Paleoclimatic Reconstruction and Archaeological Investigations at Xcoch and the Puuc Region of Yucatan, Mexico: Exploratory Research into Arctic Climate Change and Maya Culture Processes

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This report details the results of the first year of an Early Concept Grant (NSF 0940183) for Exploratory Research (EAGER). This work took place at the ancient Maya center of Xcoch and the Puuc region of Yucatan, Mexico (Figure 1) beginning in 2009 and was focused on reconstructing climate change and human responses over the past 3000 years, especially during the time period known as the Classic Maya collapse (800-900 AD). This time period is especially relevant to Arctic researchers because it coincides with the Medieval Warm Period (AD 800-1300), when climatic conditions enabled Norse peoples to explore and colonize the North Atlantic Islands and reach the shores of America long before Columbus (Dugmore et al. 2007; McGovern et al. 2007) How Arctic climate change affected processes of cultural development and decline in the North Atlantic and Maya Lowlands has the potential to inform us today regarding the far reaching and serious cultural-environmental impact of global climate change.

This NSF grant was funded on October 1st, 2009 even though related fieldwork at Xcoch had commenced before this time with other funding sources. The general results from the research carried out in 2009 and early 2010 show that Xcoch was indeed a large Prehispanic Maya center with a long occupation dating back to the Middle Preclassic period (800-400 BC) and peaking in the Late Classic period (600-800 AD) before general abandonment of the site occurred, though the deep water cave at the site continued to be visited up until modern times. Archaeological contextual and chronometrical data so far suggest that there were two periods of intense construction activity that may correspond to contemporary episodes of cyclical drought. Based on climatic data from Lake Chichencanab, Yucatan and Belize (Hodell et al. 2001; Webster et al. 2007; Moyes et al. 2009), the first series of drought cycles may to have occurred near the end of the Preclassic period between the 2nd and 3rd centuries AD and about the same time for massive efforts at Xcoch for rainwater capture in the form of aguadas (water ponds), catchment surfaces, drainage canals, and chultuns (underground water cisterns). Excavations show that these efforts may have been in vain because stratigraphic evidence for an occupation hiatus associated with the end of the Preclassic indicates that many site areas were abandoned at this time.

Near the end of the Early Classic period (~500 AD), Xcoch is reoccupied and settlement slowly begins to build in a crescendo-like fashion to reach a maximum in the Late Classic. However, there is again evidence for another series of drought cycles (Hodell et al. 2001; Webster et al. 2007; Wahl et al. 2007; Media-Elizade et al. 2010)) that may have pressured populations to intensify water management at the site by resurrecting and expanding old water control systems or by constructing new ones for capturing rainwater. Evidently, these efforts were insufficient because the site shows settlement abandonment, perhaps abruptly, by the beginning of the Terminal Classic period (~800 AD). Though clearly suggestive, previous climate change data in the Yucatan has been far too course-grained and non-site specific for specific cultural interpretations in the Puuc region. Much more localized and comprehensive paleoclimate and settlement data are required to properly assess the relationships between drought cycles and cultural responses at Xcoch and the Puuc region in general. Such research is currently underway (see below).

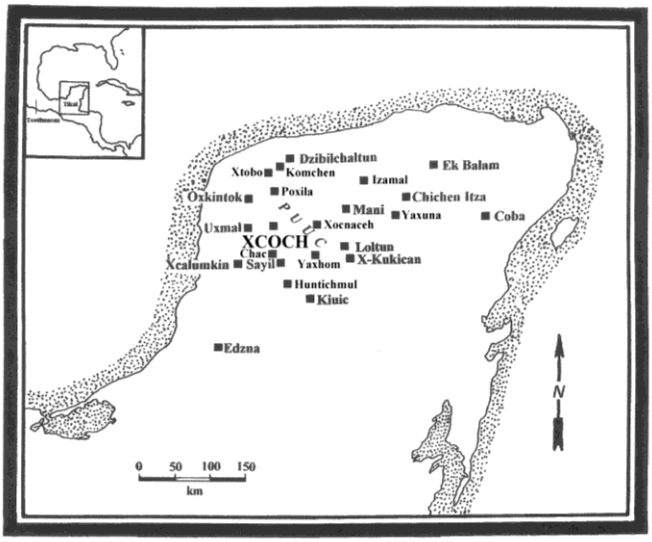


Figure 1: Map of the northern Yucatan showing Xcoch, the Puuc region and relate sites.

Settlement Survey and Surface Collection

To document urban phenomenon and to investigate human adaptations in the tropics, the Xcoch Project of 2009 continued surface survey in a zone of 30 hectares around the central zone of Xcoch (Figure 2). The surface survey was composed of 257 3x3-mts units spaced at intervals of 25-mts. Within the central area of Xcoch, most architectural features were mapped at a scale to 1:250. The site-scale surface survey continued from the site base line datum at N5000 E5000 where the municipal border (mensura) runs E-W separating the lands of Santa Elena from Ticul. From this starting point, main N-S breches (trails) were opened 300-mts to N5300 and south to N4700. We could not push the survey west of E4600, 500-mts to the west of the Great Pyramid, but were able to reach east towards E5400 between N5400 and N4900. With the aid of a full-station EDM (Electronic Distance Measuring Theodolite)) and GPS receiver, main breaches N-S and S-N were opened each 100-mts. Collection units were placed every 25-m.

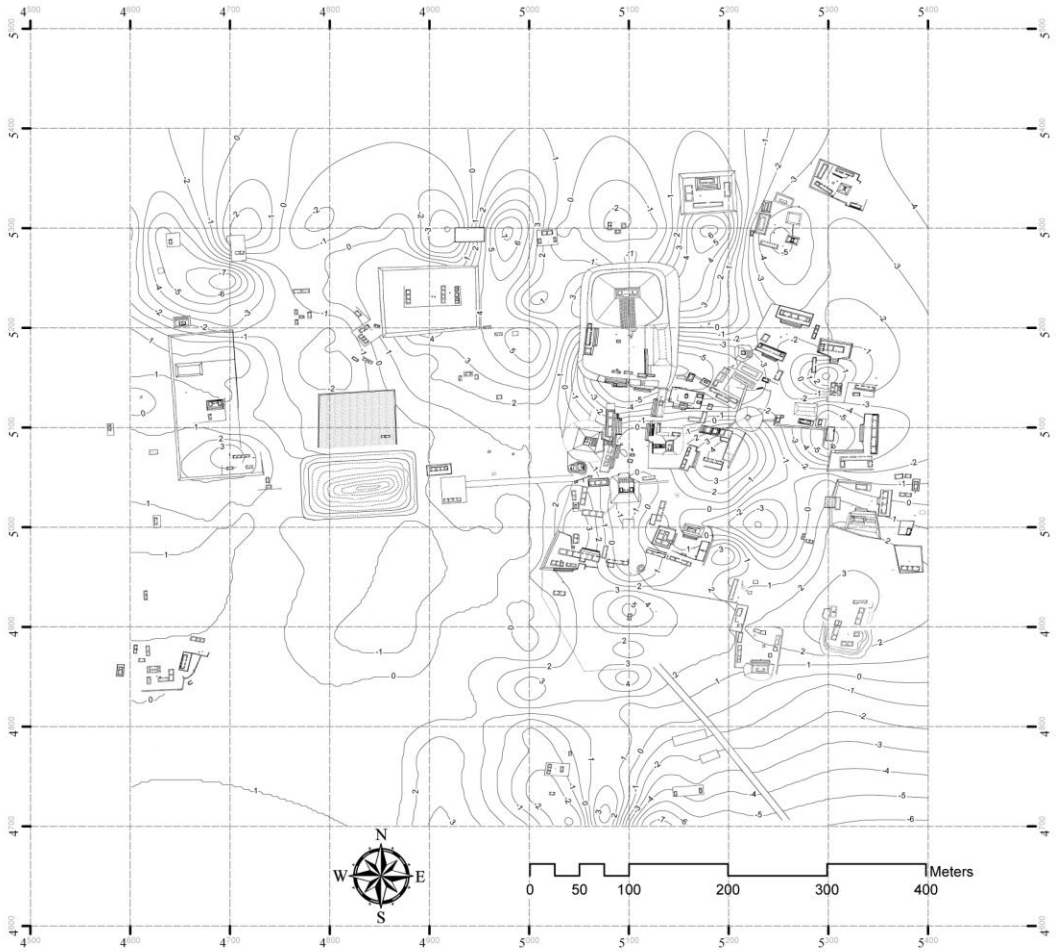


Figure 2: Topographic and planimetric map of Xcoch settlement showing the site area mapped through 2009

Significant architectural and ceramic surface remains were found in a 30 hectare area around the central groups at Xcoch, including the dense settlement zone known as the Elite District northeast and east of the Great Pyramid and Grand Platform. Also, a group south of the Gruta Xcoch and three groups to the west, including massive habitation platforms, an immense aguada (La Gondola) and the Chac-Na group. Though the exact settlement limits of Xcoch have not been determined, there is evidence for settlement radiating outwards in all directions including pyramid groups, aguada features, and causeways both long and short.

The grotto of Xcoch is directly underneath the Cave Pyramid found along the west side of the Xcoch Plaza. There are at least two causeways that converge near the Cave Pyramid to the west and southeast. The southeast causeway travels almost 1-km before arriving at a natural hill that supports three structures forming a triadic group placed upon an expansive leveling platform: two pyramids of the megalithic style without vaulted summit buildings and a vaulted range structure to the east. Less than 1-km to the south of this group are two aguadas (one is the South Aguada, below) within the mechanized parcels of the municipality of Santa Elena. From previous reconnaissance, we know that there are other pyramid groups and substantial settlement 1-km to the east of the Great

Pyramid and still several other groups with substantial architecture in the intermediate zone. Although we could not yet survey north of the Great Pyramid, there are significant groups in this direction as well including a number of with pyramids.

Clearly, settlement at Xcoch was much more dense and extensive than was believed previously. It is estimated that Xcoch may cover more than a total of up to 6-km². The survey indicates that Xcoch settlement is continuous at least up to 1-km north and could include another aguada 1.5-km to the northeast and its associated settlement remains (Dunning 1992). It is now believed that Xcoch extends at least 1-km more to the west and at least 1-km to the east, because there is no evidence of any settlement drop-off beyond the area of the preliminary reconnaissance. This same kind of settlement pattern continues to the south indicating that Xcoch extends another 2-km in this direction. Therefore, several more seasons of surface survey are required to completely investigate the site.

Arquitectural Mapping

The site of Xcoch is recognized for a deep water cave, a tall pyramid, and giant platform covering 1 hectare that together stand more than 40-m above the ground surface. The survey work in 2006 revealed that the Great Pyramid is the highest point of a massive multi-level acropolis with at least 5 architectural groups covering more than 10 hectares, representing one of the largest structures in the Puuc region (Figure 2). Constructed in the early megalithic style characterized by large shaped boulders with abundant chinking stones, megalithic architecture is believed to be an indicator of Preclassic to Early Classic occupation. On the south site of the Grand Platform leading to the Great Pyramid are two megalithic staircases with treads and risers some measuring up to 2-m in length. The central Megalithic Staircase is virtually identical to one recently consolidated at Xocnaceh, a relatively small site approximately 20-km to the east of Xcoch with an enormous Preclassic platform (Gallareta Negrón and Ringle 2004; Bey 2006). Atop the Megalithic Staircase at Xcoch are three buildings, two with early-style vaulted roofs.

In 2009, 10 large architectonic groups and topography were mapped intensively at a scale of 1:250 using a Topcon total-station EDM transit, compass and tape, and GPS receiver (Figure 2). Additionally, the remains of several settlement groups also were located. The general site is composed of many features, including platforms and multiple room buildings, >15 pyramids (5 to 30-m in height), the Great Acropolis, many plazas, a causeway connecting the Acropolis to a pyramid group almost 1-km to the south, and comparatively few chultuns especially near the site center, and numerous stone basins (pilas). The architectural remains mapped in 2009 were concentrated in an area of more than 30-ha around central Xcoch and outside of the enormous Acropolis, although there are substantial remains of settlement outside the surveyed areas. The high quality and scale of construction indicate that Xcoch was a first-order settlement and perhaps among the largest of the early sites in the Puuc region.

Of all mapped groups, the largest were architectural complexes associated with the Great Acropolis. The Elite District is a settlement zone covering 6 hectares located to the east of the central Xcoch and contains numerous platforms, vaulted buildings, foundations for

perishable houses (foundation braces), plazuelas, and at least four pyramid platforms. In the western part this district (N5100 E5200 and N5200 E5200) is the Residential Group, a high platform surrounded by foundation braces and a central platform that has an altar to the south and a short plain stela to the north. To the southeast of this group is a multi-room, L-shaped vaulted building with a four column entrance and a linear pyramid platform with a single-room temple structure at the summit and two lower structures to the east. To the south of the linear pyramid platform are two chultuns within a plazuela. A 10-m tall pyramid apparently round in form is nearby but badly preserved. To the northwest is a plaza with two vaulted four-room buildings on the south and west wings. These vaults are triangular shaped stones and the rooms are of average height but show architectural characteristics of the early Puuc style. Two megalithic stelae, one standing upright and the other laying flat, are to west and north of the vaulted buildings and there is a platform that probably supported a vaulted range structure on the north side. Another parallel platform further north suggests these two platforms could have formed a ballcourt but this identification is not certain.

To the north of the parallel platforms is a 7-m pyramid that exhibits the remains of stairs on the east side and apparently had a summit temple that was vaulted (Figure 2). An adjacent long platform to the northeast shows the remains of apron molding decoration that supported a probable vaulted building with two lateral room wings on the west and east sides set between a long building with no internal room divisions. The decoration and the style of the rooms suggest the Proto-Puuc style dated to the Early Classic period. Two foundation braces are to the south. To the north is another plaza and a vaulted building with a single column entryway on the west side. Further north is a large palace-type range structure with 5 rooms each of which had columned doorways and evidence of high vaulted roofs in the Classic Puuc style (boot stone vaults). The columns and door jambs were found out of their original places along the west part of the plaza. Within the plaza itself, is a deep chultun, a columnar stone altar, and two large rectangular stone basins which appear to have been metates. A foundation brace structure and a vaulted building without room divisions is oriented north-south alongside the east side of the plaza. A large and high platform for a two story, multi-room building is also found to the east near N5200 E5300. Although poorly preserved, this building has a lower level of three small rooms on the west wing that must be a lower story for the larger room block near the center of the structure.

The next building group is to the south where two vaulted buildings are connected by wide staircases; one is a foundation brace and the other is multi-room vaulted building (~ 6 rooms) possibly arranged in two floors. To the southeast near N5100 and N5300 and to the east of the 10–m tall pyramid is a high terrace with a large building that is almost totally collapsed. Also to the south are three stone buildings with faced stones that clearly never had vaulted roofs or high stone walls. About 50-m east and 50-m south are two large vaulted buildings with multiple rooms. The building to the east is 40-m in length and has 6 rooms oriented the north-south showing decorative stones indicating a facade adorned with stone mask mosaics of the rain god Chac and figures of grecas water symbols. The other building has a long single-room with lateral rooms on the north and south sides. This building appears to be in the Early Classic or Proto-Puuc styles.

To the south between N5100 E5300 and N5100 E5400 atop a west staircase is a high basal platform with two deep, well preserved chultuns (Figure 2). This group is dominated by a pyramid platform that has a temple at the summit and perhaps another lower-level building to the east. These buildings are poorly preserved but appear to be constructed in an early archaic style. To the north of the same plaza is a single-room vaulted building with an entrance formed by a single piece column. To the east is a three-room building with a vaulted roof and corners decorated with large spools (junquillos). Behind this is a triadic-like group of foundation brace structures adjacent to a collapsed chultun and a stone basin. To the south of the triadic group are two platforms; one supporting a foundation brace and the other larger platform a three-room Early Puuc style vaulted building oriented east-west. A columnar altar set to the north in front of this building and an archaic chultun is located to the west side just off the platform.

To the northeast of the Great Pyramid between N5300 E5200 and N5300 E5300 is a settlement zone within a cornfield (milpa) consisting of three groups of platforms, buildings, and pyramids (Figures 2). The first group is a small quadrangle situated on a high basal platform more than 7-m in height composed of a pyramid platform with megalithic stairs and an unvaulted summit building and three other buildings (two are stone buildings but without vaulted roofs); the south building had three rooms and a vaulted roof. Less than 50-m to the east, the second group exhibits four platforms three with collapsed buildings surrounding a small plaza and the remains of a vaulted building to the south; a small pyramid is on this side as well. Two chultuns are located off-platform on the west and south and 3 pilas suggest domestic activities. About 50-m to the east atop a 3-m high platform is the third group with three vaulted buildings and a 6-m pyramid to the east. There is a chultun outside the platform on the west side and a large foundation brace located to the extreme southeast

The Group of the Grotto is located to the north of the mensura dividing the lands of the municipalities of Ticul and Santa Elena near a deep cave that reaches water (Figure 2). The Group of the Grotto is composed of two groups of vaulted and unvaulted buildings. The first group has three vaulted buildings each with three rooms oriented around a small plaza; the South Pyramid of Xcoch Plaza is located to the east. Also, to the west are two megalithic foundations oriented north-south aligned with the grotto clearly dating to a previous time period. To the west of the grotto is a 6-m wide causeway that runs 100-m to the west passing two collapsed chultuns and one ring structure before arriving near two platforms with four-room foundation braces.

Near N5000 E5000 south of the mensura is the other settlement of the Grotto Group situated atop the second terrace level of the Great Acropolis. The main building is a seven-room vaulted range structure oriented east-west with a wide north staircase. This building was constructed in the Classic style because there are “boot” stone vaults seen within the building collapse. Two vaulted buildings to the east are earlier and seem to be in the Proto-Puuc and Early Puuc styles respectively; the first structure is oriented north-south with single piece moldings and carved stones decorated with bird feathers. The other building has an entrance formed by a single column and two jambs and there is a conical altar at the center of a small adjacent plaza. Three foundations for buildings with perishable roofs show megalithic stones; one is located to the north and two to the south

of the large seven-room range structure and seem to be archaic perhaps Preclassic in style. Megalithic stairs give to access to these archaic foundations as well as the second level of the Acropolis. There is another similar foundation along the south border of the first terrace of the Acropolis where three collapsed chultuns are found, two of which were covered over with inverted pilas and platform fill; another flight of megalithic stairs, and several stone basins. Clearly, this area must have been the principal south access to the Great Acropolis and Xcoch Grotto in Classic and Preclassic times.

Some 200-m to the west of the Great Pyramid is the Chikin Mul group, an enormous 5-m tall basal platform measuring 100-m east-west and 80-m north-south (Figure 2). This platform only supports foundation brace buildings but with multiple rooms. These structures are clearly habitation structures because there are many associated pilas (basins-metates) but there are no on-platform chultuns. Just west of the Great Acropolis oriented east-west, this massive platform may have been constructed at about the same time as the Grand Platform perhaps in the Middle Preclassic period at the beginning of site occupation. Around the Chikin Mul group are several small platforms for foundation braces and chultuns but no vaulted buildings and appear to be from a later occupation.

At the end of the west causeway between N5000 E4900 and N5000 E4800 is the Aguada Gondola, an enormous rectangular depression constructed by the ancient Maya (Figure 2). This aguada measures 110-m east-west by 90-m the north-south and has a depth of more than 10-m. To the north of the aguada is an expansive low platform that covers almost one hectare constructed of small fist-size cobble stones (chich). This chich platform slopes towards the aquada and seems to have been a catchment area to collect runoff rainwater. A foundation brace is the only associated structures located near the southeast corner. In all respects, these two massive constructions represent a tremendous effort by the ancient Maya to collect and store water at Xcoch.

The Long Group is located between of N5100 E4700 and N5200 E4700 and is another massive platform that measures 125-m north-south and 50-m east-west with a height of 4-m (Figure 2). In center is a building platform with a megalithic staircase and a three-room stone walled building that may have not been vaulted. To the south is a group of foundation brace buildings and to the north a wide pyramid platform near a chultun with another structure with stone walls but no vaulted roof set upon a platform accessed by a northern megalithic staircase.

The Chac-Na group (between N4900 E4600 and N4900 E4700) is the furthermost west group mapped so far at Xcoch (Figure 2). The group takes its name from the principal structure which is a four-room Proto-Puuc style building still partially standing. This structure has a type of vault with roughly shaped slabs stones. The exposed ends were tilted upward and were heavily plastered to approximate a smooth soffit and wall facing is of well-cut and well-fitted stones that are slightly smaller than normal (similar to a building at Cacabxnuc, Campeche). Another multiple room building to the southeast has an L-shaped layout and is constructed in a similar style. There is another vaulted building to the south and two more to the northeast that appear to be in the later Early Puuc style. Also, there are four foundations braces to the northwest and probably three additional buildings to the north of the Chac-Na group, including an apsidal-shaped foundation to

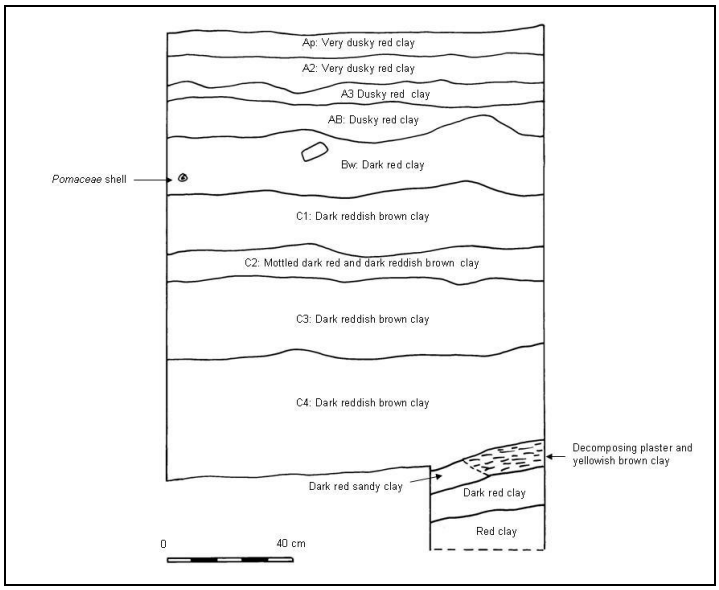
the southeast that may have been historic.

Aguadas and Water Control Systems

The site of Xcoch has three confirmed depression features (aguadas or water holding ponds) and several others that are suspected but not yet verified. In 2009 and 2010, three aguadas were mapped and sampled by sediment coring and trenching operations to obtain pollen and stratigraphic information that can be dated by radiocarbon methods (Figures 3a-c). The sediment cores, unfortunately, produced no usable pollen remains partly because these aguada features have not held water for long periods which is necessary for pollen preservation. The aguada zone approximately 2-km south of central Xcoch was the first area to be investigated in 2009 because it showed preliminary evidence of possible irrigation canals associated with ponding features in a rich agricultural zone of modern farm fields near the town of Santa Elena (Smyth and Ortegón 2008).

The South Aguada is an irregular depression south of the Xcoch site center (Figure 3a). In recent years, the surface of the aguada has been significantly altered by forest clearance and mechanized plowing associated with the development of modern irrigation agriculture. Local informants report that the aguada no longer holds significant quantities of water, but did so within recent memory especially after heavy rainfall. Pozo 1 was excavated in the floor of the aguada towards its eastern side (Figure 3c). The excavation was halted at about 175-cm when an apparent floor was encountered. The eastern end of the pit was continued to a depth of 205-cm then halted because of logistical difficulties of continuing to greater depth. Augering was conducted to about 280-cm without encountering bedrock or additional plaster. A largely decomposed plaster floor was revealed in a portion of the pit at a depth of about 170-cm. The sandy clay C5 horizon is horizontally contiguous with the plaster layer and likely represents the further decomposed floor. The C3 and C4 horizons overlying the floor show elevated levels of OM and P and likely represent sediment that accumulated while the aguada was in active use. The charcoal-rich C2 horizon may represent a drying episode in the aguada's history, with wetter conditions likely returning when the sediments comprising the overlying C1 horizon were deposited providing a suitable habitat for *Pomaceae* snails.

(a) (b)



(c)

Figures 3a-c: Aerial photos (3a and 3b) of the South Aguada zone and canals and profile drawing of the north wall of Pozo 1 (3c).

Pozo 3 was excavated near the apex of the northern berm of the Xcoch South Aguada. Excavation was halted at an arbitrary depth of 100-cm (Figure 4). Two probable linings were encountered at 52-67-cm and 75-89-cm. The probable linings present light-colored sandy clay layers with abundant pebbles, chich cobbles, and charcoal: likely the highly weathered remains of former low quality plaster surfaces and underlying preparation matrixes. An apparent buried, weakly developed surface soil (Ab horizon) appears at 47-52-cm, likely having formed atop the upper of the two exposed linings and probably reflecting a period of abandonment in the use history of the aguada. The burial of the Ab horizon likely indicates a later reuse of the aguada, including dredging of sediment and deposition on the northern berm. The current surface soil (Ap horizon) shows a loss of organic matter and silt due to modern cultivation. Small numbers of weathered sherds were found at all levels.

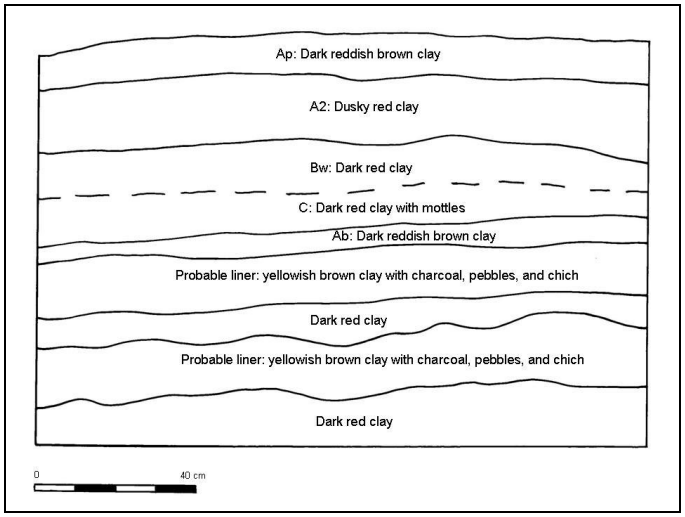


Figure 4: Profile drawing of the east wall of Pozo 3 at the South Aguada.

The South Aguada showed possible irrigation canals passing through the north and south berms. Large boulders near the north berm suggest that these stones may have served as some form of sleuce gate allowing water to be released out of the aguada. These canals appear to run for several hundred meters in both directions but have been badly damaged by modern plowing activity. It is possible, however, that these canals were used to transport water from the aguada to surrounding agricultural fields especially during dry periods such as the local "canicula;" a mini dry spell in the middle of the rainy season that usually occurs in mid July. This is a critical time in the early grow cycle of maize and if sufficient water is not available, maize plants will produce only a few, small ears or no ears at all, even if abundant rainfall comes later. This is still the case today and deep wells and electric pumps are now used to irrigate fields especially during prolonged canicula periods.

Aguada La Gondola lies approximately 100-meters west of the Gruta Xcoch entrance and site center (Figure 5a). It is a roughly rectangular depression about 110-m on its east-west axis, 90 meters on its north-south axis, and about 10-m deep. Alignments of large stone blocks (berms) are visible at varying elevations on each of the interior walls of the depression.

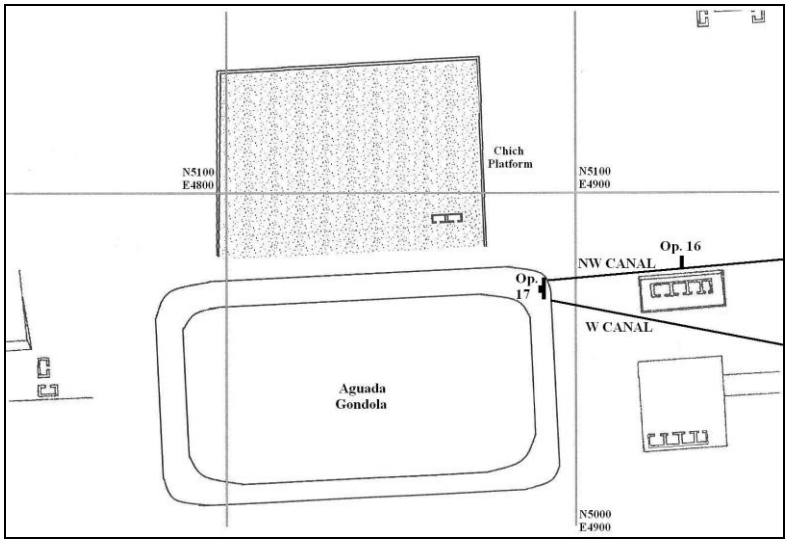


Figure 5a: Planimetric map of the Gondola Aguada, the Chich Platform, and the locations of the northwest (Op. 16) and west canals and junction (Op. 17) at southwest Xcoch.

Pozo 1 was excavated across one such alignment situated about midway up the north wall of the aguada (Figure 5b). Although mostly fallen, the trench seems to reveal a former "bench" supported by a double retaining wall of large stones seated in a thick plaster reservoir liner. A possible interpretation of the stone alignments along the walls of the aguada is that these features were benches or steps created within an ancient reservoir so that people could more easily get access to water as the water level within the reservoir was lowered during the course of the dry season. Weathered ceramics were recovered throughout Pozo 1.

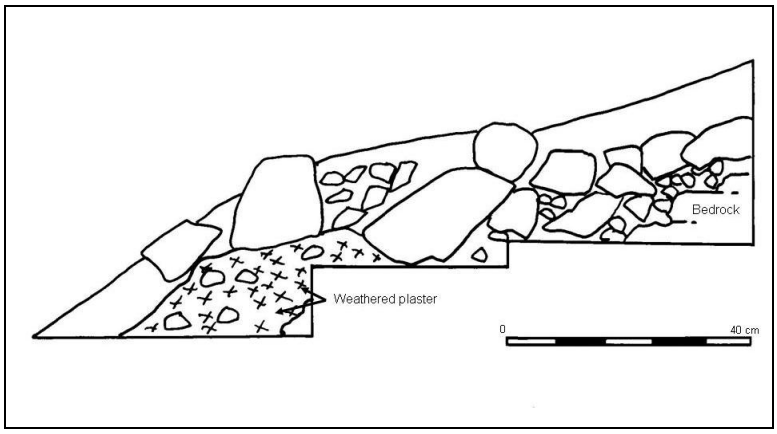


Figure 5b: Profile drawing of the west wall of Pozo 1 at the Gondola Aguada.

In Pozo 2 the 2C1 horizon may represent a decomposed lining on the floor of Aguada La Gondola based on the quantity of small limestone rock fragments (gravel), sand, and charcoal (Figure 5c). Ab horizon would then represent relatively organic and P rich sediment that accumulated on the aguada floor along with sherds, charcoal, and aeolian silt while the aguada was in ancient use. C and AC horizons have developed in inorganic clay sediments and show signs of greater past desiccation in the form of slickensides and deep cracking that are no longer active under current forested conditions. Excavation was discontinued at 120 cm due to time constraints in 2009. Three additional test pits were opened in 2010 but are pending analysis and will be included in the next field report.

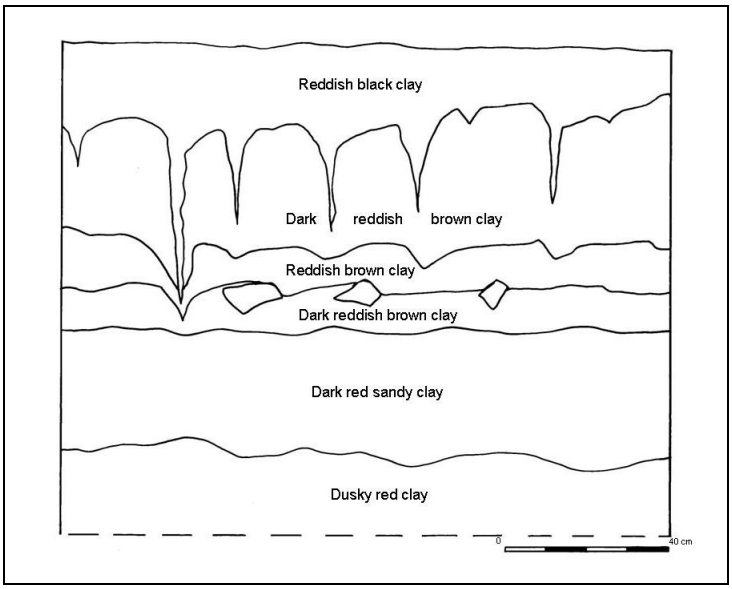


Figure 5c: Profile drawing of the east wall of Pozo 2 at the South Aguada.

Probing excavations took place within the Grand Platform, along the west side of Xcoch Plaza, and adjacent to the Gondola Aguada to assess the possibility of a system of rainfall capture and water management (Figures 6a-b and Figures 7a-b). Operation (Op.) 4 was opened within the south central portion of the Great Platform to determine the chronology and construction sequence of this massive support platform for the Great

Pyramid on the north end that covers more than one hectare and rising over 7-m above the Xcoch Plaza. Results including ceramic diagnostics and radiocarbon dating indicate a Middle Preclassic date (600-800 B.C.) of construction with numerous stucco floor resurfacings including floors II and III tentatively dated to the Late Preclassic that clearly show a stucco surface sloping towards the southwest in the general direction of the Gondola Aguada.

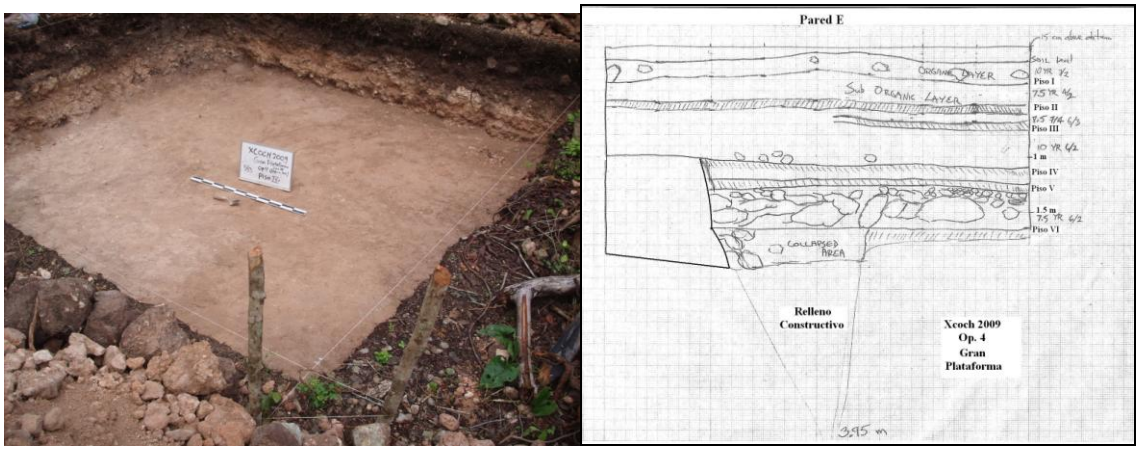


Figure 6a-b: Photo (6a) of Operation 4, stucco floor III on the Grand Platform looking southwest and profile drawing (6b) of the east wall of this same excavation unit showing all floor levels and construction fill.

Based upon the findings of Op. 4 and the absence of stone masonry on the southwest corner of the Grand Platform, a trenching unit (Op. 6) was placed within the SW platform corner (Figures 7a-b). The remains of a stucco drainage canal were exposed showing three concave steps that were clearly designed to channel rainwater from the Grand Platform's stucco catchment surface and slow the flow of rain water downhill towards the Gondola Aguada some 250-m to the southwest. Additional probes to the south along the Xcoch Plaza revealed stucco and stone canals and a megalithic boulder check damn set in front of the Cave Pyramid obviously engineered to turn the flow of rainwater to the southwest before cascading down the western terrace edge of the acropolis. At the base of the acropolis, trenching operations exposed a canal of natural bedrock running adjacent to a building platform as well as a junction point along the northeast corner of the Gondola Aguada where this canal and another one to the south arrive from the Xcoch Plaza to the west to discharge rainwater into the aguada. In addition, an enormous cobblestone (chich) platform covering about .75 hectares was located along the north end of the aguada suggesting another massive catchment surface constructed to direct rainwater into the aguada.


Figure 7a-b: Photos looking north (7a) and northwest (7b) of Operation 6 showing the stucco drainage feature with concave steps located on the southwest corner of the Grand Platform.

The Aktun Xcoch

Work at the Xcoch cave began in 2009 and included the logistics of opening and preparing the cave for exploration and systematic mapping by a team of experienced cavers as well as pottery collections, soil sampling, and geological and biological survey. These data provide a more comprehensive understanding of the natural and cultural factors that formed this important cave system, the early occupation of the Puuc region, and well as the potential for collecting climate based data from this subterranean context.

The Xcoch cave contains a permanent water pool with almost inexhaustible surface concentrations of pottery sherds and near-complete vessels, including Early Classic Chac polychrome and Chemax slateware water jars (Smyth 1999). There are Preclassic diagnostic types such as Ucu negro, Sierra Red and sherds of at least three vessels with long, narrow necks, globular bodies, and long monopod supports identified as Yotolin Patterned Burnished (Brainerd 1958; Folan 1968). Yotolin pottery, found only in caves/cenotes near Mani, Sacalum, Loltun cave, Tzucacab, and now Xcoch, appears to date to the early Middle Preclassic period or contemporaneous with the Early Nabanche phase pottery defined at Komchen (Andrews V. 1988, 1990; Ringle and Andrews 1988). These finds began to provide the context for chronological placement of Yotolin and the more important question of early Middle Preclassic occupation in the Puuc region.

The first known published account of Xcoch cave comes from John Lloyd Stephens in 1841 from his "Incidents of Travel in the Yucatan." Stephens' (2008) account of the cave expresses both disappointment and wonder in that the cave fails to live up to claims made by the local residents but he was still excited about what the cave did actually contain. There are mentions of the cave at Xcoch in Hubert Bancroft's (1883) "The Native Races of the Pacific States of North America" and the 1854 third volume of the "Illustrated Magazine of Art;" all seem to be retelling Stephen's account. "The Fauna of the Caves of Yucatan" makes a reference to collecting invertebrates in what they referred to as Santa Elena cave in 1939. "Bulletin #1 of the Association of Mexican Cave Studies Activities Report" indicates that several caves in the vicinity of Santa Elena were explored in October 1974 including Xcoch Cave. This report indicates that the explorers had to re-open the entrance and that it had been sealed for forty years, which is close to

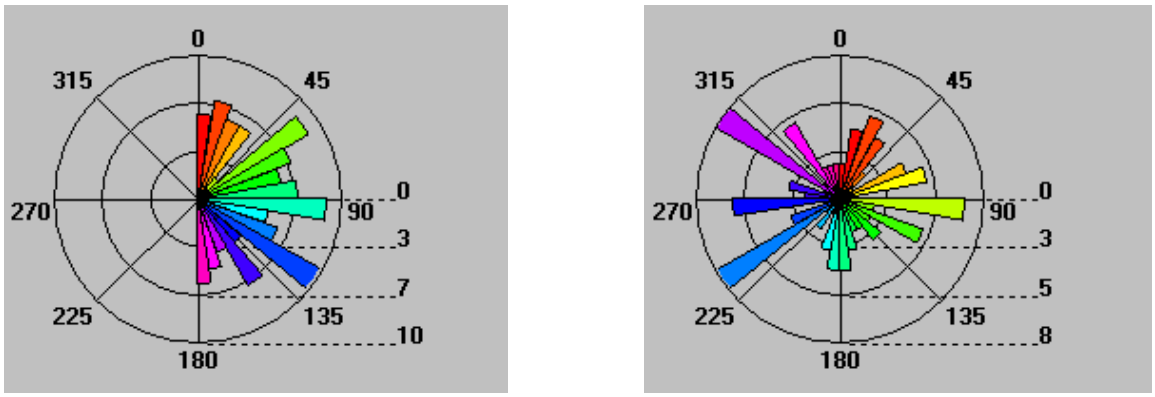
the 1939 date in "The Fauna of Yucatan Caves." Written correspondence with one of the explorers, Dave McKenzie, recounted that the cave had poor air quality on their visit and consequently was explored for only approximately the first 300-m. The primary interest of the trip was the collection of cave invertebrates. The cave was apparently sealed up again after these visits. The Xcoch Project re-opened the cave in 2006 and the site entrance was cleared, expanded, and prepared for exploration and mapping for our caving team in 2009.

The total surveyed length of the cave as of 2009 is 641.8-m (2,105 feet) with a surface length of 103.0 meters (337.9 feet).The average diameter of the cave passage was 3.9-m (12.7 feet). The depth of the cave is 34.9-m (114.4 feet) and drops 34.9-m (114.4 feet) in 0.24-km (0.15 miles). The average inclination of the cave was 9.8 degrees, indicating a relatively steep slope to the cave passage. The upper passages of the cave are composed of a white powdery limestone that is relatively friable. In some areas of the upper passage, especially in the D Passage, the limestone contains a reddish tint with a more solid texture. The lower passages are composed of a more solid, harder grey limestone. Some boulders in the D Passage present a band of an unidentified mineral that is also evident in a wall in the chamber located at Station A15. Whole fossils are not significantly represented in any of the cave limestone. The cave appears to have been hypogenic in origin, with several of the large side passages showing evidence of epigenic (hypergenic) development (Klimchouk 2007, 2009). These two processes are so distinctly different within the cave that one may go from one passage/chamber to the next and get the impression of being in two separate caves.

The cave is largely composed of four chambers that trend from the southwest to northeast. Chamber I is located between Stations A9 and A12; Chamber II is between A14 to A16; Chamber III is between A24 to A26; and Chamber IV is located between A29 to A35. Many of the side passages are mazes of break-aways and reconnections with the main passage. Numerous pillars in the cave present an even more complex framework to these chambers. The overall layout of the cave appears to be sponge work with some passages exhibiting an anastomotic pattern (Figure 8a). The cave contains cupolas, ceiling pendants, boxwork, dogtooth spar, rising water channels, and possibly folia bubbles. Meteoric water may have infiltrated the cave in some high passages through openings with sharp inclines resembling chutes. The ends of these passages reach levels almost as high as the entrance. There is no evidence of current water activity in the cave or even water seepage from the walls. The passages have been abandoned and dried out with vague remnants of stalactites, flowstone, and travertine dams. A rose diagram using the passage inclinations shows that the flow of water occurred in a northeast, southeast, and easterly directions (Figure 8b).

A small pit about 6-m deep contains large boulders that are at least partially composed of gypsum. The survey team did not initially notice this because the boulders are covered in a hard coat of an unknown deposit. These boulders slightly obstruct a larger drop, which is an opening in the ceiling of Chamber III. Chambers III and IV have low levels of oxygen. There is not a complete explanation for this phenomenon. Chamber IV, the chamber closest to the water source, may act as a trap for other gases which could be

displacing the oxygen. It is located after a significant change in the depth of the cave and the entrance to the area is restricted by breakdown which must reduce airflow.



(a) (b)

Figure 8: Passage direction (a) and water flow (b)

Throughout the cave, the ceiling is coated black from the soot of the torches used by the Maya over the past 3000 years. In some areas the soot when touched produced an oily residue. The floor of the cave is covered by a loose layer of a rich, black soil. The upper passage has a well-defined trail carved or worn (15-20-cm in depth) into the floor surface. It has not been determined the depth of the soil layer throughout the cave but near the entrance remnant pollen was recovered and suggests that a record of ancient vegetation outside the cave can be reconstructed. The floor of Chamber IV is covered by a hill of broken ceramics and compacted soil and is the only time that the floor is not level; a portion seems to have been built up as a platform.

Xcoch Cave Survey

The standards employed for the survey of Xcoch cave are those set forth by the Cave Research Foundation. These standards are similar to what the National Park Service uses for sensitive cave systems like Lechuguilla Cave in New Mexico. The Xcoch cave survey would be classified as a Grade 5 survey based on the British Cave Research Association grading system. Two sets of calibrated instruments were used in each survey, one for front sight and one to obtain a redundant back sight. The instruments used were the Suunto KB14 compass and Suunto inclinometer. A minimum standard of accuracy of two degrees was implemented for inclination and azimuth readings between two sets of readings. Fiberglass tapes and Leica Distos were used for distance and passage measurements. The survey produced 120 stations and maintained the established accuracy throughout. The goal was to maintain a distance between stations no greater than 15-m in length in order to ensure the quality of the survey and ease the sketching of the cave passages. The average shot length upon the completion of the survey was 5.9-m (19.5 feet). Sketches were done on all surveyed passages. These sketches included plan, profile and cross-sections. Sketches were done at a scale of 1-cm to 2.5-m to capture a significant amount of detail in the cave. The symbol set used was established through the International Union of Speleology (UIS).

An inventory was conducted of each passage station that detailed archaeological, geological and biological features. An attempt was made to cordon off locations of archaeologically-significant materials using flagging tape in order to help re-locate the items and to protect from inadvertent damage during the survey. Red polka dot flagging tape was used because it is the most visually detectable. Side passages and leads were marked with black and yellow striped flagging tape.

The cave is a relatively complex system with multiple side passages and brief deviations in the main passage that eventually reconnect to the trunk. Our primary goal was to map the main passage to the water source. As we mapped the main section of the cave, we marked potential side passages to return later. We were able to map these side leads to a level where they appeared to terminate and where no previous activity had occurred. The low oxygen areas of the cave created additional obstacles. It was decided that we would initially survey the cave passage one day and then return the next day to complete the sketch. For this part of the survey, we used a DistoX, a laser device that obtains measurements for distance, azimuth, and inclination. The instrument allowed us to survey the passage at a relatively fast pace with the same accuracy as using traditional survey methods.

Data were input into a software program called Compass Cave Survey, a proprietary program similar to AutoCad but designed specifically for cave surveys. This program derives x, y coordinates from data and produces a line plot of the plan and profile view of the cave. Additionally, it can produce a representation of the cave walls and a 3-dimensional image of the cave. This can be geo-referenced and exported as a shapefile to be used in ArcGIS. The inventory was input into a SQL database that could be combined with the cave line plot. This software program is also capable of checking for blunders by anticipating where the next station should be and locating all shots that are three standard deviations away from this location. The program makes assessments of the quality of loop closures. Our loop closures showed a high level of accuracy, indicating that the survey was well-conducted. We had a total of six loop closures with an overall standard deviation of 0.58, based on the Least Squares algorithm with compensation for the inaccuracy of the instruments (2 degrees). A standard deviation of 0-1 is considered a good closure, 1-2 a closure within a tolerable range, and over 2 is an unacceptable closure.

The cave entrance, Station A1, is situated at the bottom of a large depression. The actual opening is a small pit (2.3-m deep) and there is a carved stone colonnette at the bottom on the left-hand side (Figure 9). The pit immediately becomes a crawl (less than 1-m in height) from Stations A1-A3 and then proceeds to a stoop walk from A3 to A5 (between 1 and 1.5-m in height) where a strong breeze blows through the cave passage. Stephens aptly describes this breeze as being capable of taking a person’s breath away and is strong enough to blow dirt directly at the person crawling into the entrance. This breeze is lost at Station A4 where another carved stone is located and where there is evidence of a filled passage. A relatively strong breeze for such a small cave is often related to a large discrepancy between cave temperature and outside temperature. There may also be a

chimney effect where a dome in the cave is opened at the surface in a location higher than the entrance. This effect may be caused by the D Passage.

At Station A5 the cave becomes large enough to walk upright, where the ceiling has multiple cupolas. There is a side lead (the B passage) to the left of A8 that loops back into the main passage. This side lead has a rounded stone that may mark this particular passage. The main passage begins to open into a larger room at A8. The room is relatively complex with several bedrock pillars, pronounced belling, and ceiling pendants. Several significant passages branch out from this room. The C Passage is a small passage that loops into the much longer E Passage. The E Passage heads in a southern direction and surpasses the entrance as the most southerly point in the cave. The convergence of the A Passage with the E and D Passages are marked by a conical shaped altar stone. There are significant remains of human bone at this location, primarily in the E Passage. The D Passage branches to the east and reaches the most easterly point of the cave. Around the D Passage there are also human bones that appear to be marked to designate their location. While broken pottery and used torches are evident in the smaller passageways, this room where the A and D Passages pass through is the point where these remains become more visible and in significant amounts. An area of relatively high concentration of pottery is found at a small alcove between Stations A11 and A12. Some human bones also are located in this same vicinity and are almost directly above the water source (A38).

After A12, there is a drop in the ceiling and a small crawl is necessary to enter another smaller room. A small passage, the F Passage, breaks off to the right and may have once reconnected with the A Passage. Between A13 and A14, the passage begins to expand into a larger room. It immediately branches off from a side passage to the left. This passage, the K Passage, is the first passage that shows significant evidence of being formed by groundwater penetration resulting in rapid downward erosion. There are several columns and stalactites in the passage that have dried out and are in a state of dissolution. There is also evidence of sizable travertine dams that are also dried out. A small hole in the floor near the start of the K passage is viewable but impassable. Station A15 is the center of a large room that exhibits several unusual ceiling features and are the most geologically interesting in the cave. A rising wall channel is present in the ceiling and some of the walls and both are covered in indefinable calcite formations. Some boxwork is also apparent. One wall has a small karst window and one large rock has a peculiar hole (20-cm in diameter) at its tip. Some of the rocks at this hole appears to have been chiseled and may have been a quarrying area. Station A15 is on a large rock in the room next to a drop in the floor where a small passage was found at the bottom of the drop. A small amount of pottery is present and the passage quickly dead-ends in breakdown. Dogtooth spar as well as an unidentified mineral band is also seen in some of the walls.

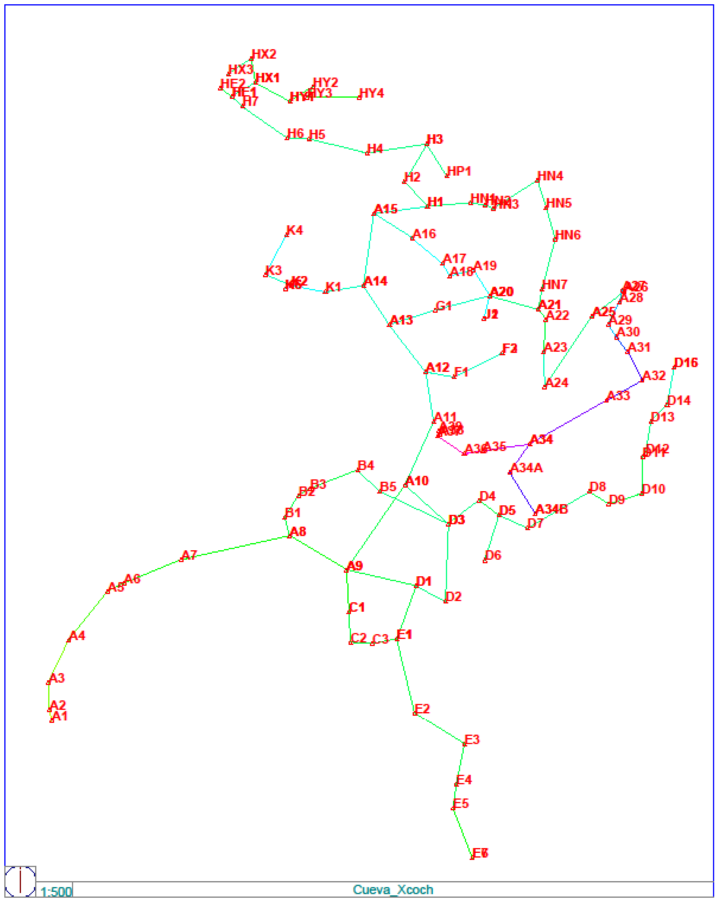


Figure 9: Map of the cave survey passages and stations in 2009.

Above the drop in the floor is a small traverse that connects the A Passage with the H Passage. It is very evident that the floor of this traverse was artificially built-up as a trail in prehispanic times. The H Passage is made up of a combination of several interconnected passages and begins as a large walking passage with a relatively steep incline. There is evidence that a significant amount of water once ran through this passage with several winding holes in the ceiling that appear to have channeled surface water in the past. The wall in this area shows flowstone with rimstone pools and there is a rounded out hole that may have been humanly modified to isolate some of the flowing water. An obsidian blade was found near this hole and small rock cairns of unknown origin were heaped in this passage. The passage splits off to the left in a northwestern direction (HX and HE Passages) and then to the right in a southeast/southerly (HN Passage) direction. Station HX2 is the most northern point in the cave and is approximately 77-m from the center of Xcoch Pyramid. The HX2 Passage extends further than what has been mapped; however, the continuation encounters a significant amount of breakdown. The continuation is heading at a steep upward incline and may lead to the surface and an alternate entrance to the cave. The highest location in the cave is at the entrance station (A1) which is 44 m above sea level based on a reading from a Garmin GPSMAP 60CSX altimeter. The HE Passage contains the second highest passage in the cave (38.545-m) but an additional 10+ m was visible at the final station. A climb

up to ascertain if there is an alternate entrance was not attempted because of the instability of the rocks in the area. The HN Passage is a long loop that connects with the bottom of the pit in the A Passage at Station A21. The final climb down into the pit showed some unusual gypsum encrusted boulders.

Station A21 is at the junction of several passages and the pivot point for the continuation of the A Passage; the HN passage connects here as does the G Passage. This is the location of the chasm that Stephens describes in "Incidents of Travel in the Yucatan" and is approximately 5.5-m in depth and choked-up with breakdown. A secondary drop extends into a natural room further below. An old wood log bridge is still present but appears to have been used more to prevent slips rather than serving as a span to cross any drop-off. The A Passage begins to wind downward into a room via a small trail that maneuvers through a large breakdown pile. A wood barrel was noted at the top of this climb down at Station A27. Another large room filled with breakdown is at the bottom of this route home to a large number of bats with rocks that are coated in a layer of guano. The breakdown pile also contains a significant number of broken pottery vessels including Preclassic wares such as Yotolin Pattern Burnished water jars discussed above. An upper portion of the ceiling is brilliantly striking when a light source is shown upon it and is referred to as the Crystal Chamber. This chamber may have held great significance to the ancient Maya given the quantities of pottery and wood remains found there. This room contains some very small but active stalactites and flowstone and there is a significant drop in the oxygen level at this point making breathing increasingly difficult. A simple test of air quality using a cigarette lighter indicated oxygen levels as low as 12 percent (the lighter did not light). From this point to the end of the survey at the water source, the oxygen levels remained low causing all movement to result in laborious breathing.

A steep drop in the room's floor directly below the chasm is where the A Passage continues. This passage was previously accessed by a wooden ladder but its remains have been subsequently removed and set aside. The descent becomes a downward crawl and another climb down reaches the lower passage that is filled on each side with broken pottery sherds. The floor of the passage changes from soil to a charcoal surface creating a hollow sound when walked upon. Whether this sound indicates that the floor was artificially built up or is just a result of the chamber's acoustics is unclear. The passage then opens into a large room with limestone that is of a harder, gray quality as opposed to the soft, white powdery limestone seen in the upper passages. At the entrance of the large room (the point where one transitions from a hands and knees crawl to a full standing position), there appears to be two fire pits: one to the left and another to right of the trail. This may explain the origin of the charcoal paving the trail. Directly beyond these pits, one can follow a small upslope path composed of sediment and broken pottery. At the end of the trail is a small alcove at Station A34b that exhibits a broken stone basin (pila or metate). The stone basin shows a relatively deep trough in comparison to other examples seen at the Xcoch site and may have been unusable because the trough is too deeply worn for grinding activity and would seem more suitable for holding water from the nearby water pool. This observation is reinforced by its location at the center of an alcove at the top of a hill of broken pottery. To the right on the wall is an area that

resembles flowstone; however, if this is the case, it has long since stopped flowing. About 3 m above, is a passage emerging from the wall. While not impossible to ascend, it would be risky and perhaps dangerous without formal climbing gear given the low oxygen levels.

Returning to the main trail, the survey continued towards a small pool of water trapped within a drop in the floor located at Station A39. The entire pool is encircled with thick layers of broken pottery as is the adjacent chamber and is the lowest point in the cave at 16.259-m (53.342 ft) above sea level. The bottom of the pool is littered with the skeletal remains of a numerous bats and isopods, crayfish, and shrimp were seen living in the water. The cave passage continues past the water source through considerable breakdown, though this area has not been mapped or extensively explored and shows no obvious evidence of human activity.

Pollen and Speleothem Sampling at the Gruta Xcoch and the Vaca Perdida Cave

In 2009, a pollen sample was taken at about 30-m from the Xcoch cave entrance approximately 10-cm below the surface to see if pollen grains have preserved in this more controlled subterranean context. Unlike the samples taken from the aguadas, pollen is present and fairly well preserved in this cave sample; although most grains show some amount of erosion. This sample was countable and most grains are from an unknown plant–possible Sapindaceae? (email communication, John Glendon Jones to Nicholas Dunning 1/14/2010) These results suggest that additional sampling in the cave could provide usable results for reconstructing vegetation history and climate patterns at Xcoch. In 2010, more extensive pollen sampling took place at the Gruta Xcoch, including a 40-cm soil-charcoal core near the water pool, and another 40-cm core at a cave 11-km east called La Vaca Perdida (The Lost Cow). These samples are now undergoing analysis and the results will be reported in the next NSF report.

In 2009, the mapping and exploration of the Xcoch cave yielded no speleothems. A more extensive program of exploration in 2010, however, did recover speleothems from the Xcoch and the Vaca Perdida caves. A variety of samples (stalagmites, stalactites, soda straws, etc.) were taken from the Xcoch cave as well as large stalagmites that came from the Vaca Perdida cave. The speleothems from the Xcoch cave were mostly stalactites and not currently active in terms of drip water formation and appear not to be usable for climatic reconstruction. The Vaca Perdida cave, however, produced three stalagmites that are still active and show at least 11 hiatuses in cross-section. The hiatuses mean drought conditions, which is fundamental to this study. Hence, we are now attempting to date these specimens and determine when the cessation (11 hiatuses) in calcite deposition occurred. These data should provide a strong measure of diachronic climate patterns related to variations in rainfall over the centuries.

Obsidian Hydration and Paleothermometry Analysis

Natural hydration of obsidian was first proposed as a dating technique for young geological and archaeological specimens by Friedman and Smith (1960), who noted that

the thickness of the hydrated layer on obsidian artifacts increases with time. Sensitive to temperature and humidity under earth-surface conditions, however, obsidian hydration dating has been problematic, but potentially provides a unique tool for paleoclimatic reconstructions (Anovtiz et al. 2006). The first successful application of "paleothermometry" was based on combining laboratory-based experimental calibrations with archaeological samples from the site of Chalco in the Basin of Mexico. These samples were dated using stratigraphically correlated C-14 results and measuring hydration depths by secondary ion mass spectrometry (SIMS). The results indicate that a cooling trend, corroborated by other paleoclimatic data, occurred in the Basin of Mexico almost 1500 years ago, and that this approach should be viable and applicable to other culture areas in Mesoamerica.

To apply this approach to the site of Xcoch and the Puuc region, obsidian from Chac,Yucatan (20-km south of Xcoch) dated using stratigraphy and C-14 was submitted to the University of Missouri Research Reactor in 2009 for sourcing information. Obsidian source must be first controlled to calibrate the hydration process. El Chayal, Guatemala is the most common source for obsidian found at archaeological sites in the Puuc region and 23 samples from the Chac site all sourced to El Chayal were submitted in July of 2009 for paleothermometry analysis to the Oak Ridge National Laboratories. If this analysis, which is still in progress, proves successful for paleoclimate reconstruction at Chac, obsidian samples from Xcoch and sourced to El Chayal will be submitted for additional obsidian hydration paleothermometry analysis. The results will be detailed in the next NSF report.

Stratigraphic Excavation

Twenty-one test pit operations (Op.) were excavated in levels following natural or cultural stratigraphy when possible in non-architectural contexts outside of buildings within the Plaza Xcoch, the Great Platform, the Residential Group, and other settlement localities (Figure 2). Those excavations produced typical Cehpech ceramics (800-1000 AD) in the upper levels. Nevertheless, significant quantities of ceramic diagnostics included Motul (600-800 AD), Cochuah (300-600 AD), and Preclassic Mamom and Tihosuco complexes (800/700-400/300 BC) in stratigraphic contexts associated with early architecture. These data demonstrate that Xcoch had a large occupation during the Preclassic period

Operations 1 and 2 were 2 x 2-m units located within the Xcoch Plaza in front of the megalithic staircases of the Grand Platform. Operation 1 probed the space to the southwest of the Grand Platform. In level 1 a pavement of well-cut and well-fitted stones (Floor I) was exposed that showed traces of a thin layer of hard white stucco (1-cm) at 47-cm below the surface (b.s.). The pavement was placed upon layers of chich and medium size stones (bak pek) and had a maximum thickness of 30-cm. Beneath floor I was another stucco floor (II) in level 2 at the 70-cm. b.s. Floor II was a relatively complete floor only damaged by the weight of stones above but the stucco layer was 2-cm thick supported by a 30-cm layer of lime marl (sascab) mixed with a few stones. In level 3, floor III appeared at 100-cm b.s. and in level 4 one can see that floor III is composed of a stucco layer (2-cm) and sascab (15-cm) laid upon natural reddish soil atop

an irregular bedrock surface between 118 and 142-cm b.s. The ceramics associated with floors I and II were diagnostic types of the Cehpech complex but the ceramic material underneath Floor III were types from the Motul and Cochuah complexes dated to the Middle and Early Classic periods.

Op. 2 was placed in the Xcoch Plaza in the front-center of the Megalithic Staircase that gave access to the south side the Grand Platform. Floor I appeared at the bottom of level 1 at 40-cm. b.s. and was very fragmented but better preserved in center and the southwestern corner of the unit. In level 2 floor II appeared at 56-cm. b.s. and corresponds to the first tread of the staircase and is better preserved underneath a heavy layer (50-cm.) of chich stones, sascab, and natural soil. At the end of level 3 at 101-cm. b.s. was floor III, a stucco surface supported by a heavy layer of sascab and reddish brown soil. An irregular natural surface of bedrock appeared between 138 y164-cm. b.s. The ceramics of this unit were similar to Op. 1 but Preclassic sherds were recovered in levels 3 and 4 below floors II and III..

Op. 3 was a 2 x 2-m unit located on the west side of the Xcoch Plaza in front of a cylindrical stone altar aligned with the center of the staircase for the Cave Pyramid. In level 1 the same stone pavement (Floor I) with traces of a thin hard stucco layer (1-cm.) found in Op. 1, about 50-m north, appeared at 8-cm. b.s. At 26-cm. b.s. stucco floor II was set upon 2 compact layers of sascab: a white layer and another tan sascab layer. Floor III was between 60 and 65-cm b.s., floor IV 75 and 77-cm., and floor V 84 and 86-cm. b.s.; the last two floors had 1-cm stucco coats superposed upon 10-15-cm layers of very compact sascab. No ceramics were found in floors III and IV and only 1 sherd came from floor V. Underneath floor V, a tan layer of sascab was set upon a thick layer of chich stones and bak pek until 178-cm where Floor VI appeared which was a downward sloping stucco surface towards the east. Supporting floor VI was 1-m of stone fill superposed upon bedrock at 280-cm. b.s. Below floor VI was a significant quantity of Preclassic ceramics.

Op. 4 was a 4 x 4-m unit located upon the Grand Platform 25-m south of the Great Pyramid (Figures 6a-b). It was necessary to excavate a large area at the outset because of the unstable platform stone fill. For safety, we decided to reduce the size of the unit as the excavation became deeper. The first floor of the platform was very eroded and only stucco fragments were detected between 23 and 25-cm. b.s. Floor II appeared between 30 and 52-cm. b.s. in level 2. In the southwestern corner was an irregular stone concentration that suggests a platform or feature such as a check dam to control the flow of rainwater drainage off the platform surface. Floor III was a stucco layer (2-cm.) laid upon a heavy layer of sascab and small stones (35-cm.) appearing at the end of level 3 between the 46 and 70 cm. b.s. This floor is clearly sloping towards the southwest as is floor II. Floor IV is between 68 and 97-cm. and continues sloping towards the southwest and also shows a burned zone in the northeast corner. In level 5 we decided to reduce the excavation unit to 3 x 3-m for safety reasons. Floor V was encountered at 95 and 102-cm b.s. directly beneath Floor IV and the direction or surface drainage changed towards the south-southeast. Floor VI appeared between the 145 and 151-cm. b.s. underneath a considerable amount of bak pek and large boulders (buk) but now the floor surface slopes toward the northeast. On floor VI was considerable cultural material including marine shell and black corral, serpentine, bone, part of a Chunhinta black plate and numerous other Preclassic sherds, and wood charcoal samples. Similar material come out of the floor

itself within level 7 at 190 cm. b.s. Excavation concluded at 395-cm b.s. because of the risk of avalanche and became too dangerous to continue further. Clearly, the fill of the Grand Platform continues down at least another 4-m in depth.

Op. 4 provided crucial data about the Preclassic period. A total of 1,238 Preclassic sherds were recovered; the majority identified as Middle Preclassic wares of the Mamom ceramic complex. The presence of worked marine shell, serpentine, and well-made stucco floors suggest that the Grand Platform and associated architecture was constructed at the beginning of occupation at Xcoch centuries before the time of Christ. Two wood charcoal samples from floors V and VI were radiocarbon dated to 570 BC +/-25 and 600 BC +/-30 respectively (Table 1).

Op. 5, a 2 x 2-m unit, was located on the east side of the Plaza Xcoch in front of a cylindrical megalithic altar aligned with the center of the staircase for the East Pyramid. In level 1 the same stone pavement (floor I) with traces of a thin stucco coat (1-cm.) found in Ops.1 and 3 appeared at 40-cm. b.s. This stone floor formed the base for the megalithic altar suggesting that both features were contemporary. The associated ceramics were Early Classic Timucuy polychrome and Late Classic Muna slate respectively. Floor I was superimposed directly upon stucco floor II (level 3) at 62-cm. atop a 10-cm layer of gray-white sascab. Below this within levels 4 and 5 were floors III (70-cm.b.s.) and IV (80-cm. b.s.). Floor III was a gray-white layer of sascab and floor IV was placed upon a layer of tan sascab. Material for these two floors clearly came from two different quarries. Although the few associated ceramics are Cehpech wares (Muna slate and Teabo red), it is not certain if these floors date to Late Classic. Floors V (90-cm. b.s.), VI (99-cm. b.s.), VII (108-cm. b.s.), and VIII (119-cm. b.s.) did not produce one potsherd. Nevertheless, between floors IX and X at 140 to 194-cm. b.s. including the bak pek construction fill, Preclassic sherds began to appear. Underneath floors X and XI, significant quantities of Middle Preclassic materials were recovered including animal bone and charcoal samples before encountering bedrock at 299-cm. b.s. Also, a wall of medium size stones was exposed within the north wall of the unit that is clearly associated with floor XI to suggest a Middle Preclassic structure built upon leveled bedrock (a wood charcoal sample was radiocarbon dated to 610 BC +/-25; Table 1)

A trench of 1 x 6-m (Op. 6) oriented north-south was excavated within the southwestern corner of the Grand Platform (Figures 7a-b). The objective of this operation was to explore an open space of 20-m showing no remains of platform retaining walls but exhibiting a great concentration of stucco mixed with natural soil. The southwest sloping floors of Op. 4 indicate that rainwater drainage had to pass through this area. Between 10 and 80-cm b.s., a canal with a sloping irregular stucco surface and a concave-oval step were exposed and is clearly a water drainage feature designed to capture and control rainwater draining away from the Grand Platform. Two similar stepped stucco features were found below to the south revealing a check dam and sloping stucco surfaces. We believe that this water control feature was designed to slow and direct rainwater draining from the Grand Platform towards the Gondola Aguada some 250-m to the southwest.

The first 2 x 1-m section of Op. 6 located at the foot of the platform reached 103-cm b.s. before the excavation was terminated--it did not find bedrock. Of the 594 ceramic sherds recovered, 554 are Cehpech complex wares and the rest are dated to the Early Classic and Preclassic periods. It is likely that this drainage feature was constructed near the end of

Preclassic period but the significant number of Cehpech ceramics suggests that it was reused in Late Classic.

Op. 7 was a 3 x 1.5-m unit placed in front (south) of the Niches Building located along the south edge of the Grand Platform above Op. 1. The main idea was to date this rare building that had no vaulted roof but shows megalithic corner stones, megalithic niches on the south facade, and heavy jambs forming a central entrance. In level 1 floor I was exposed (54-cm b.s) and appears to have been a stucco surface that was part of a late renovation of the structure. Floor II (71-cm. b.s.) was associated with a small column 33-cm wide that was part of the original building doorway. At the end of level 2 another stucco floor (III) at 120-cm. b.s. produced ceramics that are a mixture of Preclassic, Early Classic, and Late Classic types. Floor III is clearly part of a Grand Platform surface and beneath floor II we found the south facade of the Grand Platform with several roughly faced stones still in situ. All ceramics in level 3 are Middle Preclassic types including pieces of serpentine, black corral, and charcoal samples (one sample was C-14 dated to 620 BC +/-25; Table 1). These data demonstrate that this part of the Grand Platform was remodeled at the end of the Preclassic period or the beginning of the Early Classic, and are in contextual agreement with the absence of the Preclassic ceramics but the presence of Early Classic material in the lowest levels of Op. 1, located at the foot of this same platform.

Op. 8 was a 2 x 2-m unit placed within the Residential Group south of the central platform near a conical altar. In level 1 a pavement of rough stones (Floor I) showed pieces of a thin layer of in situ stucco at the 34-cm b.s. that probably represents the last floor surface for this group. At the end of level 2 at 92-cm b.s., floor II appeared which is a better preserved stucco surface but still broken in places. A lens of the gray ash mixed with soil was found near the altar. In level 3 at 109-cm b.s. floor III was encountered and within floor III and above floor IV (120-cm b.s.) two nearly complete broken Muna slate chultunera jars were recovered; one was normal size and the other a miniature vessel. These vessels represent an offering associated with the altar. Recovered later within the north wall near the altar, a Ticul thin slate tripod dish was clearly part of the same vessel offering. Below floor IV, which was also broken, were human bone, basalt, black serpentine, and a quantity of black stone nodules identified as imported iron ore (hematite, magnetic, or pyrite) for manufacturing mirrors. Pieces of ground and polished iron ore mirrors also were found at different stages of production suggesting a mirror workshop(s) associated with the lower levels of this Residential Group. Mirror workshops have found at San Jose Mogote in Oaxaca dating to the Early and Middle Preclassic periods (Pires-Ferreira 1976). Below floor V beginning at the 152-cm. b.s. were more of the same iron ore nodules as well as other exotic material including marine shell, fish scales, one obsidian blade, and charcoal samples. The ceramics within floors IV and V are a mixture of Early Classic and Preclassic wares. Within the floors VI (200-cm. b.s.), VII (245 - cm. b.s.), VIII (255-cm. b.s.), the ceramics are Middle Preclassic and a building wall running to the north-south appeared in the center of the unit associated with floors VII and VIII. Also, another east-west wall was exposed at 212-cm. b.s. It is almost certain that these walls represent a habitation structure with at least two rooms and floors dating to the Middle Preclassic period (a wood charcoal sample from floor VIII was C-14 dated to 540 BC +/-30; Table 1). Near the west wall of the unit and part of the wall of the substructure was an offering of green serpentine and a large thin walled sherd that was part of a cylindrical vessel. This sherd has not been identified but is obviously

very early and likely a foreign ceramic ware. Op. 8 encountered bedrock between 300 and 320-cm b.s.

Op. 9 was a 2 x 2-m unit located just south, off-platform of the Residential Group near a columnar altar at the foot of a staircase. This area probably was an access route for the Xcoch Plaza because it lies near an open space between buildings along the Plaza's east wing. Floor I appeared at 50-cm b.s. and contained a heavy layer of compact sascab with typical Cehpech complex. Floors II (70-cm b.s.), III (81-cm b.s.), IV (89-cm b.s) and V (98-cm b.s.) were superimposed compact layers of a tan colored sascab. The ceramics associated with these floors were identified as the Motul and Cochuah complexes of the Middle to Early Classic periods. Floors VI (106-cm b.s.), VII (138-cm b.s.), VIII (149-cm b.s.), and IX (203-cm b.s.) were also formed by compact layers of a tan sascab mixed with medium size stones. The upper floors (VI and VII) contained a mixture of Early Classic and Preclassic ceramics and the lower floors (VII and IX) produced pure Middle Preclassic diagnostics. Stone alignments (wall) running towards the west near the north and south unit walls are contextually related to floors VII and VIII and probably represent the remains of a Preclassic substructure. Floor IX was superposed upon successive layers of chich and bak pek before arriving at bedrock at 220-cm b.s.

Op. 10 was a 1 x 2-m unit that probed an upright plain megalithic stela 25-m northeast of the Residential Group and behind the vaulted buildings where Elite District begins. Floor I was placed upon a stone pavement between 29 and 31-cm b.s. and contained the typical diagnostics of the Cehpech ceramic complex on-floor but Middle and Early Classic ceramics came from below the floor. Floor II appeared at 78-cm b.s. and contained a layer of stucco placed upon faced stones and construction fill for a platform on which the stela is seated. The megalithic stela measured 200-cm in height and the associated ceramics are mostly Early Classic though a Chunhinta black (Middle Preclassic) sherd was recovered beneath the platform. Op. 10 did not reach at bedrock and the unit was terminated with level 4 at 85-cm b.s.

Op. 11 was a 2 x 2-m unit within the space between two linear structures along the north side of the plaza where the Elite District begins. This probe hoped to determine if these parallel structures could be a Maya ballcourt. The unit contained many diagnostic building stones (facing, molding, and vault stones) indicating that there were standing high walled, vaulted buildings on both sides that had collapsed into this space. A stone pavement appeared at 140-cm b.s. and consisted of a stucco surface placed upon a layer of chich stones and bak pek. Op. 11 was closed out at 150 cm b.s. The ceramics from Op. 11 were all typical Cehpech wares dated to the Late-Terminal Classic period. Unfortunately, this test excavation could not confirm the presence of a ballcourt in this location and the current evidence simply indicates an inter-building space for two vaulted range structures.

Ops.12, 13, and 14 were horizontal excavations that took place between the Grand Platform drainage feature (Op. 6) and the Cave Pyramid along the west section of the Xcoch Plaza. These extensive surface stripping operations were designed to reveal any water management features connected to the drainage feature (canals, check dams, diversion points, etc.). Op. 12 was 20-m south of Op. 6, Op. 13 20-m south of Op. 12, and Op. 14 midway between Ops.12 and 13. Op. 12 was a 1 x 2-m unit oriented east-west. The unit exposed a stone retaining wall on the east side at 20-cm b.s., a sloping stucco surface to the west at 64-cm b.s., and a stucco floor surface at 71-cm b.s. that are

all clearly aligned with the drainage feature to the north. Op.13. was a 2 x 1-m unit oriented east-west with two 1 x 1-m north extensions designed to find the turning point for the canal found 20-m to the north (Op. 12). This area, which is north of the Cave Pyramid, consisted of a rough stone pavement and small retaining wall for a platform surface but did not reveal any continuation of the channel or a turning point for a canal. Op. 14 was a 1 x 2-m surface probe oriented east-west and a 1 x 1-m north extension near several large boulders about 10-m north of Op. 13. Between 13 and 24-cm b.s. a boulder retaining wall was exposed at 53-cm b.s. and in the north part of the unit a stucco surface appeared that continued 1.5-m to the west. A north extension of the unit exposed a concave and channeled stucco surface between 52 and 59-cm b.s. that represents a canal for flowing water. The curvilinear boulder retaining wall to the south was obviously a diversion point where water was turned downhill in a west-southwest direction towards the Gondola Aguada. All recovered ceramics were Cehpech wares suggest that the last use of this system took place in the Late Classic period, but no deep stratigraphic cuts were performed to determine the date of this canal or if there were earlier water control features. The one probe within Op. 6 and the excavations from Op. 4, however, do indicate that this drainage feature and the entire water control system were originally constructed during the Late Preclassic period.

Op. 15 (Chultun 2) took place within a wide-mouth chultun in a settlement group east of the East Pyramid of the Xcoch Plaza and south of a linear pyramid platform. This chultun was one of two chultuns within the plazuela of a residential group with numerous stone basins and a four-room foundation brace. Chultun 2 was selected for testing because of its unusual wide mouth (55-cm north-south by 62-cm east-west) and noticeably high level of fill (1-m in depth below the mouth). A hole within the chultun roof 160-cm to the south provided good ventilation and reasonably good lighting necessary for excavation activity. A 1-m square was located directly beneath the chultun mouth and excavated in arbitrary or natural levels where possible. Levels 1 and 2 were taken down to 60-cm and 120-cm respectively. Level 3 began at 160-cm and continued to 210-cm b.s. Level 4 was begun where large chunks of roof stucco began to appear then level 5 began at 270-cm b.s. and proceeded to the floor of the chultun at 300-cm b.s. What became curiously apparent during excavation was the tendency for Early Classic and Preclassic ceramics to be concentrated near the upper levels (1-3) while Late, Terminal, and Postclassic pottery were associated with the lowest levels (4-5). This appears to be a clear case of inverted stratigraphy in which an early chultun and it contents was cleaned out for reuse in later time periods, thus superimposing early materials atop later deposition. This observation is supported by multiple layers of stucco still seen on preserved portions of the chultun roof where various blue-tinted stucco coats (Preclassic-Early Classic?) were covered by coats of white stucco (Late-Terminal Classic?).

Op. 15 produced more than 5,000 potsherds (nearly 60,000-g), many where large portions of ceramic vessels such as chultuneras and other water jars that were found on-floor. About 70% of all pottery recovered is Late-Terminal Classic while almost 30% is Preclassic to Early Classic. There were also a wide variety of other artifact and ecofact remains including worked marine shell, chipped stone, obsidian blade fragments, ground stone, serpentine celt flakes, animal and human? bone, and wood charcoal samples. One wood charcoal sample produced a radiocarbon date of 530 AD +/-30 from level 5 near

the chultun floor indicating that the chultun was constructed before the Early Classic period (Table 1).

Ops.16 and 17 were trenches designed to expose the downhill canals associated with a water management system found atop the west side of the Great Acropolis. Op. 16 was a 1 x 6-m trench oriented north-south between Op. 13, where a diversion dam was found, and the Gondola Aguada. Though bedrock was encountered throughout the trench, a possible canal of bedrock and retaining wall for a building platform on south side suggest that water passed though this area. It is fairly clear that the north edge of this building platform, supporting a four-room foundation brace building, was placed here to channel rainwater traveling from the acropolis to the aguada.

Op. 17 was a 1 x 4-m trench oriented north-south with a 2 x 2-m western extension placed within the lower berm on the northwest corner of the Gondola Aguada. The purpose of this unit was to expose any water features to help understand how and from where water entered into the aguada. The trench revealed a junction point of two canals separated by a 1-m thick retaining wall of medium-large boulders and canal retaining walls on the north and south sides. Many of the wall stones appear to be white limestone-travertine similar to stone seen in the Xcoch cave. The canals were lined with thick layers of kancab-alkache soils heavily mottled with sascab. In fact all potsherds and other artifacts from this unit were coated with this glue-like, water impermeable soil that was very difficult to remove. Evidently, this feature served as a junction for two canals channeling water into the aguada; a northwest canal as documented by Ops. 6, 12, 13, 14, and 16 and a west canal (Op. 17) moving rainwater likely from the Xcoch Plaza (Figure 5a). The west extension showed that the central retaining wall of this canal junction was contoured in accordance with the slope and berms of the aguada to help control the flow of water coming from two different directions. This unit in particular demonstrates that the Maya employed sophisticated engineering knowledge and techniques to manage and control rainwater across the surface of this large Maya center.

Ops.18, 19, and 21 were 2 x 2 m units placed within the Grotto Group to sample two megalithic foundations. Ops. 18 and 19 probed the area near the entryway of structure 1, room 1 of the north group located just south of the entrance to the Gruta de Xcoch. Op. 18 sampled the east entry space and megalithic doorjambs for a perishable walled and roofed building. A concentration of stones between doorjambs suggests that the walls had collapsed but a stone surface made up of layers of chich and bak pek with traces of stucco indicates a floor (I) and foundation for the building between 38 and 109-cm b.s. dating to the Late Preclassic period. A more visible stucco floor appeared below 109-cm b.s. associated with stones for a substructure running towards the southwest placed upon bedrock between 129 and 140-cm b.s. Op. 19 was opened to the south of structure 1 to follow this lower substructure wall alignment and revealed a upper stone surface showing medium size boulders set in unusual upright positions. Beneath the same stucco surface found in Op. 18 were more remains of an early substructure continuing towards the southwest and an associated stone pavement between 132 and 135-cm. b.s. that runs across the unit. These features were placed upon bedrock at 142-cm b.s. The ceramics in both units show a mix of Early and Late Classic wares in the upper levels and a mix of

Preclassic materials below floor II, including a preponderance of Middle Preclassic diagnostics associated with the lowest stone surfaces, structural alignments, and bedrock.

Op. 20 (a 2 x 2-m unit) was placed in front the central-east foundation brace (Structure 5) of the Triadic Group located over 400-m east of the Gruta. Level 1 exposed the fragmented remains of a stucco floor (I) between 33 and 43-cm b.s. connected to a faced stone step for Structure 5. Another fractured floor surface (II) appeared between 80 and 87-cm b.s. Below floor II at 92 cm b.s., jamb stones of a substructure were clearly apparent and a stucco floor surface (III) appeared at 114-cm b.s., especially between the door jambs. Bedrock was encountered at 134-cm b.s. A 1 x 2-m extension was opened to the southwest to follow the substructure and additional faced stones were exposed, including other jamb stones and more of the stucco floor but most of substructure was collapsed in ancient times and extends well beyond the limits of the excavation. The ceramics of levels 1 and 2 (floor1) were exclusively Cehpech wares while level 3 (floor II) yielded a mix of Late Classic, Early Classic, and Preclassic wares. The ceramics of floor III directly associated with the substructure were pure Middle Preclassic diagnostics.

Op. 21 was placed in front of the east entryway of structure 1, room 2 of the south portion of Grotto Group. This building contained a perishable roof and shows large shaped megalithic foundation stones measuring approximately 50-cm square set atop a bak bek stone pavement between 40 and 54-cm .b.s. Many of the pavement stones have the same texture and white color of limestone seen in the nearby cave. A stucco surface (floor II) appeared in level 2 below the stone pavement at 84-cm b.s. This white sascab surface is associated with the building platform for structure 1. At the bottom of level 3 between 95 and 99-cm b.s., a tan stucco/sascab surface (floor III) appeared that was set upon layers of chich and bak pek. A more pinkish surface (Floor IV) appeared in level 4 at 132 to 138-cm b.s. with a lens of ash and bone (human?) near the north wall before bedrock was encountered at 212-cm b.s. Pure Preclassic ceramic deposits were recovered from below level 3, floor II suggesting that structure 1 and its building platform were constructed in the Late Preclassic period. The earliest floor surfaces (III and IV) must date to the Middle Preclassic period because only ceramic diagnostics of this early time period were found.

Ceramic Analysis

During the season of 2009 at Xcoch, 20,406 ceramic sherds were analyzed using the type-variety classification system employed by most Maya ceramists in the last three decades that has been adapted for the identification and comparison of analytical units from different sites. This system allows us to infer cultural relations between different sites of the Maya area through time (Sabloff 1975: 3; Robles 1990:25).

In Operations 1-21, the ceramics near the surface are identified as typical of the Cehpech ceramic complex of the Late –Terminal Classic period including Yocat striated, Muna slate, Ticul thin, Teabo red, and Holactun. There are, nevertheless, a significant amount of Early Classic types including polychromes such as Chac, Timucuy, and Dos Arroyos within the middle levels. In almost every test pit, the lower levels produced Preclassic

diagnostics such as Chancenote striated, Chunhinta black, Joventud red, Sierra red, Dzudzuquil, Muxanal and others. There are the remains of least 3 large hemispherical vessels with cylindrical monopod supports, long narrow necks identified as Yotolin Patterned Burnished, among the earliest ceramics of Yucatan, within the Grotto of Xcoch (Brainerd 1958; Smyth and Ortegón 2006, 2008; Figures 8b- e). Although there is no agreement on the dating of these mysterious ceramics only found near Mani, Sacalum, Loltun Cave, Tzucacab, and now Xcoch, Yotolin Patterned Burnished dates to at least the early Middle Preclassic, though some have argued for an Early Preclassic date (Brainerd 1958; Folan 1968; Andrews V 1990). Its finding underneath the Cave Pyramid in the middle of a Middle Preclassic center is very significant and importantly suggests that the producers and the consumers of this early ceramic ware lived nearby.

The presence of early ceramics in many surface units cannot be a random pattern. The 2009 surface survey collected 5,056 sherds from 259 3x3-m collection units resulting in an average of 19.5 sherds per collection unit. As expected, most surface ceramics are of the Cehpech complex; almost all are Yokat striated and Muna slate types without decoration and there are few fine paste wares (112 sherds or ~ 2%). This pattern is very unusual given the fact that the majority of the collections came from around the central monumental zone of Xcoch, especially within the Elite District where there is much monumental architecture. These same contexts produced significant quantities (~5%) of fine paste ceramics in the previous surveys of Sayil and Chac II. Also, the amounts of Muna slate are greater than the amounts of Yokat striated; normally Yokat consists of more than 60% of all the ceramics found on the surface of Puuc sites. So far, Early Classic and Preclassic ceramics at Xcoch are found within 17 different surface units, approximately 1 Preclassic sherd for every 12 squares. This pattern is almost identical to the surface patterns of 2006 surface survey, although the 2006 survey covered the monumental center of Xcoch. These data may be significant because the surface survey in Sayil produced very few Preclassic ceramics within 5,261 squares and at Chac II there were no Preclassic sherds from 3,970 collection squares.

The stratigraphic test pits at Xcoch produced 15,350 sherds many associated with stucco floors, architectural stratigraphy, and charcoal samples. Within the upper level contexts (Late Classic), a total of 10,960 sherds (71%) were recovered. However, 5,224 Late Classic sherds came from Chultun 2 (Op. 15) alone which skews representative ceramic samples at the site level. Removing the ceramic totals from Chultun 2 shows that in the middle levels there were 1,606 sherds (16 %) diagnostic of the Early-Middle Classic periods. In the lowest levels there were 2,564 sherds (26%) that are Preclassic ceramics of which the majority seem to be Middle Preclassic. These data strongly suggest the center of Xcoch had a significant occupation during Middle Preclassic when many of the largest monuments at the site were constructed such as the Grand Platform, the Great Pyramid, and Plaza Xcoch with its two pyramids to the east and west. In fact, ceramic and architectural data suggest that Preclassic occupation can be found at all areas of the settlement survey so far that currently covers more than 1 square kilometer.

Radiocarbon Dating

Thirteen samples of wood charcoal were submitted to National Ocean Accelerator Mass Spectrometry Facility (NOSAMS) for radiocarbon dating (Table 1). These samples were recovered from Ops. 4-8, 15, the South Aguada, and the Gondola Aguada. Though five samples turned out to be historic or modern in date and are likely the result of contamination, eight samples were prehispanic. The most notable were five Middle Preclassic dates from the lower levels of the Grand Platform, Xcoch Plaza, and Grupo Residencial. These dates clearly show that the central architecture at Xcoch was constructed between the 5th and 8th centuries BC and represent among the earliest and largest monumental constructions in northern Yucatan. Two late Early Classic dates were associated with the South Aguada and Chultun 2 (Op.15), a time when we believe that the site of Xcoch was being reoccupied after abandonment in the Late Preclassic period. To refine the site chronology further additional samples for radiocarbon dating are scheduled to be submitted in the near future.

Table 1: Radiocarbon dates from Xcoch, Yucatán. All dates were calculated using the Accelerator Mass Spectrometer (AMS) technique from the National Ocean Accelerator Mass Spectrometry Facility (NOSAMS) and the Calib Radiocarbon Calibration Program.

Field Spec.	Lab Num. NOSAMS	Conventional C-14 Age BP	Uncalibrated Calendar Date	Calibrated C-14 BC/AD (2 sigma, 96% probability)	Context
20013	78754	1460+/-25	490 AD	560-646 AD	Aguada S, Pozo 1(200 cm)
20020	78755	305+/-30	1645 AD	1488-1603 and 1609-1651 AD	Aguada Gondola, Pozo 2 (100 cm)
20045	78756	2520+/-30	570 BC	716-792 and 539-695 BC	Grand Platform, Op. 4, Lev. 6 - Piso V
20046	78757	2550+/-30	600 BC	743-800, 663-689, and 549-647 BC	Grand Platform, Op. 4, Lev. 7 - Piso VI
20059	78758	2560+/-25	610 BC	749-802, 666-687, 591-641, 567-578 BC	Xcoch Plaza, Op. 5, Lev. 11 - Piso X
20063	78759	145+/-30	1805 AD	1668-1710, 1717-1781, 1797-1891, and 1909-1948 AD	Gr. Platform SW, Op. 6 ext. 2, Lev. 1
20072	78760	2570+/-25	620 BC	751-806, 667-686, 623-634, 594-614 BC	Gr. Platform, Niche Bldg, Op. 7, Lev. 3 - Piso II
20076	78761	330+/-25	1620 AD	1483-1641 AD	Grp. Residencial, Op. 8, Lev. 3 - Piso II
20078	78762	Modern			Grp. Residencial, Op. 8, Lev. 5 - Piso IV
20079	78763	245+/-25	1705 AD	1528-1552, 1633-1673, 1778-1799, and 1942-1951 AD	Grp. Residencial, Op. 8, Lev. 6 - Piso V
20082	78764	2490+/-30	540 BC	508-776, 454-458, 419-438 BC	Grp. Residencial, Op. 8, Lev. 9 - Piso VIII
20088	78765	625+/-25	1325 AD	1291-1331, 1338-1397 AD	Chultun 2, Op. 15, Lev. 4 (270 cm)
20089	78766	1420+/-30	530 AD	581-660 AD	Chultun 2, Op. 15, Lev. 5

Discussion and Conclusions

The Maya center of Xcoch is providing important new environmental data on rainfall and response to global climate change potentially related to Arctic climatic warming. Xcoch experienced a long occupation and appears to have been a major Maya center with massive monumental architecture as early as the Middle Preclassic period (800-400 BC) and was based upon an agricultural economy with complex social organization until the Late Classic period. Xcoch is particularly well suited to investigate climate change because of its long span of occupation and because it appears to have experienced multiple collapses; one in the Late Preclassic and another in the Late Classic perhaps brought on, in part, by repeated cycles of drought. The site also seems to have had 5-6 depression features (aguadas or water holding ponds) and canal systems constructed to store vast amounts of rain water perhaps in response to reoccurring drought cycles beginning in the Preclassic period. Such an intense, short-term water storage strategy, however, may have born the seeds of its own destruction. The storage of so much surface water in such a hot and humid environment where evaporation is intense may have negatively affected subsurface runoff to a degree that reduced the level of the water in the Xcoch cave to a point where the water pool ran dry or the water became inaccessible during critical drought periods.

The beginnings of sedentary farming communities, complex societies, and early community organization in the Puuc region is being be addressed by the work at Xcoch. Multiple data sources are helping identify Preclassic patterns of chronology, community structure, and culture process: indigenous development versus in-migration or some combination thereof. The survey data indicate that the site was indeed a large Preclassic Maya center as supported by the presence of Megalithic public architecture and Preclassic ceramics. Similar finds at other Puuc sites such as Kiuic, Huntichmul, Paso de Macho, and Xocnaceh show evidence that sedentary farming communities were already established in the Puuc region. With the possible exception of Xocnaceh, which may have been a special purpose center of religious significance, these sites, however, are not regional centers as some researchers have been argued for the site of Xtobó in northwest Yucatan (A. Andrews and Robles Castellano 2003; Anderson 2004); Xcoch may have been a Preclassic center for the Puuc hills of special importance because of its water bearing cave; only one of three water caves known for the region. Other early sites such as Komchen, Dzibilchaltun (El Mirador Group), and Poxila to the north, Xtobó to the northwest; Yaxachen and Acanceh to the east, Edzna to the west imply the existence of a Preclassic regional settlement hierarchy across Northern Yucatan that included the Puuc hills.

Climate change, surface survey, mapping, and excavation data in 2009 are providing exciting and important insights into human ecodynamics among the ancient Maya at Xcoch. This “high risk-high payoff” exploratory research is addressing compelling cultural reaction and failure to adapt to rapid climatic change that can be potentially traced to the Arctic region. This transformational work engages the Arctic community because it is becoming increasingly apparent that Arctic climate changes have global culture-environmental impacts. Also, this work brings to the forefront a tangible example

of how tropical and Arctic climate processes may be interrelated and helps liberate researchers from 19th century regional boundary paradigms to contemplate and appreciate the dynamics of global climate change past and present. Continued work at Xcoch and the Puuc region will certainly enhance and advance understanding of the human ecodynamics of climate change and past cultural response.

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