovery in 2004 at site 15 led to the realization that Paynes Creek salt production was a massive industry with an extensive infrastructure. Excavation of what appeared to be naturally occurring wood revealed a post with a sharpened end that had been driven into the ground. The post was

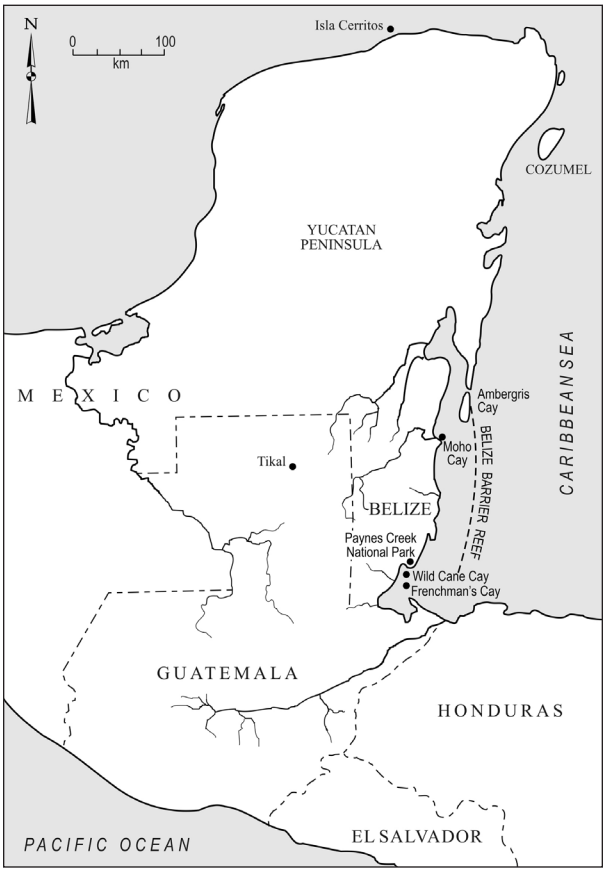

FIGURE 1. Map of the Maya area showing location of Paynes Creek National Park. (Map by Mary Lee Eggart, Louisiana State University.)

waterlogged but retained the natural color and structure of the wood. While the upper end of the post was worm-eaten and decayed where it protruded from the sea floor, the lower tip of the post that was embedded in the peat and silt was well preserved with clear tool marks. Survey revealed additional posts in the sea floor associated with briquetage, but without accurate mapping instruments, the patterning of the posts was not evident. A radiocarbon date of 1300 B.P. ± 60 years places the posts in the Late Classic period, and is supported by the Late Classic pottery at the site (McKillop 2005a). Following the discovery of posts at site 15, the team revisited the other sites located during the survey, and found posts at all of them. Clear evidence had been found of wooden structures built by the ancient Maya, preserved in a peat bog below the sea floor.

The discovery of posts outlining wooden structures indicated that salt production took place indoors and that a significant infrastructure was involved in the production, storage, and distribution of salt, fuel, pots, and furniture in the ancient Maya salt industry (McKillop 2005a). The initial study of the saltworks based only on the briquetage had suggested a more ephemeral imprint on the landscape, consisting of small groups working outdoors, as represented in an artist's reconstruction based on this description of the salt making process (Mosnier 1994). However, at Paynes Creek, salt production was evidently undertaken indoors, in a manner similar to that documented at an historic saltworks associated with a salt spring at Sacapulas in the highlands of Guatemala (Reina and Monaghan 1981) and at other historic and prehistoric sites worldwide (Adshead 1992). At Sacapulas, some two dozen bowls are supported over a fire inside a salt making building and brine is poured continuously into the vessels as the contents evaporate, until salt crystals fill the bowls. The loose salt is either transferred to large storage jars or the bowls are turned over on the fire to bake the salt into solid cakes. In addition to manufacturing and storing salt, the building is used to store firewood and pots, as well as discarded and broken vessels. In Paynes Creek, where there is significant rainfall year-round, producing salt indoors would have provided protection from the elements.

New Techniques for Locating Wooden Architecture Underwater

There is a long history of underwater archaeological studies in the Maya area (Andrews and Corletta 1995; Romey 2004) and elsewhere in Latin America (Leshikar-Denton and Luna Erreguerena 2008), which were useful in developing a methodology appropriate for the Paynes Creek research. At Paynes Creek, survey techniques were modified to protect the underwater saltworks from potential damage caused by walking on the sites and to enhance visibility of the sea floor, in order to find posts that protruded only slightly above the sea floor into a lens of loose silt (Figure 2).

FIGURE 2. Survey of underwater sites in Paynes Creek National Park, with flags marking wooden post locations. Insets show details of wooden posts. (Photos by author.)

The team snorkeled on Research Flotation Devices (RFDs), swimming shoulder to shoulder in lines traversing sections of the lagoon to locate posts and to define the boundaries of the associated briquetage. Post locations were marked using wire or plastic survey flags in depths less than 30 in. (McKillop 2005c, 2006, 2007a). For deeper sites, floats attached to fishing line were skewered into the sea floor with wire to mark post locations. Post and artifact numbers were written on the flags or on survey tape attached to the floats using a permanent marker. Lines of posts were evident from flags visible above the water surface. Sites deeper than 1.3 m will require the use of scuba or surface-supplied diving equipment to locate and mark posts in the future.

Sites were mapped using a Topcon total station from permanent datum markers made from PVC pipes sunk into cement and located using GPS. All posts and selected diagnostic artifacts were piece-plotted by placing the prism pole on the center of the post or artifact. The digital data were transferred to Microsoft Excel spreadsheets and attached to the project geographic information system (GIS) Underwater Maya, created using Intergraph GeoMedia software. Initial site maps were used to reexamine sites in order to locate additional posts in areas indicated by patterns that were evident on the map, but difficult to discern in the water using flags and floats. The site revisits were successful at locating additional posts and refining building footprints.

Wood samples were cut from posts for wood species identification and for radiocarbon and dendrochronological dating. Representative artifacts were collected to develop a ceramic chronology. Each flag was furled, covered with a plastic straw, and sunk into the sea floor beside the appropriate post to help in future relocation. Wood samples and representative artifacts were transported to Louisiana State University under temporary export permits for conservation and study. Selected artifacts were conserved under the direction of Wayne Smith at Texas A&M University's Archaeological Preservation Research Labora-

tory using the polymer process (Smith 2003), which is expected to be especially useful for artifacts that will be returned to Belize, where humidity and temperature control are limited.

Spatial Analysis of Wooden Posts

GIS analysis of the posts revealed patterns in the distribution of the sites and in the arrangement of posts within individual sites. Site boundaries were estimated based on the distribution of artifacts and posts on the sea floor. The distance between sites varies, but is generally determined by an absence of surface artifacts and wooden posts. Mangroves have obscured the spatial extent of some sites that extend under vegetation (Sills 2007). However, most of the sites are clearly demarcated and it is usually evident where mangroves have obscured parts of sites (Somers 2007).

Rectangular structures are evident in the distribution of wooden posts at some of the saltworks, notably sites 74, 75, and 77. Some sites have more than one rectangular structure. The distribution of posts shows interior walls for some buildings, such as at site 75. The structures vary in size.

In the absence of evidence for other ancient Maya wooden structures, comparisons were made with modern Maya wooden buildings. Wauchope (1938) noted that load-bearing posts were located at the corners of buildings, with smaller posts on the walls. Using the thematic tool in Geomedia, the Paynes Creek post diameters were divided into the size ranges established by Wauchope (1938). At site 75, for example, load-bearing posts of similar diameters to those described by Wauchope, were observed at the corners (Figure 3).

Lines of posts made from palmetto palm (*Acoelorraphe wrightii*) were found at many of the Paynes Creek underwater sites. In some cases, the lines of posts abut the walls of rectangular structures. In other cases, the lines of palmetto posts are up to 10 m away, suggesting a role in land retention or in delimiting the boundaries of saltworks. Elsewhere, lines of small posts mark the walls of saltpans (Andrews 1983).

Two saltworks located in the mangroves have earthen mounds that may be slag heaps created when brine was leached through salt-saturated soil. Excavations of the earthen mound at the Killer Bee saltwork support this interpretation (McKillop 2002:49). There were no stone foundations and few artifacts were recovered that suggested the features were mounded remains of structures. Slag heaps at the underwater saltworks would now be submerged below sea level (McKillop 2002:49). The brine-boiling method of salt production typically uses some method of enriching the brine before it is boiled, so this is also expected at the Paynes Creek saltworks (McKillop 2002). Excavations may provide further information about brine enrichment processes.

Ancient and Modern Maya Site Planning

The Paynes Creek settlement pattern departs from the plaza groups that are characteristic of Maya architectural site planning. From stone temples and palaces arranged to form open plazas at the center of cities, to the mounded remains of more modest domestic architecture, the plaza group is the building block of ancient Maya site planning (McKillop 2006). In contrast, the Paynes Creek wooden structures are arranged linearly, with individual structures aligned northwest to southeast, and there is no evidence of plaza groups. The buildings may have been aligned along a former shoreline, which will be investigated using bathymetry.

Although now underwater, the sites are located on firm mangrove sediment that is assumed to have been dry land at the time when the saltworks were in operation. Loose silt covers the mangrove peat, creating an initial appearance of a uniform sea floor and masking the undulations of the surface of the underlying peat layer. In some non-site areas, the depth from the water surface to the top of the mangrove peat is quite deep, suggesting areas where salt water would have been accessible from the saltworks. Proximity to salt water

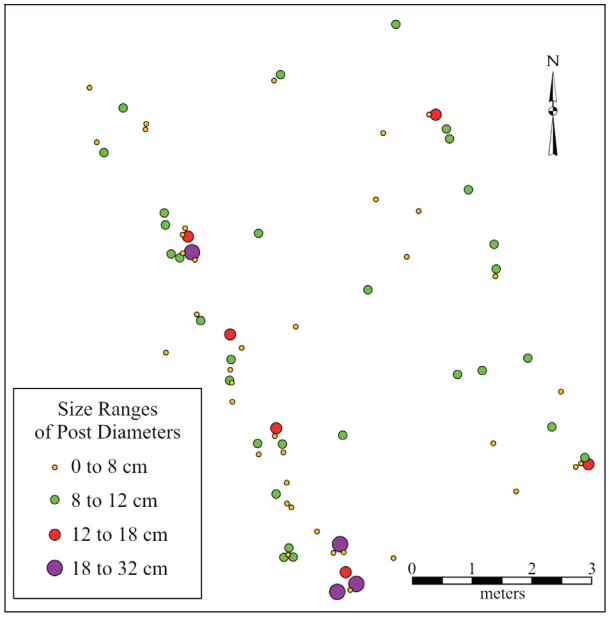

FIGURE 3. Range of post diameters at site 75, showing larger posts at corners and smaller posts in between. (Map by author.)

would have been necessary both for salt production and for transporting the salt and the workers.

Discovery of an Ancient Maya Canoe Paddle

The discovery of the first known ancient Maya wooden canoe paddle at K'ak' Naab' (site 14) provides direct evidence for canoe transportation at Paynes Creek (Figure 4). No ancient Maya wooden canoes have been reported. The K'ak' Naab' paddle ties the production of salt to its transport via canoe to inland cities where salt was in demand.

When the Spaniards arrived in Central America, they disrupted a network of canoe trade and transportation along the coastal and inland waterways that had endured for millennia. There was sea trade with the Yucatan (Hammond 1972; Healy et al. 1984; Andrews et al. 1989), but also shorter distance travel along inland waterways in Belize, Mexico, and Guatemala that supplied the Maya living at inland urban cities with coastal resources (Graham and Pendergast 1989; McKillop 1996, 2004). Stingray spines for ritual bloodletting, seafood, shells for ornament and food, and quantities of salt were transported inland (McKillop 2007b). The Paynes Creek Maya were engaged in the production and distribution of salt for inland trade up nearby rivers to Late Classic inland cities in Belize and adjacent Guatemala (McKillop 2002).

Before the discovery of the K'ak' Naab' paddle, knowledge of canoe travel was based on artistic depictions of canoes and paddles (Thompson 1951; Trik 1963), settlement of offshore islands, and models and hypotheses about the timing and importance of ancient Maya sea trade (Hammond 1972; Sabloff and Rathje 1975; Healy et al. 1984; Andrews et al. 1989; Graham and Pendergast 1989; Guderjan and Garber 1995; McKillop 2004; McKillop et al. 2004). Settlement of offshore islands provides evidence that the ancient Maya were familiar with sea travel. The ancient Maya visited and settled on islands located off the coasts of Belize and the Yucatan, including near shore islands such as Isla Cerritos, Wild Cane Cay, Moho Cay, and Frenchman's Cay (Andrews et al. 1989; McKillop 2004, 2005b; McKillop et al. 2004); islands located farther from the mainland such as Ambergris Caye and Cozumel (Sabloff and Rathje 1975; Graham and Pendergast 1989; Guderjan and Garber 1995); sites over 40 km offshore on the Belize Barrier Reef, such as Hunting Cay; and atolls beyond the reef.

Infrastructure of Paynes Creek Salt Industry

At Paynes Creek, salt was produced in rectangular wooden buildings, where brine was boiled in pots to produce loose salt or salt cakes, leaving behind broken bowls and jars, cylindrical clay vessel supports, and water jars. Several activities took place at the saltworks. Salt boiling vessels were made using local clays with quartzite sand temper that was readily available locally. Brine was boiled to produce salt. Salt production took place inside wooden structures, providing protection from the rain that is common, even during the dry season. Mapping individual pottery sherds at the K'ak' Naab' saltworks indicated waste

FIGURE 4. K'ak' Naab' wooden canoe paddle from Paynes Creek National Park, with close-up of paddle blade. (Photos by author.)

was moved outdoors, presumably to keep the workshop clean of debris (McKillop 2007a). Buildings also were used to store equipment and supplies, such as firewood, jars for storing brine, and salt pots for boiling, as seen at Sacapulas. Some structures were likely warehouses where salt was stored before it was transported elsewhere. A full-size wooden canoe paddle found at the K'ak' Naab' saltworks provides evidence for water transport (McKillop 2005a, 2007a). Some of the saltworks hosted periodic salt rituals, as evidenced by pottery ocarinas and serving vessels (McKillop 2002). These were not locally produced, in contrast to the salt boiling vessels.

Late Classic Maya Supply and Demand for Salt

With up to 80 inland city states, some with estimated populations of up to 100,000 (Harrison 1999), there was a significant inland demand for salt. The Belizean coast was the nearest source of this basic biological necessity. There are several models that could explain how these population centers were supplied with salt (McKillop 2008). In the household production model, coastal salt production was limited to a household or cottage industry, with limited distribution, requiring long-distance import from the northern Yucatan salt flats (Andrews 1983), or implying that inland salt sources were adequate to meet demand (Dillon 1977). A second model, the tribute model, parallels the Aztec or Inca strategy of using military force or imposing local rulers to incorporate the coastal Maya saltworks into a regional state and to obtain salt as tribute. The third model, the alliance model, suggest that the inland dynastic Maya may have created trading and other alliances, sanctified by rituals and feasts, in order to maintain a regular trade in salt.

The Paynes Creek saltworks were not part of the household production model, since they appear not to have been directly associated with residences or communities, and because the scale of production exceeded household demand. The salt workers presumably lived

year-round at the contemporary coastal settlements nearby. There is no evidence to support the tribute model at the Paynes Creek saltworks. They were not part of the royal court workshops supplying goods for the dynastic Maya, because of the considerable distance. There is no evidence for direct control of production by the dynastic Maya, similar to that used, for example, by the Inca to establish a system of warehouses throughout their empire. The alliance model best fits the evidence from the Paynes Creek saltworks, with independent, local producers engaged in a negotiated trade relationship with the inland dynastic Maya. Because of the distance and the special skills needed for salt production and canoe navigation, the dynastic Maya at their inland urban centers may have found it more cost effective to negotiate trade and perhaps marriage alliances with the coastal salt producers than to manage the production and distribution of salt directly. Moreover, the Late Classic Maya polities of southern Belize located closest to the saltworks were decentralized, placing the coastal Maya in an advantageous position both economically and politically.

Acknowledgments

Fieldwork since 2004 has been carried out under permits from the Belize Institute of Archaeology. The Belize Department of Forestry issued a permit for work in 2008. This work was supported by the National Science Foundation (Grant No. 0513398) and National Geographic Society (Grant No. 7809-5), as well as a grant from the Foundation for the Advancement for Mesoamerican Studies (2005), an LSU Faculty Research Grant (2004), and grant NSF (2008)-PFUND-95 from the Louisiana Experimental Program to Stimulate Competitive Research (EPSCoR), with funding from the National Science Foundation and the Louisiana Board of Regents Support Fund. Fieldwork was accomplished with the assistance of Louisiana State University students Bretton Somers, Cory Sills, Mark Robinson, Amanda Evans, Kevin Pemberton, Zoe Morris, Michael Mirobelli, Matt Helmer, and Amanda Pitcock, along with John Young of Punta Gorda. Fieldwork was facilitated by the friendship and hospitality of John Spang and Tanya Russ.

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