The Beginnings of Complex Society in the Puuc Region: Survey and Exploration at Xcoch (Cave), Yucatan, Mexico

Final Report to the
National Geographic Society Waitt Program (W62-09).

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Xcoch was a significant Preclassic Maya center with potential for addressing the beginnings of complex societies in the Puuc hills region of northern Yucatan. Built around a deep water cave with settlement that radiates from a massive, multi-level acropolis topped by a gigantic pyramid and platform, of large stone block construction--typical of the early Megalithic-style--numerous pyramid quadrangles, widespread Preclassic surface pottery, Middle Preclassic and Early Classic water jars recovered from the Xcoch cave, and early water management features (aguadas). These data suggest that Xcoch had a large occupation and may have been a complex society in the early Middle Preclassic period (~800-700 BC) and was also an important Early Classic settlement, but not a major player in the great Terminal Classic florescence. In 2009, survey and exploration took place in the Xcoch cave to show that the cave had a complex geological and cultural history, was the watering hole for a large early Maya center, and was a place where Maya priests performed intensive dark rituals related to water perhaps related to past climate change. The thin air in the lower chambers made mapping and exploration difficult but there is evidence for other entrances into the cave including one near the Great Pyramid. Though considerable further work is required, this research is beginning to place the beginnings of the Puuc region and the development of complex societies in greater chronological and geographical context of Mesoamerica, with the potential to establish new insight and understanding of the beginnings of Yucatan Maya prehistory.

The beginnings of complex societies in Puuc region is a crucial unanswered question in the Maya archaeology of Northern Yucatan. When sedentary farming communities and hierarchical societies first became established, whether or not they were indigenous to the region, and how they were organized as they adapted to the region's challenging environmental conditions constitute important hypotheses that must be addressed with new data sets. Survey work begun in 2006, with support from the National Geographic Society (#7989-06) suggests that Xcoch was a significant Preclassic Maya center with monumental architecture of large stone block construction--typical of the early Megalithic-style--numerous pyramid quadrangles, and widespread Preclassic surface pottery (Fig 1). Xcoch can be now added to a growing list of Puuc sites such as Kiuic, Paso de Macho, Huntichmul, and Xocnaceh that had Middle Preclassic occupations comparable to northwest Yucatan (Robles Castellanos and Andrews 2003). At Xcoch, preliminary results also indicate that density of settlement and scale of monumental architecture, often seen as measures of social complexity, are early at both urban and rural settings and appear to be organized differently from later time periods. Also, Middle Preclassic (~800/700-400/300 BC) water jars collected from the Xcoch cave beneath the second largest pyramid at the site, and numerous aguadas (or water-holding ponds) and linear features suggest early concerns with water shortages and water management strategies. These multiple sources of data suggest early occupation like other initial Puuc communities (Bey 2006; Bey and May C. 2005; Gallareta and Ringle 2004; Smyth and Ortegón Zapata 2006, 2008).

This report presents findings of work completed at the Xcoch cave in 2009 with funding support from the National Geographic Waitt Program (W62-09). This work 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 as well as the early occupation of the Puuc region.

Xcoch Cave

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 Rojo 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 begin to provide the context for chronological placement of Yotolin and the more important question of early Middle Preclassic occupation in the Puuc region.

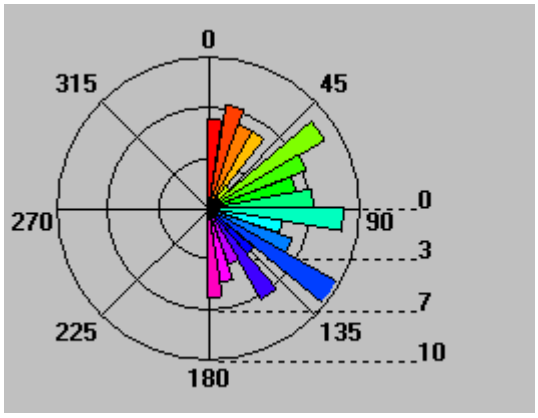
The first known published account of Xcoch Cave comes from John Lloyd Stephens in 1841 from his "Incidents of Travel in the Yucatan." Stephens' (2008) account of the cave expresses both disappointment and wonder in that the cave fails to live up to claims made by the local residents but he was still 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 is currently 641.8 meters (2,105 feet) with a surface length of 103.0 meters (337.9 feet).The average diameter of the cave passage was 3.9 meters (12.7 feet). The depth of the cave is 34.9 meters (114.4 feet) and drops 34.9 meters (114.4 feet) in 0.24 kilometers (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.

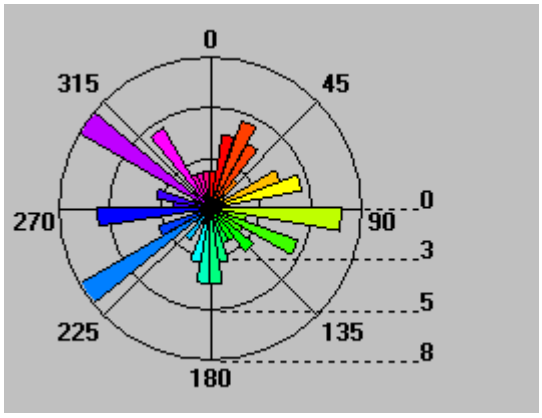
The cave is largely composed of four chambers that trend from the southwest to northeast. Chamber I is located between Stations A9 and A12; Chamber II is between A14 to A16; Chamber III is between A24 to A26; and Chamber IV is located between A29 to A35. Many of the side passages are mazes of break-aways 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 1a). 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 1b).

A small pit about 6 meters 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.

Figure 1: Passage direction (a) and water flow (b)



(a)



(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 meters 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 meters (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 survey team was compiled of five members. Eric Weaver primarily coordinated the survey project and did the plan sketch of the cave. Tammy Otten primarily did the running profile, cross-section sketches, and plan sketches for many segments of the cave. Harry Goepel and Beth Cortright primarily read instruments and also created some of the cross-sections of the

cave. Dorothy Goepel was primarily responsible for conducting the cave inventory. In addition, Dorothy was responsible for taking photographs at each significant station of the cave survey.

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.

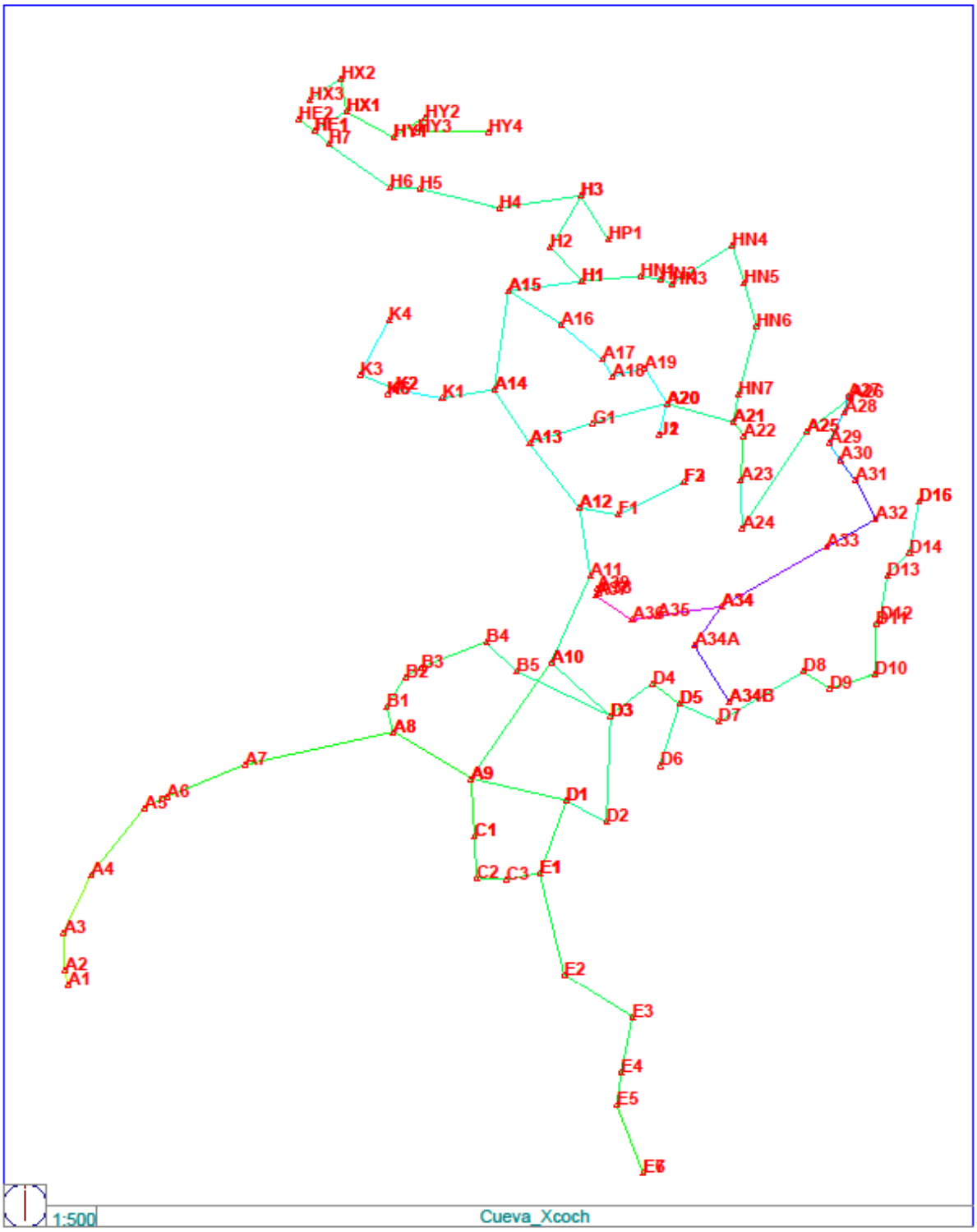
The cave entrance, Station A1, is situated at the bottom of a large depression. The actual opening is a small pit (2.3 m deep) and there is a carved stone colonnette at the bottom on the left-hand side (Figure 2). The pit immediately becomes a crawl (less than 1 m in height) from Stations A1-A3 and then 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 is 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. This room 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. 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

Figure 2: Map of the cave survey passages and stations



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.

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 housing 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. 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.

The Biology of the Xcoch cave

Xcoch cave contains an abundance of life, as well as evidence of past lives. Both terrestrial and aquatic fauna are present. Throughout the cave, there are beetles (*Tenebrionidae sp.)*, which are black with six red spots; two on the thorax and two on each elytron. A beetle was seen feeding on a dead adult cockroach. Adult and juvenile cockroaches are abundant in the

beginning sections of the cave, but their numbers dwindle in the areas that contain large amounts of bat guano and where the oxygen level abruptly drops. The adults have wide flattened light gray bodies. The juveniles are more brightly colored with orange and black forewings, an orange prothorax, and a black head.

The arachnids that live in the Xcoch cave include spiders and whip scorpions. Most of the higher passages have many small, red-brown spiders that make webs on the floor, walls, and ceiling of the cave. In the D Passage, one adult tarantula was found with a red-brown cephalothorax (prosoma), black abdomen, and black legs. Tailless whip scorpions are found in most of the cave and vary in size.

There are hundreds of bats living in Xcoch cave. They appear to move to and from the larger rooms of the cave resting in different locations each day. In the lower reaches of cave, where the floor is composed of mostly charcoal and near the location of the water source, small terrestrial cave isopods are found. These isopods are white and less than 7 mm in length. Within the small pool of water, there are aquatic isopods that are larger in size compared to the terrestrial isopods and are also white and range in sizes from about 15 to 35 mm long. Alongside the aquatic isopods, we saw one large (about 70 mm long), white cave crayfish and there are also some smaller cave crustaceans seen in the water. It is not known whether these aquatic organisms are able to reach any other source of water, but it is possible, though unlikely, that they were trapped in this small pool, isolated from the rest of the water table. The main source of food for the aquatic fauna appears to be deceased bats because the bottom of the pool contains remnants of many bats.

The bones found in Xcoch Cave appear to have a variety of origins. Around station D2, there is a skeleton of an immature equine. A mandible, metacarpal, and other bones belonged to a horse relative that was not fully grown (donkey or mule?). This is curious because there is a local legend told by the residents of the town of Santa Elena about a ceramic donkey (Burro Kat). At certain times in the evening, especially during a full moon, it is said that the Burro Kat will come to life and can be heard braying loudly and will do mischief and even harm to any person who happens to wander near the cave. This Maya “boogy man” story, it seems, is designed to discourage youngsters and others from venturing into the cave.

Further on in the D passage, a small concentration of human bones was sectioned off by two pieces of wood approximately 40 mm and 50 mm long and perpendicular to each other. The identity of the person who placed the wood is unknown as is the remains of the individual interred there. At the entrance to the E passage, about three m from a large altar, human bones and teeth were found. The majority of the bones are located under a ledge to the left of the passage. Human vertebrae, tibias, skull fragments, femurs, ribs, pelvises, and more are identified in a linear bone concentration

suggesting that there were multiple individuals laid out in extended body positions. There are small amounts of human bones around Station A11, just to the left of the trail. This includes skull fragments and probably the leg bones of a young child.

No bones in the cave can be accurately dated without the aid of radiocarbon dating, though the immature equine remains are surely post-Contact period (16th century) and may be even historic (19th century). Due to the process of decomposition that occurs after death and possible fossilization, a time of death cannot be estimated for the animals in the Xcoch cave without closer examination of these fauna remains and without laboratory testing.

Ceramic Collections

The Xcoch cave contains as much prehispanic pottery as there can found in any one place in Northern Yucatan. There are literally thousands of broken pottery vessels scattered throughout the cave passages and chambers. The highest concentrations are found throughout the A Passage, most notably near Stations A34 to the water source at Station A39. A sample of pottery was collected during the clearing and reopening of the cave entrance but within the cave itself larger samples came from the B, D, and H Passages. In total, 555 potsherds and vessel portions were collected and analyzed employing type-variety classification and formal ceramic analysis. This collection weighs 37.29 kg (~82 lbs) with an average sherd size of 67.19 grams (~2.4 oz) indicating that many of these sherds are from large diagnostic vessel portions such as rim, handle, body, and basal sherds. In fact, virtually all of the vessels from within the cave are for water storage/transport or serving vessels consisting of large lung-shaped *cantero* jars with triple handles and smaller double handled *chultunera* forms used to draw water; only a few sherds were from plates. The majority (59%) of the cave pottery is identified as Chac Polychrome and Chemax Slateware types—all are decorated water jar forms and date to the Early Classic period (AD 300-600). Interestingly, the cave contains no Late Classic pottery, though typical Late Classic types were found immediately outside the cave entrance. There were, however, vessel portions of a number Sacpukana water jars, a red ware dated to the 16th century Contact Period in Yucatan. Preclassic pottery was also present in the cave including diagnostic types such as Ucu black and Sierra red that have been found in great quantities on survey and from excavations across the site of Xcoch. The remains of more than 3 vessels of Yotolin patterned burnished, unusual hemispherical shaped water jars with long narrow necks and one single monopod support dated to the Middle Preclassic period, were found in the A Passage near station A27. Other Yotolin vessels were seen but not collected throughout the lower chambers of the cave. Curiously, it is not known how these vessels were stood up since they only have one single support. It is speculated that they were leaned against a wall surface or perhaps were suspended using a chord of some sort.

Yotolin was certainly an important ritual ware during the Preclassic period and is only found in certain cave contexts within or near the Puuc region. There is still an ongoing, unresolved debate of whether this pottery dates to the Early Preclassic (1000 B.C.E.) or the early phases of the Middle Preclassic period (700-800 B.C.E.) as assumed here.

Conclusions

Xcoch Cave is an interesting cave from archaeological, geological, and biological perspectives. The mapping of the cave was much more complicated than originally anticipated. This was due to the complex maze and lack of oxygen in the lower chambers of the cave. The majority of the cave passages have been pushed to their terminus; however, there are several leads remaining that need to be explored further. For example, the H Passage is relatively close to the surface and is the passage nearest to the Xcoch Pyramid. We were not prepared this season to explore or map this newly discovered and nearly inaccessible passage. The H Passage is interesting in that it appears to have had a path constructed through it, so it is reasonable to assume that it was heavily utilized in the past. Though there are few ceramics in this passage, an obsidian blade was found here and it also seems to have been a place of active water flow from rainfall runoff.

The D Passage is sizable though this passage has not been fully explored or mapped. A tarantula and large mammal scat was noted in the D Passage indicating a potential opening to the surface. The E Passage is connected with the D Passage and is the most southerly point of the cave. While this passage could not be fully explored or mapped, it does not initially show evidence for human activity. The K Passage appears to have had running water passing through it in the past and is located in the vicinity of the H Passage. The K Passage survey was abandoned because a narrow constriction made it difficult and perhaps dangerous to proceed further. While there is no evidence of past visitation in this area, the K Passage may contain active speleothems that can be used to reconstruct paleoclimate related to past rainfall patterns—a major objective of the Xcoch Project. The A Passage continues past the water pool but does not show signs of visitation past or present. The low oxygen levels here made continued exploration and mapping virtually impossible with specialized breathing equipment.

The cause of the low oxygen in the cave continues to be undetermined and somewhat of a mystery. There is no evidence of rotting debris that could have caused reduced oxygen levels. While organic levels are higher in the lower chambers due to bat populations, it seems unlikely that there are enough bats there to have created this condition. The lower chambers descend significantly and could form a trap for other gasses especially given the tight restricted spaces between chambers. A critical question that must be answered is what other gasses, if any, are displacing the oxygen. This could potentially create a dangerous situation if there are episodic events where spikes occur in the concentration of these unknown gases.

Interestingly, it is unlikely that poor air quantity was problem in the cave for the Prehispanic Maya. Because matches and lighters fail to ignite in such low oxygen levels today, it would have been impossible to light torches in a similar oxygen environment in the past. Additionally, there are two fire pits in Chamber IV indicating a well-ventilated chamber. Stephens acknowledged a breeze at the entrance that took his breath away but fails to mention the low oxygen levels in the bottom chambers. They also used torches as a light source. The difficulty of withstanding oxygen-starved chambers is a memorable experience that he would not have soon forgotten or left his out of his otherwise accurate descriptive account. Obviously, some condition has resulted in reducing ventilation of the cave. If caused by a surface obstruction, it could be related to the breakdown of the H Passage. If not a ventilation issue, then oxygen must be being displaced by another gas. We are unfamiliar with the potential dynamics that would create this phenomenon. It is advisable to employ a five gas detector, such as the Altair 5 Multigas Detector, to determine the safety of the atmosphere in the bottom chambers. This is particularly required if prolonged excavation takes place in the future. While low-oxygen environments can be mitigated with proper equipment; the presence of certain gases to this environment (in particular, carbon dioxide and hydrogen sulfide) could produce significant complications.

The work completed in the Xcoch cave shows that this location had a complex natural and cultural history. It is clear that there must be at least one additional entrance into the cave that was sealed sometime in the distant past. This could have occurred more recently because John Stephens was able to reach the water source in 1841 using torches as a light source suggesting that there was sufficient air in cave's lower chamber unlike today. One such opening may be near the Great Pyramid since the H Passage ascends in this general direction. Another possible entrance is found to the east within a building group about 400 m from the current cave entrance. One cool morning in November 2009, steam vapors were seen rising from this settlement group indicating an opening allowing warmer subterranean air to escape. This is the same vicinity as the D Passage which runs in this general eastern direction. Clearly, this is much more work to be undertaken in this fascinating cave setting. Given the enormous quantities of ceramics and other cultural remains such as human and animal bone, wood fragments, worked stone, etc., the Xcoch cave was obviously a significant venue for Maya priests to perform complex dark rituals related water perhaps inspired by periods of drought or unpredictable rainfall—problems that still plague the Maya of this area. Such a cave located in the middle of a large Maya center with major occupation in the Preclassic period is testament to the key role played by the residents of Xcoch among the earliest occupants of the Puuc region of Northern Yucatan.

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Table 1: Cave Stations and UTM Coordinates

Xcoch Cave Project

Station Index	Station	Parent	Above-Ground Coordinates (UTM NAD 1983 16N) east	north	vertical	to entrance
0	A1	Ent	220053.8	2255140	44.000 m.	0.000 m.
1	Entrance1	A1	220043.3	2255136	48.665 m.	12.320 m.
2	A2	A1	220053.5	2255142	42.325 m.	2.329 m.
3	A3	A2	220053.3	2255146	41.333 m.	6.578 m.
4	A4	A3	220056.3	2255152	40.413 m.	13.628 m.
5	A5	A4	220062.1	2255159	39.029 m.	22.988 m.
6	A6	A5	220064.5	2255161	38.875 m.	25.707 m.
7	A7	A6	220073	2255164	38.755 m.	34.906 m.
8	A8	A7	220089.2	2255168	37.236 m.	51.505 m.
9	B1	A8	220088.5	2255171	37.669 m.	54.434 m.
10	B2	B1	220090.5	2255174	36.030 m.	58.586 m.
11	B3	B2	220092.2	2255175	36.429 m.	60.585 m.
12	B4	B3	220099.3	2255177	35.864 m.	68.205 m.
13	B5	B4	220102.6	2255174	35.765 m.	72.756 m.
14	D3	B5	220112.8	2255169	35.518 m.	84.067 m.
15	A9	A8	220097.6	2255163	38.011 m.	61.384 m.
16	C1	A9	220098	2255156	37.072 m.	67.733 m.
17	D1	A9	220107.9	2255160	36.520 m.	72.094 m.
18	E1	D1	220105.1	2255152	36.667 m.	80.485 m.
19	D2	D1	220112.3	2255158	34.959 m.	77.285 m.
20	A10	A9	220106.3	2255175	35.015 m.	77.084 m.
21	A11	A10	220110.6	2255185	34.476 m.	87.383 m.
22	A12	A11	220109.4	2255192	34.279 m.	94.912 m.
23	A13	A12	220104	2255199	33.034 m.	103.861 m.
24	A14	A13	220100.1	2255205	33.034 m.	110.880 m.
25	A15	A14	220101.7	2255216	33.223 m.	121.725 m.
26	A16	A15	220107.4	2255212	32.690 m.	128.516 m.
27	A17	A16	220111.9	2255208	32.845 m.	134.426 m.
28	A18	A17	220113	2255206	32.732 m.	136.575 m.
29	A19	A18	220116.4	2255207	32.624 m.	140.135 m.
30	A20	A19	220118.9	2255203	32.663 m.	144.704 m.
31	F1	A12	220113.6	2255191	33.375 m.	99.261 m.
32	F2	F1	220120.7	2255195	33.655 m.	107.280 m.
33	F3	F2	220120.7	2255195	33.655 m.	107.280 m.
34	G1	A13	220110.8	2255201	33.253 m.	111.042 m.
35	H1	A15	220109.6	2255217	34.297 m.	129.845 m.
36	H2	H1	220106.2	2255220	34.993 m.	134.914 m.
37	H3	H2	220109.5	2255226	35.339 m.	141.513 m.
38	H4	H3	220100.7	2255225	35.119 m.	150.492 m.
39	H5	H4	220092	2255227	34.824 m.	159.401 m.
40	H6	H5	220088.8	2255227	34.678 m.	162.611 m.
41	H7	H6	220082.1	2255232	34.408 m.	170.770 m.
42	HE1	H7	220080.6	2255233	35.489 m.	173.160 m.
43	HE2	HE1	220078.9	2255235	38.858 m.	177.150 m.
44	HX1	HE1	220084.1	2255235	35.531 m.	177.189 m.
45	HY1	HX1	220089.2	2255233	36.636 m.	183.139 m.
46	HX2	HX1	220083.5	2255239	36.474 m.	180.929 m.
47	HX3	HX2	220080	2255237	35.317 m.	185.230 m.
48	HY2	HY1	220092.6	2255235	37.300 m.	187.248 m.
49	HY3	HY2	220091.8	2255233	37.354 m.	189.058 m.
50	HY4	HY3	220099.5	2255233	37.785 m.	196.788 m.
51	HP1	H3	220112.5	2255221	33.884 m.	147.322 m.
52	J1	A20	220118	2255200	32.863 m.	148.224 m.
53	J2	J1	220118	2255200	32.863 m.	148.224 m.
54	A21	A20	220126.1	2255201	37.054 m.	153.354 m.
55	A22	A21	220127.2	2255200	37.021 m.	155.253 m.
56	A23	A22	220126.9	2255195	36.368 m.	160.093 m.
57	A24	A23	220127.1	2255190	31.783 m.	167.082 m.
58	A25	A24	220134.1	2255200	37.754 m.	181.082 m.
59	A26	A25	220138.9	2255204	33.060 m.	188.723 m.
60	A27	A26	220138.6	2255204	31.269 m.	190.564 m.
61	A28	A27	220138.2	2255203	30.267 m.	192.643 m.

62	A29	A28	220136.5	2255199	30.079 m.	196.361 m.
63	A30	A29	220137.7	2255197	30.157 m.	198.580 m.
64	A31	A30	220139.3	2255195	25.335 m.	204.131 m.
65	A32	A31	220141.5	2255191	24.350 m.	208.989 m.
66	A33	A32	220136.2	2255188	24.671 m.	215.119 m.
67	A34	A33	220124.8	2255181	22.609 m.	228.448 m.
68	A35	A34	220117.8	2255180	21.276 m.	235.629 m.
69	A36	A35	220115.1	2255180	19.178 m.	239.097 m.
70	A37	A36	220111.2	2255183	18.288 m.	243.938 m.
71	A38	A37	220111.5	2255183	18.323 m.	244.416 m.
72	A39	A38	220111.3	2255183	16.259 m.	246.537 m.
73	E2	E1	220107.7	2255141	35.971 m.	91.885 m.
74	E3	E2	220115.1	2255137	36.581 m.	100.636 m.
75	E4	E3	220113.9	2255131	37.120 m.	106.817 m.
76	E5	E4	220113.4	2255127	37.581 m.	110.469 m.
77	E6	E5	220116.3	2255120	38.033 m.	118.448 m.
78	E7	E6	220116.3	2255120	38.033 m.	118.448 m.
79	C2	C1	220098.2	2255152	37.072 m.	72.283 m.
80	C3	C2	220101.5	2255152	37.491 m.	75.603 m.
81	D4	D3	220117.4	2255173	35.771 m.	89.867 m.
82	D5	D4	220120.3	2255171	36.255 m.	93.577 m.
83	D6	D5	220118.1	2255164	35.606 m.	100.675 m.
84	D6Z1	D6	220118.1	2255160	44.174 m.	109.984 m.
85	D7	D5	220124.5	2255169	35.018 m.	98.356 m.
86	D8	D7	220133.7	2255174	35.814 m.	109.097 m.
87	D9	D8	220136.6	2255172	37.281 m.	112.776 m.
88	D10	D9	220141.5	2255174	36.352 m.	117.997 m.
89	D11	D10	220141.6	2255180	35.867 m.	123.566 m.
90	D12	D11	220142	2255180	35.155 m.	124.547 m.
91	D13	D12	220142.8	2255185	35.339 m.	129.247 m.
92	D14	D13	220145.2	2255187	34.314 m.	132.966 m.
93	D15	D14	220146.3	2255193	34.216 m.	138.577 m.
94	D16	D15	220146.3	2255193	34.216 m.	138.577 m.
95	D5Z1	D5	220115.3	2255172	36.708 m.	98.777 m.
96	D5Z2	D5Z1	220112.8	2255177	37.901 m.	104.077 m.
97	D5Z3	D5Z1	220120	2255178	42.623 m.	108.277 m.
98	D8Z1	D8	220129.9	2255176	36.561 m.	113.398 m.
99	D8Z2	D8Z1	220126.8	2255181	35.575 m.	119.698 m.
100	A34A	A34	220121.9	2255177	24.075 m.	233.766 m.
101	A34B	A34A	220125.7	2255171	25.085 m.	241.027 m.
102	A34C	A34B	220125.7	2255171	25.085 m.	241.027 m.
103	K1	A14	220094.5	2255204	32.858 m.	116.641 m.
104	K2	K1	220089.4	2255205	32.947 m.	121.771 m.
105	K3	K2	220085.6	2255207	33.094 m.	125.980 m.
106	K4	K3	220088.7	2255213	32.568 m.	132.679 m.
107	K5	K2	220088.5	2255205	32.929 m.	122.840 m.
108	K6	K5	220088.5	2255205	32.929 m.	122.840 m.
109	HN1	H1	220116	2255217	34.689 m.	136.264 m.
110	HN2	HN1	220118.2	2255217	35.122 m.	138.535 m.
111	HN3	HN2	220119.4	2255216	34.935 m.	139.876 m.
112	HN4	HN3	220126	2255221	35.754 m.	147.706 m.
113	HN5	HN4	220127.3	2255217	34.350 m.	152.248 m.
114	HN6	HN5	220128.6	2255212	36.899 m.	157.676 m.
115	HN7	HN6	220126.6	2255204	33.130 m.	166.335 m.
116	Entrance2	Entrance1	220050.6	2255132	48.953 m.	20.571 m.
117	Entrance3	Entrance2	220056.2	2255133	49.361 m.	26.420 m.
118	Entrance4	Entrance3	220056.7	2255140	50.019 m.	32.720 m.
119	Entrance5	Entrance4	220054.3	2255147	51.140 m.	40.770 m.
120	Entrance6	Entrance5	220046.9	2255144	49.456 m.	48.869 m.

Figure 3: Schematic of the Xcoch cave (yellow) and map of the Xcoch Plaza (North is at the top).

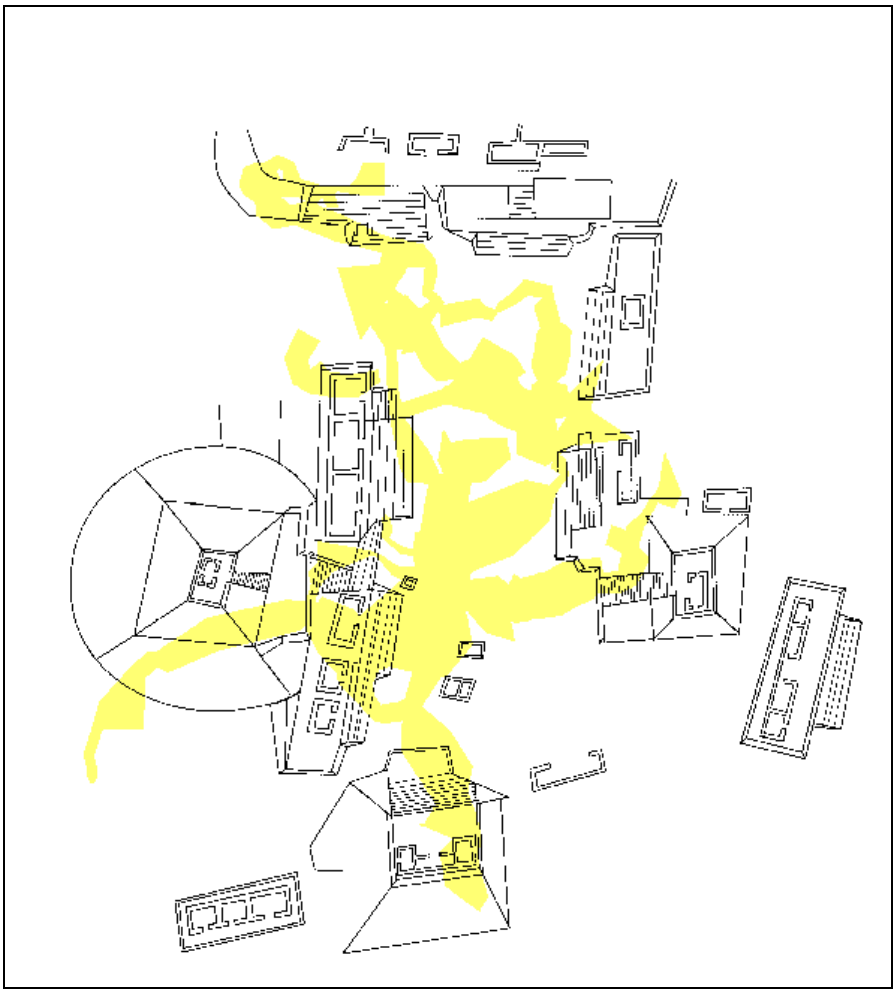

Figure 4: Detailed map of the Xcoch cave.

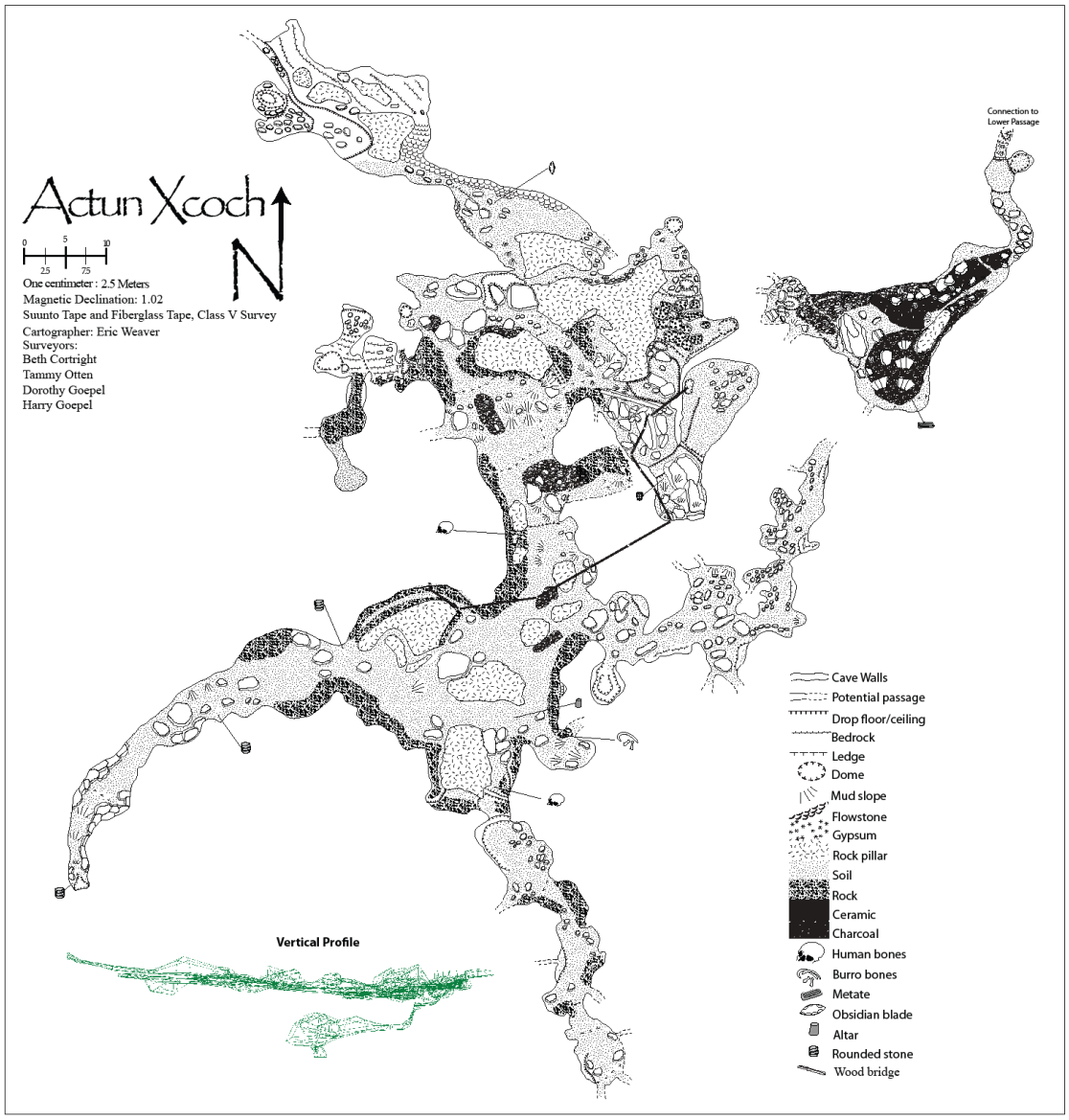

Figure 5a: Photos of the Xcoch Pyramid (upper left), depression, and cave opening.

Figure 5b: The Caver Team from left to right: Harry Goepel, Dorothy M. Goepel, Eric Weaver, Tammy Otten, and Beth Cortright

Figure 6: Selected photos of the Xcoch cave, Yotolin Pattern Burnished, and pottery by the water pool.