RE-ANALYSING ASTRONOMICAL ALIGNMENTS OF POTENTIAL E GROUP STRUCTURES TO DEMONSTRATE THE UTILITY OF ARCHEOASTRONOMY RESEARCH ABOUT THE ANCIENT MAYA

By

Elizabeth Karen Shikrallah

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Elizabeth Karen Shikrallah

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Arlen Chase, Ph.D.
Examination Committee Co-Chair

Diane Chase, Ph.D.
Examination Committee Co-Chair

Alan Farahani, Ph.D.
Examination Committee Member

Gabriel Judkins, Ph.D.
Graduate College Faculty Representative

Kathryn Hausbeck Korgan, Ph.D.
Vice Provost for Graduate Education &
Dean of the Graduate College

Abstract

There has been much study of Maya astronomy and the relationship and/or manifestation of astronomy within architecture and other aspects of Maya material culture. Despite this, there is little agreement about the commonalities and variation in potential astronomical representation across sites and regions as it is difficult to compare sites to determine whether spatial patterning exists between similar building classifications. Also, it can be difficult to understand and pursue archeoastronomy research due to the jargon and methodology employed. This thesis provides an updated dataset that shows the utility of pursuing archeoastronomy research about the ancient Maya. Combining archaeological and archeoastronomical data showed potential differences between the classifications of E Groups that may better define those classifications if pursued through future research. By re-analyzing alignments previously provided in publication and placing these alignments into better context according to more current archaeological interpretations, this dataset demonstrates the utility of archeoastronomy research for archaeologists.

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Chapter 1: Introduction and Background

There has been much study of Maya astronomy and the relationship and/or manifestation of astronomy within architecture and other aspects of Maya material culture. Despite this, there is little agreement about the commonalities and variation in potential astronomical representation across sites and regions as it is difficult to compare sites to determine whether spatial patterning exists due to differences in recording e.g. varying time period names and durations specific to certain sites, among other differences. Also, it can be difficult to understand and pursue archeoastronomy research due to the jargon and methodology employed. Šprajc (2005: 215) tried to “bridge the communication gap between [archaeology and archeoastronomy]” and calls on others to “combine our efforts in the pursuit of common anthropological goals”. Therefore, this thesis provides an updated dataset that shows the utility of pursuing archeoastronomy research about the ancient Maya. By re-analyzing alignments previously provided in publication and placing these alignments into better context according to more current archaeological interpretations, this dataset demonstrates the utility of archeoastronomy research for archaeologists.

First, I will provide background about the ancient Maya, the use of archeoastronomy in Maya archaeology, and about E Groups, as they are the features this dataset focuses on. Then, after explaining the methodology involved, I will provide the specific context for the sites included in this dataset followed by analysis of the alignment data. Finally, I will explore new possibilities brought forward by this research through both current knowledge and future research potential.

Environment

The natural environment where the ancient Maya lived – mainly the Yucatan Peninsula and surrounding land in Guatemala, Belize, and Mexico – was a highly variable environment (e.g. Chase et al 2014). Across the region, there was a range of rainfall from 500mm to 2500mm, with some portions changing year to year while other regions change seasonally. Most of the bedrock in the area is limestone, and the soils are highly variable. The primary soils are either thin, fertile, and well drained, or they are deeper, not well drained, and not as fertile. This difference in drainage and thickness is mainly due to how the limestone impacts drainage and soil depth (Dunning and Beach 2010: 371).

The ancient Maya cultural region can be split into the Northern Lowlands, Southern Lowlands, and the Highlands (see Figure 1). There are vast environmental differences across this space, as the southeastern Maya Lowlands support a tropical rainforest while the northwestern portion of the Yucatan Peninsula is much drier and models closer to a desert extreme (Chase et al 2014: 13). The pollen record indicates that many major tree species were depleted by the 9th century CE through construction efforts of the ancient Maya (Lentz and Hockaday 2009; Ford and Nigh 2009) but they did practice some arboriculture to combat this (Lentz 1999). Even with this effort, the ancient Maya at multiple points "reached a precarious imbalance with their environments that proved unsustainable" and when this happened exactly ranges as much as the environment does (Chase et al 2014: 24).

Figure 1: Ancient Maya Regions (Halperin et al 2019: 3)

Overall, the dry season is fairly uniform – occurring between May and December – but topography, temperature, elevation, rainfall, water access, and available plants and animals change across the entire peninsula (Chase et al 2014: 16). This diversity is demonstrated by the fact that the whole area can be split up into as many as 10 zones that all vary environmentally and culturally from one another (see Chase et al 2014 and Dunning et al 1998). An example of how this is the case can be seen through water management during a drought. In a drought during the early 9th century, the Maya from the Puuc Hills sustained their population with household water collection systems while their neighbors to the west experienced a population decrease due to this same drought (Gunn and Folan 2000). This demonstrates how, even with similar environmental conditions, the ancient Maya from one area can be very different from the ancient Maya in a neighboring area.

Culture

"The ancient Maya" is a broad category within the archaeological literature that is ascribed to a diverse collection of peoples who vary as much as the environment they inhabited was. It is estimated that approximately 4,665,000 people lived in the lowlands alone (Storey 2012: 910). All of these people spoke different languages (Sharer and Traxler 2006: 25-28 cited in Chase et al 2014: 13), had multiple government structures (Roys 1957 cited in Chase et al 2014: 13), and varied cultural and kinship practices – all of which are considered "ancient Maya" (Fox and Justeson 1986 cited in Chase et al 2014: 13). One major point to remember in regard to ancient Maya culture is that researchers believe the ancient Maya saw everything as connected and influencing each other – people, gods, what we consider the "natural" environment, etc. (Freidel 2017: 178).

The chronology of the ancient Maya is typically divided into three broad time periods – the Preclassic (2000 BCE – 250 CE), the Classic (250 – 900 CE), and the Post-classic (900-1539 CE); all three of these time periods can be further broken down with some subclassifications unique to specific regions and sites (Sharer and Traxler 2006). These broad time periods are so named because the Preclassic was originally seen as formative and "lacking" the qualifications of a civilization on its own. The Classic, on the other hand, was considered to be the height of Maya Civilization, in contrast to the Post-classic which was seen as a "decline from the peak" of the Classic period (Sharer and Traxler 2006: 157). While the interpretations of these time periods' have changed, their names have not. Instead, there are notable features of each time period that can delineate one from another. For example, the Preclassic sees much vertical and horizontal monumental construction, as seen in E Groups, the Classic sees a transition to regional polities as the primary form of government, while the Post-classic sees a transition in occupation from the Southern Lowlands to the Eastern Yucatán (Chase, A.F. et al 2017: 4). These features are not the only notable characteristics for these time periods and can be further broken down into the smaller time periods within the major three.

This project focuses primarily on portions of the Preclassic and the early Classic due to the high amount of E Group construction. The E Group is a common architectural form of a raised eastern platform facing a western pyramid across a plaza, which was the first shared form of public architecture for the ancient Maya (Chase, A. F. et al 2017: 3-10). While the focus is from 100 B.C.E to 500 CE, this is not a strict limit on the time periods investigated and included in this project, as they are researcher specific time periods and not distinctions made by the ancient Maya. Therefore, some of the proposed E Groups do not fall within this timeline.

Calendar

The various calendars used by the ancient Maya are tied closely with E Groups (how is discussed later) and so what these calendars are and their history is important to the argument made in this thesis. Overall, the ancient Maya had multiple calendars; among the three more important ones were: the Long Count, the Tzolk'in, and the Haab. The Long Count is considered one of the key features of the Classic Maya, as it was "used to anchor major historical events in time [like] royal successions, ritual[s], victories and defeats in war, hierarchical relationships, and regal marriages" (Kennet et al 2013: 2). As such, these dates are commonly found on the stela at many ancient Maya archaeological sites. Overall, there are five units to the Long Count: the Bak'tun, K'atun, Tun, Winal or Uinal, and K'in. See Table 1 for a more detailed breakdown of the Long Count Units. Figure 2 is an example of a Long Count date found on a stela at Tikal. It depicts 8 Bak'tuns, 12 K'atuns, 14 Tuns, 8 Winals, and 15 K'ins. In the archaeological literature, this is depicted as Long Count Date 8.12.14.8.15, 13 Men 3 Zip, for while the day and month at the end are missing on the stela, they were retroactively determined (Marcus 1976: 59). This date marks how many days since a fixed point in time the events marked on this stela occurred, and what day and month in the Calendar Round (discussed below) this event falls on.

Unit	Number of Days in Unit	Conversion
Bak’tun	144,000	20 K’atun = 1 Bak’tun
K’atun	7,200	20 Tun = 1 K’atun
Tun	360	18 Winal = 1 Tun
Winal or Uinal	20	20 K’in = 1 Winal
K’in	1	

Table 1: Breakdown of Long Count Units

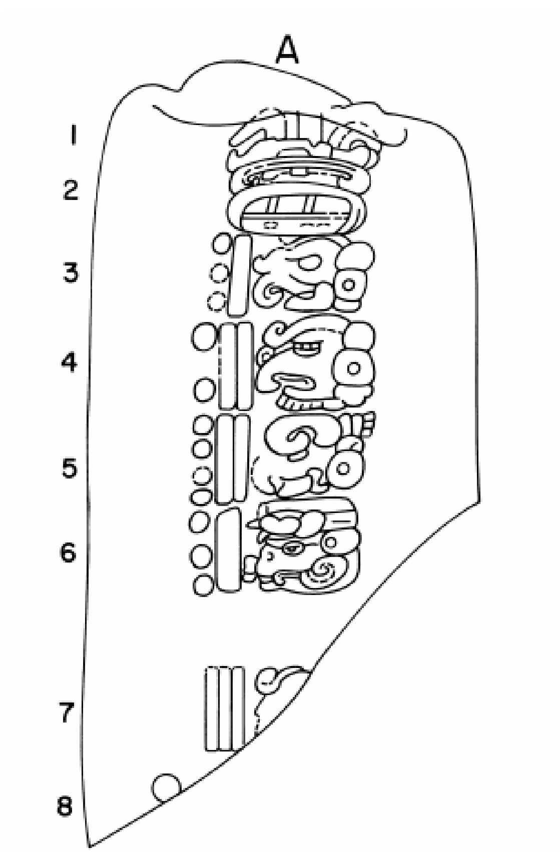


Figure 2: Long Count Date example from a Tikal Stela (Marcus 1976: 58)

Another calendar commonly used by the ancient Maya is a combination of the Tzolk'in and Haab, or the 260-day ritual calendar and the 365-day civic calendar respectively. Together, these form a 52-year Calendar Round, or a calendar that repeats itself every 52 years (Zaro and Lohse 2005: 86; see Figure 3 below). The Tzolk'in comprises of 13 numbers and 20 days. This means that events that are 13 days apart have the same number, events that are 20 days apart have the same name, and events 260 days apart have the same name and number. The Haab consists of 18 months of 20 days each, with a 5-day Wayeb or short month at the end resulting in the 365 days (Vail 2006: 498, 501). The Long Count, Tzolk'in, Haab, or a combination thereof are the primary ancient Maya means of tracking time that are commonly found and discussed in the archaeological record (Zaro and Lohse 2005: 86).

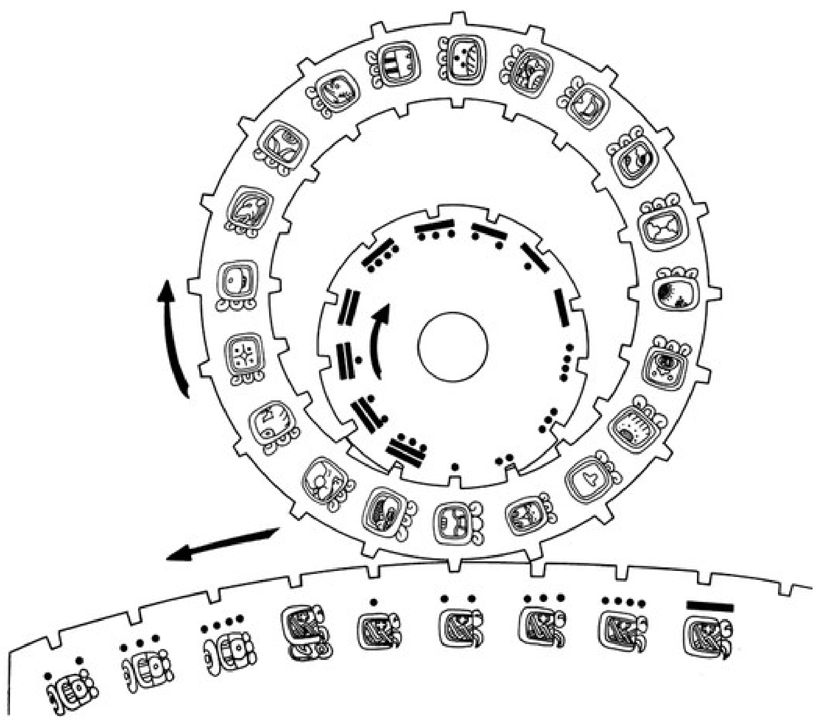


Figure 3: Depiction of the 52-Year Calendar Round

As evidenced by the conversions depicted in Table 1, the ancient Maya used a base 20 system. This means they cycle through the numbers 0-19 instead of 0-9 like those of us today who are used to a base-10 system. In their written record, their numbers are marked using a bar and dot system – a dot equals one, a bar equals 5, and 0 is marked symbolically. In Figure 4 below, the left most column – which is read from top to bottom – begins with a Tzolk'in day marker and is followed by five numbers: 8, 6, 1, 9, and 0. These numbers appear to form a Long Count Date; however they are not (see Saturno et al 2012 for a discussion on how they are different). The number 20 may have been important to the ancient Maya for many reasons: the ideal subdivision of the maize agricultural cycle is 20 days, humans usually have 20 fingers and toes, and where E Groups are concentrated the "year can be segmented into multiples of 20 days that separate the solstices, equinoxes, and solar zeniths" all of which may have been important to the ancient Maya among other examples not listed here (Milbrath 2017: 96-99).

Figure 4: Example of Written Numbers (Saturno et al 2012: 716)

It is important to remember that when the ancient Maya and other Mesoamericans started keeping a calendar is difficult to assess archaeologically (see Freidel 2017), but it may have been as early as the Archaic period with gaming boards (Voorhies 2012 cited in Freidel 2017: 205). Takalik Abaj is thought to be the site with early calendar records where the Tzolk'in potentially originated (Milbrath 2017: 105). However, it is also thought that the earliest appearance of the 260-day calender with both bar/dot notation and names is in the Middle Preclassic in Oaxaca (Marcus 1976 cited in Freidel 2017: 181). The earliest Long Count dates appear in epi-Olmec and Maya Late Preclassic in the Southeastern Lowlands (Freidel 2017: 181). The confusion surrounding the start of calendar-keeping, combined with both natural and manmade preservation issues surrounding tools the ancient Maya used in their astronomy practices (discussed later), are why there is little to go on for day tracking and positional tracking so often looked for in archeoastronomy. This is also why the E Groups in the southeastern lowlands are so often cited as the most convincing evidence for archeoastronomy– as discussed later.

Archeoastronomy

Archeoastronomy is sometimes categorized as Cultural Astronomy and is included in Cultural Astronomy conferences and general discussions, along with Astro-archaeology (archeoastronomy's predecessor), ethno-astronomy, historical astronomy, and the history of WEIRD (Western Educated Industrialized Rich and Democratic) astronomy (Polcaro and Polcaro 2009: 223). There is some disagreement about whether archeoastronomy should be considered a subdiscipline of archaeology or of cultural astronomy, given its connection to the archaeological record. The disagreement comes from whether or not archeoastronomy should be grounded in archaeological context, or whether the celestial influence alone reflects astronomical significance, regardless of if other avenues of evidence support the theory as well (Polcaro and Polcaro 2009: 223). This project demonstrates why archeoastronomy research should be grounded in archaeological context by showing what can be learned by combining the two.

Anthony Aveni, one of the authors of the 2003 publication the data from which this project derives, entered the field of archeoastronomy in the early 1970s with a background in astronomy, helping to make his studies scientific. He published his first article about archeoastronomy in 1972 dealing with the astronomical tables of the ancient Maya (Aveni 1972). He attempts to ground his astronomical studies about the ancient Maya with the archaeological context of the region that is known at the time of his study (Aveni and Dowd 2017). Therefore, going back to his previous studies and reanalyzing them with an updated archaeological record from the region keeps the original dataset up to date and has the potential to illuminate new understandings.

For the ancient Maya, astronomy and cosmology are separate but often related concepts. Because of this correlation, archeoastronomy is used as an indication of their cosmology because astronomical orientations and the fact that “the sky will never lie” (Aveni and Hotaling 1994: S22) lend credibility towards cosmological interpretations that researchers make. However, this connection between ancient Maya astronomy and cosmology has shifted along with the archaeologists’ and epigraphers’ understanding of the written record.

At first there was a natural philosophy approach where ancient Maya writing was viewed as being about time and cyclical temporal cycles. However, Proskouriakoff demonstrated that some texts dealt with the life events of rulers (Proskouriakoff 1960, cited in Aveni and Hotaling 1994: S21) and Berlin identified emblem glyphs that correlated with specific sites (Berlin 1958, cited in Aveni and Hotaling 1994: S21); together they forced a shift into a more historic view of ancient Maya writings with this updated understanding although time still played an important role by linking the elite to their legendary history and myth.

Then, in the 1990s, there were more and more challenges against the “faithfulness of Maya deed to word” with researchers suggesting that some ancient Maya writing was propaganda for the ruling class instead of simply stating events in chronological order. This marked the shift to a political philosophy approach to ancient Maya writing (Marcus 1992, cited in Aveni and Hotaling 1994: S21-S22; see Coe 1993). Even with a shift to a political philosophy approach, Aveni and Hotaling (1994: S22) wanted to understand how the ancient Maya categorized natural phenomena to better understand ancient Maya astronomy.

The two researchers debated how ancient Maya astronomers observed Venus as it seems to be observed more often than other celestial bodies, save the sun. An important bias to remember is that it is difficult to assume that the ancient Maya observed the same way and cared about the same phenomena that Western society does, and these are questions Aveni and Hotaling grappled with while testing how the ancient Maya might have observed Venus. Both of these are difficult questions to answer, especially given that there are no direct statements of what they were tracking in ways that are easily understood by our current perception of astronomy. Regardless, the best evidence that we have that the ancient Maya were tracking some astronomical events of Venus is from pages 24 and 26-50 of the Dresden Codex. While the aspects of Venus that were being tracked are contested, the fact that they were tracking Venus is not. This fact in and of itself lends credibility to the claim that the ancient Maya had some underlying system for astronomical observation. These tables in the Codex (See Figure 5) also show that they placed more importance on the cyclical aspect of timing instead of where the celestial body was in outer space (Aveni and Hotaling 1994: S22-S23). This focus makes sense when the calendrical system of the ancient Maya, discussed before, is taken into consideration as a potential motive for astronomical observation.

Figure 5: Dresden Codex Page 35 (World Digital Library 2017)

Archeoastronomy then built from this understanding of what the ancient Maya tracked in order to assess how accurate monumental inscriptions were to the visual reality of celestial bodies. Using glyphs or iconography that may reference astronomical events – like the main sign T510 (Figure 6) – which is currently associated with major warfare events called "starwars" (e.g. Schele 1982: 99) – they compared the dates associated with the glyphs with what celestial events were occurring around that time in order to understand what Venus events the monumental record could have been referencing (Aveni and Hotaling 1994: S24).

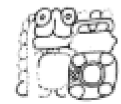
2.	Nar HS N1b	9.9.18.16. 3	????	Ruler 4 of Caracol	9.10.10. 0. 0	
3.	Nar HS B1	9.10. 3. 2.12	18-Rabbit	Ruler 4 of Caracol	9.10.10. 0. 0	
4.	Tort 6 A10-A11	9.10.11. 9. 6	????	deleted	9.12. 0. 0. 0	

Figure 6: Main Sign T510 Variants (Schele 1982: 100)

However, the ancient Maya are limited by what can actually be observed and observed accurately enough to track the cyclical patterns evidenced in the codices. There is little archaeological evidence of astronomical tools other than the possibility of the pecked circles found at Uaxactun and Teotihuacan (see Aveni et al 1978). This lack of evidence means they either used tools that do not preserve well, buildings and natural formations like E Groups, or a combination of unpreserved tools and preserved features. This preservation bias does mean there has been a focus on building alignments as sightings for astronomical observations in Maya research (e.g. Ricketson et al 1937).

There is a distinct possibility of potential alignments being coincidental, especially given the sheer number of potential alignments. This is why is it important to look at the archaeological and iconographic records to see if any specific celestial bodies held significance for the ancient Maya. There is also the possibility that the construction of the buildings was not 100% accurate for whatever alignments they may or may not have been targeting. To combat this uncertainty, Aveni and Hotaling allow an arbitrary 5-day window on either side of an event for an alignment to still be considered potentially valid (1994: S33).

Analysis of what events are easier to see at a given site is also necessary, as evidenced at Copan. An evening appearance of Venus to the west was more accessible than a morning appearance to the east at that site (Aveni and Hotaling 1994: S33), suggesting astronomers at Copan would likely track evening appearances rather than morning appearances. Also, they considered the fact that Mercury and Venus get confused in the sky by casual observers in our society and that the same may have happened to ancient Maya observers. However, since Mercury is not visible for 35% of the time and therefore harder to track, they were more likely to track Venus rather than Mercury (Aveni and Hotaling 1994: S30-S39).

Looking to the combination of archeoastronomy alignments and the archaeological record, the importance of Venus and its connection to the changing seasons is shown through the orientation of the governor's Palace at Uxmal and the Venus glyphs in the rain god Chac masks on the same building (Aveni and Hartung 1986, cited in Šprajc 2015: 725). The changing seasons, however, indicate another potential influence on what was observed. The weather in the different seasons – as the peninsula does have both a wet and dry season, as discussed above – could have limited potential observations times (Aveni and Hotaling 1994: S41-47).

It is also possible that instead of focusing on a single astronomical phenomenon to relate to a specific date, the ancient Maya may have instead chosen dates surrounded by multiple planetary events. However, it is very rare to see a conjunction (the lining up of celestial bodies) of two or more planets. There are only a few dates during the ancient Maya timeline that had conjunctions, and while there are indications of the importance of these dates in the archaeological record (see Aveni and Hotaling 1994: S41-47), there is much disagreement about the significance of the astronomical phenomenon surrounding these dates to the ancient Maya (see Houston 1996, and Schele 1978).

No matter which interpretation is considered correct in the current understanding, the movement, appearance, and disappearance of Venus would have been the most significant events for the monumental inscriptions to record – and they appeared to record the first evening appearance of this celestial body. This is an interesting divergence from the codices where the first morning appearance is tracked instead (Aveni and Hotaling 1994: S41-S47). This may be due to the fact that the monuments studied above are from the Classic Period and the codices are from the Post-classic; alternatively, the monuments may not be observing Venus but another phenomenon occurring at the same time. Evidence from Tikal suggests that they may have cared about when planets were in retrograde, for the K'atun endings that were recorded appeared to all be in the Early Classic when planets were in retrograde (Milbrath 2017: 114).

The orientations of civic and ceremonial buildings that do not have inscriptions are also commonly considered in archeoastronomy. These structures do not always have the same alignments even if they are thought to be used for the same purposes. However, there are some trends in these alignments. Many orientations are consistently skewed clockwise (amount not specified in publication), although there are exceptions in western Mesoamerica and along the Gulf Coast (Šprajc 2018: 205). Most of the orientations of buildings have been linked to sunrises or sunsets and show a change through time connected to common time intervals (Šprajc 2015: 778) and not the shifting of magnetic north (Šprajc 2018: 205). Most of the alignments discussed by researchers at first were to the solstices, but then more celestial phenomena like lunar standstill and Venus extremes (discussed before) were included as possibilities in the literature (Šprajc 2015: 778).

Many of the events that are tracked by a single alignment have intervals of 13 or 20 days, which line up with important intervals of the 260-day ritual calendar (discussed before). This association suggests an astronomical calendar instead of a day/hour calendar. One potential advantage for the ancient Maya that an astronomical calendar has over a day/hour calendar is that an astronomical calendar allows the anticipation of relevant dates by observing that an astronomical event is approaching or has passed. This lessens the importance of viewing the actual event, which is a particularly relevant issue for an area where the unpredictable weather can impact what events you can see consistently (Šprajc 2005: 211-213). Lessening the importance of viewing the actual event would potentially explain why there are clusters of alignments in the two days before and after the equinox (Šprajc 2018: 208).

There are other solar alignment clusters found at ancient Maya sites that correspond with the "preparation of land plots...burning of fields ...ripening of the first maize cobs...and harvest" for Modern populations, suggesting that many alignments may have been tied to the agricultural cycle of maize (Šprajc 2018: 221). Together with the suggested importance of the agricultural cycle of maize to the calendars as a whole discussed above, the connection with agriculture and alignments suggests that alignments may have assisted in the development of the calendars in the first place. It has been suggested that ancient Maya politics and religion both turned to astronomy for “divination, situating cosmological beliefs, [and] calendar cycles” and that all of these abilities would not only help with successful agriculture, but also help with “commemorating ancestors, scheduling exchange markets or trade, and timing civic or ritual events” (Dowd 2017: 517).

While there has been much study into orientations of ancient Maya structures, Šprajc (2018: 238) explains how his overview only touches the surface and “illustrate[s] the need for a holistic approach, in which archaeoastronomy is an integral part of archaeological pursuit” because the cosmological influence can only be properly understood by researchers who understand the “environmental peculiarities, prevalent subsistence strategies, and the sociopolitical organization” (Šprajc 2018: 237) of a given site. This project bridges the gap between archeoastronomy and archaeology by discussing the two side-by-side while explaining the jargon from each discipline. Doing so helps demonstrate the effectiveness of archeoastronomy for archaeological interpretation.

E Groups

An E Group is classified as a raised eastern platform with three buildings facing a western pyramid across a plaza and was the first shared form of public architecture for the ancient Maya (Chase, A. F. et al 2017: 3-5). The earliest dated E Group found so far is in Ceibal, Guatamala and is dated to 950 BCE (Inomata 2017: 215). The first recorded E Group was published in 1924 and 1926, when Frans Blom realized that Uaxactun’s E Group had alignments with the sun’s solstice and equinox dates (Blom 1924, Blom 1926 cited in Chase, A. F. et al 2017: 8). At the time, Structure E-VII-sub at Uaxactun was the earliest known structure in the Maya Lowlands, and so while the Uaxactun E Group is no longer considered the oldest, it is still the token E Group discussed in many publications (Aimers and Rice 2006: 79)

Out of the buildings included in the group, the eastern platform is thought to be the most important, as there are sites that do not have a western pyramid, or it was removed later through urban renewal projects (Chase and Chase 2017: 59). The eastern platform is the first hallmark of an E Group instead of the central building, because the earliest styles found are La Venta style E Groups that may not have permanent buildings above the platform, (Chase and Chase 2017: 32) although this style is not found in this dataset, and so will not be discussed further. Takeshi Inomata suggests that it started in the Isthmian interaction sphere - the southern Gulf Coast, central Chiapas, and the southern Pacific Coast - due to elements of the E Group style that are found in that region; then, the E Groups further evolved into the ancient Maya style in the central Chiapas region, because of the early date and gradual growth of the E Group at Ceibal (Inomata 2017: 215-220). This adoption and further modification of the E Group style demonstrates how the ancient Maya "were neither the sole inventors of the E Group nor passive recipients of external influence … [by selecting] specific elements and integrating them into their own system of cultural practices" (Inomata 2017: 229).

Overall, there are two kinds of E Groups important to this thesis: Cenote and Uaxactun styles as shown in Figure 7. Cenote style E Groups are commonly found in the Preclassic – between 100 BCE and 250 CE – and have a long eastern platform supporting a larger central building while Uaxactun style E Groups are commonly found in the Classic – between 250 and 550 CE – and have a shorter eastern platform supporting three equal structures (Chase, A. F. et al 2017: 10). However, it is difficult to assess the architectural form of E Groups as there are few excavated E Group complexes, and those that have been excavated show that the surface version occurs after the original structures have been heavily modified (Aylesworth 2004: 40). All told, only about 20% of E Groups have seen some excavation (Chase, A. F. et al 2017: 12).

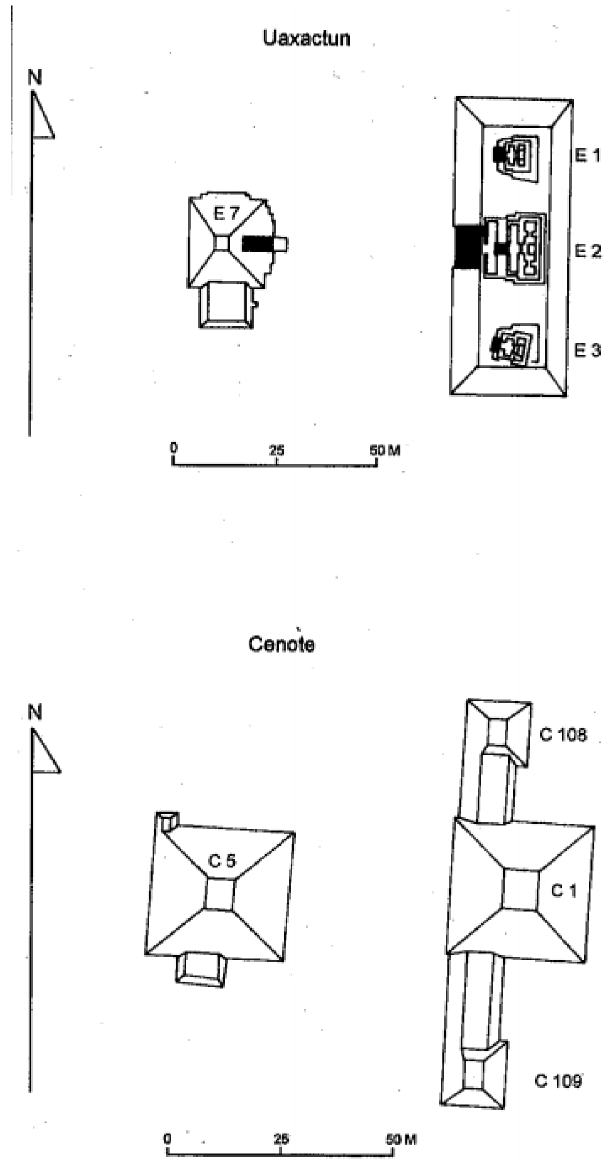


Figure 7: Examples of Uaxactun and Cenote Style E Groups (Chase and Chase 2017: 33)

E Groups tend to be clustered along trade routes in the Northern and Southern Lowlands and are used to define a Maya central place by 350 BCE to 0 CE, although they do show up as early as 1000 BCE (Chase, A. F. et al 2017: 16-17). It is also thought that their locations are strategically chosen for their line of site and viewshed (see Doyle 2012 and Doyle 2017). The earliest concentration of E Groups in the southeastern Petén likely represents some of the earliest known Maya and represents the “coalescence of formal Maya communities that shared a unified belief system” (Chase and Chase 2017: 32, 64). While oftentimes one meaning is ascribed to E Groups for the ancient Maya, it is likely that the meanings of these architectural assemblages varied from site to site, as shown by the change in frequency and spacing between Cenote and Uaxactun Style E Groups (Chase and Chase 2017: 61-62). This change in distribution of E Groups across the landscape can also be interpreted as evidence of enlarged polities over time (Chase, D. Z. et al 2017: 581).

All told, there are six general categories of use proposed for ancient Maya E Groups: 1) astronomical observation, 2) scheduling trade and agriculture, 3) agricultural ritual, 4) geomantic systems, 5) ancestor rituals by emerging elites, and 6) "valedictory ceremonies" like K'atun endings (Awe et al 2017: 414). All of these, however, link E Groups with calendars and the development of the calendars, albeit for different reasons. Of note is that many E Groups began to decline in importance around the same time that the Long Count emerged, further supporting this association (Milbrath 2017: 99) although not all E Groups follow this pattern (see Chase and Chase 2017). There also appear to be links between E Groups and figurines, and a noticeable lack of figurines in areas that had few or no E Groups like the Usumacinta drainage, suggesting ties to rituals of "place making" (Rice 2017: 151-157). Keeping track of a calendar for maize agriculture is commonly touted as the motivation behind E Groups (see Milbrath 2017) but Takeshi Inomata (2017: 233) cautions against this association by stating that the separate pieces of the E Group classification started when maize cultivation was not as important. Many E Groups also have a connection with water and the underworld that often gets overlooked because of the attention on astronomy and alignments (Chase, D. Z. et al 2017: 580).

Many E Groups do have other associated architecture, like triadic structures that are thought to have housed priests, as at Cival and San Bartolo (Dowd 2017: 551-552). This leads Dowd to eliminate "secular function, residential, commercial, or recreational [purposes] for E Groups in part because we have identified locations for these activities elsewhere … [but] functional overlap took place in some centers in which separate … facilities had not been constructed" (Dowd 2017: 539).

Chapter 2: Methodology

Before delving into the methodology of this thesis, it is important to make the following disclaimer: "any attempt to connect the matter of precision with the issue of intention or purpose on the part of the builders can be misleading" (Aveni and Dowd 2017: 87). As noted in previous sections, there are many potential reasons why an alignment may point to what it does, and coincidence is a potentially common one. This is, once again, why it is important to approach these questions with multiple lines of evidence, and not to rely solely on alignment data (like those found in Aveni et al 2003). That is why this thesis combines alignment data with the corresponding archaeological record, where possible, in order to better understand the alignments and their potential significance.

First, all 31 sites in Aveni et al's. (2003) original analysis were separated into those with more exact measurements and those without. The rationale behind this is that the ones with the more specific measurements are the ones that Aveni and his team measured themselves in the field, while the less exact measurements are based on maps and secondhand data. Aveni said he and his team went back and measured 12 sites and included previous measurements of Uaxactun, so there should be a total of 13 sites with more accurate measurements. However, there were 14 sites with specific measurements and it was not possible to tell from the publication which were the ones measured in the field, other than Uaxactun. Aveni did note that he had access to maps that had not been published yet and was able to make the measurements more accurate, so the assumption was that the 14th site fell into that category.

These potential E Groups were then classified based on definitions found in section 3. To determine these classifications, site records and excavation data from each of the 14 sites were consulted, where possible. However, not all of the sites had the desired excavation data. Maps of all 14 sites were consulted, with more recently published maps taking precedence where they were available; although once again, not all of the sites had recently published maps. Two of the assemblages were determined to simply be a collection of three buildings to the east and not an E Group or similar classification, and so were removed from the analysis.

Next, the alignments from the remaining 12 sites were compared with astronomical data to see what buildings and celestial bodies the alignments were associated with specifically. The original 2003 publication stated that the authors were looking specifically at sunrises to investigate similarities with Uaxactun's E Group. Therefore, the only celestial body of interest for this thesis was the sun, as that was the focus of the original publication. To determine which structures the alignments came from, a solar calculator (US Department of Commerce 2005) was used to find the angle of the sunrise for that particular site on the date in question and matched it to the closest angles reported for the structures of the assemblage. Once the alignments were associated with specific buildings, they were cross referenced with other sources to check the validity of this method as some sources explicitly stated which alignments were with what buildings. This methods check demonstrated that the method pursued with the solar calculator worked as intended.

Finally, the outcomes of the reclassification and alignment assignments were combined into a table and then graphed in order to investigate new trends that may come to light by updating the original publication. This was done by graphing – in R (version 3.6.3) – density plots of the alignments and bar plots of the dates, each of which were sorted by their building classification. Density plots were chosen for the alignment analysis due to the alignments being a continuous variable, and because the shape of the distribution was useful for comparisons between the classifications. Bar plots were chosen for the dates, as they are a discrete variable.

Chapter 3: Site Backgrounds and E Group Determinations

The first step to reevaluate the data presented in Aveni et al 2003 was to go through fourteen sites that Anthony Aveni and his team took measurements on and then determine which, if any, are actually E Groups. The sites reviewed are listed in Table 2. To determine the classification of the structures in question, definitions of Uaxactun Style E Groups, Cenote Style E Groups, TEBs, and ETAs – of which the last two are not E Groups - are necessary (see Chase 1983; Chase 1985; Chase and Chase 1995; Awe et al 2017; Inomata 2017) . Some sites are also classified as three eastern buildings: these sites do not fit into any of the definitions mentioned above. These definitions are:

Uaxactun Style E Groups - an architectural assemblage that has a structure (typically a pyramid) on the west side of a plaza across from a set of three structures on an eastern platform. The eastern structures are roughly the same size and have similar construction histories. E Groups of this style occur during the Early Classic.

Cenote Style E Groups - A set of one to three structures on a longer eastern platform facing a western structure (typically a pyramid). The eastern structures are of varying sizes but have similar construction histories in that they were built after the eastern platform even when the larger building is offset from the platform. This category can also have cenote style variants, where morphologically they are very varied, but they still have similar construction histories as mentioned above. E Groups of this style occur during the Middle and Late Preclassic.

Triple Eastern Building (TEB) – A western structure with either a set of three structures on an eastern platform or three structures built separately that were joined together by a later platform. This category has been called Triadic Structures or Eastern Triadic Structures (see Awe et al. 2017); however, Triple Eastern Building was chosen as the designation in order to separate this category from Triadic Groups (see Szymański 2014) which is a separate architectural category not discussed here.

Eastern Triadic Assemblage (ETA) - TEBs specifically from the Belize River Valley (Awe et al. 2017: 413).

Therefore, in order to determine whether the structures in question are E Groups or not, excavation histories of these structures are necessary. Not all of the sites in question had excavation data. Thus, these determinations are based on excavations in neighboring areas and map analysis. Table 2 below summarizes the data used for each of the sites and the determinations as to whether or not the structures in question form an E Group or something else. Figure 8 maps the site's locations, separating them by their classification. Following the table is a section dedicated to providing a general overview and a more detailed look into the information about the proposed E Groups for each of the fourteen sites.

Site Name	Excavation Data	Map Data	E Group Determination
Arroyo Negro	Šprajc et al 1997; Flores Esquival and Šprajc 2008; Castillo 2009	Castillo 2009: 109	Three Eastern Buildings
Cahal Pech	Awe et al 2017	Awe et al 1991: 26; Awe et al 2017	ETA
Calakmul	Dominguez 1992; Folan et al 1995; Carrasco Vargas 1996,	Folan et al 1995: 314, 315;	Cenote Style E Group

	1999; Braswell et al 2004; Dowd et al 2017; Šprajc 2021b		
Ixkun	Laporte et al 1994; Laporte and Mejía 2005; Graham 1980	Laporte et al 1994: 34, 35	Cenote Style E Group
Kabah	Carrasco Vargas 1993	Aveni and Hartung 1986: 25	Three Eastern Buildings
Nakbe	Hansen 1997; Aguiar et al 2008	Hansen 1997: 65; Hansen 2001: 313	Cenote Style E Group
Nakum	Źralka and Hermes 2012; Źralka et al 2017; Šprajc 2021a	Źralka et al 2017, 2018	TEB
Pacbitun	Healy 1990; Healy et al 2004; Micheletti 2016; Awe et al 2017; Šprajc 2021a	Healy 1992: 231	ETA
Santa Rosa Xtampak (Xtampak)	Andrews 1988; Lopez and Folan 2005	Andrews 1988: 5	TEB
Tayasal	Chase 1983; Chase 1985; Aimers and Rice 2006; Pugh et al 2012; Chase and Chase 2017	Chase 1983: 941	Uaxactun Style E Group
Tikal	Laporte and Fialko 1995; Grube and Martin 1998;	Carr and Hazard 1961: 33,35; Aimers	Uaxactun Style E Group

	Aimers and Rice 2006; Šprajc 2021a	and Rice 2006: 82	
Uaxactun	Blom 1924; Ricketson and Ricketson 1937; Freidel 1979; Coggins 1980; Freidel 1981; Aveni and Hartung 1989; Valdes and Fahsen 1995; Aimers and Rice 2006; Chase and Chase 2017; Šprajc 2021a	Ricketson 1933; Ricketson and Ricketson 1937	Uaxactun Style E Group
Xunantunich	Jamison 2010; Brown et al 2017; Awe et al 2017; Šprajc 2021a	Jamison 2010: 125	ETA
Yaxha	Grube 2000; Aimers and Rice 2006; Morales and Valiente 2006; Źralka and Hermes 2012; Chase and Chase 2017; Šprajc 2021b	Gamez Diaz 2013: 13	Uaxactun Style E Group

Table 2: Summary of data used and determination of what is an E Group

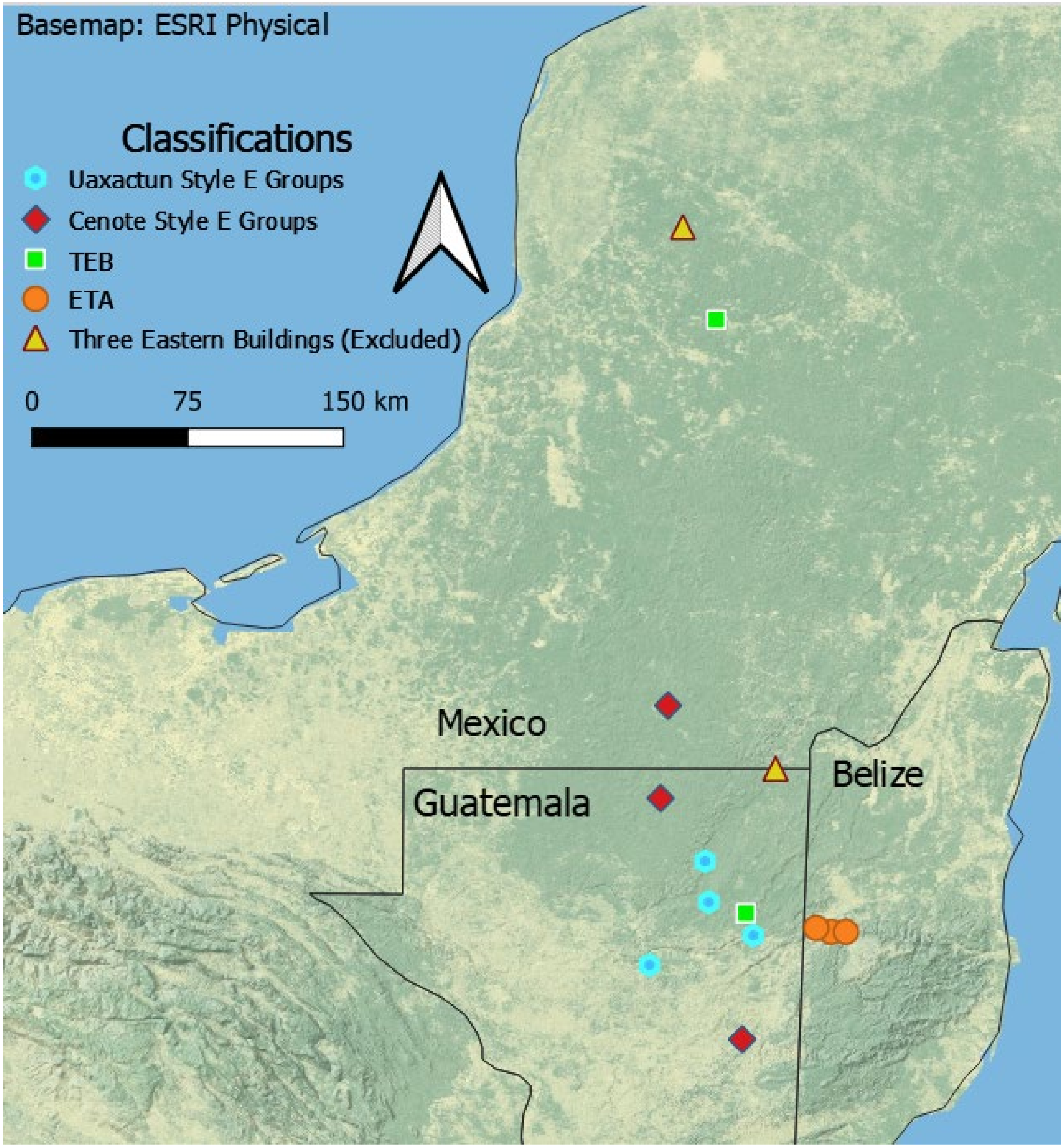


Figure 8: Map of Site Locations by Classification

Arroyo Negro

Arroyo Negro is a site in the southern portion of the state of Campeche, Mexico (see Figure 9). It sits on the edge of a geologic platform, like many other sites in the region that appear to cluster on many of the platforms (Flores Esquival and Šprajc 2008: 17-18). Adams (1990: 25, 29, 34, 37) identified another site as Arroyo Negro, but due to the placement of rivers it is thought that he is referencing a different site 5 km south of Arroyo Negro (Šprajc and Flores Esquivel 2008:109). It has been suggested (Flores Esquival and Šprajc 2008: 23 and Šprajc et al 1997: 6) that there is an E Group at this site, however there is no map or excavation data included in these sources. Ivan Šprajc and Atasta Flores Esquivel (2008:109) includes a map of the E Group in question (Figure 10) and states that while there are four structures on the eastern platform, the northernmost one is significantly smaller than the other three, which all average at about 5 to 6 meters high while the mounds in the rest of the site average about 4 meters high. Looking at Figure 10 below demonstrates that there are three buildings to the east that appear to form a platform, however there is not a platform connecting just those three buildings but the entire plaza. Therefore, this is not a potential E Group but three structures on the eastern side of a platform. Because the eastern structures do not appear on a platform of their own, the alignments will not be included in later analysis.

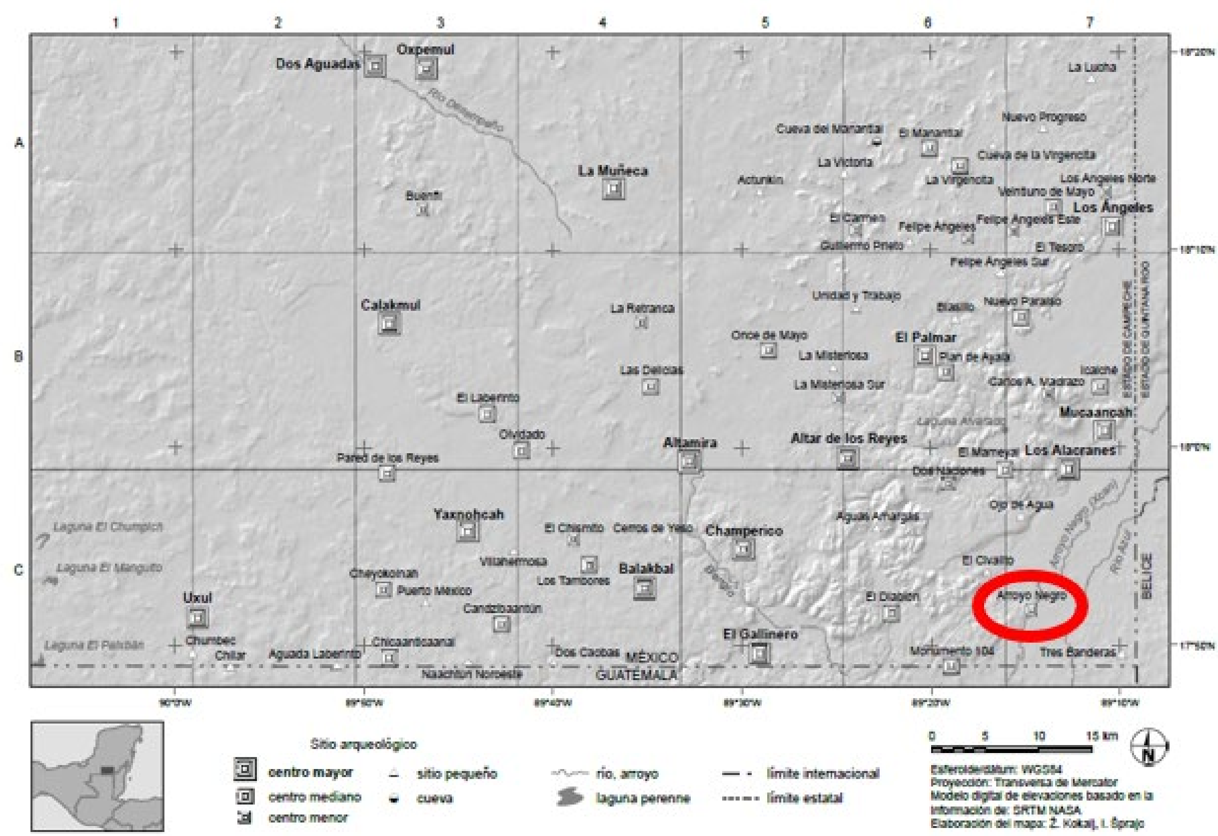


Figure 9: Location of Arroyo Negro, circled in red (Grube 2008: 229)

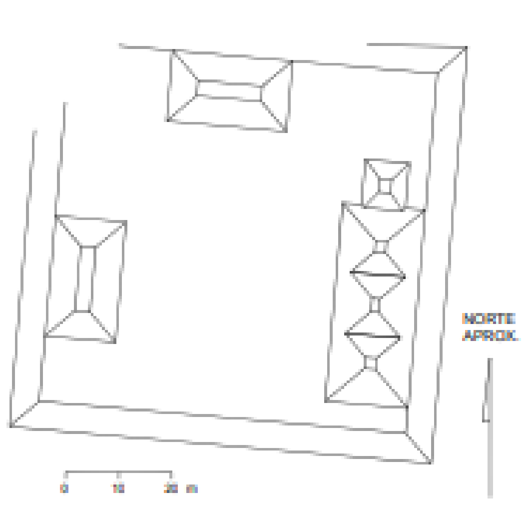


Figure 10: E Group in Question at Arroyo Negro (Šprajc and Flores Esquivel 2008: 109)

Cahal Pech

The site of Cahal Pech is a medium-sized Maya site outside of San Ignacio Town in the Belize River Valley (see Figure 11) dating from 900 BCE to A.D. 800. Excavations in 1988 (Awe 1988; Awe and Campbell 1988) showed that the site core - which includes the E Group in question (see Figure 12) - has at least 34 non-domestic structures mostly clustered around 7 plazas (Awe et al 1991: 25). Looking specifically at the potential E Group, the western pyramid did exist but was modified later in such a way that it was difficult to clearly establish line of sight; but the potential E Group did exist as a coherent group at one point in time (Awe et al 2017: 413). The heights of the eastern structures are not uniform (see Figure 13) as one would expect with an E Group. There is also an uneven distribution of burials and caches between the three eastern structures which range in date from the Late Middle Preclassic to the Terminal Classic; out of a total of 18 burials and 8 caches, 12 of the burials and 6 of the caches are located in the center structure (Awe et al 2017: 432-433). Finally, the construction histories of the eastern structures were different with the three buildings built at different times and then linked together in the Late Preclassic (Awe et al 2017: 422). Due to the different sizes and the different construction histories of the eastern structures, this E Group in question is not an E Group, but an ETA, the TEB specific to the Belize River Valley (as stated in Awe et al 2017).

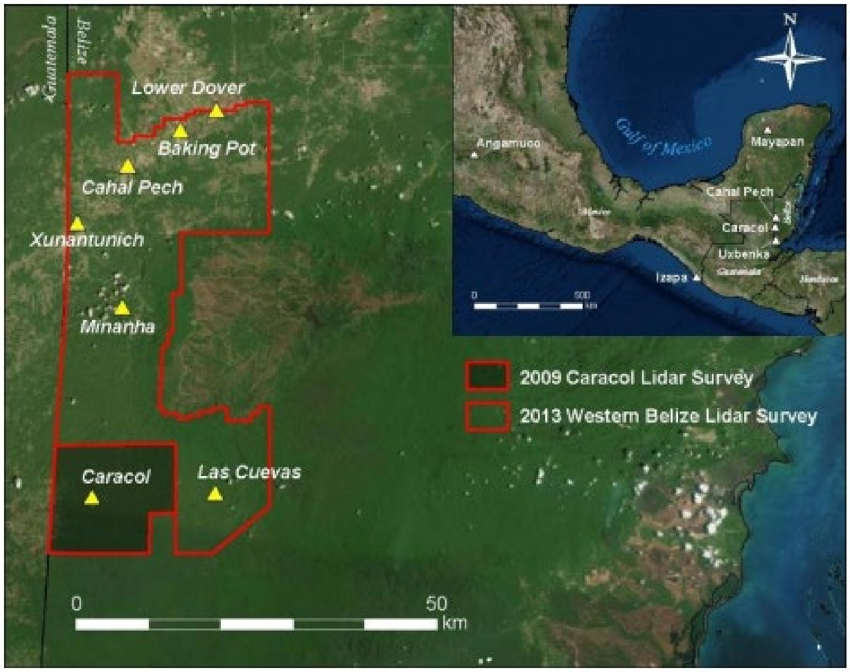


Figure 11: Location of Cahal Pech (Ebert 2015: 148)

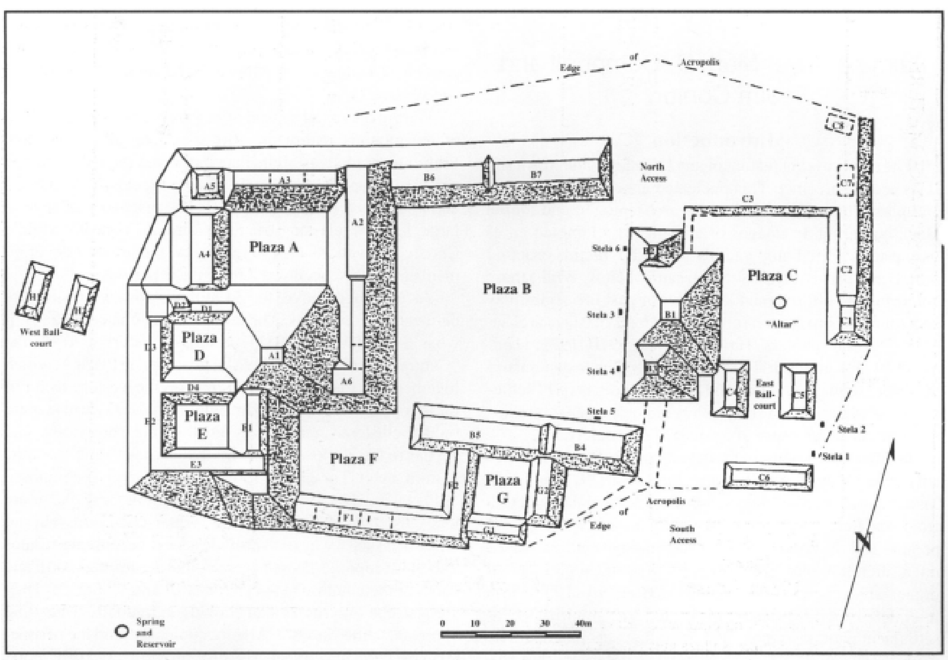


Fig. 2. Rectified plan of the site core at Cahal Pech, Belize

Figure 12: E Group in Question at Cahal Pech (Awe et al 1991: 26)

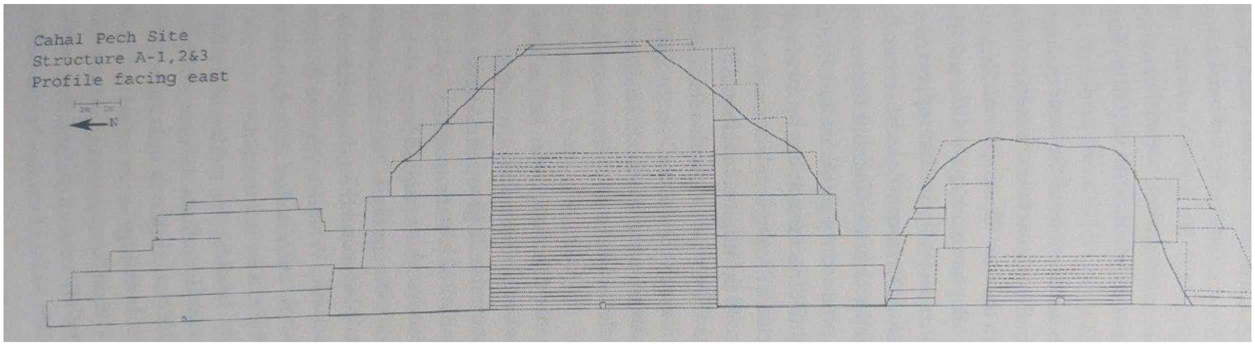


Figure 13: North-south profile of Eastern Structures at Cahal Pech (Awe et al 2017: 425)

Calakmul

Calakmul is located next to a bajo in Mexico north of the Guatemalan border, and north of the ruins of El Mirador (see Figure 14). As a whole, the site was occupied from the Middle Preclassic to the Post-classic (Folan et al 1995: 310-311). The potential E Group at this site (see Figure 15 and Figure 16) is boasted as "excavated, accurately measured, and … one of the best-preserved, largest, and ...complex examples known in the Maya region" (Dowd et al 2017: 559). The eastern platform is 150m from end to end (Dowd et al 2017: 563). The earliest construction phase for this potential group is in the Late Preclassic (350 BCE - A.D. 225) associated with Structures IV-b and VI, the central and western structure respectively (Šprajc 2021b: 44). There are four Early Classic building episodes for Structure IVb, and then construction phases/modifications for Structures IVa, IVb, and IVc (Dowd et al 2017: 561). Out of the three Late Classic building phases, single rooms were built on top of IVa,b, and c in AD 672, second chambers were added to the same buildings and stelae were potentially added to Structure VI in AD 702, and the third episode saw a chamber added to IVb and a superstructure completed for Structure VI in AD 721 (Carrasco Vargas 1996, 1999; cited in Dowd et al 2017: 561). Also, out of a total of 4 burials associated with the IV structures, three are found in IVb (Carrasco Vargas 1996, 1999; Braswell et al 2004: 177; Dominguez 1992; Folan et al 1995: 319; cited in Dowd et al 2017: 562). All the burials belong to the Early and Late Classic period, with Burial 1 and 2 associated with the Early Classic substructure of

Structure IVb, and the final burial associated with Structure IVb from the Late Classic (Carrasco Vargas 1996, 1999; cited in Dowd et al 2017: 562). While the structures on top of IVa, IVc, and VI were not constructed until the Late Classic, it appears the base platforms were constructed at the same time as Structure IVb although this might change with further excavation data. In order to be considered an E Group, construction has to occur during the Preclassic or the Early Classic; this excludes Structures IVa and IVc. Therefore, the only structures that could be a part of an E Group are structures IVb and VI. This means it cannot be a Uaxactun Style E Group. The caches and burials associated with these two structures indicate it was used during the Early Classic, and originally constructed during the Late Preclassic. This group presents itself as a Cenote Style E Group with structures IVa and IVc added later, turning the E Group into a different assemblage in the Late Classic. Šprajc's (2021b: 44-45) reanalysis of this same E Group came to a similar conclusion, suggesting that the E Group may have started out with astronomical alignments that became less important as the central structure was modified and blocked the horizon; however, he does also mention that the original height of the central structure is impossible to know (Šprajc 2021b: 44).

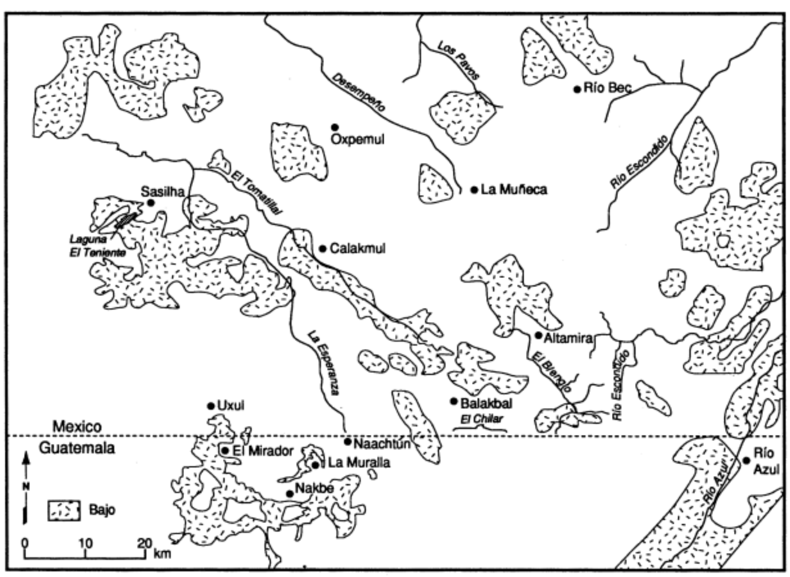


Figure 14: Location of Calakmul (Folan et al 1995: 311)

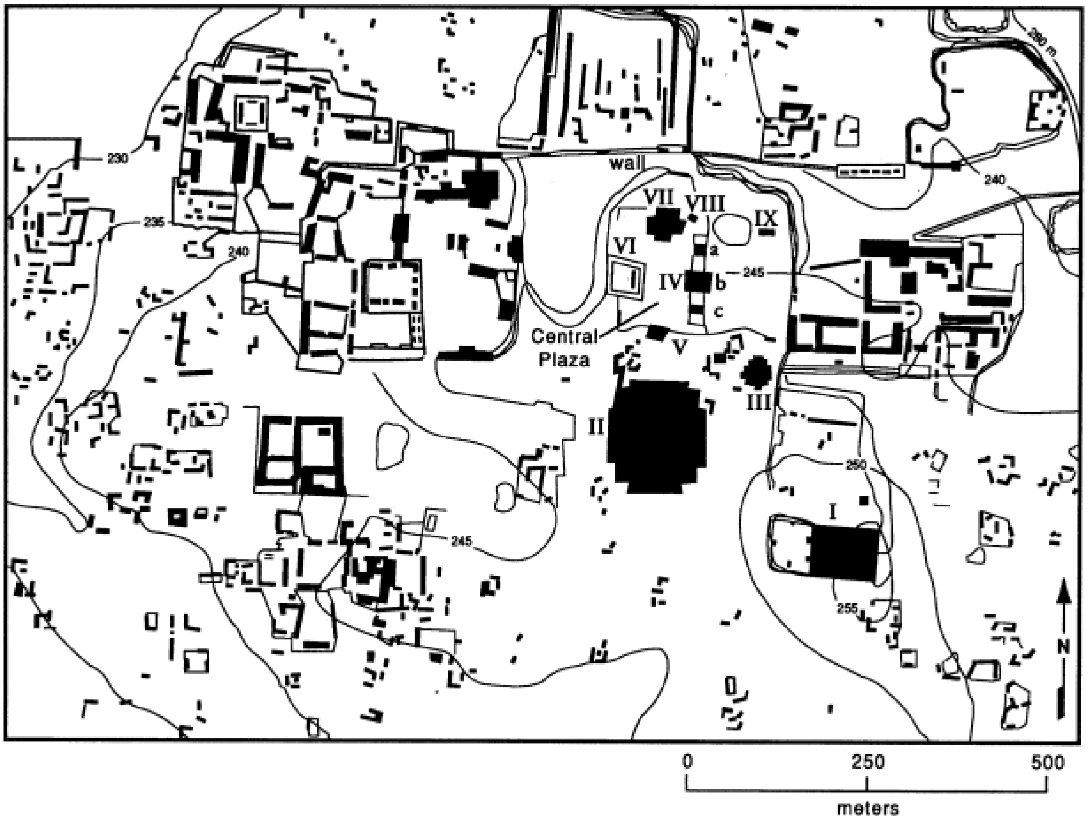


Figure 15: Calakmul's site map (Folan et al 1995: 314)

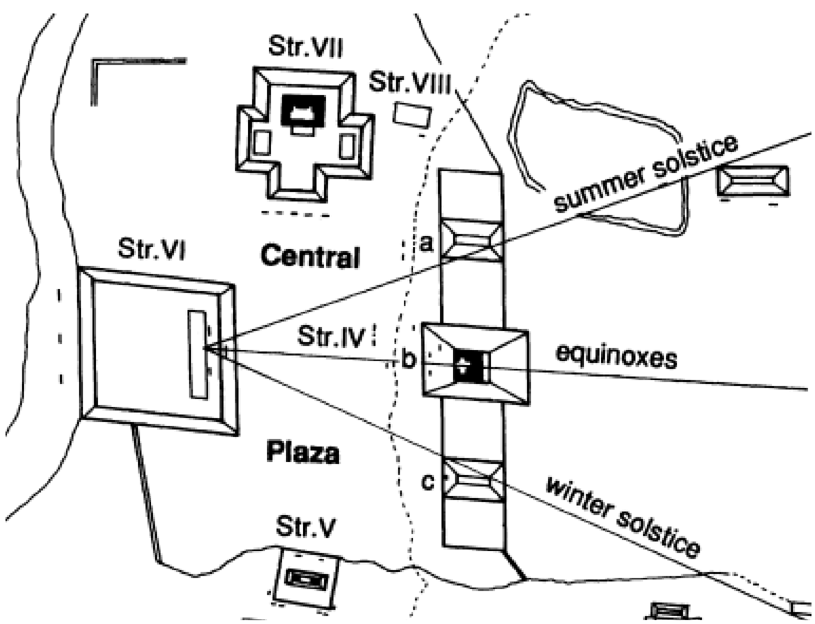


Figure 16: Close up of Potential E Group at Calakmul (Folan et al 1995: 315)

Ixkun

Ixkun is found in the Dolores region, Petén, of Guatemala (see Figure 17) and was occupied as early as the Late Preclassic (Laporte and Mejía 2005: 6). This potential E Group consists of two structures: Structure 3 as the 15m high western pyramid (Graham 1980: 2:135), and Structure 6 as the 76m long, 11m high eastern platform (Graham 1980: 2:135) with a single structure on top, as shown in Figure 18 and Figure 19 (Laporte et al 1994: 34, 35). Ceramic fill in the western pyramid date construction to the Late Preclassic; there is also evidence of extensive use in the Late, Terminal, and Post Classic (Laporte and Mejía 2005: 33). The eastern platform was first constructed in the Late Preclassic, and the platforms branching off of the central structure were added on in remodeling during the Late Classic (Laporte and Mejía 2005: 41-42). Overall, there is evidence of this group being used through the Late, Terminal, and Post Classic (Laporte et al 1994: 36) after its Late Preclassic construction (Laporte and Mejía 2005: 33, 41-42). The construction date combined with the form reflects a Cenote Style E Group.

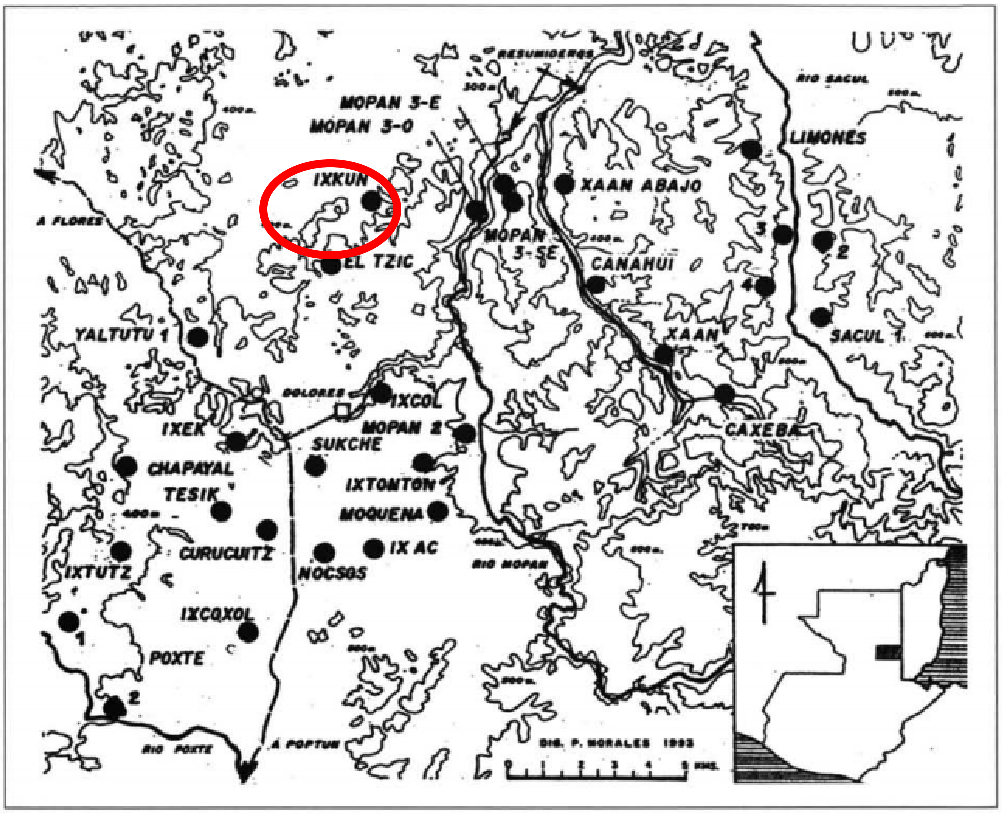


Figure 17: Location of Ixkun (Laporte et al 1994: 32)

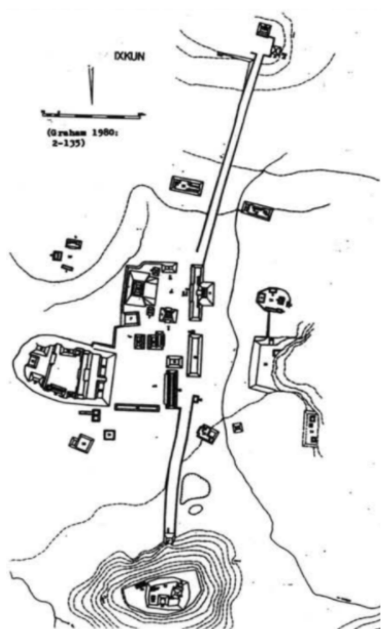


Figure 18: Site Map of the center of Ixkun (Laporte et al 1994: 34)

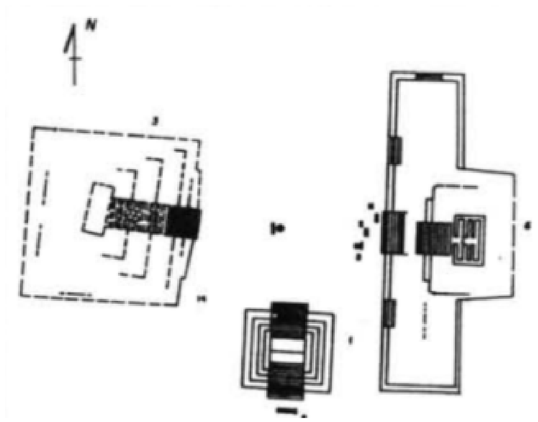


Figure 19: Close up of the potential E Group at Ixkun (Laporte et al 1994: 35)

Kabah

Kabah is located in the Puuc region in the Northern Lowlands (see Figure 20) (Vargas 1993: 3). There is no excavation data associated with this potential E Group for this site, as it was in an "advance state of collapse" when Pollock recorded data about it in 1936 (Carrasco Vargas 1993: 55). The site is divided by a causeway that connected to Uxmal, with the famous arch located immediately to the west of the E Group in question as shown in Figure 21 (Aveni and Hartung 1986: 43). Given the location of a massive pyramid partially blocking the alignment and another structure directly in front of the eastern platform that aligns with the western pyramid better, this group should be classified as three structures on the eastern side of a platform as the pyramid and eastern structures do not look related when looking strictly at the map. This, of course, is pending construction histories of the plaza to determine when these obstructing buildings were built in relation to the western pyramid and eastern platform. Because the western pyramid and eastern structures do not appear related, the alignments will not be included in later analysis.

Figure 20: Location of Kabah (Carmean and Sabloff 1996: 318)

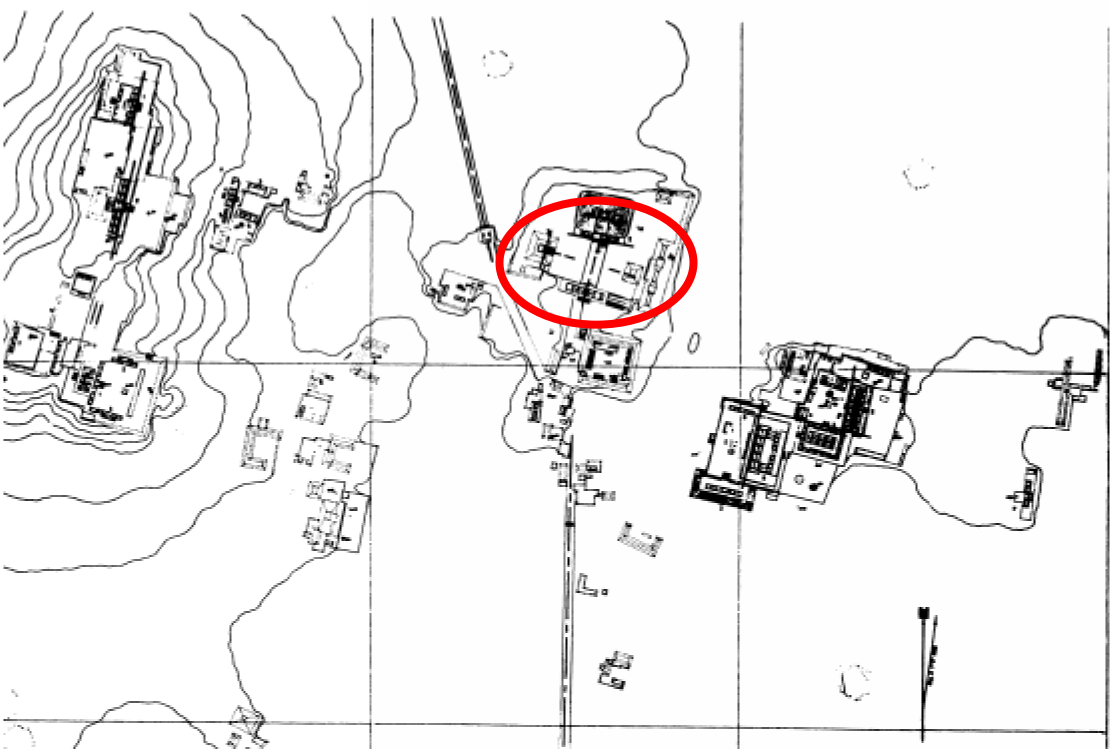


Figure 21: Site map of Kabah (Aveni and Hartung 1986: 25)

Nakbe

The site of Nakbe is found in the Mirador Basin (see Figure 22), which is bordered by rugged karstic formations and has extensive bajos throughout the area. The site as a whole dates from 1000 BCE to A.D. 150 (Hansen 1997: 53-54). The E Group in question (see Figure 23) was built in the late Middle Preclassic around 600-400 BCE (Hansen 1997: 65; Aguilar et al 2008 :201). Like Ixkun, this group only has one structure in the center of the eastern platform. This group can be classified as a Cenote Style E Group given the similar construction histories and the form of the group.

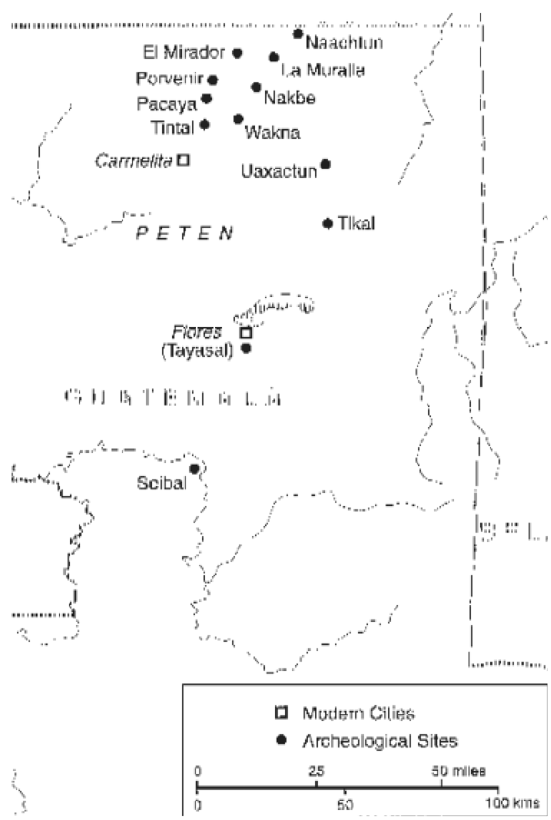


Figure 22: Location of Nakbe (Hansen 1997: 53)

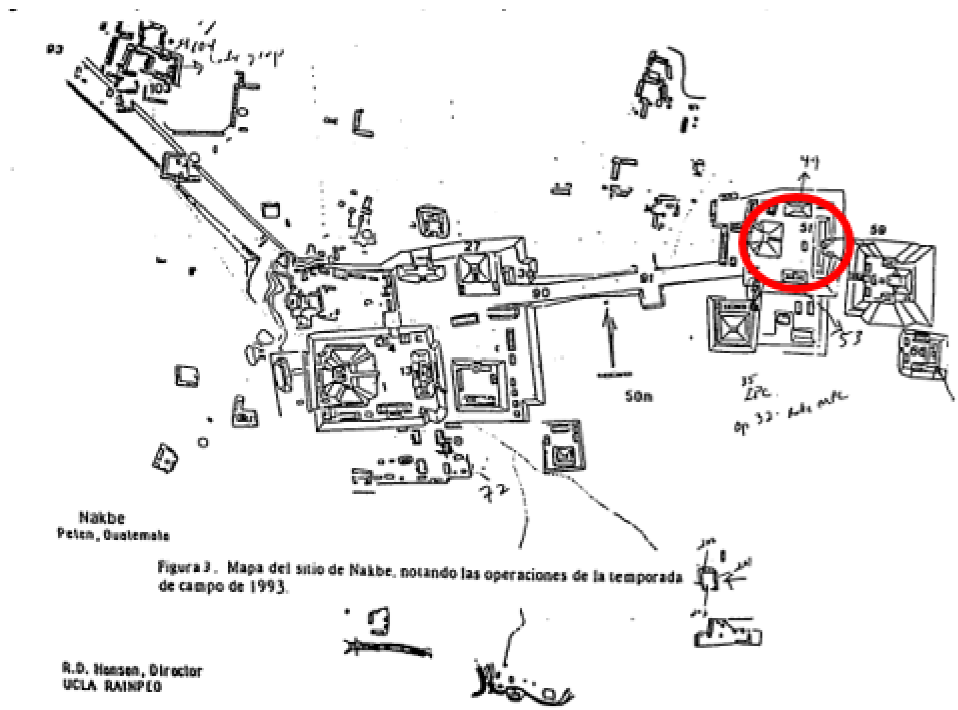


Figure 23: Site Map of Nakbe with the potential E Group circled (Hansen 2001: 313)

Nakum

Nakum is located north of Lake Yaxha and southeast of Tikal in Guatemala as shown in Figure 24 and is divided into two major sectors: the Northern Sector and the Southern Sector as shown in Figure 25 (Źralka and Hermes 2012: 161-162). The E Group in question is from the Southern Sector (see Figure 26), but there is another E Group in the Northern Section (see Figure 27). This other E Group was constructed before the E Group in question, as the Northern E Group was built in the Preclassic (600-300 BCE) (Źralka et al 2017: 451) while Structure A was built in the Late Classic, remodeled in the Terminal Classic, and the western pyramid was built in the Terminal Classic (Źralka and Hermes 2012: 164, 170). The Northern E Group also got converted into a large pyramidal temple with several burials in the Classic period (A.D. 250-800) (Źralka et al 2017: 451). There is at least one offering or burial associated with the group in question along the central axis of the complex (Šprajc 2021a: 14). Given that the other E Group was built and converted before the E Group in question was constructed, that the eastern portion was built before the western pyramid, that the eastern platform only has the central building, and that it was not constructed until the Late/Terminal Classic, this group is not an E Group but a TEB. While it can be classified instead as three buildings on the eastern end of a platform, the structures are still associated with the western pyramid, just in an unorthodox construction order thereby classifying it as a TEB instead of an E Group.

Figure 24: Location of Nakum (Źralka et al 2018: 2)

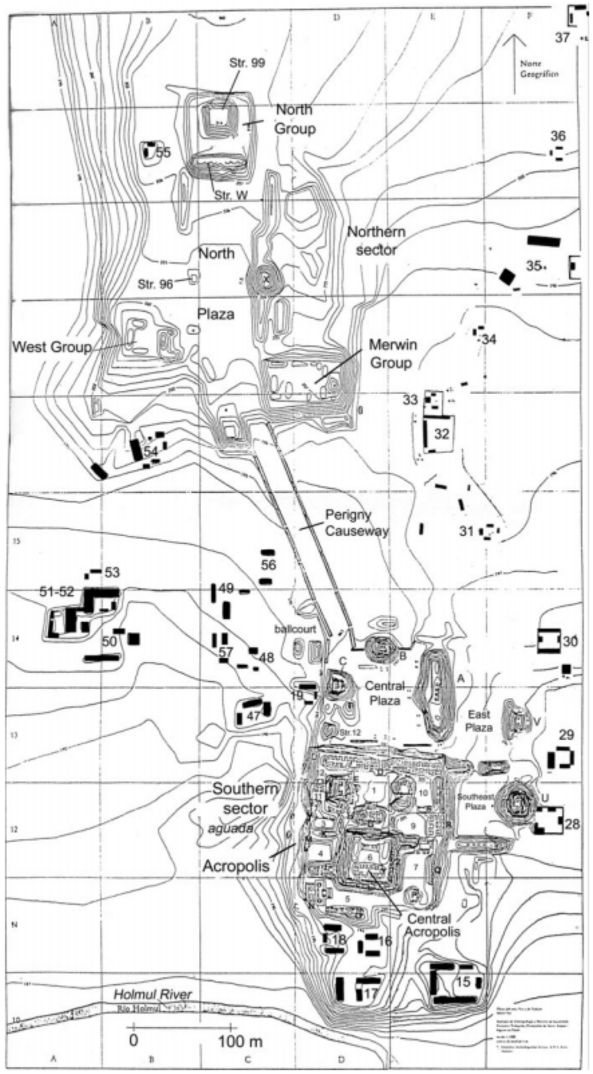


Figure 25: Site Map of Nakum (Źralka and Hermes 2012: 163)

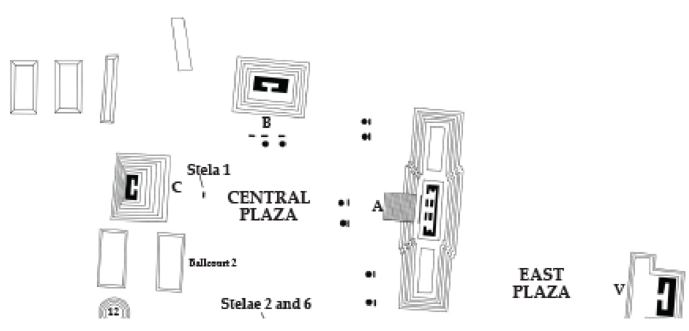


Figure 26: Close up map of the E Group in question at Nakum (Źralka et al 2018)

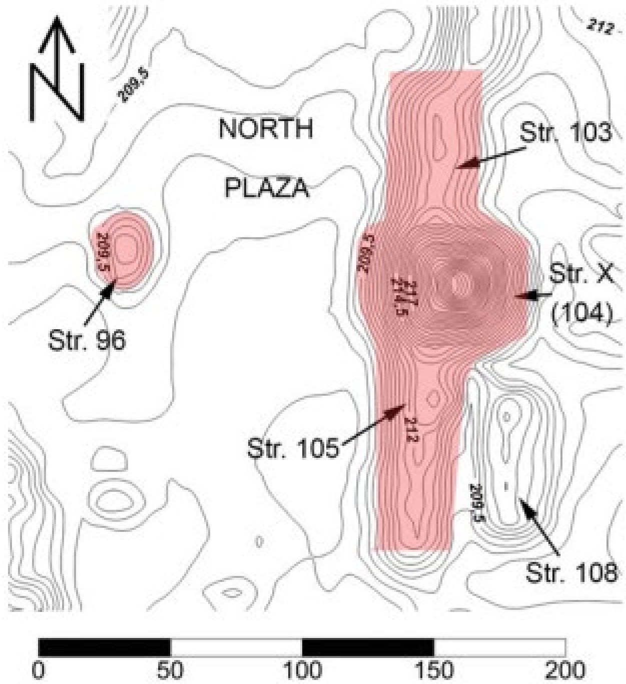


Figure 27: Close up of the other E Group at Nakum (Źralka et al 2017: 453)

Pacbitun

Pacbitun is a medium-sized civic ceremonial center in the Lowland Maya region, as shown in Figure 28, that was occupied from the Middle Preclassic (900 BCE) to the Terminal Classic (A.D. 900) but reached its peak in the Classic period (Healy 1992: 229). The E Group in question (see Figure 29) began as separate structures that were joined together by the Late Preclassic period. The eastern structures had five construction phases, while the western structure only had four (Healy 1990: 252; cited in Micheletti 2016: 43). The central building of the eastern structures and the western structure were the first two of the group built in the Middle Preclassic with the other two structures not joining the group until the Late Preclassic and then subsequently joined together (Micheletti 2016: 48-49). Even once they were joined together, the modifications that happened in the Classic period did not coincide with each other (Healy et al 2004: 229; cited in Awe et al 2017: 424). The group at Pacbitun follows a trend of the region, where alignments are skewed counterclockwise of the cardinal directions (Šprajc 2021a: 7). Of the twenty burials associated with this potential E Group, six were associated with Structure 2 to the west, while nine were associated with the central structure to the east and a total of five associated with the flanking structures (Micheletti 2016: 43-44). However, the earliest burials associated with any of these structures date to the Terminal Preclassic (Healy 1990: 256; cited in Micheletti 2016: 57). Given the size difference, different construction histories, and association with the Belize River Valley, this group is not an E Group but an ETA.

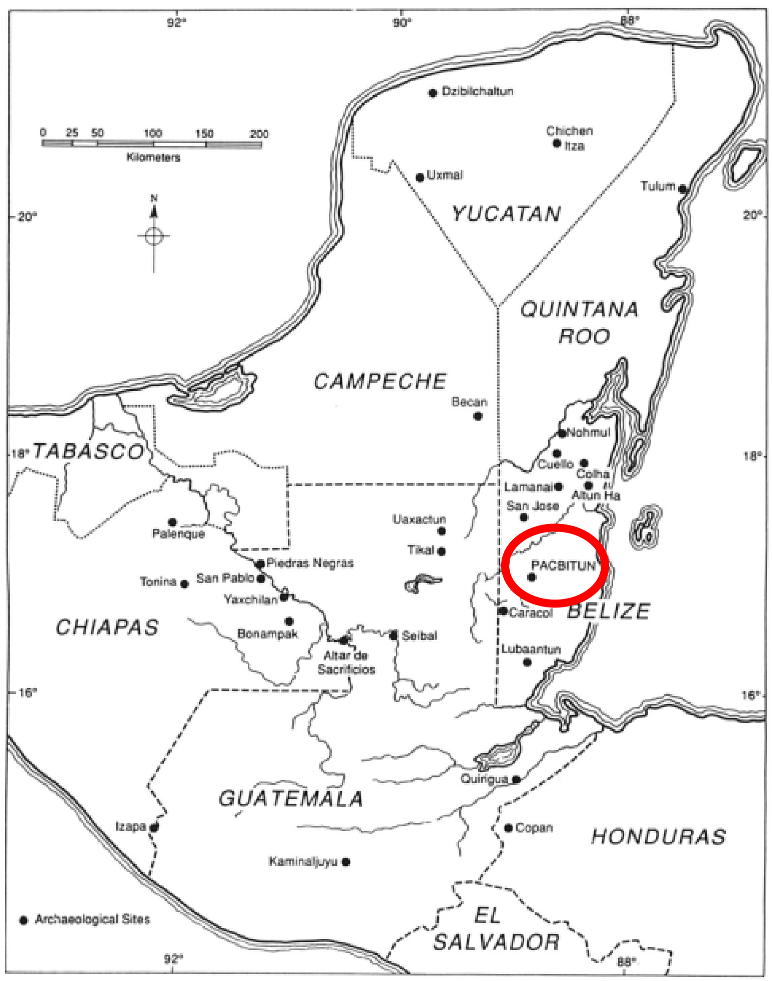


Figure 28: Location of Pacbitun (Healy 1992: 230)

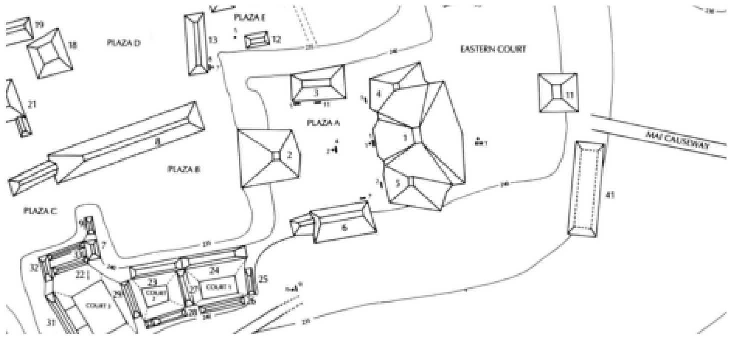


Figure 29: The E Group in question at Pacbitun (Healy 1992: 231)

Santa Rosa Xtampak (Xtampak)

Santa Rosa Xtampak, also known as Xtampak, is located close to the border between Campeche and Yucatan, Mexico (see Figure 30) near a bajo (Andrews 1988: 3). There are 8 carved stelae found on the eastern side of the Plaza where the E Group in question is located (see Figure 31) however most are in poor condition and only 2 have solid dates, although these dates were not included (Andrews 1988: 4). Lopez and Folan (2005: 13) claim that there are alignments to the solstices and equinox that Aveni and his team verified in 2003. There are ceramic sherds from the Mamon sphere reported from the platform base of the eastern structure (Lopez and Folan 2005: 13), however there is no citation for this excavation data other than a citation to Brainerd 1958 for the classification of Mamon sphere ceramics. There is no other mention of excavation. Therefore, based off the map, it appears to be a TEB as the western structure does not appear to be a pyramid and the number of structures associated with this group is not clear. This is, of course, pending excavation data to understand the construction history of the group and clearer maps of the group demonstrating what is a part of it in the first place. Even though the number of structures associated are not clear, there does appear to be a link between the western structures and eastern structures. This allows for the alignments to be considered in the TEB alignment analysis.

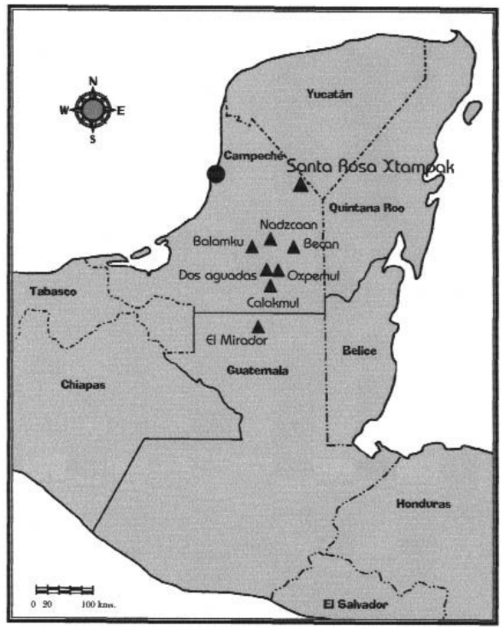


Figure 30: Location of Santa Rosa Xtampak (Lopez and Folan 2005: 6)

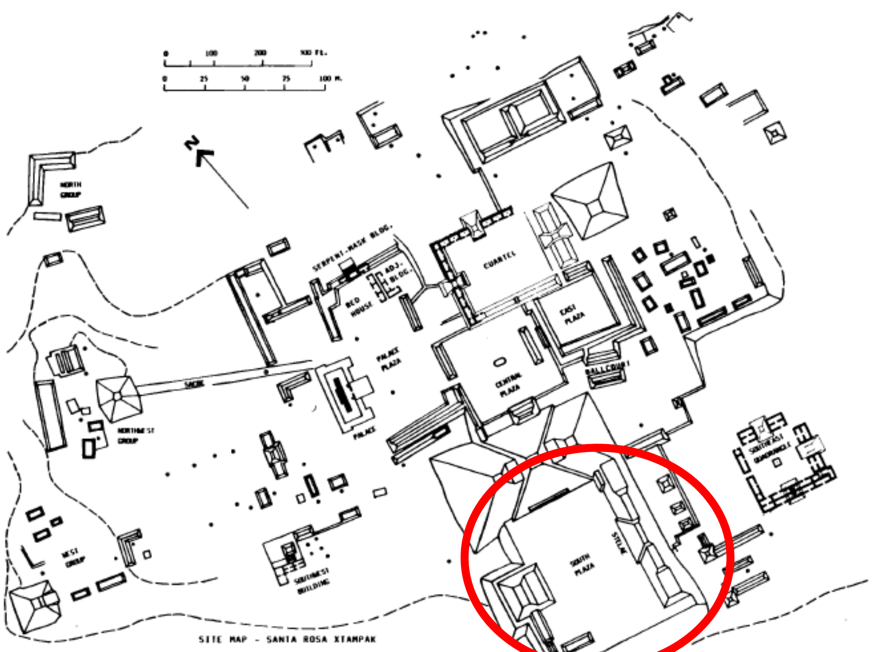


Figure 31: Site map of Santa Rosa Xtampak (Andrews 1988: 5)

Tayasal

Part of Tayasal lies within a savanna on the tip of the peninsula in Lake Peten (see Figure 32) (Chase 1985: 32). The site began in the Middle Preclassic but did not really start to grow until the Late Preclassic and the monumental architecture did not peak until the Late Classic (Chase 1985: 36, 38). The E Group in question (see Figure 33) was probably built in the late Preclassic (300 BCE - A.D. 200) although some of the eastern structures were heavily used and remodeled in the Post-classic (Pugh et al 2012: 8-9). The western temple is also assumed to have been dismantled in the Post-classic (Chase 1985: 37; Chase and Chase 2017: 47). There is at least one stela associated with the eastern platform (Chase 1983: 368) that was reset into the Terminal Classic plaster floor in the Post-classic (Pugh et al 2012: 9). Given the similar size of the eastern buildings, the similar construction history, and the similar remodeling and dismantling history in the Post-classic, this group is an Uaxactun Style E Group.

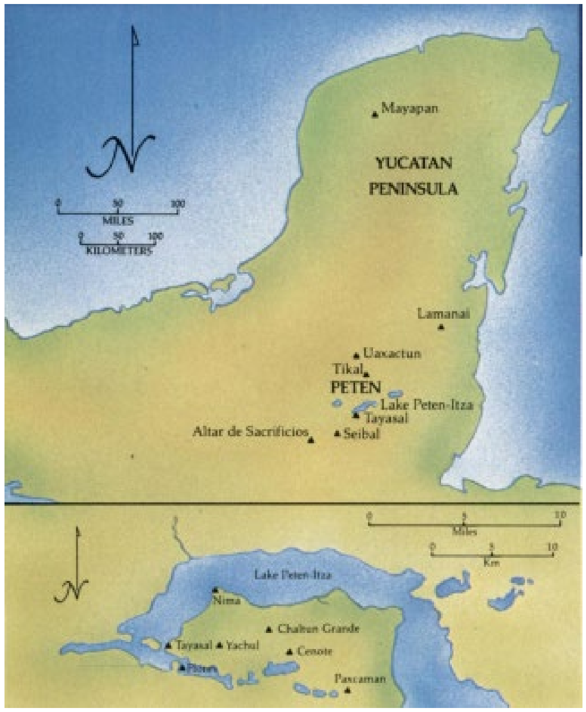


Figure 32: Location of Tayasal (Chase 1985: 34)

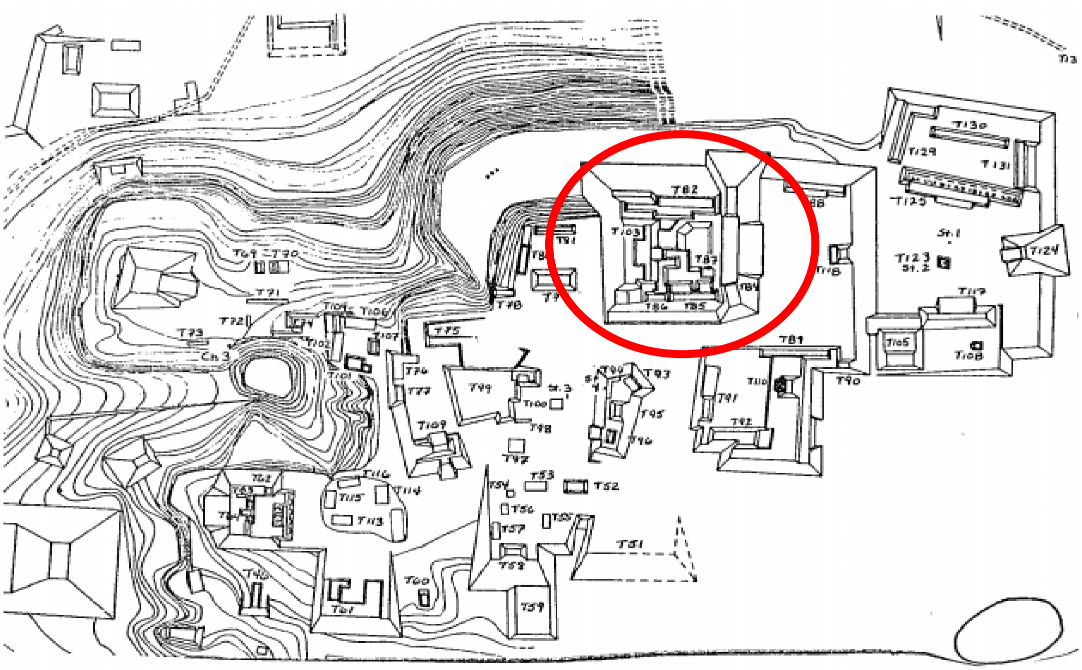


Figure 33: Site map of Tayasal (Chase 1983: 941)

Tikal

Tikal is a well-known site in Guatemala (see Figure 34). The E Group here (see Figure 35, Figure 36, and Figure 37) is one of the earliest ones, dated to the Preclassic period. The first building episodes were in 700-600BCE and consisted of multiple iterations of strictly the western pyramid and the eastern platform, an example of a La Venta Style E Group (see Figure 38). The second building episodes were in 500-400BCE when structures were added to the eastern platform and resembled a Cenote Style E Group (see Figure 39); these structures were then remodeled in 400-200BCE to a Uaxactun Style E Group (see Figure 37) (Aimers and Rice 2006: 79). There might be links to the ballgame for this specific E Group, given imagery (Laporte and Fialko 1995; cited in Aimers and Rice 2006) and nearby ballcourts. There is a mass grave in front of the center structure with 17 individuals dating to A.D. 250-300 (Laporte and Fialko 1995: 56; cited in Aimers and Rice 2006: 89), and Stela 39 celebrates the completion of the Katun (Grube and Martin 1998: 81; cited in Aimers and Rice 2006: 91). The central axis of this group has offerings along it like the mass grave referenced above and also ceramic pieces that may have astronomical connotations to them (Šprajc 2021a: 14). The measurements of this axis did not change throughout all of the iterations of the group evolving through the different styles, and the importance of this axis is reflected in other nearby buildings at the site that reference the same axis (Šprajc 2021a: 14,25). Looking strictly at the similar construction history and the final physical shape of the group, this is an Uaxactun Style E Group.

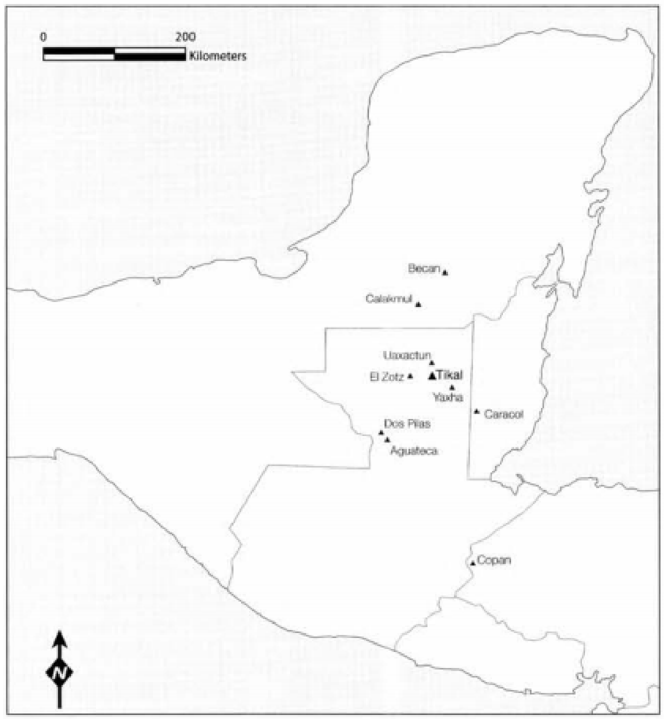


Figure 34: Location of Tikal (Webster et al 2007: 42)

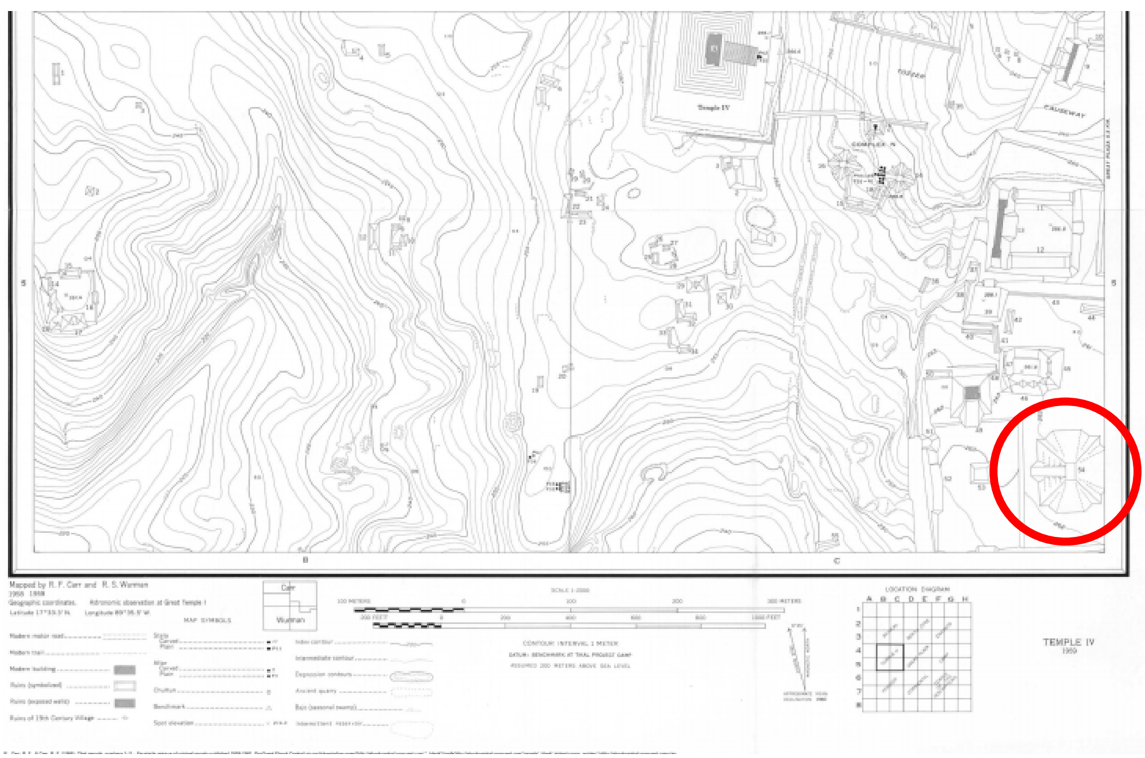


Figure 35: Portion of Tikal site map showing western pyramid (Carr and Hazard 1961:35)

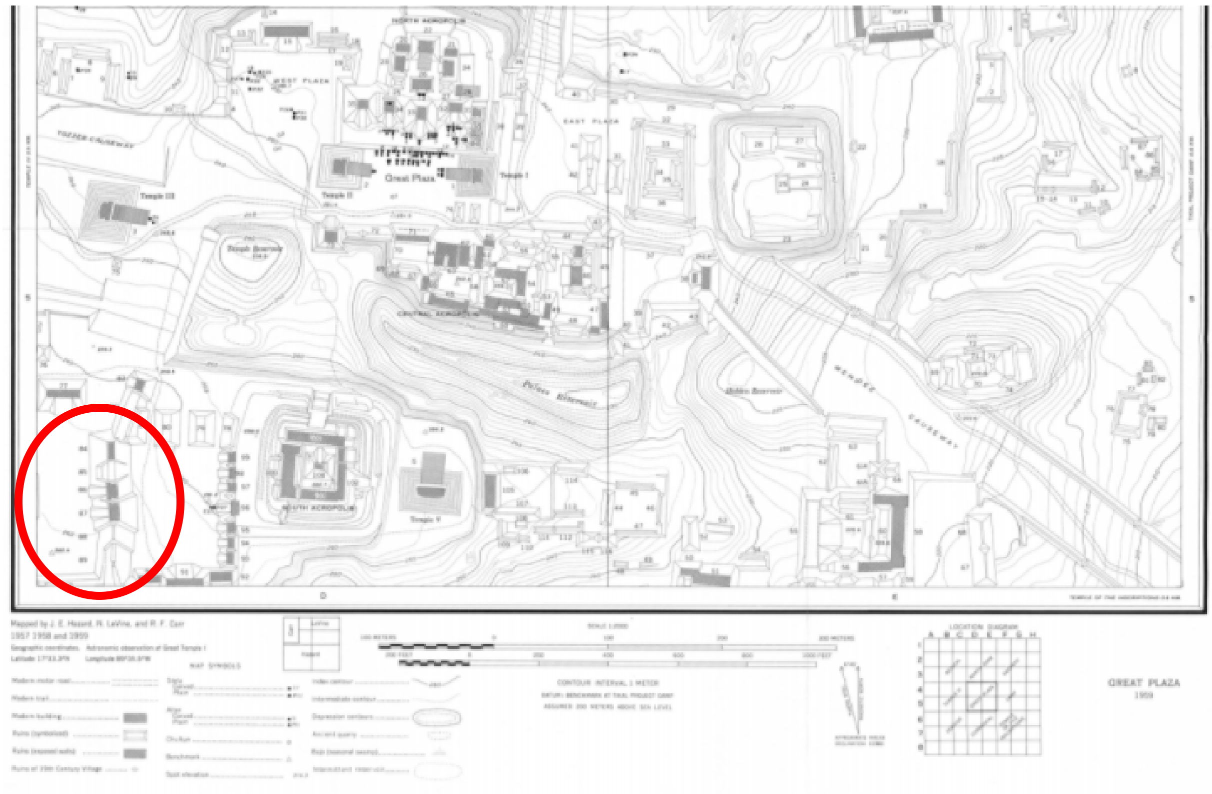


Figure 36: Portion of Tikal site map showing eastern platform (Carr and Hazard 1961: 33)

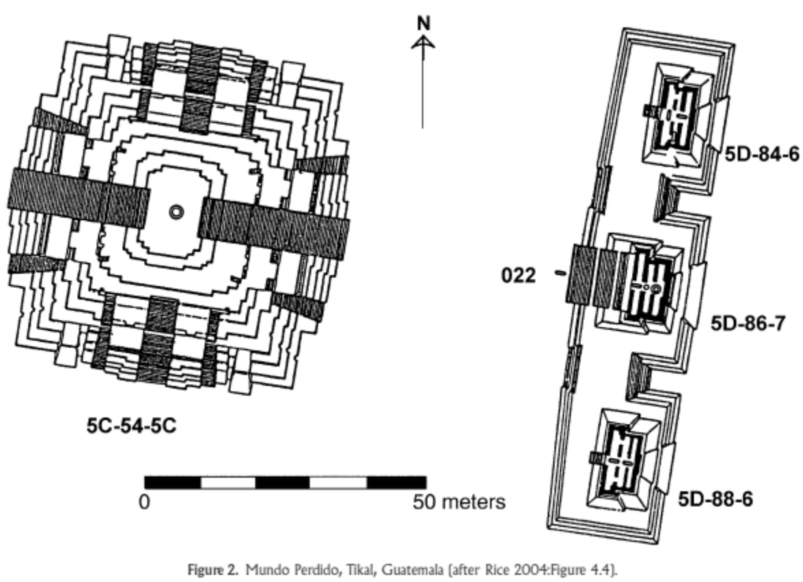


Figure 37: Close up of Tikal E Group (Aimers and Rice 2006: 82)

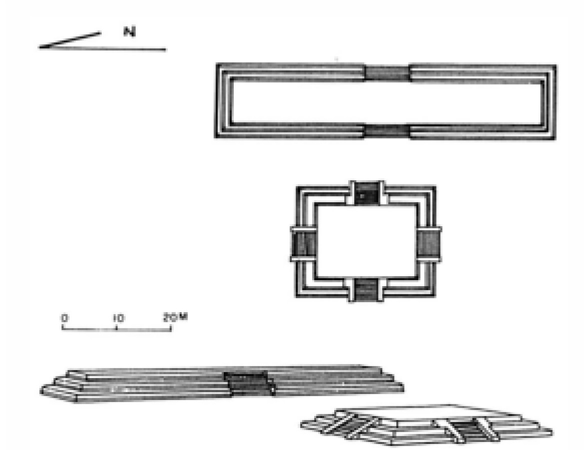


Figure 38: First iteration of the Tikal E Group (Laporte and Fialko 1995: 47)

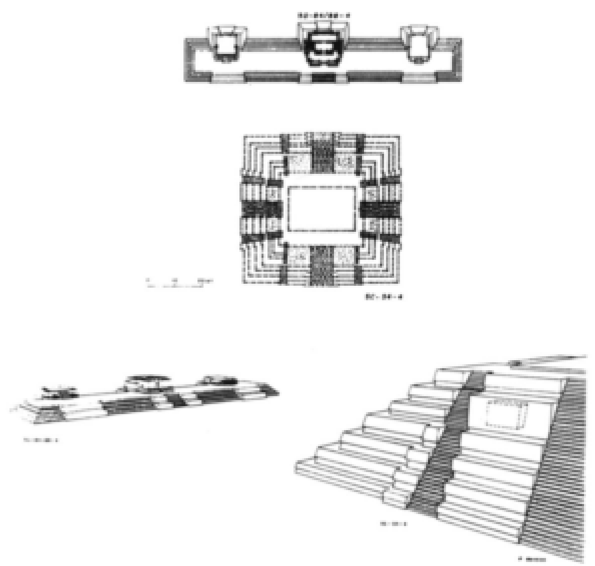


Figure 39: Fourth iteration of the Tikal E Group (Laporte and Fialko 1995: 51)

Uaxactun

Uaxactun is located in the central portion of the Department of Peten, Guatemala (see Figure 40) on top of artificially flattened hill tops (Ricketson 1933: 74, 76). According to the World Monuments

Fund, it is thought that Uaxactun was first occupied anywhere between 1000-600BCE (2020). The E Group at Uaxactun (see Figure 41, Figure 42, and Figure 43) dates to the Early Classic period although there are earlier constructions associated with the complex but not a part of the Uaxactun Style E Group template (Chase and Chase 2017: 31). Either way, this complex is the first example of an E Group found in the archaeological literature (see Blom 1924)(Aimers and Rice 2006: 79). Because this E Group is the model E Group comparisons are made to, it has three eastern structures on the eastern platform that are approximately the same size (Aimers and Rice 2006: 81). The equinox alignment first proposed by Blom (1924) is not precise but is one of the only alignments that fall within 2 degrees north or south of due east. If it were greater than this there would be more discrepancy in determining an equinox date (Aimers and Rice 2006: 85). A contributing factor is that Group E and other E Groups at Uaxactun (like Group D) is skewed about 1° counterclockwise from the cardinal directions (Šprajc 2021a: 17). Aveni and Hartung proposed that while the E Group was originally an observatory, architectural renovations made it less accurate over time (1989:451, cited in Aimers and Rice 2006: 86). There are Stelae associated with this group that celebrate the 8.16.0.0.0 katun ending, in CE 357 (Valdes and Fahsen 1995:204, cited in Aimers and Rice 2006: 91) demonstrating its longevity of use. It has been proposed that the western pyramid was an intentional architectural representation of quadripartite directional symbolism (Coggins 1980, cited in Aimers and Rice 2006: 87) and that there are connections to the underworld, sun, earth, and sky gods through the masks on this same pyramid (Freidel 1979:46; Ricketson and Ricketson 1937:84, Freidel 1981; cited in Aimers and Rice 2006: 87). Given that this is the original Uaxactun Style E Group, there is no need to question that this is a Uaxactun Style E Group.

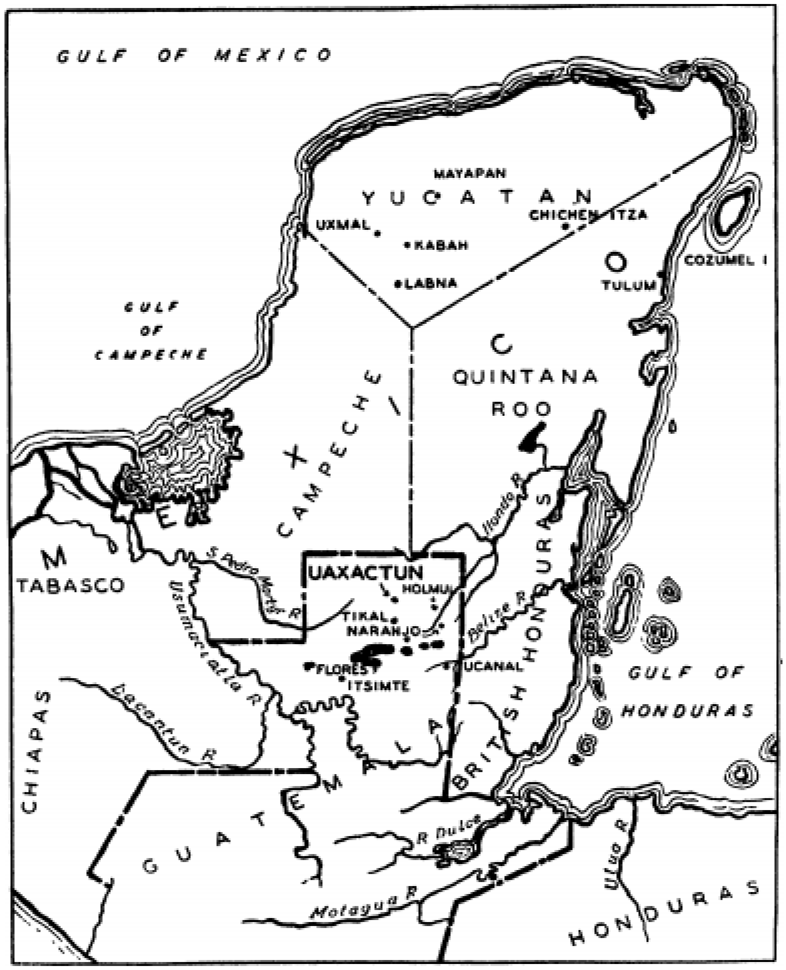


Figure 40: Location of Uaxactun (Ricketson 1933: 75)

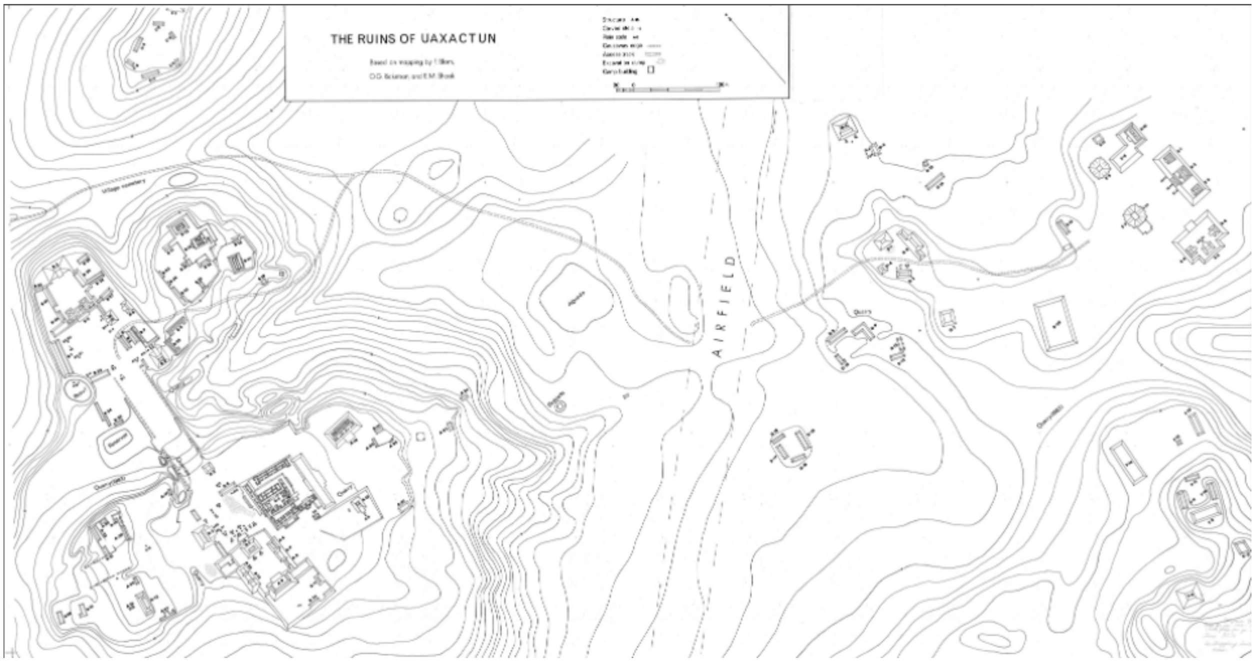


Figure 41: Site Map of Uaxactun (latinamericanstudies.org)

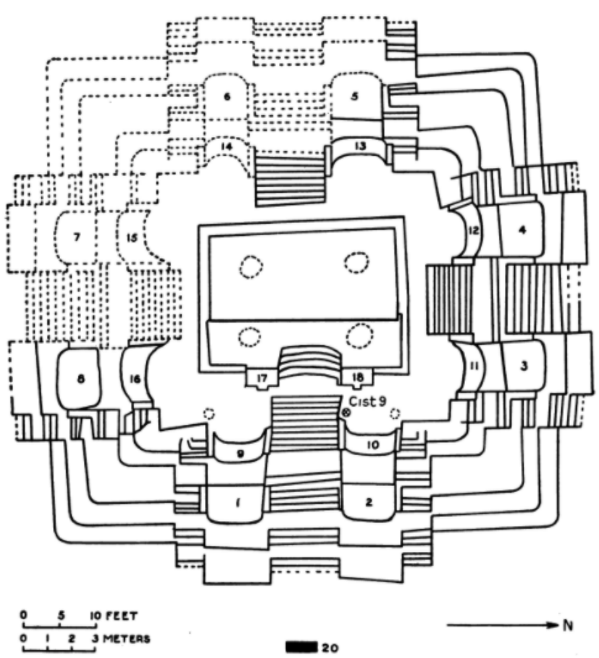


Figure 42: Close up of Uaxactun E Group Western Pyramid (Ricketson and Ricketson 1937:73)

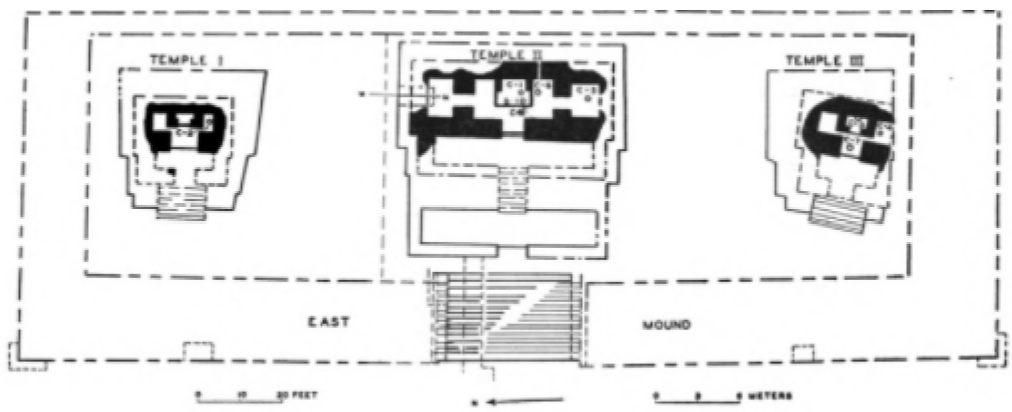


Figure 43: Close up of Uaxactun E Group Eastern Platform and Structures (Ricketson and Ricketson 1937: 48)

Xunantunich

Xunantunich is a medium-sized center near the Mopan River in Belize, 3 kilometers east of the modern border with Guatemala as shown in Figure 44 (LeCount 2001: 937). It is split into two different ceremonial centers constructed and used at two different times; Early Xunantunich was constructed and used in the Preclassic (Brown et al 2017: 55) and Classic Xunantunich was primarily built in the Hats' Chaak phase between 670-780 CE (LeCount 2001: 937). The site appears to stop being used during the Terminal Classic, around 780-850 CE (LeCount 2001: 937). There are two E Groups at this site, one in each of the ceremonial centers, but the one in question here is from Classic Xunantunich. However, it is important to note that the Early Xunantunich E Group is thought to be the earliest one to date and is a cenote style E Group (Brown et al 2017: 55). Focusing back in on the E Group in question (see Figure 45 and Figure 46), the eastern structures were built and modified separately. The Southern Structure was built in two construction phases in the Late Classic, the Center Structure built in one construction phase in the Late Classic Samal Phase (Jamison 2010: 124) and renovated in the Terminal Classic, and the

Northern Structure, currently being investigated, appears to have been built in at most 2 construction phases in the Late Classic as well (Awe et al 2017: 426). The western pyramid has Late Classic construction fill as well, suggesting it was contemporary with the eastern structures (Jamison 2010: 124). While the western structure does not appear like a pyramid, it is thought that it was extended to connect to structure A-7 therefore changing its overall shape (Jamison 2010: 130). However, this connection has not been excavated. Also, Structure A-1, the pyramid in the middle of the proposed E Group, was also built in the Late Classic between 670-750 CE and blocked any potential E Group alignments after its construction (Jamison 2010: 125). While Structure A-1 was constructed after the proposed E Group, it was constructed soon after. Like other potential E Groups in the area, there is the same counterclockwise skew from the cardinal directions noted in previous sections (Šprajc 2021a: 7). Awe et al (2017) say this is an ETA, and this research tentatively agrees. This is demonstrated through the different and late construction histories, suggesting that at first it was an ETA. However, the presence of western structures where a western pyramid should be and Structure A-1 blocking potential alignments between the western structures and the eastern structures soon after they were constructed suggests that this ETA may have been shifted to a collection of eastern structures with less association to the western structures soon after they were constructed. This classification confusion will be further addressed after alignment data discussion.

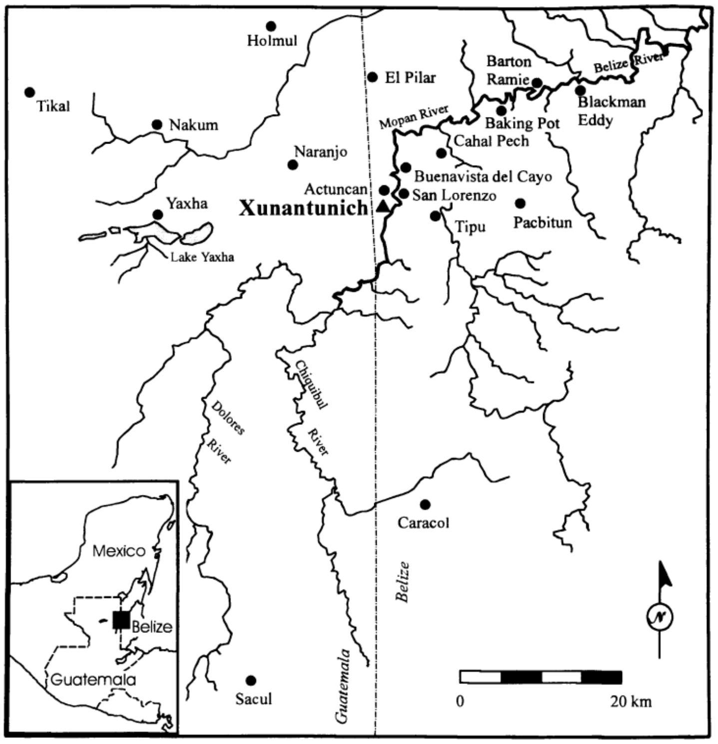


Figure 44: Location of Xunantunich (LeCount 2001: 398)

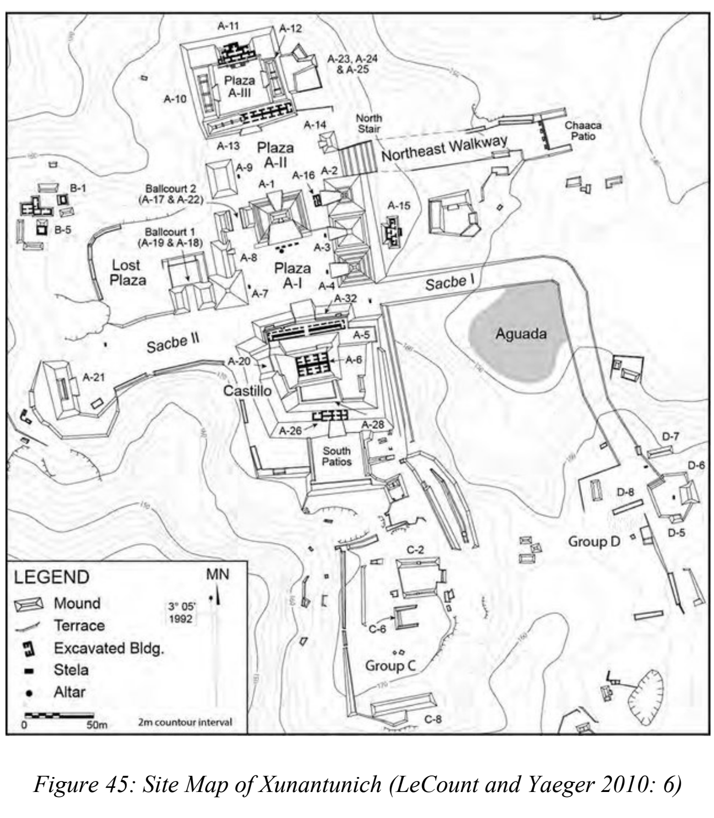


Figure 45: Site Map of Xunantunich (LeCount and Yaeger 2010: 6)

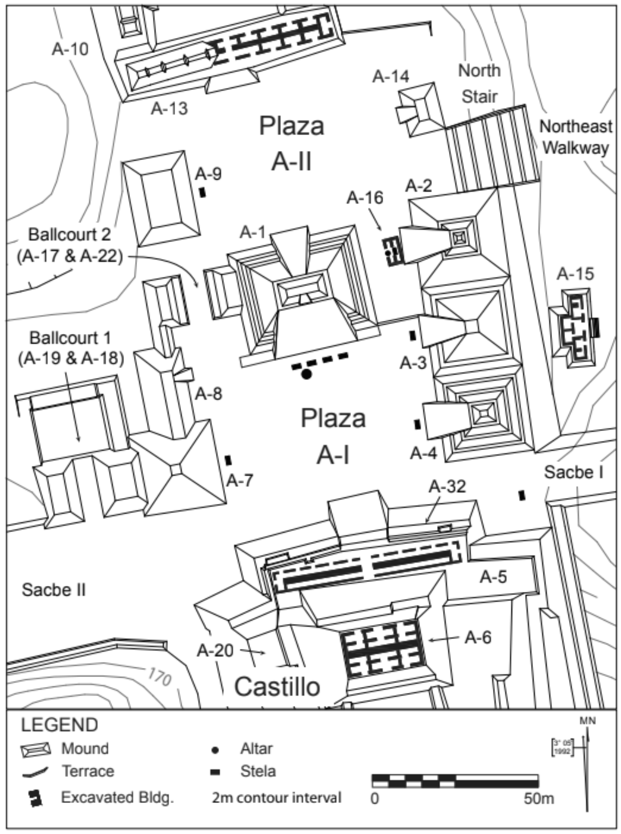


Figure 46: Close up of proposed Xunantunich E Group (Jamison 2010: 125)

Yaxha

Finally, Yaxha is located in the Triangulo Park of eastern Peten, Guatemala (see Figure 47) (Źralka and Hermes 2012: 176). The earliest ceramics and architecture for Yaxha date to about 700 BCE (Hermes 2000 and 2001; cited in Gamez Diaz 2013); there are two peaks culturally and architecturally in the Late Preclassic and the Late Classic, with more building episodes in the Terminal Classic (Źralka and Hermes 2012: 185). There are two of at least 3 E Groups reported at Yaxha in Aveni et al 2003; however, the only one under investigation here is located in Plaza C, as shown in Figure 48. It is important to note that another E Group in the Central Plaza is primarily a Cenote Style E Group, and while the focus shifted to a Uaxactun Style E Group for a bit, it ultimately shifted back to a focus on a radial structure with the advent of the 10th Baktun (Chase and Chase 2017: 62-63). This potential E Group is dated to the Late Preclassic due to the western pyramid, although how is not specified (see Šprajc 2021b: 84). Also, there are some stelae associated with the group that fall around this time as well. Stela 6 is undated but stylistically Early Classic (Aimers and Rice 2006: 91) and Stela 4 is also undated and has the Yaxha emblem glyph on it (Morales and Valiente 2006: 1016). Given that no carved monuments were dedicated in Yaxha after CE 799 (Grube 2000: 264; cited in Źralka and Hermes 2012: 192) that Stela 6 is stylistically Early Classic, and that the main construction phases of the site were in the Late Preclassic and the Late Classic, this potential E Group was probably built sometime between the Late Preclassic and the Early Classic. This proposed E Group is a Uaxactun Style E Group. The fact that the central building is not noticeably larger than the other two or offset on the eastern platform in Figure 48 demonstrates how this is stylistically more like a Uaxactun Style E Group. This determination, of course, is pending excavation data.

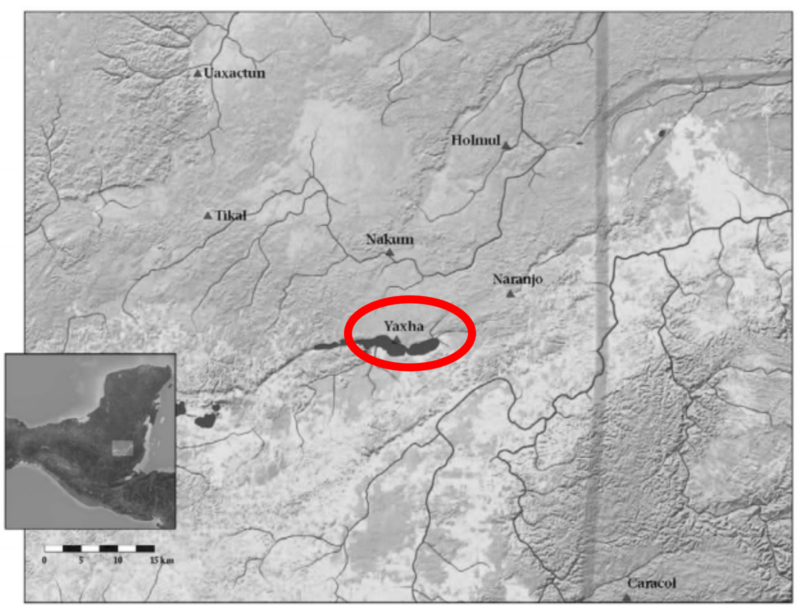


Figure 47: Location of Yaxha (Źralka and Hermes 2012: 177)

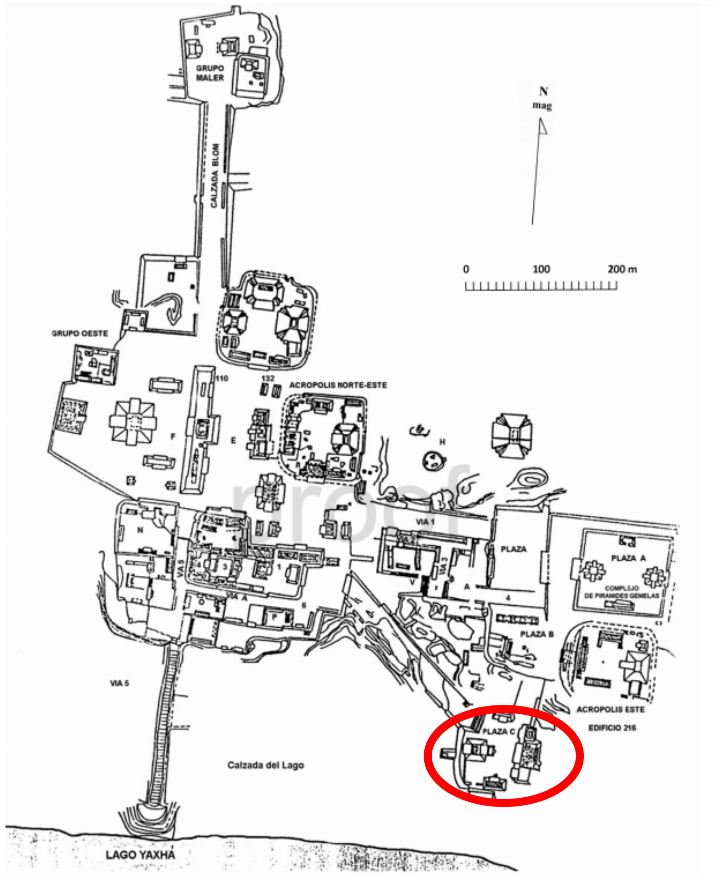


Figure 48: Site Map of Yaxha (Chase and Chase 2017: 61)

The aim of this phase of the project was to determine which of the original 14 proposed E Groups are Uaxactun Style E Groups, Cenote Style E Groups, or not E Groups at all but TEBs, ETAs, or simply three buildings on the eastern side of a platform. This portion was necessary before continuing on to the next phase, which is verifying the alignment dates and patterns discussed in Aveni et al 2003 and separating them out by the categorizations in Table 3.

Sites Grouped by E Group Classifications			
Uaxactun Style E Group	Cenote Style E Group	TEB	ETA
Tayasal Tikal Uaxactun Yaxha	Calakmul Nakbe Ixkun	Nakum Santa Rosa Xtampak	Cahal Pech Pacbitun Xunantunich

Table 3: Sites Grouped by E Group Classifications.

Chapter 4: Data Analysis

In the previous section, we have examined fourteen sites on which Anthony Aveni and his team took measurements and have reclassified them as specific styles of E Groups or as TEBs. The next step is to examine the alignments themselves in order to verify the measurements associated with specific structures and attempt to determine any celestial phenomenon that potentially inspired the alignment. It is important to note that the alignments looked at here are observer alignments – an azimuth or line between an observer and another point – and not structural alignments – the direction a building itself is facing (Aylesworth 2004: 41). The 2003 publication by Aveni and his team specifically investigated whether or not E Group complexes are “astronomically aligned as the prototype at Uaxactun evidently was” (Aveni et al 2003: 162). Because of this focus, the original authors tracked alignments to sunrises on the equinoxes and solstices, especially as those alignments were associated with structures at Uaxactun (see Blom 1924; Aveni and Hartung 1989; Aveni et al 2003; Aimers and Rice 2006; Šprajc 2021a). The potential sunrises associated with the buildings in question (the axes from the western structure to the eastern structures that are present at each site) were verified by inputting the alignment dates and locations into a NOAA Solar Calculator (US Department of Commerce 2005) and comparing the azimuth output to the listed azimuths of the structures. The difference between the alignment dates and the year 2020 was originally a concern, especially as the NOAA Solar Calculator could not project back to the original alignment dates; however, the calculator was appropriate for this project because the sun’s position does not vary enough year-to-year to alter the alignment from one structure to the next.

Alignment Analysis

Comparisons can be made between the different categorizations to see the distribution of azimuths for each of the buildings and the eastern platform. Unfortunately, alignment verification in the field was not possible before conducting this analysis. The first concern for analysis accuracy is the sample size, as demonstrated in Figure 49. The sample size creates an issue with the reliability of the analysis, as it is simply too small for any analysis other than a preliminary one. It is important to note the difficulty of establishing alignments from unexcavated buildings; unfortunately, there are a fair number of unexcavated samples in this dataset – both samples that have yet to be excavated and samples that were excavated after these measurements were taken in 2003. For the alignment charts, the platform azimuths for the ETA groups were not included because the samples with azimuths over 300° (see Figure 50) skewed the graphs in such a way that the other structure's azimuths were indistinguishable from one another as the large azimuths acted as outliers for the overall graphs. Therefore, analysis for the platform azimuths for that category are not included on the corresponding graph and instead induced from Table 4.

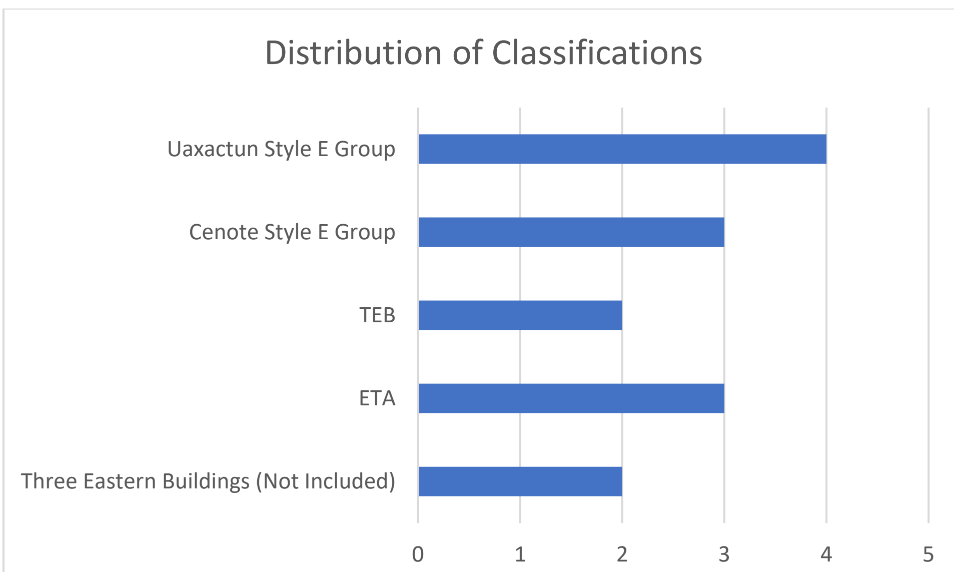


Figure 49: Distribution of Classifications

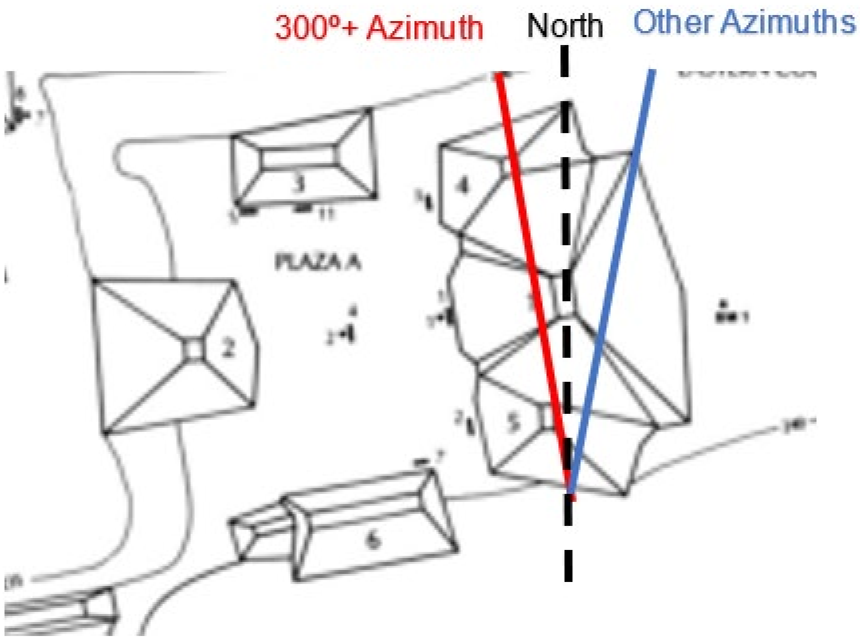


Figure 50: Demonstration of 300º Azimuth Problem

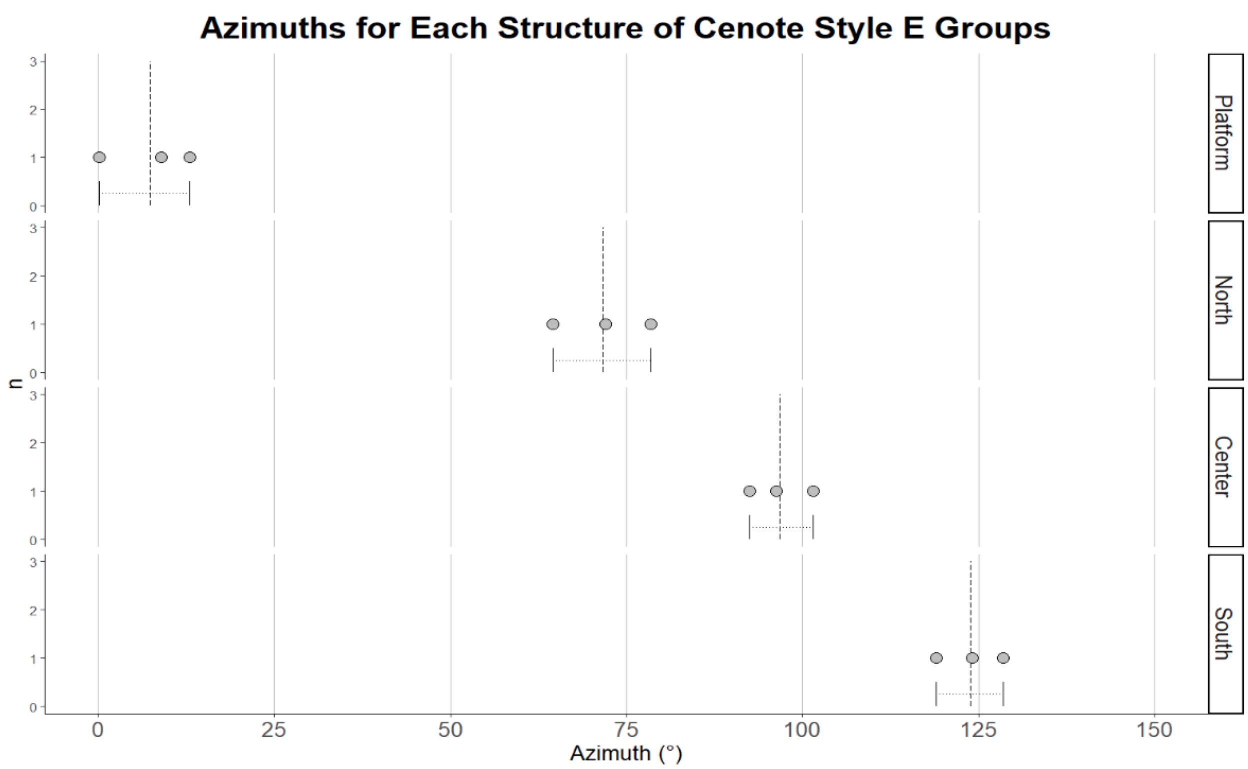


Figure 51: Azimuths for Each Structure of Cenote Style E Groups

The preliminary analysis for Cenote Style E Groups' alignments is not robust even though it is one of the largest samples with 3 examples. The central and southern structures are clustered, meaning they have one peak in the distribution instead of separate peaks, suggesting that the two structures may have had a common angle the builders were aiming for across all 3 examples. If the clustering of the southern structure was due to accommodating the larger central structure, the north structure should reflect a similar clustering. It is clustered, but not nearly as tightly as the central and southern structures. Comparing the overall distribution of the alignments for Cenote Style vs the other classifications demonstrates that Cenote Style E Groups have slightly more extreme alignments for the south structures. However, that may be explained by the fact that Cenote Style E Groups have a larger center structure compared to the other groups. Again though, the northern structure should have a similarly extreme cluster unless the central structure only impacts the southern structure. Either way, this could suggest that the alignment of the center structure is more important astronomically out of the three, given its larger size and the fact that at least one if not both flanking structures have to accommodate for the size and positioning of the center structure. Turning to the archaeological record for these sites may help determine the importance astronomically and functionally of the center structure compared to the others.

As noted in section 3, 3 of the 4 burials associated with the Calakmul E Group are associated specifically with the central structure (Carrasco Vargas 1996, 1999; Braswell et al 2004: 177; Dominguez 1992; Folan et al 1995: 319; cited in Dowd et al 2017: 562) and the central structure and Western Pyramid are technically the only portions of the E Group at Calakmul, given that the flanking buildings were constructed in the Late Classic while the supporting platforms appear to have been built at the same time as Structure IVb (Carrasco Vargas 1996, 1999; cited in Dowd et al 2017: 561). This assertion about the platforms is, of course, pending excavation data specifically about the platform's construction history. Ixkun has the Late Preclassic central structure as the only structure on the eastern platform (see Figure 19; Laporte et al 1994: 34-36). Nakbe also supports the idea that the central structure is the more functionally important, given that Nakbe only has a central structure and not a northern or southern one. The lack of a northern and southern structure is not unusual for Cenote-Style E Groups (see Chase and Chase 2017), but it does raise the question of what the alignments listed for the northern and southern structures in Aveni et al 2003 are referencing. Either way, the archaeological data supports that the central structure is the more functionally important of the three.

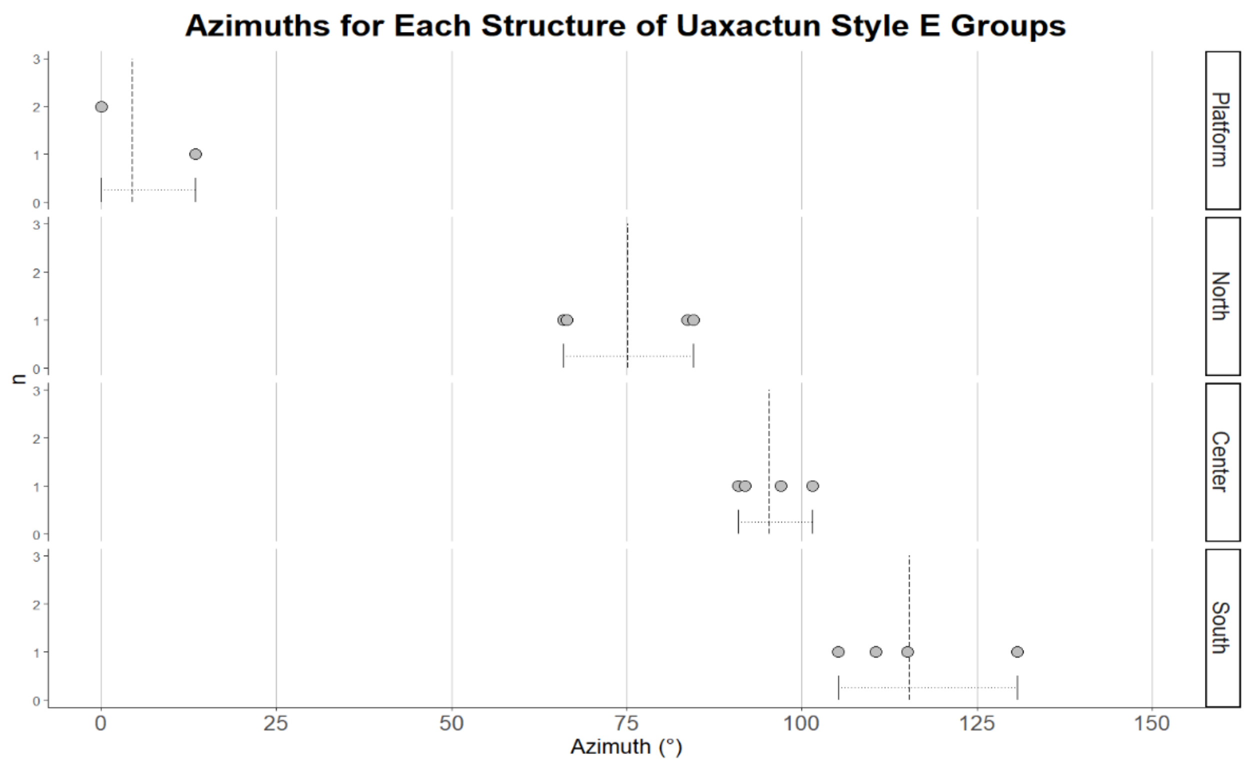


Figure 52: Azimuths for Each Structure of Uaxactun Style E Groups

The preliminary analysis for Uaxactun Style E Groups' alignments is the largest, with a sample size of 4. Looking at the peaks of the four graphs in Figure 52 indicates that for everything except the north structure there was a central tendency for each alignment that was followed by most of the four Uaxactun Style E Groups. However, the bimodal nature of the density distribution for the north structure are interesting, as this is the only instance for this style of E Group that there is an even split in the alignments. This suggests that there was a semi-uniform construction for Uaxactun Style E Groups, but that something was different about the north structure to warrant a more dramatic break from the other examples. To understand why that might be, the archaeological record for these four sites should be considered in regard to the north structure. For Tayasal, the only potential explanation is that all of the structures were heavily remodeled or dismantled in the Post-classic (Pugh et al 2012: 8-9; Chase 1985: 37; Chase and Chase 2017: 47), so the alignments may have been based off of those remodels instead of the E Group as it was in the Late Preclassic. At Tikal, it appears that the central structure was the more functionally important of the eastern structures due to the mass burials in front of it (Laporte and Fialko 1995: 56; cited in Aimers and Rice 2006: 89) and there was no indication of something different with the northern structure. Like with Tayasal, there were multiple iterations of the group but this time the last iteration was the Uaxactun Style E Group and so the measurements are probably valid. For Uaxactun, there is also no indication of anything different with the northern structure, and the alignments are also probably accurate to the correct time. However, as shown in Figure 43, the southern structure is skewed compared to the other structures on the eastern platform suggesting something is different with that structure instead. Finally, the E Group studied in this project at Yaxha appears to be a Uaxactun Style E Group; however, without the construction history it is difficult to say for certain. All of the archaeological data does not suggest any differences that the northern structure had, and instead may show that the central structure was the only one that was different. Looking at the graphs and the archaeological record together suggests that Uaxactun Style E Groups were more uniform than the other classifications. However, the definition of a Uaxactun Style E Group leads this classification to be the most uniform, as it is the strictest definition.

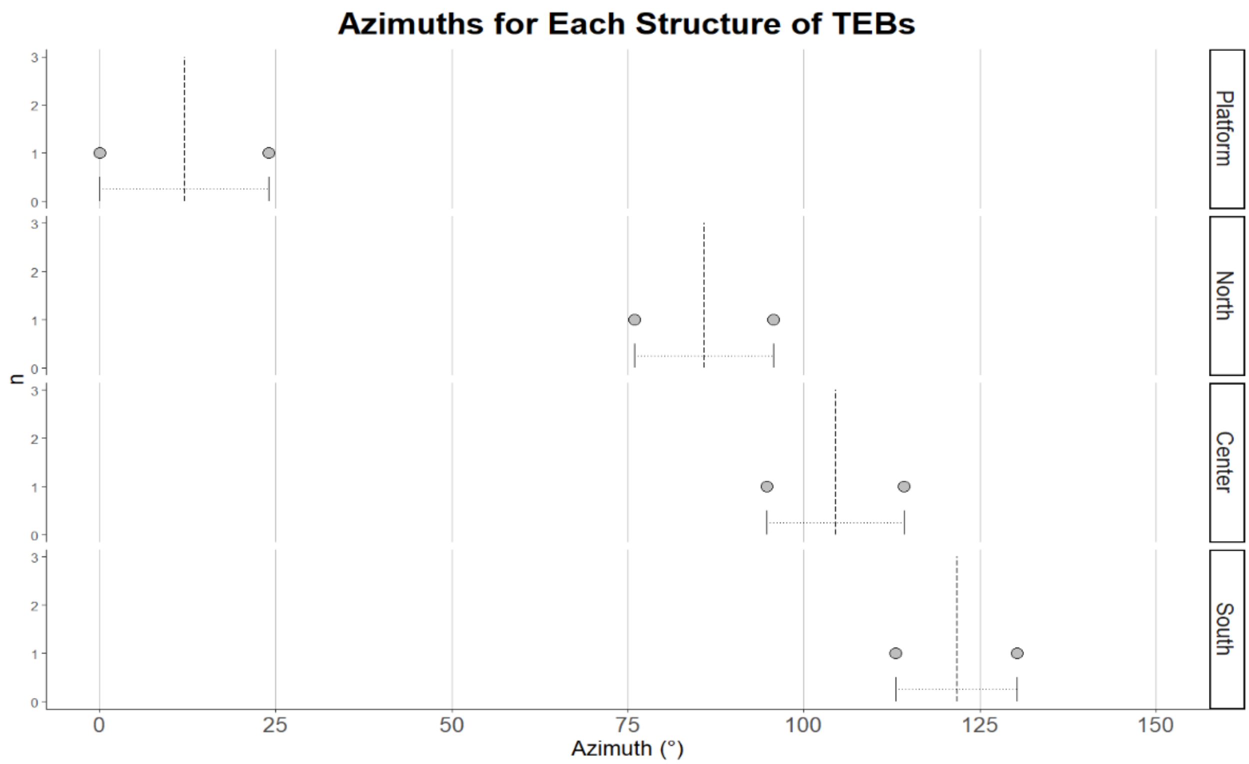


Figure 53: Azimuths for Each Structure of TEBs

TEBs could also afford a larger sample size, as there are only 2 sites with TEBs in this dataset, with 1 of each structure at each of the sites, making it the smallest sample. Because of this sample size, the only useful information from the density plots are how close the peaks are, as each peak represents one of the sites. The south structure is the most clustered in azimuth distribution even with the bimodal nature of the density distribution. Compared to the spread of the other azimuths, this suggests that the south structure is the most astronomically significant of the structures. This said, all of the structures still appear to be clustered similarly to the other classifications. The archaeological record is helpful here to determine the functional importance of the individual structures compared to the others. Unfortunately, the lack of excavation data from Santa Rosa Xtampak excludes it from this discussion, even though its inclusion would be insightful as the only example with eastern structures other than the central one. Nakum also only has the central structure on the eastern platform and has at least one offering or burial along the central axis of the arrangement (Šprajc 2021a: 14). Also, the fact that the eastern platform was constructed before the western pyramid – Late Classic vs Terminal Classic, respectively (Źralka and Hermes 2012: 164, 170) - suggests that the eastern platform was more important functionally than the western pyramid. Based on the one example out of two, the central building is the most functionally important as it is the only one to exist on the eastern platform. However, this is pending a larger sample size and excavation data. The ETAs are the only ones that have a similar spread of azimuths for all of the structures. This is probably due to the fact that it is a subcategory of TEBs specific to the Belize River Valley, but the fact that there are some differences (discussed later) suggests that it is a subclassification and not just a TEB. Compared to the two E Group classifications, the wider spread does make sense. The definitions of E Groups are more specific than the definition of TEBs, so it would make sense that the alignments from these classifications would represent that as well. It could also indicate that TEBs are more varied in their base form.

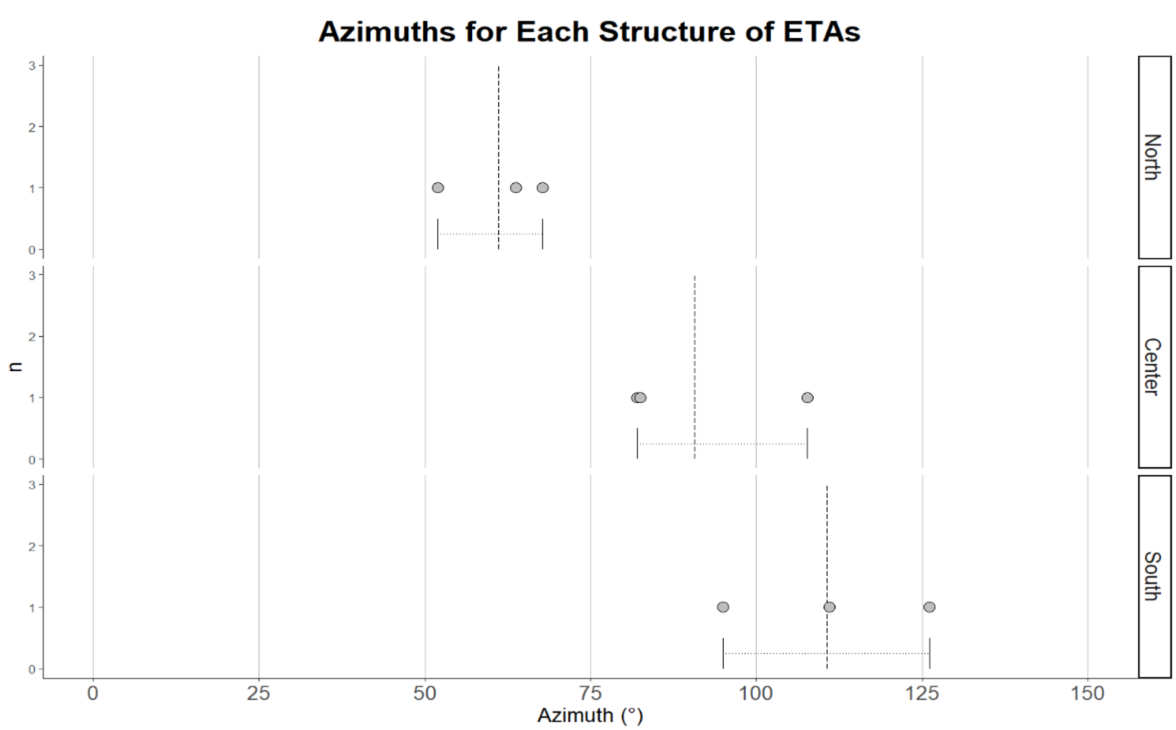


Figure 54: Azimuths for Each Structure of ETAs

Finally, ETAs were problematic to analyze on multiple fronts. There were only three examples of this classification and the platform azimuth distribution made graphing difficult, as discussed earlier. The platforms are clustered, but the issue is that some azimuths point West of North instead of East of North like the other examples. This makes them clustered but difficult to graphically represent side-by-side to the other structures. Looking at Figure 54 demonstrates that both the north and center structures were clustered. In a break from the trends discussed with the other classifications, the north structure is the tighter cluster of the group. The south structure has the least defined peak, suggesting that it is not replicated from site to site. Looking to the archaeological record for the three sites represented here, we might be able to determine if the northern structure was a functionally important part of this classification. At Cahal Pech, 12 burials and 6 caches are associated with the central structure, 2 burials with the northern structure, and 4 burials and 2 caches with the southern structure (Awe et al. 2017: 432-433). Also, the central structure was constructed first, and only the central and southern structures were modified towards the end of the Late Classic; the southern structure is also taller than the northern one (Awe et al 2017: 422). Therefore, the archaeological data from Cahal Pech does not support that the northern structures are the more important, but rather suggests that they were the least functionally important. Pacbitun follows in Cahal Pech's footsteps as well, with indications that the central structure was the more significant of the three but splits by suggesting the southern is the least functionally important of the three. Nine burials were associated with the central structure, three with the north structure and two with the southern (Micheletti 2016: 43-44). The example from Xunantunich proves problematic, as there was no burial data reported, the construction order was not reported beyond that they were all built separately in the Late Classic (Awe et al 2017: 426), and that there was a pyramid constructed that would block potential alignments between the Western structures and the Eastern ones (Jamison 2010: 125). This raises the question of when the alignments mattered - if they did at all (Awe et al 2017: 426). Taking all of this into consideration, the archaeological data suggests that the importance of the northern structure as suggested by Figure 54 is a byproduct of the sample size instead of an archaeological trend and that it is actually the central structure that is more functionally important. What the archaeological record also suggests is that the functional importance of the northern and southern structures vary from site to site, which does align with the trend noted for the southern structures in Figure 54 and is a noted difference from the other classifications.

Alignment Date Analysis

Matching the dates to the closest alignments produced associations to specific buildings (Table 4). Some of the dates listed in the original publication were to other buildings and not the standard E Group structures and so they were not included. The original table also included indications when there were alignments below the horizon; these were also not included as they were not observable by the naked eye. The observer point for all of the alignments was the western structure.

Site Name	Center Azimuth	Center Dates	North Azimuth	North Dates	South Azimuth	South Dates	Platform Azimuth
Cahal Pech (ETA)	82°30’	6 Apr, 7 Sep	67°43’	26 May, 19 Jul	94°55'	8 Mar, 6 Oct	355°
Calakmul (Cenote)	92°30’	15 Mar, 29 Sep	64°30’	21 Jun	128°30'		13°
Ixkun (Cenote)	96°13’	6 Mar, 8 Oct	72°	9 May, 4 Aug	119°		7°08’
Nakbe (Cenote)	101°30’	18 Feb, 23 Oct	78°30’	19 Apr, 24 Aug	124°00'		9°

Nakum (TEB)	94°40’	10 Mar, 5 Oct	76°	26 Apr, 18 Aug	113°	10 Jan, 2 Dec	0°
Pacbitun (ETA)	81°59’	6 Apr, 7 Sep	52°		111°	22 Nov, 21 Jan	353°30’
Santa Rosa Xtampak (TEB)	114°14’	7 Mar, 8 Oct	95°40’		130°15'	10 Dec, 5 Jan	24°
Tayasal (Uaxactun)	97°	3 Mar, 10 Oct	84°30’	3 Apr, 9 Sep	110°30'	23 Jan, 20 Nov	
Tikal (Uaxactun)	91°51’	17 Mar, 27 Sep	66°, 81°	9 Jun, 4 Jul	105°07', 117°30'		0°
Uaxactun (Uaxactun)	90°54’	20 Mar, 2 Oct	66°27’	21 Jun, 22 Sep	115°00'	15 Jan, 30 Nov	0°00’
Xunantunich (ETA)	107°39’	25 Oct, 18 Feb	63°40’		126°08'		13°
Yaxha (Uaxactun)	101°29’	18 Feb, 22 Oct	83°40’	6 Apr, 8 Sep	130°40'		13°30’

Table 4: Alignment Dates with their corresponding structures.

First, all of the dates are divided by classification (see Figure 55 below). This demonstrates a general trend with the data; almost all the dates are clustered at the Spring and Fall equinoxes - around March 20th and September 23rd, respectively. Aveni and his team’s original analysis in 2003 stated that there were alignments to dates 20-, 40-, and 60-days surrounding the average zenith passage for the area (when the sun is directly overhead, a phenomenon only found in the tropics); these dates do fall near the equinoxes and the dates in the spring are suggested as agriculturally logical dates to track (see Aveni et al 2003: 162). This trend did not change in this analysis as none of the dates have changed, so this wide window of dates still persists for the dataset as a whole. However, this analysis demonstrates that the Cenote Style E Groups, TEBs, and the ETAs mostly have those interval dates instead of alignments to the equinoxes themselves; therefore, separating the data by classification helps narrow the window by clustering the dates. This analysis may change with more data, however. Another noticeable difference between the classifications is that the Uaxactun Style E Group is the only one with more than one alignment in the summer. Therefore, Uaxactun Style E Groups are the most likely ones to have tracked the Summer Solstice. TEBs are the only ones that might have tracked the Winter Solstice, as they are the only structures with dates in December and early January, although the Uaxactun Style E Groups do have one date in Early January. Why TEBs would have alignments to the Winter Solstice is unclear, as most of the research focus has been on connections between building alignments and agricultural cycle events from the Spring, Summer, and Fall, as mentioned above.

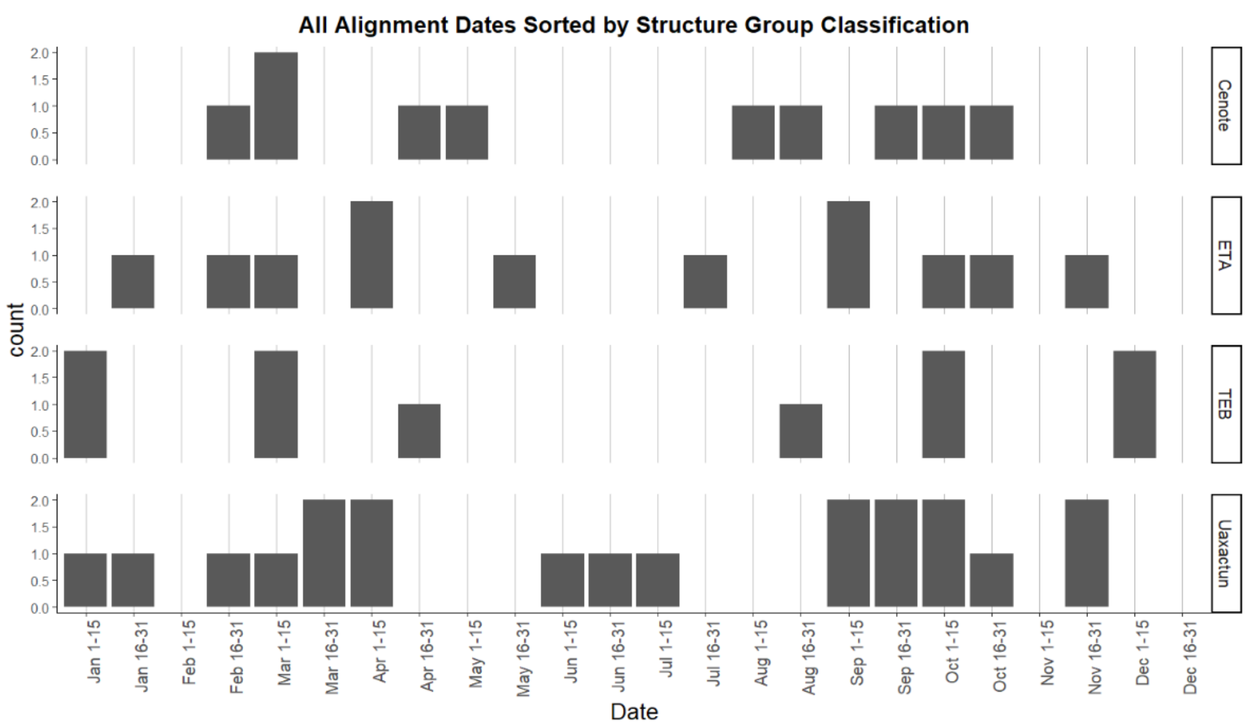


Figure 55: All of the Alignment Dates divided by Classification

Looking specifically at the TEB alignment dates, Figure 56 below demonstrates how the south structure is the only one with dates surrounding the Winter Solstice and only the Winter Solstice. The 20-day interval before and after the Spring Equinox may be marked by both the central and north buildings, respectively; the 20-day interval after the Fall equinox could be marked by the central building; and the intervals leading up to the Fall Equinox may be marked by the north structure but could also mark the intervals following the summer solstice. The uniformity of alignment dates between the sites for each particular building is not surprising, as TEBs have the smallest sample size.

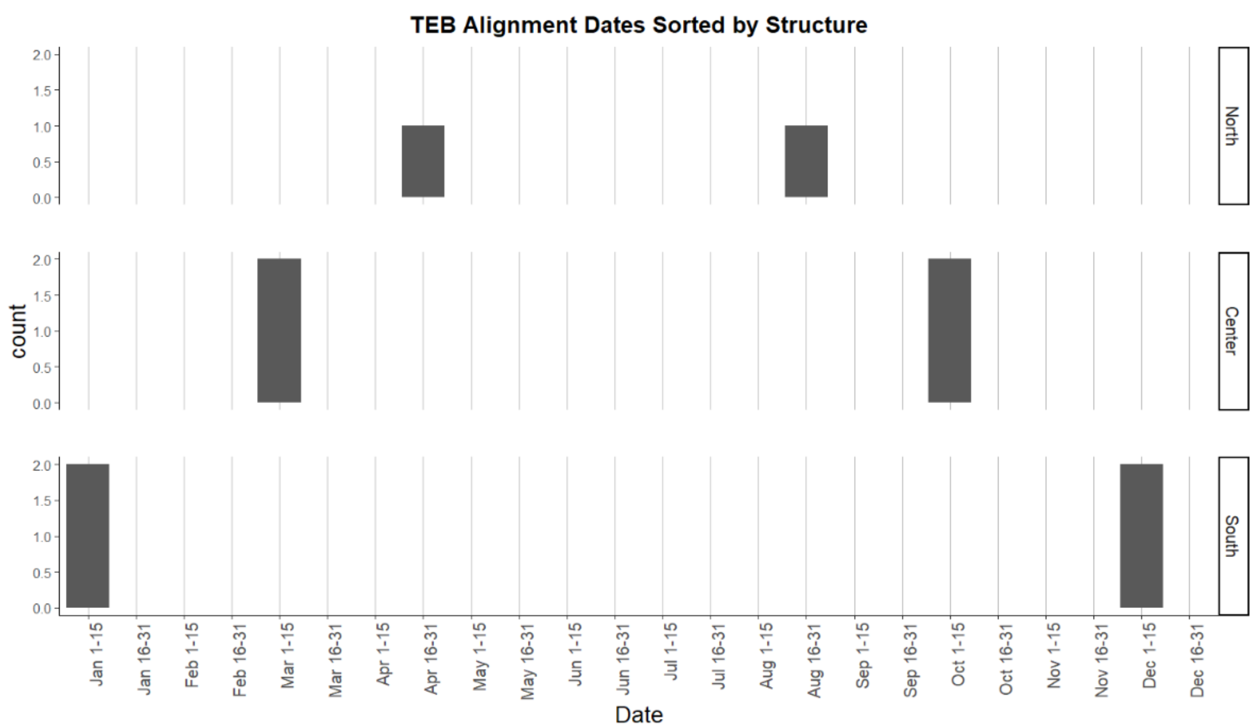


Figure 56: TEB Alignment Dates Sorted by Structure

For the ETAs from the Belize River Valley, Figure 57 below shows that the northern structures do not have dates on the Equinoxes or Solstices, but rather at 20-day intervals following the Spring

Equinox and the Summer Solstice. The central structures have dates both 20 days before and after both the Spring and Fall Equinoxes, while the southern structures surround both the Spring and Fall Equinoxes, along with potentially surrounding the Winter Solstice. However, as noted before, none of these dates fall on the actual dates of the Equinoxes and Solstices, suggesting that ETAs either did not track alignment dates, tracked alignment dates for calendrical purposes, or tracked alignment dates for different purposes than the other classifications. Of note, however, is that the central structures of Cahal Pech and Pacbitun have the same alignment dates, while Xunantunich has dates that do not match the rest of the classification.

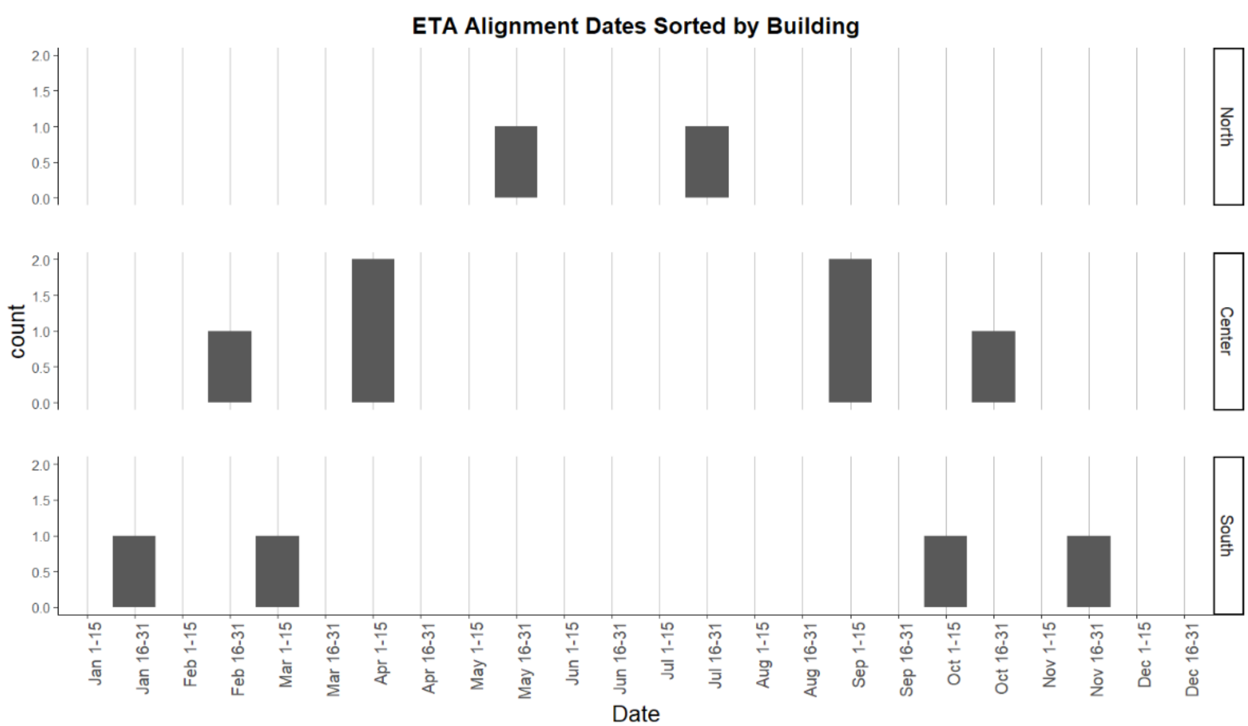


Figure 57: ETA Alignment Dates Sorted by Building

Figure 58 below shows alignment dates for Cenote Style E Groups. None of the sites had dates included for the southern structure. It appears that the north structure may have marked the coming of the Fall Equinox and the passing of the Spring Equinox, although the dates in August could also have marked the passing of the Summer Solstice. The central structure marked the coming of the Spring Equinox and marked the Fall Equinox itself as well as the passing of the Equinox. This demonstrates that the Equinoxes and the 20-day intervals surrounding them could have been the primary alignment foci for Cenote Style E Groups.

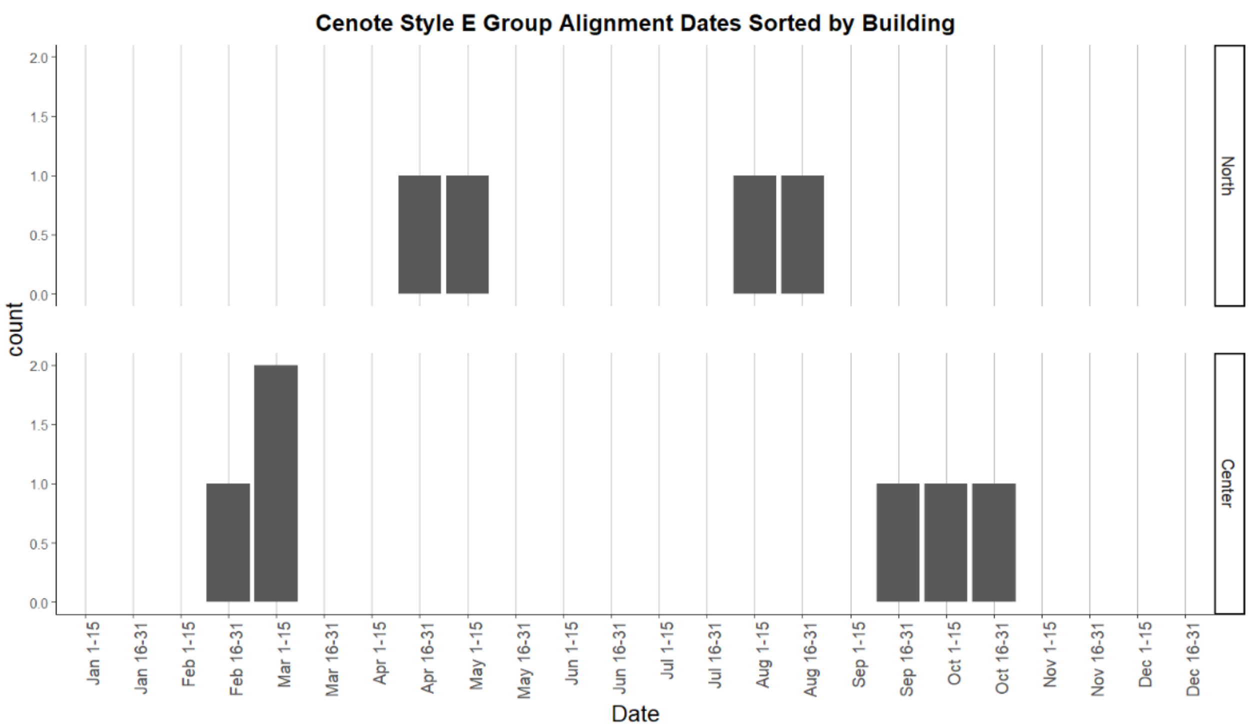


Figure 58: Cenote Style E Group Alignment Dates Sorted by Structure

Finally, Figure 59 below is the alignment dates for Uaxactun Style E Groups. As noted previously, the Uaxactun Style E Groups are the only ones with dates related to the Summer Solstice, specifically associated with the northern structure. However, the northern structure also has dates aligned with the 20-day interval following the Spring Equinox, and dates around the Fall Equinox. The central structures are solely focused on the Spring and Fall Equinoxes, and the southern structures' dates fall before and after the Winter Solstice. It is difficult to say on what the northern structure might have focused; it is the only one with Summer dates but the dates for the other events are more frequent than the Summer dates. The central structure appears to have been focused on the Spring and Fall Equinoxes, which could support the idea that the northern structure was focused on the Summer Solstice instead of repeating the Equinoxes. The southern structure only appears focused on the Winter Solstice, but the fact that they have less alignment dates compared to the other structures and compared to Winter Solstice dates from TEBs suggests that perhaps these alignment dates were not an astronomically significant part of Uaxactun Style E Groups. However, the purposeful skew of the southern structure at Uaxactun (see Figure 43) suggests that this may not be the case for that particular site.

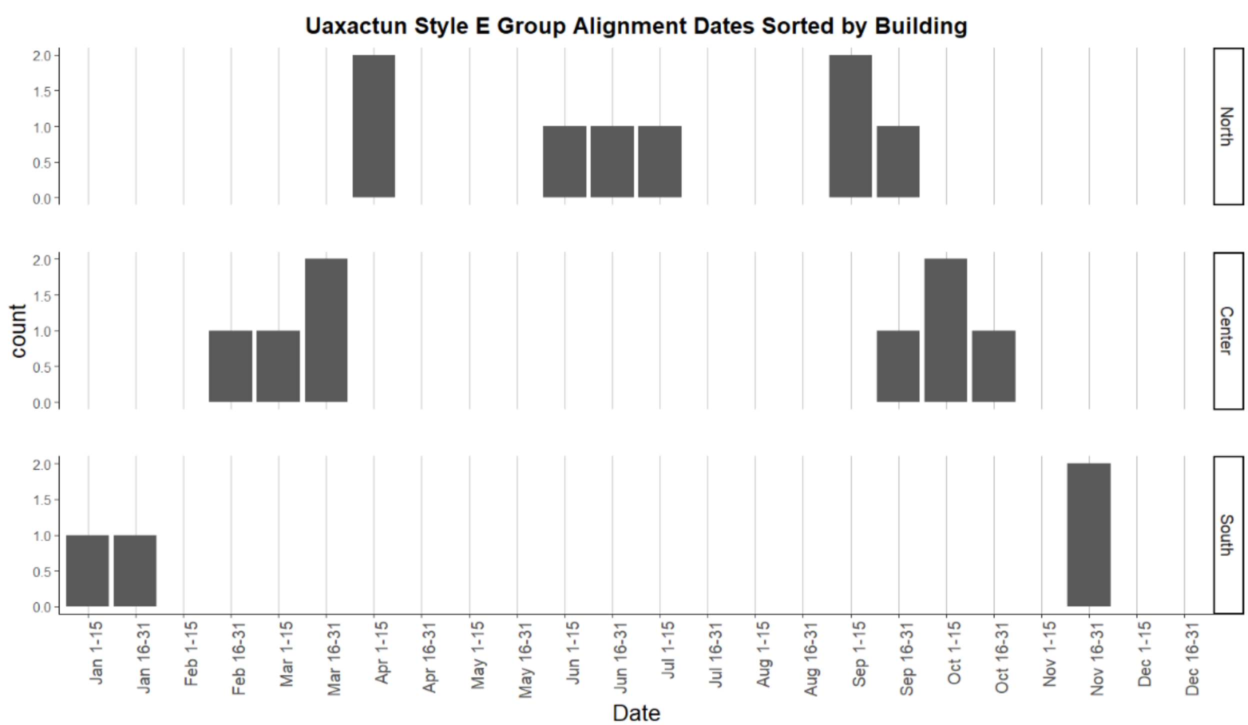


Figure 59: Uaxactun Style E Group Alignment Dates Sorted by Structure

Chapter 5: Conclusion

Alignment analysis and alignment date analysis can be combined in order to better understand what celestial, agricultural, or other events may have been tracked with this sample and what future directions of research may be able to answer. As noted previously, it is important to remember that the sample size is not robust enough for anything other than preliminary conclusions. However, there are some trends that extend to all of the classifications. The archaeological data and sometimes the alignment data demonstrate that the central structure was the more functionally and astronomically important of the three eastern structures. This central structure could also only be used to track the Spring and Fall Equinoxes for all the classifications. However, this could reflect the fact that most of the dates for all the classifications clustered around the Spring and Fall Equinoxes. Also, most E Group center structure dates – both Uaxactun Style and Cenote Style – fall in March while two do not; however, both Nakbe and Yaxha line up with each other, suggesting that other potential alignments were possible.

Looking specifically at Uaxactun Style E Groups, the alignment data suggested that all but the northern structures were similar in construction across all examples. However, the archaeological data did not support this. Instead, it suggested that the central structure is the different one based on burial data from Tikal (Laporte and Fialko 1995: 56; cited in Aimers and Rice 2006: 89). The similarity in alignments across all examples could be due to the strict definition of what qualifies as an Uaxactun Style E Group. What sets them apart from the rest of the classifications in terms of alignment dates is that the only dates related to the Summer Solstice were associated with the northern structures of Uaxactun Style E Groups. As noted, the central structures only tracked the Equinoxes and, while the southern structures potentially tracked the Winter Solstice, they had fewer dates that were less clustered than the TEBs.

Cenote Style E Groups, on the other hand, had both the alignments and the archaeological data indicate that the central structure was the more important of the eastern three, both astronomically and functionally. This is reflected in the size difference, the burial data from Calakmul (Carrasco Vargas

1996, 1999; Braswell et al 2004: 177; Dominguez 1992; Folan et al 1995: 319; cited in Dowd et al 2017: 562) and the fact that Nakbe and Ixkun only had the central structure. The alignment date data separated Cenote Style E Groups from Uaxactun Style E Groups by tracking the 20-day intervals before and after the Equinoxes and not the Equinoxes themselves in most cases.

The alignment data for TEBs suggested that the central structure is the more astronomically important of the three. The burial data from Nakum (Šprajc 2021a: 14) supports the idea that the central structure is the most functionally important as well. The alignment data from this classification is the least clustered. This could reflect the wide definition of TEBs or that TEBs are naturally more varied in construction. Of note from the alignment date data is that the south structures are the only ones tracking the Winter Solstice in this classification, and that they have the largest sample of Winter Solstice dates across all classifications even with a sample size of 2.

Finally, the alignment data from Eastern Triadic Assemblages (ETAs) suggested that the northern structure may have been the most astronomically important, but the archaeological data indicates that the northern structure may not have been as functionally important. Cahal Pech had burial data, construction history, and structure measurements (Awe et al. 2017: 432-433) that suggested the central structure was the most functionally important, followed by the southern structure. Pacbitun, on the other hand, determined that while the central structure was the most functionally important again, the northern one was next in importance due to its associated burial data (Micheletti 2016: 43-44). In terms of alignment date data, the northern structures did have one date following the Summer Solstice; however, not much can be read into this fact. The southern structure had dates surrounding the Equinoxes but also potentially had dates surrounding the Winter Solstice. This similarity to TEBs supports that ETAs may have been a subcategory of TEBs and not a separate category. However, the different alignment dates for the central structure at Xunantunich combined with the confusion in the original classification suggests that this particular structure group at Xunantunich is not an ETA but a collection of three structures on the eastern end of a plaza. In order to verify this, further analysis of ETA alignments and construction history is necessary.

The analysis suggests that the central structures of all of the forms may have been the most functionally and astronomically important, and that the Equinoxes and the 20-day intervals surrounding them were the most tracked dates. However, there was some variation between the classifications as to the degree of importance and what dates were tracked. This needs to be examined with future study of the E Group styles, ETAs, TEBs, and their alignments to see if there are differences beyond those definitions discussed in previous sections. By utilizing a larger sample size and incorporating more archaeological data, future research may shine light onto other potential similarities and differences, as well as their broader meaning to the ancient Maya. Also, future research should analyze the significance of the western pyramids in these groups and what is known about their archaeological records, especially as they are usually suggested as the observer point for E Groups.

This thesis provides an updated dataset that shows the utility of pursuing archeoastronomy research about the ancient Maya. By combining the archaeological data for sites with the alignment data from Aveni et al's (2003) study, it demonstrated the utility of archeoastronomy for archaeology by bringing new patterns to light. The study helped illuminate these patterns by looking to the archaeology to remove sites that were not E Groups and putting them in their appropriate categories, like Eastern Triadic Assemblages and Triple Eastern Buildings. Doing this, and again looking at the archaeological data, showed that the central structures are important astronomically and functionally by having the closest cluster of alignments and that the established categories of buildings correspond with different dates that may have been tracked by the ancient Maya. This study demonstrates the utility of archeoastronomy for archaeologists and the knowledge that can be gained when the two datasets are combined. Future researchers should continue this path of investigation and look into these potential patterns with a larger dataset of E Groups, TEBs, and ETAs.

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Curriculum Vitae

Elizabeth Shikrallah

elizabeth.shikrallah@gmail.com
4505 S. Maryland Pkwy.
Las Vegas, NV, 89154

Employment

Cultural Resources Intern, Center for Environmental Management of Military Lands (2021-present)
Analyze military projects on federal land to determine their impact on archaeological resources. Incorporates researching local history and prehistory, correspondence with military, civilian, and tribal parties, and public outreach.

Graduate Assistant, University of Nevada Las Vegas Anthropology Department (2018-2021). Assisted five professors and two research labs. Work included lab setup, GIS map and photogrammetry model building, data management in multiple languages, journal article formatting, lab management, and assisting class creation and management.

Cultural Resource Review Intern, New Jersey Department of Environmental Protection, Water Quality Division (2017-2018)
Analyzed municipal projects to determine their compliance with Section 106 of the National Historic Preservation Act. Incorporated building a GIS model to assist in the review process, researching local history and prehistory, and database creation and management.

Education

Master of Arts (In Progress)
University of Nevada, Las Vegas
Anthropology focused on Archaeology, Advisors Dr. Arlen Chase and Dr. Diane Chase

Bachelor of Arts with Honors (2018)

University of Massachusetts Amherst

Anthropology and Astronomy, Advisor Dr. Whitney Battle-Baptiste

Fields of Interest

Digital Archaeology, ancient Maya archaeology, digital presentation, digital research techniques, archaeoastronomy, political and religious astronomy, architectural analysis, settlement layout, social organization, community archaeology

Research Experience

Graduate Volunteer, Shivwitz Research Project (2019)

Assisted with excavation, artifact cleaning, and sorting in field and in lab at a dissertation site. Conducting analysis of small scale site use to be presented at conferences in the upcoming year.

Honors Thesis (2017)

Analysis of megalithic mortuary monuments in Senegal and Gambia to determine cultural connections and differences in use.

Crew Chief, Dr. James Still Community Archaeology Project (2017)

Assisted with excavation, artifact cleaning, and sorting in field and in lab at this dissertation site.

Field Student, Programme for Belize Archaeological Project (2016)

Archaeological field school researching the Ancient Maya through the University of Massachusetts Boston. Helped generate 3D models of key artifacts, catalogued and sorted artifacts, and excavated and documented two dissertation sites.

Teaching Experience

Teacher's Assistant, Anthropology 447: Archaeological Field Methods (2019)

Helped create and run in-class labs to develop the students' understanding of archaeological field methods.

Teacher's Assistant, Anthropology 101: Intro to Cultural Anthro (2018-2019)

Created weekly quizzes, assisted with creating the midterm and final, and assisted grading quizzes, midterms, and finals.

Crew Chief, Dr. James Still Community Archaeology Project (2017)
Helped teach other volunteers archaeological techniques for excavation, and proper documentation for both in the field and in the lab.

Conferences and Workshops Attended

Society of American Archaeology Annual Meeting (2019 – 2020)
Posters presented in 2020 (Cancelled due to COVID-19):

Elizabeth Shikrallah and Danielle Romero - Costume or Chimera: Hybrid Human/Animal Imagery on Mimbres Ceramics;

Melissa Badillo and Elizabeth Shikrallah - Time to clean house: Analyzing the General Intensity of Occupation at Santa Rita, Corozal

William Willis and Elizabeth Shikrallah: The Role of Small Habitation Sites in Virgin Branch Puebloan Settlement Systems.

22nd Annual GPSA Research Forum (2020)
Elizabeth Shikrallah - Digging Digitally: Utilizing Digital Technologies in Archaeological Projects.

8th Biennial Three Corners Conference (2019)
William Willis, Elizabeth Shikrallah, and Kara Jones - Activity Patterns from a Small Virgin Branch Habitation Site on the Shivwits Plateau

14th Annual Geosymposium (2019)
Elizabeth Shikrallah - Building a Floor of “Trash:” Analyzing Urban Decrease Through Artifact Distribution at Dhiban, Jordan.

Aveni, Anthony et al. (2017)

Workshop on a Workshop: Viewing Maya Murals, Excavations, and Inscriptions through Interdisciplinary Eyes. Invited workshop at Dartmouth College.

Honors

Best Student Paper, Nevada Archaeological Association (2020)
Kara Jones, William Willis, Elizabeth Shikrallah: "A Peculiar Lithic Assemblage from a Small Habitation Site on the Shivwits Plateau."

GPSA Travel Sponsorship (2020)

Graduate Assistantship (2018 – Present)

First in Category: Analytical Presentation, 30th Annual DEP Bureau of GIS Poster Contest (2018)
Elizabeth Shikrallah and Christina Servetnick: "Sewers Invincible: Camden History Beneath the Streets"

Professional Affiliations

The Society of American Archaeologists (2018 – Present)

The Honors Society of Phi Kappa Phi (2015 – Present)

Society of Women Engineers (2014 – Present)

Skills

GIS (ArcGIS, QGIS)	MySQL	Python (Jupyter Notebooks, R Studio)
Photogrammetry (Metashape)	R (R Studio)	Microsoft Suite
Database Management and Creation		Professional Communication