THESIS

THE PYRAMIDS AND TEMPLES OF ANGAMUCO (MICHOACÁN, MEXICO): DECODING MEANING THROUGH SPATIAL ANALYSIS OF FORM, SCALE, AND DIRECTIONAL ORIENTATION

Submitted by

Alexandra Friedl

Department of Anthropology

In partial fulfillment of the requirements

For the Degree of Master of Arts

Colorado State University

Fort Collins, Colorado

Spring 2019

Master's Committee:

Advisor: Christopher Fisher

Stephen Leisz
Michael Lefsky

ABSTRACT

THE PYRAMIDS AND TEMPLES OF ANGAMUCO (MICHOACÁN, MEXICO): DECODING MEANING THROUGH SPATIAL ANALYSIS OF FORM, SCALE, AND DIRECTIONAL ORIENTATION

The ancient Purépecha site of Angamuco (Michoacán, Mexico) in the Lake Pátzcuaro basin represents a significant example of Mesoamerican urbanism that is not explained by current cultural-historical narratives for the region. Occupied primarily in the Middle and Postclassic periods, this site features many monumental architectural constructions, including pyramids and temples that vary in form, size, and configuration. Based on known examples of these structures documented through the course of LORE-LPB ground survey, and other examples from Mesoamerica, identification of pyramids and temples across the entire site was possible using digital models derived from Lidar data. Through the collection of basic spatial data including scale expressed as volume, axial dimensions, and axial orientation, comparison of these structures is possible on both intra-site and regional levels. These spatial data suggest that there are different urban planning principles at work at Angamuco when it comes to monumental architecture. While some of these buildings seem to conform to broader Mesoamerican urban planning tradition, this does not explain the orientation of most of the pyramids and temples at Angamuco. Investigation of these features has provided additional evidence for the standardization of the built form at the site and allowed for preliminary insights on sociocultural evolutionary processes. Future research at Angamuco on the specific orientational groups

proposed here will further elucidate urban planning principles for monumental architecture at the site and may even clarify possible connections to the cosmos reflected in the built environment

ACKNOWLEDGEMENTS

I would sincerely like to thank all of my family, friends, and advisors who have helped me get to this point in my academic career. A special thank you goes out to my advisor Chris Fisher, my colleagues Nick Simpson and Edwin Harris, and all the current and former members of the LORE-LPB research team. Without their willingness to share ideas and data, this type of research would not be possible. I would additionally like to thank several organizations for their support of the LORE-LPB research team, including the Instituto Nacional de Historia e Antropología (INAH), The National Science Foundation (NSF), and the National Aeronautics and Space Administration (NASA). Last, but certainly not least I would like to thank the local communities of Fontezuelas and Tzintzuntzan in the state of Michoacán, Mexico for their continued support of the LORE-LPB research team and their unwavering commitment to the preservation of the region's pre-hispanic past. While I was unable to see the site of Angamuco throughout the course of this research, I hope that I will one day make it to see what I already know to be an incredible place.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The study of monumental architectural remains at ancient urban centers has a long tradition in archaeology (Smith 2007). In Mesoamerica, these structures often include pyramids, temples, open plazas, ballcourts, and public houses, as well as other features (Trigger 1990). Buildings of monumental proportion often served important civic and ceremonial functions and acted as multi-purpose spaces. Additionally, these features communicated sociocultural messages through their built characteristics and overall construction processes. Understanding the form and distribution of monumental architecture in ancient urban contexts can help archaeologists gain insights related to the sociocultural evolution of a society, as well as potentially inform our view of urban planning principles in individual cities as a whole. Additionally, the collection of data related to the scale and directional orientation of monumental architecture provides a starting point for the comparison of such structures on intra-site and regional scales.

When archaeologists study monumental architecture in complex societies, they often focus on spatial characteristics as a means for understanding cultural influences on the built environment. Researchers commonly examine directional orientation of monumental buildings in an effort to access the high-level sociocultural meaning of these buildings as defined by Amos Rapoport (1990). High-level meaning within the urban built environment involves the communication of messages related to cosmology and worldview, typically referencing elements of the sacred. The study of monumental architecture is also important for elucidating middle-level meaning of the built environment in urban contexts. Middle-level meaning has to do with sociocultural messages related to identity, status, and power (Rapoport 1990). Monumental structures are considered the ultimate example of architecture intended to communicate middle-level meaning because these building projects were often completed by commoner labor forces, commanded by the elite classes or rulers for the purposes of the state. In contrast to the specific cultural nature of high-level meaning, middle-level meaning is more obvious and can be communicated across cultures and time periods. As Smith (2007) points out, the attributes of urban architecture that are commonly associated with high-level meaning (i.e. symmetry, axiality, plazas, city walls) are better viewed as features that communicate middle-level meaning. While we may never know the specific cosmological events referenced by buildings in ancient urban contexts, information on the on the size, forms, and locations of such buildings on the landscape can allow for insights on the power of the state or ruling body, as well as its control of labor forces, and the degree to which hierarchical political control is consolidated within a society.

Throughout this thesis, I will broadly explore the meaning of monumental architecture and urban planning principles related to its construction in Mesoamerica. This will provide the theoretical basis for my own methodological approach to identifying and quantifying pyramid and temple structures at the urban site of Sacapu Angamuco (Michoacán, Mexico). Additionally, a focused discussion on general trends in urban planning principles of monumental architecture recognized across ancient Mesoamerica will set the foundation for how my results are processed and compared on intra-site and regional scales. At ancient urban sites across Mesoamerica, the practice of orienting civic and ceremonial buildings followed similar principles. Based on alignment data collected across the region, there are several distinct and widespread orientation groups, which can be linked to cosmological and astronomical phenomena. Most of these groups refer to sunrises and sunsets on specific dates of the year, however, other orientation groups are related to the lunar cycle and the position of Venus in the sky (Šprajc 2018: 198). These patterns will be discussed in terms of their general celestial importance as established at various archaeological sites throughout Mexico and the Maya region and will be revisited again in reference to the pyramid and temple orientation groups at Angamuco proposed in Chapter 4 of this thesis. Following a conversation on monumental architecture and urban planning in Mesoamerica, I will provide environmental and cultural-historical background information on the Lake Patzcuaro Basin, as well as the archaeological site of Sacapu Angamuco. Monumental architectural forms at Angamuco can be linked to similar features at other Purépecha sites, especially those surrounding Lake Pátzcuaro and in the Zacapu Basin to the north (Pereira et al. 2012). The background emphasizes what we know about the history of the construction of these features in the Purépecha imperial territory and discusses various aspects related to suspected building function and contextual indicators for middle and high-level meaning. The next topic in the thesis moves to my own methods for the analysis of form, dimension, and directional orientation of pyramid and temple structures at Angamuco. This methodology is divided into two parts, with an initial explanation of how these features were first identified from digital models derived from remotely-sensed data, and then a discussion on how various spatial metrics were determined for each civic and ceremonial feature. I will then break down several patterns that emerged from the spatial data at Angamuco and propose multiple groupings for these features, primarily based on their directional orientation. Similarities in the size (expressed as volume and basic axial dimension) will also be considered in the making of several potential subgroups within the alignment categories. Finally, I will make preliminary inferences on the meaning of pyramid and temple structures at Angamuco using other regional archaeological examples and my own pyramid group determinations at the site.

This thesis addresses specific questions concerning pyramid and temple structures at Angamuco, particularly related to their location, form, scale, and axial orientation. These questions include:

1. How many pyramid and temple structures are present at the site of Angamuco and how are they distributed on the landscape?
2. How can these features be quantified for intra-site and reginal analysis using digital models derived from remotely sensed data?
3. Are there recognizable patterns within the spatial data collected for civic and ceremonial features at the site?
4. Can insights be formed on the meaning of monumental architecture at Angamuco based on its spatial characteristics and do any of these features relate to other civic and ceremonial architecture that has already identified throughout Mesoamerica?

Examination of these questions could help us better understand how civic and ceremonial spaces are organized at Angamuco and how these undeniable symbols of power are laid out within the greater built environment. Furthermore, analysis of pyramid and temple form and directional orientation could link Angamuco to a greater Mesoamerican tradition of monumental architecture planned with celestial influences in mind. My central finding in this thesis is that the pyramid and temple structures at Angamuco vary in form, scale, and orientation, but there are noticeable patterns that likely reflect standardized building form or at least similar urban planning considerations. I hope that an in-depth discussion of pyramid and temple structures from Angamuco will provide additional support for the importance of this urban site on the

Postclassic West Mexican landscape and enrich our understanding of the evolution of significant Purépecha sites that lay outside the traditionally defined geopolitical core for the empire.

CHAPTER 1 : THEORETICAL DISCUSSION

Across ancient cultures, monumental architecture represents the physical manifestation of a culture's collective ideals and its construction is often linked to the symbolic expression of a hierarchical political order in complex societies. These buildings, including pyramids and temples, often gained their symbolic role over time and were built for reasons that cannot be explained on a functional basis alone (Baker 2003). One of the most popular definitions for monumental architecture comes from Trigger (1990:119) who describes it as buildings whose "scale and elaboration exceed the requirements of any practical functions that a building is meant to perform." While this definition does succeed in setting monumental architecture apart from other structures such as those in domestic spaces, it does not properly address the important symbolic functions that these buildings served and how their form and configuration on the landscape were commonly the result of intentional planning meant to communicate specific cultural messages within ancient urban contexts.

Central to this thesis is an exploration of the cultural meaning of monumental architecture in prehistoric urban centers and how that meaning is conveyed through standardization of the built form, especially in Mesoamerica. Amos Rapoport's (1990) model for levels of meaning within the built environment provides a useful framework for addressing the cultural motives for monumental construction. Rapoport suggests there are three levels of architectural meaning, including 1) high-level meaning related to cosmological and supernatural symbolism, 2) middle-level meaning related to identity and status, and 3) low-level meaning concerning how the built environment affects behavior related to movement. In this conceptual model, high-level meaning is considered culturally specific, including themes related to worldview and the sacred. This is contrasted by middle-level meaning, which is related to messaging on identity, status, and power that can be recognized cross-culturally. Monumental architecture is most commonly related to the middle-level of meaning, however, there is a long scholarly tradition promoting high-level meaning as a guiding principle for the construction of such features in ancient urban centers.

The works of Mircea Eliade have been particularly influential for archaeologists trying to understand architectural planning in terms of high-level meaning as defined by Rapoport (1990). Eliade (1959) proposed that many ancient settlements shared four basic cosmological beliefs that governed city planning: 1) a parallel connection between the heavens and earth, 2) a link between earth and the cosmos along an *axis mundi*, 3) orientation of buildings in cardinal directions as a reflection of cosmological organization, and 4) the identification and making of sacred spaces on earth can only be achieved through divination. This was one of the first frameworks linking architectural planning with cosmological concerns and it rapidly became a popular interpretation for the orientation of buildings at sites worldwide. In a now classic application of these ideas, Paul Wheatley (1971) examined the layout of ancient Chinese cities for their adherence to Eliade's (1959) model and found that cosmological alignments seemed to be of chief concern for urban planners across the region. This particular study, as well as others that apply Eliade's model, were so influential at the time that one interpretive tradition extended the cosmological principles for city planning to all ancient urban cultures (e.g. Carlson 1981; Carrasco 1999). In a slightly different vain, Rapoport (1993) operationalizes Eliade's ideas and uses them for the identification of architectural and spatial features that he finds to be aligned with the cosmos across cultures. Despite creating a list of these features (including city walls with gates, open ceremonial plazas, and orientation with cardinal directions), Rapoport (1993) underscores the variation in cultural application of cosmological planning principles, demonstrating how one or more of the features were utilized in separate urban centers (Smith 2007: 31).

Another related, yet independently conceived, normative theory for urban meaning argues that "the form of any permanent settlement should be a magical model of the universe and the gods" (Lynch 1981: 73). Citing examples from ancient India and China, Kevin Lynch (1981) developed a set of basic form concepts for cosmological building alignment. Key to this interpretation are aspects of the built environment including axial lines of procession, encircling enclosures with gates, dominance of up versus down, grid layout and bilateral symmetry (Lynch 1981: 75-79; Smith 2007: 31). Lynch (1981) suggests that fundamental social values are echoed in the principles of urban layout, involving themes of order, stability, and dominance, as well as a negation of time, death, and decay. This represents an important connection between physical aspects of the built environment and their effect on socio-cultural relations, both intended and unintended. Lynch's (1981) model for the use of cosmological principles in urban planning is overall less flexible than Rapoport's (1993) previously mentioned theory, as it does not take into account cultural variation. The basic form concepts outlined in this theory were presented by Lynch (1981) as a consolidated model for urban planning that could be applied cross-culturally to nonwestern ancient urban traditions in some cases.

In addition to Wheatley's (1971) documentation of cosmologically influenced cities in ancient China, significant evidence for the use of cosmological principles in urban planning can also be seen in South Asia and Cambodia (Spodek and Srinivasan 1993; Coe 2003). These case studies, like Wheatley's (1971) China example, have empirical support for assertions on the cosmological influence on urban planning from multiple sources, including ancient texts, art, and archaeological data. Smith (2003) has pointed out these societies provide powerful examples of the use of the cosmos in urban planning, but that archaeologists rarely have the wealth of cultural information necessary to decode specific cosmological trends reflected in the built environment. A major criticism of the examination of cosmological influence in architectural planning is that researchers have extrapolated basic principles (seen in the China, India, and Khmer civilization of Cambodia) too far, imposing cosmological models for urban planning when not enough empirical evidence is available to support these relationships (e.g. Trigger 2004; Smith 2005).

When archaeologists have little to no textual information on urban planning, the universalistic application of cosmological theories for city layout becomes increasingly problematic. In the absence of these records, it can be exceedingly difficult to link orientation patterns to specific celestial observances and their cultural meanings. An additional problem with the universal application of cosmological theories for ancient city layout is that the form of the built environment may not actually reflect the rich symbolic interpretation of urban configuration held by ancient peoples (Smith 2007: 33). In a modern example of this phenomenon, Brahmins in the Hindu city of Bhaktapur, Nepal drew an idealized plan for the center in the form of a mandala, which bears no resemblance to the actual form of the physical city. Rather, the mandala helps communicate the symbolic importance of architectural features, sacred procession routes, and the religious meaning of the city as a whole (Gutschow 1993).

In an effort to address some of these concerns, Smith (2007: 34) proposes that a number of architectural manifestations of high-level or cosmological meaning are more usefully seen as demonstrations of middle-level meaning. Traits such as symmetry, axiality, plazas, and city walls that were viewed by Rapoport (1993) and Lynch (1981) as markers for cosmological influence on urban planning more aptly represent features that communicate social messages related to identity, status, and power. Even though the specific socio-cultural meaning of a pyramid or temple structure may never be ascertained without supplemental information from ancient or historic texts, Smith (2007: 34-5) contends that data on the size, forms, and locations of such buildings on the landscape can allow for insights on the power of the state or ruling body, as well as its control of labor forces, and the degree to which hierarchical political control is consolidated within a society. In contrast to high-level specific cosmological meaning, all of these insights are related to middle-level meaning, which can be communicated to diverse audiences through time and provide archaeologists with an opportunity for cross-cultural comparison (Smith 2007: 35). Formal, monumental architecture is the primary illustration of built features intended to convey middle-level meaning across ancient urban landscapes. Buildings of monumental proportion communicate multiple socio-cultural messages within ancient urban contexts, including the ability of the state or elite classes to orchestrate such large construction projects, centralize political order, and commandeer peasant labor for the building of structures that ultimately reinforce the power of the upper classes (Smith 2007: 35).

The socio-cultural importance of formalized monumental architecture in ancient urban contexts (as well as other principles associated with urban planning) rests at least partially in the effects of its layout on city inhabitants and visitors (Smith 2007: 35). The scale and elaboration of ancient urban architecture at centers such as Teotihuacán was clearly intended to impress its observers, therefore creating a sense of diminution in the individual in the presence of the rulers and gods represented. This psychological response to architecture of monumental proportion is most succinctly summarized by Bruce Trigger (1990) in his oft-cited article "Monumental Architecture: A Thermodynamic Explanation of Symbolic Behavior." Rosenswig and Burger (2012: 4) point out, what Trigger (1990) is essentially proposing is a universal cognitive understanding of the link between scale and power as expressed by monumental architecture.

This scale as power model has been criticized in some cases for being too reductive and Marcus (2003) cautions against over-simplifying the relationship between monumentality and power. Roseenswig and Burger (2012) express similar concerns with the application of Trigger's (1990) theory, especially in societies that do not have a state-level political apparatus or extensive evidence for social stratification. In ancient societies with lower levels of sociocultural complexity, the construction of monumental features cannot be assumed to represent the power of an elite class or influential king. Monuments such as Stonehenge in modern day Wiltshire, England demonstrate the potential for societies to create impressive monuments without the presence of state political organization or powerful rulers (Smith 2007:35). Indeed, increasing evidence for monumental collective building projects has surfaced among cultures of varying sociocultural complexity, including in egalitarian and middle-range societal contexts. This body of research suggests that the definition of monumental architecture as presented by Trigger (1990: 119) must be expanded beyond common forms in ancient urban contexts (e.g. pyramids and temples, plazas, processional ways, public houses) to include public works projects such as roadways, aqueducts, irrigation canals, agricultural terraces, and other more purely functional architectural features (Rosenswig and Burger 2012: 4). While the construction of monumental architecture in non-state-level societies is not the focus of this thesis, a useful review of related case studies in the New World can be found in Rosenswig and Burger (2012).

In ancient urban contexts with known hierarchical political control and documented social stratification, the case for linking monumental construction to displays of elite power can be made more convincingly. Another social impact of urban planning related to monumental construction has to do with the effects on people who both built and maintained the structures too (Smith 2007: 36). Labor organization for monumental construction often involved *corvée* systems where conscripted labor was conceptualized as part of regular taxes to the state and projects were executed during the dry agricultural season (Lehner and Wilkinson 1997; Trigger 2003). Through participation in monumental construction, laborers developed a sense of identity with their city and its ruler(s), which can be seen in multiple historically documented case-studies (see Cowgill 2003; Clark 2004; Smith 2000; Pauketat 2000). The very process of building construction and maintenance formed a feeling of pride among commoners, which generally served to legitimate the power of the state and remind laborers of their subordinate status at the same time. In this way, the monumental construction process itself can be viewed as a major part of ancient political dynamics through its role in cementing attachments between subjects and ruler (Smith 2007: 36). The separation of different kinds of labor organization and strategies for labor recruitment for monumental construction is a difficult task for archaeologists and it constitutes a major avenue of research at ancient urban centers (e.g. Abrams 1989, 1994; Webster and Kirker 1995).

In addition to expressing high-level and middle-level meaning as defined by Rapoport (1990), monumental buildings also function on the low-level of architectural meaning, related primarily to the properties of visibility and access. The lowest level of architectural meaning is generally concerned with the effect of the ancient urban built environments on people's behavior. Studies aimed at teasing out low-level meaning of monumental architecture often focus on the visibility of structures on the landscape from various points and relate varying degrees of accessibility of spaces to variables like political control and ritual exclusion (Smith 2007: 36). Whether it be access to urban centers, to particular precincts, or individual buildings, understanding changes in access points can allow for insights on social inequality (e.g. Moore 1996; Hillier and Hanson 1989). The lower level meaning of pyramid and temple structures is not a central theme of this thesis, however, study of visibility through viewshed analysis and examination of access points for pyramid and temple structures at Angamuco could represent an interesting avenue of research in the future.

In this chapter thus far, I have reviewed a conceptual framework for the interpretation of the significance of architecture in ancient urban spaces as proposed by Roy Rapoport (1990), with a particular focus on monumental architectural features such as pyramids and temples (Table 1.1). Like many ancient urban features, these buildings served multiple purposes and operate on multiple levels of cultural meaning. The section that follows will highlight how archaeologists in Mesoamerica have investigated high-level and middle-level meaning of monumental structures using data on the scale, dimensions, and axial orientations of individual features. Additionally, the possibility for broad patterning of urban planning principles related to monumental features in Mesoamerica will be discussed.

Table 1.1: Table summarizing the levels of meaning within the built environment, as expressed by Amos Rapoport (1990, 1993).

Level of Meaning	**Description**
High-level Meaning	Related to cosmology, worldview, and the sacred; culturally specific and hard to access without additional contextual information
Middle-level Meaning	Related to identity, status, and power; these cultural messages are less specific than high-level and can be understood across cultures and through time
Low-level Meaning	Related to mobility within the built environment; often linked to visibility of and access to built features

Accessing the Meaning of Monumental Architecture in Ancient Urban Mesoamerica

Earlier in this chapter, universalistic theories for interpreting ancient city layouts according to celestial principles were discussed (e.g. Eliade 1959; Lynch 1981). While not all ancient cities can be interpreted through the lens of directional orientation, this form of analysis has been especially fruitful in Mesoamerica. Across ancient Mesoamerican cities, it is possible to identify spatial and directional patterns between individual buildings that suggest some level of coordinated urban planning. For example, ancient urban contexts in Mesoamerica tend to have a central district for public architecture that is highly planned and many of the most important buildings border formal rectangular shaped plazas. These general spatial patterns are not applicable to all centers (see Smith's 2003 discussion of Teotihuacán), but there are many cities exhibiting these patterns that suggest common concepts for urban design throughout the various cultures of the ancient Mesoamerican world (Smith 2007: 27).

In addition to allowing intra-site comparison of urban monumental structures, collecting data on form, dimension, and orientation of these buildings can create the opportunity for cross-cultural comparison. Throughout the ancient world, cities were often oriented according to cardinal directions (Wheatley 1971: 423-435). The standardization of orientations between urban centers of a single urban tradition suggest adherence to a common model for city layout (Smith 2007: 29). Based on widespread analysis of ancient Mesoamerican temples and other monumental features (e.g. ballcourts, processional ways, ceremonial plazas), we know that there are several prevalent orientation patterns across the region involving a certain degree of skew from cardinal directions. Anthony Aveni (2003) best describes this phenomenon, observing that alignment studies expose a broad pattern of systematically deviated orientations, which he then uses to argue for the importance of celestial alignments in urban planning. Smith (2007: 29) believes this is an area that needs further quantitative research, however, there are convincing examples in Mexico and other parts of Mesoamerica of the commonality in orientation between urban monumental features that are worth discussing in more detail.

There is a growing body of archaeoastronomical literature from the last several decades that indicates a clearly non-random distribution of architectural orientations in Mesoamerica. According to this research, civic and ceremonial buildings were regularly oriented based on astronomical considerations, especially related to the position of the sun at various points in the year (Šprajc 2000: 403; Aveni 2001; Aveni and Gibbs 1976; Aveni and Hartung 1986; Šprajc 1997; Tichy 1991). It has been widely hypothesized that the dates recorded by architectural orientations can be viewed in relation to the agricultural cycle and interpretation of Mesoamerican calendrical systems. Aveni 1997 and others (Aveni and Hartung 1986; Tichy 1991) have proposed that the dates marked by orientation of civic and ceremonial features may even be separated by calendrically important intervals. Other authors have operated on the assumption that significant peaks on the local horizon functioned as environmental markers of sunrises and sunsets on pertinent dates (Šprajc 2000: 403; Aveni et al. 1988; Broda 1993; Galindo 1994; Iwaniszewski 1994; Morante 1993, 1996; Ponce de León 1982; Tichy 1991).

In one of the most comprehensive efforts at interpreting civic and ceremonial feature orientation in Mesoamerica, Šprajc (2018) analyzed over 500 alignments from features at 206 archaeological sites occupied throughout varying time periods. This analysis also included declination data for each feature, allowing for building orientations to be linked to specific celestial observances. As explained by Šprajc (2018: 203), the declination is a "celestial coordinate that expresses angular distance measured from the celestial equator to the north or south." This metric is specific to each individual feature and is dependent upon azimuth alignment, geographic latitude of the observer, and horizon altitude corrected for atmospheric refraction. While the study of the distribution of azimuths in an area can provide insights on the general orientation patterns, the presumed astronomical targets of any alignment cannot be identified without the declination of the reciprocal point on the horizon (Šprajc 2018: 203). When azimuth alignment data and declinations are considered together for sites throughout Mesoamerica, consistent spatial patterns become evident, suggesting that urban planners in the region likely had similar concerns for monumental construction.

The importance of this study and others like it is that they support the argument for widespread similarities in the orientation of Mesoamerican civic and ceremonial architecture and strongly suggest that the locations of such important structures were carefully selected with celestial processes in mind. Several of the most common building orientation patterns revealed by Šprajc's (2018) analysis are related to observance of the solar cycle and their orientations mark sunrises and sunsets on culturally significant dates. These solar-aligned buildings typically have a skew from cardinal directions between 11-17° and east-west azimuths between 65-115°, however, there is considerable variation across the region. A few of the most popular solar orientation patterns and their related sunrise/sunset dates are summarized in Table 1.2. Šprajc (2000: 404) notes that the intervals between the dates recorded at individual sites are typically multiples of 13 and 20 days, making them significant in terms of the broader Mesoamerican calendrical system. Additionally, it appears that decisive moments in the agricultural cycle generally correspond with the most frequently occurring dates. Consideration of architectural orientation as it relates to prominent peaks on the local horizon and the angle of the sun at various points in the year permitted ancient peoples to utilize "observational calendars," which were crucial for predicting seasonal changes and coordinating appropriate agricultural activities

(Šprajc 2000: 404). The reconstruction of an observational calendar from monumental features and natural peaks at Angamuco is beyond the scope of this thesis, but it could represent an interesting avenue of research at the site in the future. Rather, the data on form, dimension, and orientation of pyramids and temples collected for this study will be mostly compared on an intra-site level, with basic consideration of its compliance to the broader Mesoamerican urban planning principles discussed here.

Table 1.2: Table expressing popular solar orientations for civic and ceremonial architecture in Mesoamerica, as identified by Šprajc (2018).

Rotation Pattern	Sunrises	Sunsets	Day Intervals	Total Day Count
11° clockwise	Feb. 22	April 17	12 x 20	240
	Oct. 20	Aug. 28		
14°clockwise	Feb. 12	April 27	13 x 20	260
	Oct. 30	Aug. 18		
17° "Family"	Feb. 9	May 3	10 x 20	200
	Nov. 1	Aug. 11		

As previously mentioned, many civic and ceremonial structures in Mesoamerica are oriented along cardinal directions with a slight, but intentional clockwise skew between 11-17°. Orientation patterns that fall in the upper part of this range are often said to belong to the "17° Family" (Aveni 2001: 269; Aveni and Gibbs 1976: 510). The ancient urban center of Teotihuacán is perhaps the best known and most extensively documented example of this sensation in Mesoamerican urban planning. The city features two slightly different architectural orientation groups that were integrated into different parts of the urban layout across multiple time periods, beginning as early as the local Tzacualli phase (A.D. 1-150) (Dow 1967: 326;

Millon et al. 1973). Most buildings in the central portion of the urban center (e.g. the Pyramid of the Sun, the Street of the Dead) are oriented with a clockwise deviation around 15º25' in respect to cardinal directions, while other significant features (e.g. the Ciudadela and two other major east-west avenues) are angled roughly 16º30' south of east (Dow 1967: 326-27). While not all architectural features at Teotihuacán fall into these orientational groups, there are other building complexes at the site where north-south walls run at angles near 15º30' and east-west axes are around 16º30' south of east. Moreover, the Temple of the Sun is aligned toward a prominent local peak (Cerro Gordo) located to the north of the city (Hartung 1977: 270, 1979: 90; Hartung and Aveni 2001: 23). This alignment is clearly intentional and represents one example of many pre-hispanic pyramids and temples in Mexico that are angled in relation to conspicuous neighborhood mountain tops (Šprajc 2001). This common alignment practice has been linked to the significant role of mountains in the greater Mesoamerican worldview (Broda 1991, 1993).

Aside from orientation patterns related to the solar cycle, there are many examples of civic and ceremonial buildings throughout Mesoamerica that are positioned in relation to the moon and the extremes of Venus (Šprajc 2018). Very generally, the buildings that are positioned for lunar and Venus cycles tend to have azimuths around 120° or 30° south of east. The extreme northern and southern declinations of Venus on the horizon follow an eight-year cycle, however, even if dates and magnitudes vary, the extremes of Venus always mark seasonal change (Šprajc 2018: 214). In the night sky, the annual northern and southern extremes of Venus roughly correspond to the June and December solstices, respectively, and they essentially delimit the rainy season and agricultural cycle in Mesoamerica. Construction of Venus-aligned architecture was prevalent in the Classis and Postclassic periods across the region, when the greatest visible extremes of the planet were on the eastern evening horizon (Šprajc 2018: 215).

Civic and ceremonial architecture with a southeastern orientation in ancient urban Mesoamerican contexts has also been associated with alignment to the lunar cycle. Based on the analysis by Šprajc (2018), declination data indicates orientations that correspond to major lunar extremes. The moon takes one month to complete the circuit between its northerly and southerly extremes, but due to celestial mechanics, the extreme declinations can vary. The corresponding moments of greatest variation in the declination of lunar extremes are known as major and minor lunar standstills, which occur at predictable 18.6-year intervals. A full discussion on the complex variation of motion in the lunar cycle is beyond the scope of this thesis, but it has been detailed by other researchers, including González-García (2015), Morrison (1980), and Ruggles (1999). Based on declination data compiled by Šprajc (2018), it seems that the observance of major lunar standstills is the most likely explanation for most lunar-oriented structures in Mesoamerica. Building orientations to lunar standstills have been identified in various parts of the broader region (Šprajc and Sánchez 2015; Šprajc et al. 2016), but there seems to be a concentration of these structures in the northeastern coastal region of the Yucatán Peninsula (Šprajc 2018: 216). Although this pattern has become increasingly clear in recent years with the addition of ample quantitative data (Sánchez and Šprajc 2015; Sánchez et al. 2016) from the area, the concentration of these lunar oriented structures was proposed as early as the 1970s by Aveni and Hartung (1978). Through the combination of archaeological data, ethnohistoric sources, and other information, we know this particular coastal region was focused on worship of the lunar goddess Ixchel, especially during the Postclassic period when many of the ritually oriented features were constructed (Šprajc 2018: 216; Freidel and Sabloff 1984; Milbrath 1999: 147–148; Miller 1982: 85–86; Thompson 1939).

At any prehispanic urban center, it cannot be assumed that the orientation of each individual architectural complex is directly associated with cosmological or astronomical concerns. As Šprajc (2000: 405) points out, horizon altitudes shift depending on the precise point of observation on the landscape and “the same azimuths do not correspond in different parts of the city to the same astronomical phenomena (declinations) on the horizon.” This makes it highly unlikely that the orientation of every individual complex or building was based on exact astronomical references. Instead, it seems that the alignment of particularly significant architectural features (e.g. the Pyramid of the Sun and the Ciudadela at Teotihuacán) served to influence the layout of other buildings and only the most important structures were “astronomically functional and precise” (Šprajc 2000: 406).

While orientation patterns for civic and ceremonial architecture have been documented across many different cultures in ancient Mesoamerica, there appears to be very little data of this kind from Purépecha cultural region. Throughout the literature, only the ceremonial center at Ihuatzio (located on the eastern shore of Lake Pátzcuaro) is discussed in relation to directionality and potential celestial orientation, but no azimuths or declinations are reported. At this site, there are two rectilinear pyramid platforms facing east over a large enclosed plaza and directly to the east of this complex are three small hills (see aerial view of temples and plaza in Figure 1.1). According to Pollard (1993:152), a line projected east from the narrow space between the two temple platforms falls mid-way between two of the adjacent hills. Additionally, when the complex is viewed from this corridor, the peaks of the small hills “bracket one lunar phase cycle either side of the equinox” (Pollard 1993:152). Although Ihuatzio represents a promising example of celestial building alignments in the Purépecha culture region, more formalized data collection is needed to elucidate potential orientation patterns. The study of directional orientations of pyramids and temples at Sacapu Angamuco (Michoacán, Mexico) could help fill this gap in the data and create an opportunity for Purépecha sites to become part of the larger discussion on cosmological influence in urban planning across Mesoamerica. Similar to other ancient state-level societies in the region, the Purépecha formed a syncretic religious system that incorporated many different deities from varying ethnic groups.

Figure 1.1: Aerial imagery showing the central ceremonial zone at Ihuatzio, located on the eastern shore of Lake Pátzcuaro. To the north are the rectilinear platforms over the east-facing plaza, and to the south are three keyhole or *yácata* pyramids. Displayed using ESRI World Imagery Basemap.

Based primarily on ethnohistoric sources, early Purépecha language dictionaries, and analyses of these sources (e.g. Álcalá 2011; León 1979 [1903]; Corona Nuñez 1957; Hurtado Mendoza 1986), we know that directionality was an essential component of the state religious system. An in-depth summary of this information can be found in Pollard's (1993) book on all aspects of the ancient Tarascan empire entitled *Taríacuri's Legacy* (see Chapter 7 pp. 133-166), but only major components of this ideological system will be discussed here. In ancient Purépecha cosmology, the universe was divided into three parts: the sky (*arandaro*), the earth (*echerendo*), and the underworld (*cumiechucuaro*). The earth was believed to be a goddess with four quarters, each of which was associated with a cardinal direction and specific color. These directional associations are summarized in Figure 1.2, which was adapted from Pollard (1993: 144). In addition to the four quarters was added the center to create five distinct directional divisions. North and south were also referred to as right and left, respectively, according to their position in relation to the rising sun (Pollard 1993: 141). Although there are many major and minor Purépecha deities mentioned in ethnographic sources, there are three religious cults that are mentioned more than any others. These deities include: Curicaueri, the warrior sun god; Cuerauáperi, the creator goddess related to rain and maize; and Xarátanga, goddess of the moon, the sea, and fertility.

The most powerful god in the Purépecha religious system and patron deity of the state is called Curicaueri. On earth, Curicaueri was represented in the form of the Tarascan king and he was most strongly associated with fire, the hearth, and the sun. In the conception of the four quarters, Curicaueri occupies the center position and he is associated with the color blue (*chupicua*), like the sky (Pollard 1993: 138-139). In ritual practice, Curicaueri was honored through monthly feasts that focused on the glorification of the state and the legitimation of the current king, often through the retelling of state origin myths and the sacrifice of both humans and animals (Pollard 1993: 143). In the ancient built environment, the power of Curicaueri and the Purépecha state were embodied in a new pyramid form (the *yacatá*), which appears in the Late Postclassic period during empire consolidation (Pollard 1993).

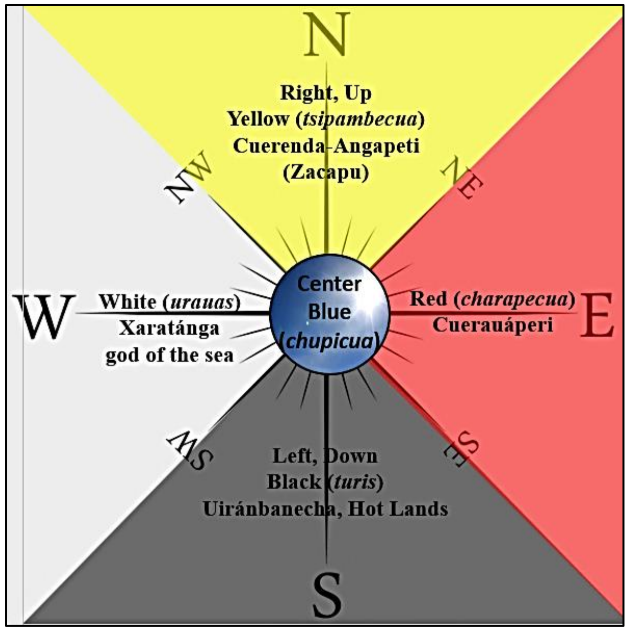

Figure 1.2: The four quarters of pre-hispanic Purépecha religion. Each direction is associated with a major deity and related color and symbols. Adapted from Pollard (1993:144).

The other two major cults in pre-hispanic Purépecha religion involve goddesses that are broadly associated with fertility themes. The most important goddess is Cuerauáperi, who was a creator deity associated with the east, the color red (*charapecua*), and life-giving rain. She controlled both life and death, and was also believed to send rain (or famine) for the crops from the east. Like many other Mesoamerican cultures with combined rain/maize deities (see discussion in Šprajc 1993), Cuerauáperi was associated with maize and the annual rainy season which is roughly delimited by the extremes of Venus. The creator goddess was associated with vapor from hot springs as well, and her cult included important locations related to thermal springs (Pollard 1993: 136). Cuerauáperi was considered the mother of all other deities, and one of her daughters, Xarátanga, was the focus of the third major cult. Xarátanga was the goddess of the moon, wife of the sun god (Curicaueri), and patronness of childbirth and fertility (Pollard 1993: 137). She is considered the goddess of the sea and is associated with the west and the color white (*urauas*). Both Cerauáperi and Xarátanga were the subject of rituals including sacrifice and auto sacrifice like Curicaueri, but their festivals revolved around the cycles of the natural world including spring rebirth, fall harvest, and the return of migratory animals (Pollard 1993:143). Major temples devoted to Cuerauáperi and Xarátanga have been identified at several sites within the Lake Pátzcuaro Basin, however, Pollard (1993) admits there are likely civic and ceremonial architecture devoted to these major cults at most Purépecha sites.

Although admittedly brief, the discussion of Purépecha cosmology presented in this chapter is intended to lay the foundation for how the directional orientation of buildings at Angamuco can be interpreted in relation to celestial observances. We know from ethnographic and other sources that directionality was essential to the Purépecha religious system, and therefore it is likely that at least some of their civic and ceremonial spaces were planned accordingly. While it seems that the directional orientation of important Purépecha architecture has not been studied on a large scale, investigation of the directionality of pyramids and temples at Angamuco could represent an exciting step toward applying this type of analysis more broadly in the cultural region as a whole.

Throughout this chapter, theories related to the meaning of monumental architecture have been discussed from an urban planning perspective, with particular attention to broad patterns for the organization and orientation of significant monumental structures recognized throughout ancient Mesoamerica. Furthermore, the importance of directionality in the Purépecha religion has been briefly explored, with attention to major religious cults associated with the sun, Venus, and the moon. These discussions provide the basic lens through which the results of this study will be interpreted in later chapters. In the chapter that follows, my own GIS methods for identifying pyramid and temple structures at the urban site of Angamuco will be laid out, along with how data on the scale and orientation of these features has been measured for the purposes of this analysis. Following methodological discussion, the results of the study will be presented and potential patterns for orientational and size class groups will be proposed. Finally, there will be a preliminary discussion of the possible meaning of pyramid and temple orientation patterns at Angamuco, both on an intra-site and regional scale.

CHAPTER 2 : ENVIRONMENTAL AND CULTURAL-HISTORICAL BACKGROUND

Physical Setting of the Lake Pátzcuaro Basin

Located in the northern central part of the state of Michoacán, the Lake Pátzcuaro Basin (LPB) represents a highland endorheic or closed drainage system on the edge of the Central Mexican Altiplano, within the Transmexican Volcanic Belt *(Eje Volcánico Transversal).* The base of the lake basin was formed as early as the Miocene, and its shape has been continuously modified by volcanic and tectonic activity extending into the present. The LPB likely became closed during the Late Pleistocene and Holocene as a result of lava damming from multiple eruptions on the northern and southern boundaries (Israde-Alcántara 2005). Today, the basin covers an area of 919 km^2, encompassing diverse topography and environments, with elevations ranging from 2035 m to over 3300 m asl.

Since the basin is a closed system, lake levels are influenced primarily by rainfall, evaporation and seepage processes that keep the shoreline in constant fluctuation. The lake currently covers about 126 km^2 within the basin and maximum water depths vary between 1-12 m depending on location (Chacón-Torres and Múzquiz-Iribe 1997). Over the last several decades, lake level shifts as great as 10-13 m have been documented (Chacón-Torres 1993; Pollard 1993; O'Hara 1993) and this fluctuation would have been common in the past as well, likely influencing settlement patterns through time. Sediment core samples collected by Metcalfe et al. (2007) indicate lake levels were high during the late Pleistocene and early Holocene, but that increased climatic variability and gradual drying have intensified since 4000 cal. BP. In addition to natural fluctuations, these cores and others taken by Fisher et al. (2003) suggest lake levels were impacted by erosion from human activity in both the pre- and post-hispanic periods.

The LPB is currently characterized as a humid and temperate climatological zone, where annual rainfall averages 950 mm and the average annual temperature is 60.8°F (or 16°C) (Bradbury 2000). At upper elevations within the basin (2500-3300 m asl), pine, oak and fir forests occur naturally on the volcanic landscape, while lower elevations (<2500 m asl) are dominated by agricultural crops, secondary vegetation, and grasses.

Prehispanic Occupation of the Lake Pátzcuaro Basin

Although the paleoenvironmental record has been studied extensively in the LPB and surrounding areas (Watts and Bradbury 1982; Ortega et al. 2002; Israde-Alcántara et al. 2008), comparatively little archaeological work has been completed across the region. Many of the details we know about the Purépecha state come from the illustrated plates of the *Relación de Michoacán* (RM), which was recorded by Franciscan Priest Fray Jeronimo de Acalá around A.D. 1540. This official history traces the origins of the empire to the early 1300s and documents specifics related to social, political, and economic activities (Acalá 2011). In terms of archaeological research, several important programs have been established in recent decades by Helen Pollard and Christopher T. Fisher in the LPB and by the Centre d´études mexicaines et centraméricaines (CEMCA) in the Zacapu Basin. These studies (see Pollard 2006, 2008; Fisher and Leisz 2013; Michelet et al. 2005), along with salvage programs by the Mexican Instituto Nacional de Antropología e Historia (INAH), have contributed to a better understanding of regional settlement patterns through time and space.

Based primarily on excavations and radiocarbon dating of prehistoric centers surrounding Lake Patzcuaro (Pollard 2000, 2006, 2008), six occupational phases have been designated within the LPB, ranging from the Late Preclassic through the Late Postclassic (100 B.C. – A.D 1525)

(Table 2.1). The earliest evidence for human occupation of the LPB comes from disturbed maize pollen in lake cores between 1690 and 940 BC (Bradbury 2000) however, additional information on these populations is minimal at best. During the Early to Middle Preclassic period, these people participated in sedentary or semi-sedentary agricultural activities, with settlements focused primarily around the lake shores. In the LPB these early sites are deeply buried, however evidence from the Bajío and Cuitzeo basins suggests these populations likely adhered to the Chupicuaro cultural tradition that was first defined in the Lerma River Basin (Guanajuato, Mexico) (Darras 2006; Darras and Faugére 2005; Darras et al. 1999; Porter Weaver 1969). While the exact origin of the first Chupícuaro peoples is unknown, their construction of circular sunken patio architecture and use of shaft tomb burials during the Early and Middle Preclassic suggests a connection to cultures further to the west (Darras and Faugére 2010).

Table 2.1: Table expressing general pre-Columbian time periods across Mesoamerica and local phases identified in the LPB. Adapted from Pollard (2008: 220).

Period	Local Phases
Late Postclassic	Tariacuri (A.D. 1350 – 1525)
Middle Postclassic	Late Urichu (A.D. 1000/1100 – 1350)
Early Postclassic	Early Urichu (A.D. 900 – 1000/1100)
Epiclassic	Lupe-La Joya (A.D. 600/700 – 900)
Middle Classic	Jaracuaro (A.D. 550 – 600/700)
Early Classic	Loma Alta 3 (A.D. 350 – 550)
Late/Terminal Preclassic	Loma Alta 1 & 2 (150 B.C. – A.D 350)
Middle Preclassic	Chupicuaro (≥500 – 150 B.C.)

The Early Classic period (A.D. 350 – 550) is when settlement can first be recorded in the LPB based on the presence of surface remains. Many of these Late Loma Alta phase settlements developed on islands or along the lakeshore, but upland occupation is documented for the first time at sites like Urichu (Pollard and Cahue-Manrique 1999) and Erongarícuaro (Pollard 2003).

During this period, we also see the intensification of wetland agriculture, as indicated by the presence of raised fields near the modern town of Nocutzepo (Fisher et al. 1999). Loma Alta 2-3 occupations are recorded in formerly inundated areas of the basin, revealing a significant drop in lake level (Fisher 2005:90). In the Zacapu Basin, the Loma Alta type site (Arnauld et al. 1993) is characterized by an early example of sunken plaza/platform style architecture constructed from non-local basalt and clay. Similar architectural complexes including Zaragoza (Fernández-V. Medina 2004) and Nogales (Pereira et al. 2007) are also located within the Lerma River Basin, however the burials at the type site provide the strongest timeline for the emergence of social stratification in the region. At this site, the richness of funerary goods is directly associated with proximity to the central platform (Pollard 2008; Pereira 1996). Despite the obvious development of social ranking during the Loma Alta phases, these settlements all fit within the category of small-scale agrarian communities. Pollard (2008) recommends that more excavations are needed to truly understand the development and degree of social inequality in the region at this time.

The Middle and Epiclassic periods (A.D. 550 – 900) represent a time of great cultural change for the LPB and surrounding areas. These changes are primarily attributed to the increasing pressures of settlement expansion and the intensification of unequal access to goods (Pollard 1997). During this time, settlements become larger and more numerous, relying on macro-regional exchange systems to obtain a variety of goods. These cultural shifts are especially evident in the burial practices of local elites that appear in the LPB during the Epiclassic. Between A.D. 500 – 700, central Michoacán elites shared a cultural tradition linked to the earlier Chupicuaro and Loma Alta societies. Burials were often primary and extended, with shell beads interred in association with children and sometimes women (Porter Weaver 1969). These mortuary practices were drastically altered by the end of the Classic period, with elites being buried in group tombs that were used similarly over generations, with little variation in construction style (Pollard and Cahue 1999). Formalized tombs were reserved for only some families and these elites were interred with finished imported goods sourced from all over Mesoamerica. At sites including Guadalupe and Tres Cerritos in the southwestern LPB, artifacts in Teotihuacan style have been recovered, suggesting possible cultural influence during the Epiclassic (A.D. 600/700 – 900) (Pollard 2008: 223; Pereira 1999). Although the size and architectural complexity of settlements varied during this time, local elites shared a common culture that they used to legitimize their increasing power.

During the Early Postclassic period or Early Urichu phase (A.D. 900/1000 – 1100), elite burial goods became even more elaborate and more numerous, indicating increasing control over trade and local labor. The edges of Lake Pátzcuaro lowered by as much as 7 m from the previous period and settlements quickly occupied the newly exposed shorelines (Pollard 2008; Fisher et al. 2003). Canal irrigation practices continued from earlier periods, but the intensification of landscape modification (e.g. terraces, mounds, retaining walls) has been well-documented in the Lake Pátzcuaro and Zacapu Basins (Pollard 2008). Importantly, this phase marks a shift from primarily lacustrine-based settlements, to rapidly increasing numbers of upland sites (Michelet et al. 2005). At upland sites in the Zacapu Basin, sunken patio architecture is replaced by square rooms with covered porticos that are more densely packed in urban settlements. Around the Early/Middle Postclassic (A.D. 900 – 1350) is when Pollard (1997, 2008) believes the Purépecha cultural core emerged. Competing chiefly/small state societies dominated the Purépecha heartland during this time and Pollard (2008: 224) describes patterns of leadership and control as "in flux."

The Tariacuri phase (A.D. 1350 – 1525) signifies the emergence of a centralized state in the LPB. According to legendary history in the RM, Tariacuri was a visionary leader who began his quest to unify the empire in AD 1300. Within about 50 years, the Tariacuri lineage controlled all major centers around Lake Pátzcuaro and his descendants spearheaded expansion into the adjacent Cuitzeo Basin (Acalá 2011). Increasingly dense populations had to adapt to fluctuating lake levels and many lakeshore communities were abandoned after A.D. 1300 due to flooding (Fisher et al. 1999; Fisher et al. 2003). Survey data from northern and central Michoacán indicate that population densities peaked during the Late Postclassic, with settlements ranging widely in population and area. Pollard (2008) proposes the rise of the state and its expansion across the region was related to a rapid increase in the scale of production and likely restriction of access to goods by elites and the royal dynasty. Compared to earlier periods, the exchange of goods and services became more regulated and imports within the LPB varied based on social class and community (Hosler and McFarlane 1996; Pollard 2003; Pollard et al. 2001).

During this time, the social separation of commoners and elites became formalized, with even nobility falling into tightly defined categories (e.g. lower nobility, higher nobility, royalty). These class divisions are clearly seen in the archaeological record, including both residential and mortuary contexts (Pollard and Cahue 1999; Pollard 2005). In secondary and tertiary centers of the LPB, elites and commoners took cues from the capital at Tzintzuntzan, helping to create a cohesive social system. In contrast to the Early Urichu phase, elites no longer rely on foreign imports to convey status, but rather focus on locally produced and distinctively Tarascan goods (Pollard 2008:225). Elite identity also shifts in the Tariacuri phase toward greater control of tributary, military, and ideological networks, creating the greatest level of socioeconomic inequality in the pre-Hispanic era.

In addition to being the geopolitical core of the Purépecha empire, the LPB was believed to be the center of cosmic power based on a newly formed state ideology. This belief system elevated the patron gods of ethnic Purépecha elites to celestial status, while also elevating, incorporating, or marginalizing other regional worldviews (Pollard 2008:225). For example, the ethnic Chichimec deity Curicaueri became linked to the ethnic Purépecha islander goddess Xarátanga and they were worshipped together at ceremonial centers at Ihuatzio and Tzintzuntzan as husband and wife (sun and moon respectively). The melding of various regional deities can also be traced through the changes in construction of ritual centers. Across, the Tarascan core, *yácata* or keyhole-shaped pyramids are constructed at major religious centers in order to honor the sun god Curicaueri (Figure 2.1). These structures were devoted to ritual activities such as human sacrifice and were also used in mortuary contexts for elite individuals (Moedano 1941; Rubín de la Barbolla 1939, 1941).

Figure 2.1: Aerial photo of the five *yácatas* of Tzintzuntzan (© 2011 LORE-LPB Project).

By the time the Spaniards arrived in the region in the early 16^{th} century, the Purépecha (Tarascan) empire extended over 75,000 km^2 in the west central Mexican highlands with the LPB at its center (Pollard 2008). For nearly two centuries the Purépecha empire fought on and off with their Aztec neighbors, never losing ground despite their smaller numbers. News of the Spanish invasion spread from the Aztecs to the imperial capital at Tzintzuntzan, however the Purépecha refused to help their enemies against the foreign threat. At the same time, the capital was plagued by political in-fighting and the royal dynasty was struggling to maintain legitimacy. In A.D. 1522, Spanish general Cristóbal de Olid reached Tzintzuntzan and encountered a weakened empire (Pollard 1993; Warren 1968). The ruler or *cazonci* Tangáxuan II willingly surrendered to the Spanish and was allowed to continue to rule with some autonomy. For several years, Purépecha populations paid tribute to both the *cazonci* and the Spanish administration until Tangáxuan II was deposed in 1530 by the conquistador Nuño de Guzman (Warren 1968). The next few decades featured violence and political instability across the Tarascan state, but indigenous populations eventually acquiesced to Spanish authority.

Geographical Context of Angamuco

The site of Angamuco is located in the southern portion of the LPB, approximately 9 km from the imperial capital of Tzintzuntzan and 13 km from the town of Pátzcuaro. Angamuco rests on a volcanic landscape comprised of multiple lava flows and is referred to as a *malpaís* or "bad land" settlement owing to the rough and inhospitable terrain. (Neuendorf et al. 2005). These barren lava fields are recognized in the American Southwest and throughout the Spanish speaking world as areas that are exceedingly difficult to traverse and unsuitable for modern agriculture.

Based on ethnohistoric data and previous work near the southern *malpaís,* the LORE-LPB Project adopted the name Sacapu Angamuco for the site. A village of the same name, in approximately the same location, is visible on a colonial map recorded by Pablo Beaumont (1932[c. 1740s]) in the 18th century. Additionally, a settlement in the same place can be seen on a later map created by Eduard Seler (1908: 35), but with the distinctly different name of Tzacapanzarадembo (Cohen 2016: 153). Following archaeological investigations of several Early Hispanic (A.D. 1520 – 1550) sites found in ethnohistoric sources, Gorenstein and Pollard (1983) concluded that historic Sacapo Angamuco is located on the western side of the landform, at the modern town of Corrales. Two of the settlements that were part of this research (identified as X07 and X08 by the authors) (Gorenstein and Pollard 1983: 21) are located along the southern edge of the *malpaís* and likely represent less-intensive occupations during the Late Postclassic period when Angamuco was mostly deserted. More recently, several sites on the southern periphery were documented by INAH archaeologists in the Gasoducto Survey. Although it is possible that the actual location of Sacapu Angamuco is further north, the LORE-LPB Project has decided to extend the name over the entirety of the modified *malpaís* landscape.

This site was first documented by Dr. Fisher in 2007 and has been the subject of ongoing archaeological investigations ever since. Between 2009 – 2010, full-coverage survey on the lower *malpaís* provided preliminary data on the age, size, spatial layout, and assortment of structures at Angamuco (Fisher and Leisz 2017; Fisher et al. 2011). Although this work covered nearly 2 km^2, recording thousands of features, traditional survey methods were hampered by the rugged terrain and dense vegetation. In order to increase the survey speed and better understand the full scope of the site, Lidar data was obtained in 2011 and 2013. These records together encompass over 35 km^2 including the entire *malpaís* and surrounding areas, allowing for site-level analysis. This work has been documented in multiple technical reports created for the Instituto Nacional de Antropología e Historia (INAH) based in Mexico City, Mexico (see Fisher et al. 2011, 2012) and it has been discussed in academic publications including Fisher (2005), Fisher and Leisz (2013), Chase et al. (2012), Fisher et al. (2011), and Fisher et al. (2017).

Excavations on the southwestern portion of the site in the summer of 2013 confirmed a long occupational sequence, spanning from AD 900 – 1520. Fisher and Leisz (2013) identify three distinct occupational phases differentiated primarily by settlement patterns and architectural styles. The Early Postclassic (AD 900 – 1200) is characterized by sunken plaza complexes and artifacts similar to those documented at contemporaneous sites in the Bajío region and other parts of Michoacán (Cárdenas Garcia 1999; Piña Chan and Oí 1982; Pomédio et al. 2013). During the Middle Postclassic (AD 1200 – 1350), the site entered a phase of major expansion, and architectural features became increasingly clustered into distinct areas. Two major pyramid forms became popular across the site including both rectilinear and semi-circular forms similar to those observed in the Zacapu Basin (Michelet 2008; Pereira and Forest 2011; Pereira et al. 2012; Cohen and Fisher 2016). This period of growth at Angamuco is followed by a contraction of settlement in the Late Postclassic (AD 1350-1522), when social differentiation and public ritual activity were likely at their height. The site was likely organized like other Late Postclassic centers in the LPB, with a focus around Purépecha imperial-style architecture including *yácatas* and large plazas.

The Angamuco *malpaís* features two distinct lava flow episodes that naturally formed lower (2100-2180 m asl) and upper (2180-2400 m asl) occupation zones at the site (Bush 2012:20; Cohen 2016:125) (Figure 2.2). Until recently, we believed the *malpaís* landform developed as a result of eruptions during the early to mid- Holocene (~9,000 ya). However, new geological work in the region by Ramírez Uribe (2017) suggests the *malpaís* may have formed as early as the late Pleistocene (27,000 years ago). Much like the whole of the LPB, it is unknown exactly when the *malpaís* was first occupied, but both the upper and lower zones are completely modified as part of a built environment. Basalt produced from the late Pleistocene flow episodes provided a ready and ample construction material that became roads, terraces, walls, houses, pyramids, plazas, and much more (Ahrens 2013:47). This notion of landscape modification is supported by the presence of anthrosols (i.e. soils formed or modified by human activity) across the site. In both the northern and southern *malpaís*, pre-Columbian inhabitants heavily reworked the local topography, clearing and constructing to suit their needs.

The upper area features low hills and narrow basins formed by multiple smaller lava flows that make for exceedingly rugged and often inaccessible terrain (Figure 2.3). Architectural remains in the upper zone are densely packed and their layout appears to be influenced by natural topography (Bush 2012:23). Since this area is unsuitable for modern agriculture, many building foundations and other features remain undisturbed except for the effects of natural vegetation. The upper region is characterized by productive yellow soil and is currently covered by dense woodland forest, including oak, pine, and fir (Cohen 2016:126). Fisher et al. (2011) suggests much of the soil in the upper elevations is of anthropogenic origin related to processes such as midden accumulation and transportation of materials from lower elevations.

On the lower *malpaís,* red earth clay has developed as a result of mechanical weathering of volcanic rock and shrub-like vegetation predominates. In contrast to the upper zone, the lower features broad slopes more favorable for the construction of monumental features. As a result, the lower elevations of the site seem to contain the majority of public civic-ceremonial centers, which are the focus of this thesis. The increased accessibility of this foothill zone has also made it conducive to non-mechanized *milpa*-style agriculture. Repeated clearing of fields has expedited the degradation of archaeological features, often leaving only partial foundations or outlines (Bush 2011:20).

Water resources in the *malpaís* region include basins along the outer edge of the landform, as well as several natural springs that rise through the volcanic basalt. The basins are evident on both sides of the site as large depressions (0.5-1 km^2) that likely served as reservoirs during the past. Reports from LORE-LPB survey (Fisher et al. 2010, 2011) have documented that these areas are typically characterized by cumulic and lacustrine soils with no artifacts, supporting the notion they were used for holding water.

Although there are fewer obvious reservoirs on the upper part of the *malpaís,* possible prehispanic *pozos*, or hand dug wells, were documented during 2010 survey (Bush 2011:24; Cohen 2016:128). Few artificial water control features have been interpreted from the Lidar data thus far, however these features (e.g. wells, reservoirs, canals) are likely numerous across the upper elevation zone of the site. During the Postclassic period, when Lake Pátzcuaro was at its highest (AD 1350-1530), the lake shoreline may have been as close as 2.5 km to the west of Angamuco. Now that the lake level is much lower, that distance has increased to 8 km or more, depending on which points are used to measure (Cohen 2016:127).

Figure 2.2: Photo of *malpaís* of Angamuco from the upper elevation zone (© 2011 LORE-LPB Project).

Angamuco represents one example of a growing number of well-documented sites exhibiting intensive Postclassic occupation in upland areas across the Purépecha core region. French archaeologists at CEMCA have spent the last several decades recording similar sites in the adjacent Zacapu Basin (Arnauld et al. 1998; Michelet 1995, 2008; Migeon 1998). There are at least a dozen settlements on the Zacapu *malpaís* that date to the Early to Middle Postclassic (AD 900 – 1350) and resemble Angamuco in form and function. Most recently, Jadot et al. (2016) have investigated Postclassic socio-political changes by tracing ceramic production at the upland urban sites of El Palacio and Malpaís Prieto. This work sought to understand ceramic source materials and the results suggest the Zacapu *malpaís* sites likely participated in exchange networks with distant coastal centers. Although these upland urban settlements are no longer considered rare across Michoacán, the reasons for their development are still poorly understood.

In this chapter, I have attempted to provide environmental and cultural context for the Lake Pátzcuaro Basin and introduce the urban site of Angamuco. Based on the current interpretation of Purépecha state formation processes (see Pollard 2008, 2016), there is very little explanation for the existence of a complex site such as Angamuco in the uplands of the LPB. Ethnohistoric texts emphasize a long history of social, economic, and material practices within the basin, however they do not discuss how the Purépecha negotiated imperial expansion with existing cities and populations. In the *Relacion de Michoacán,* the historical narrative heavily favors the royal dynasty at Tzintzuntzan and other centers are considered subordinate to the capital (Alcalá 2011 [1540]; Urquhart 2015). Archaeological investigations have been similarly limited in their scope within the LPB, focusing on Tzintzuntzan and a handful of other sites located near the lake shores (e.g. Urichu, Ihuatzio, Erongarícuaro).

The discovery of Angamuco demonstrates that complex urban centers were thriving in the core region long before Purépecha imperial consolidation. The expanding empire likely had to contend with established bureaucratic systems and large populations, making the state formation process much more complex than previously thought. At Angamuco, investigating the size, form, and spatial layout of civic-ceremonial centers could help us trace the growth of the city through time. The site features both rectilinear and *yácata* style pyramids, however these structures have yet to be quantified or compared to other regional examples in any detail. Through analyzing monumental civic-ceremonial architecture at the site, I hope to establish Angamuco as an important example of Mesoamerican urbanism outside the traditional Purépecha core area that was significant both before and after formation of the state. The next chapter will detail how these features were identified on the landscape for the purposes of this study and how they were quantified and measured using various tools available in ESRI ArcMap.

CHAPTER 3 : METHODOLOGY

The dataset analyzed in this thesis includes digital products derived from Lidar data collected over two survey seasons, as well as some products produced using more traditional visualization methods in ESRI ArcMap. The combined Lidar scans total over 35 km^2, allowing for analysis of cultural features across the entire *malpaís* landform. Initial Lidar acquisition at Angamuco was completed by Merrick and Company, Inc. in 2010 and the second scan was done by the National Center for Airborne Laser Mapping (NCALM) at the University of Houston in 2015. The basic specifications for the first of these scans and additional details can be found in Fisher and Leisz (2013), Fisher et al. (2012), and Fisher et al. (2011). Utilizing the Lidar record, digital models representing the earth's surface can be created, exposing structural remnants typically obscured by heavy vegetation. With a pixel size of 25cm and a minimum 10 cm contour interval, these high-resolution digital surface models (DSMs) allow us to visualize features on the ground as small as 25-40 cm on a side and 25 cm in height (Fisher et al. 2017:132). Although Lidar data is not a replacement for traditional ground survey methods, a direct correlation has been established between previously surveyed features at Angamuco and the Lidar data. According to Fisher et al. (2017), over 7,900 architectural features visible on the Lidar scans have been verified in the field, demonstrating the reliability and accuracy of the remotely sensed data.

My own methods include a site level analysis of Sacapu Angamuco, in which all 35 km^2 of data were analyzed with the previously discussed research questions in mind (see Introduction). In order to identify monumental pyramid structures across the *malpaís* landscape, I primarily worked with a 50 cm resolution raster DSM (Digital Surface Model) derived from the

Lidar data collected at the site. This combined DSM was created by project partner Juan Carlos Fernandez-Diaz (NCALM/University of Houston) in late 2016 and it has been used in all subsequent geospatial analyses at the site. Several pyramid and temple structures were previously identified during pedestrian survey and prior GIS analysis, however, there has thus far been no concentrated research effort focused on monumental architecture at Angamuco. Using ArcMap 10.6, I developed a method for more rapidly visualizing elevated features on the *malpaís*. Since the volcanic topography can be highly variable, it is sometimes difficult to identify built versus natural features using traditional visualization methods (e.g. multi-directional hillshades, local relief models).

To maintain spatial control, I analyzed the site in 500 m^2 blocks, which were previously established in a digital grid covering the entire data set (Figure 3.1). Each block is represented by a combination of letters and numbers (e.g. AA82), which became the basis for my own structure labeling scheme. Although buildings identified during ground survey already have labels stemming from the architectural typology at the site, these structures were given a distinct label in my own system as well for ease of recording. For example, the large *yacatá* at the southern end of the site has been recorded on the ground as MO 5037, but has also been labeled structure AN73-1 in my own analysis. This means the pyramid is in block AN73 and it was the first monumental structure identified in the block. When applicable, I include both labels to limit possible confusion.

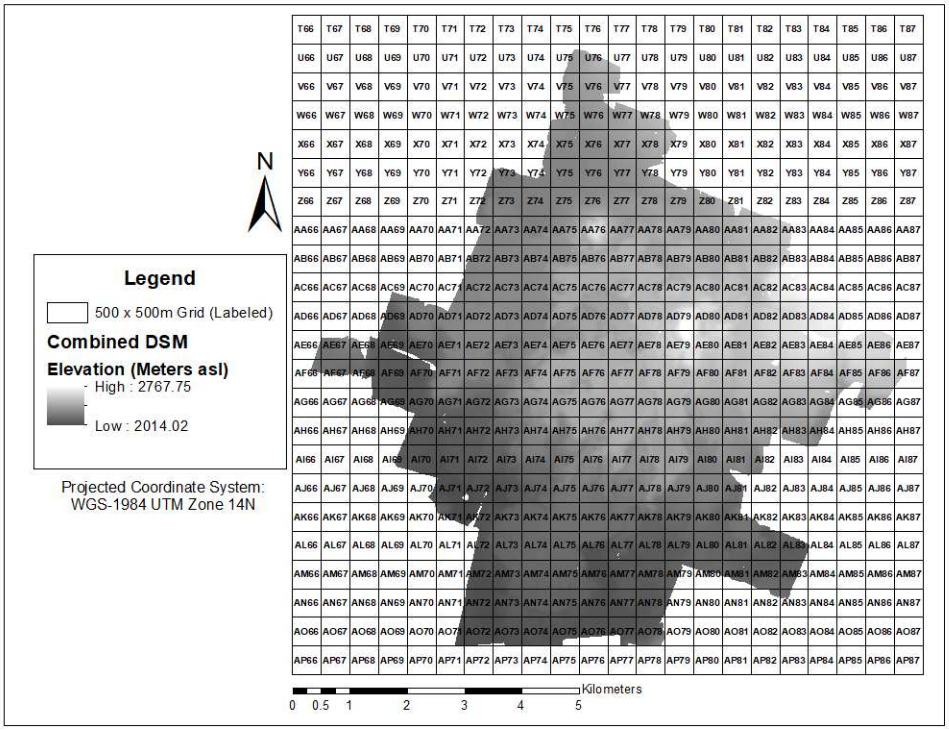

Figure 3.1: Map showing 500 x 500 m blocks and labeling system (Combined DSM by Juan Carlos Fernandez-Diaz, 2017, LORE-LPB).

An important first step for identifying pyramid and temple structures at Angamuco is understanding how these features have thus far been defined for the purposes of the LORE-LPB project. Since 2009, the LORE-LPB research team has been working to develop an architectural typology at the site that allows for the classification of all built features. This typology was recently discussed by Cohen (2016) in her doctoral dissertation and will be detailed even further in a forthcoming publication by Fisher et al. The Angamuco typology is based on over 7,000 architectural features, which have been verified and intensively mapped in the field. This architectural sample includes building foundations from houses and public structures, storage facilities, monumental architecture such as pyramids, altars, and public buildings, and landscape features such as plazas, roads, terraces, and raised roadways (Fisher et al., forthcoming publication: 5).

For the purposes of this study, we will focus on how pyramid and temple structures fit within the architectural typology for the site. On a basic level, the typology divides architectural features at Angamuco into two categories, including buildings and landscape features. Buildings are composed of walls and are associated with mounds, platforms, and other similar features that tend to delimit small spaces on the landscape and function as loci for human activity. Landscape features are differentiated from buildings in that their construction is overall more informed by natural topography, and they demarcate larger spaces that served to connect various parts of the urban environment. This category includes features such as plazas, roads, passages, and agricultural areas (Fisher et al., forthcoming publication: 11). Pyramids and temples fall within the building category; however, they often have associated landscape features such as plazas.

The first step in classifying architectural remains in the Angamuco typology is dividing features based on whether they are above or below ground (Fisher et al., forthcoming publication: 13). Above-ground features include, platforms, mounds, and raised roadways (known locally as *huatziri*), whereas ground-level features typically encompass walls or other features with low foundations. Here, we will focus on the definition of mounds within the above-ground category, since this includes pyramid structures. While platforms are above-ground features characterized by one built course or *cuerpo*, mounds are differentiated by the presence of more than one course. At Angamuco, mounds are divided into two separate groups, including pyramids and altars. These types of structures have multiple courses, where each layer has a complex structure including a rubble core that is often faced by larger, sometimes almost fitted stones (Fisher et al., forthcoming publication).

Through the course of survey and geospatial analysis, two major types of pyramid have been identified at the site: the *yácata* form and the rectilinear form. These pyramids seem to occur throughout the site and serve to anchor civic and ceremonial nodes. As mentioned in the Theoretical Discussion Chapter, the *yácata* style pyramid has a distinctive shape that is often associated with the Late Postclassic Purépecha empire. This type of pyramid is generally composed of a rectilinear element joined with a circular element. Prior to this spatial analysis, one large formal *yácata* had been identified at the southern end of the site, along with at least four other structures representing stylistic variations (Fisher et al., forthcoming publication: 17). More details on the major southern *yácata* and several of the identified variations will be discussed in the results chapter of this thesis, but the important aspect of these structures to note here is there distinctive keyhole shape.

The second type of pyramid present at Angamuco is the rectilinear pyramid, in which the primary axis is much shorter than the secondary axis. This configuration creates two long open faces and these pyramids typically occur in conjunction with a basal platform comprising the first *cuerpo* of the structure. It is likely that this basal platform served as a staging area before reaching the top of the structure and access to the top portion came from a stairway along the primary axis of the building. Several examples of large rectilinear pyramids adhering to this pattern were documented during the course of survey and the results of this spatial study confirm that these features are located throughout the Angamuco *malpaís*. Again, specific details of these structures and prominent examples will be discussed in the Results Chapter, but it is important to note that these structures vary in their configuration, size, and placement on the landscape in relationship with other features. Some of the examples from the site are related to sunken plazas similar to those in Epiclassic period (AD 600-900) contexts of the Bajío region (Cárdenas García 1999; Piña Chan and Oi 1982; Pomédio et al. 2013), but this is not always the case.

In addition to pyramid and temple features, this analysis examines two constructions that have been identified as potential ballcourts at the site of Angamuco. This type of feature is common in other parts of Western Mexico and examples have been documented in the *malpaís* zone of the Zacapu Basin (Michelet et al. 1995; Taladoire 1989) and at Tingambato (Piña Chan and Oi 1982), but no previous examples have been recorded in the Lake Pátzcuaro Basin. At Angamuco, these constructions have a general I-shape and they are classified as a type of prepared open zone within the landscape feature category. For the purposes of this analysis, the two ballcourts at Angamuco will mostly be considered in terms of their average azimuth alignments, and less in terms of their scale and dimension.

Data Processing for Identification of Elevated Features

When analyzing the Lidar derived DSM in search of pyramid and temple features, one can quickly become overwhelmed with the many elevated features, both natural and cultural. While traditional hillshades produced in ArcMap are good at highlighting some features, others can be obscured depending on the angle and azimuth of the direct light source. Shaded relief models such as hillshades are the most commonly utilized technique for raster visualization (Yoëli 1965), but they are not typically optimized for the visualization of archaeological features. In an effort to move beyond the basic hillshade, this analysis employs many different models and data processing techniques, which are discussed below.

Since the urban center at Angamuco is situated on a rugged and variable volcanic landscape, looking for monumental features among the many ridges and swales is tedious and time consuming. In many cases, monumental structures, as well as other elements of the built environment, are located on top of naturally elevated topography, making the distinction between the two that much more difficult. In the interest of accelerating the identification of monumental constructions across the entire site, I designed a method for swiftly displaying significantly elevated areas using tools available in ArcMap.

To begin with, each 500 m^2 grid block is mathematically inverted using the Raster Calculator tool in the Spatial Analyst extension. The equation below is utilized in order to essentially flip the landscape and turn elevated features into depressed features, and vice versa. [ElevRaster] represents the original 50 cm DSM raster for the block, Z Max represents the maximum elevation, and Z Min represents the minimum elevation.

$$(([ElevRaster] - Z\ Max) * -1) + Z\ Min$$

After the new inverted raster is created, the next step is to generate contours that help better define features on the surface. In order to produce slightly smoother contours, I first use the Filter tool in the Spatial Analyst extension to reduce local variation and effectively remove noise from the inverted raster. This tool runs a Low Pass filter that calculates the average value for each 3x3 pixel neighborhood and decreases extreme values present in the raster dataset. From this slightly smoothed surface, contours with a 25-centimeter interval are created using the Contour tool under the Spatial Analyst extension. Although the original DSM has a 50 cm resolution, I utilize a 25 cm interval for the contours since that is the minimum pixel size limit for the data. The benefit of generating contours from the filtered raster is that they appear less jagged, making it easier to visualize structural forms on the landscape. While it may be argued that eliminating any topographic variation at all creates less accurate contours, I found the difference to be negligible upon comparison. The filtered DSM is only used for contour production.

Following creation of contours, I use the Fill tool within the 3D Analyst extension to rapidly scan the dataset, looking for depressed features on the inverted raster. The Fill tool uses a pre-determined algorithm for identifying sinks (and peaks) on a raster surface and the tool runs until all sinks within a specified depth range (z limit) have been filled. Since the DSM for each block is inverted, the tool in this case actually "filled" elevated features (or peaks) on the landscape. One of the advantages of this tool is that it analyzes pixels in relation to their nearest neighbors, or put more simply, it takes into consideration localized topography such that peaks at all different elevations across the site can be identified. After some experimentation with different z-limits, I found that setting no limit created the most easily interpretable output. It should be noted that there is no mathematical difference in running the Fill tool on 500 m^2 blocks versus the entire dataset at once. However, more relief detail is typically visible when the selected color scale for display is stretched across a smaller spatial area.

Finally, the original inverted raster is then subtracted from the "filled" raster, to create a product displaying differences in depth (meters) between the two. This output consists mostly of zero value data, but significantly elevated features (both cultural and topographic) become immediately apparent. Once the entire process for inverting, filling, and subtracting the rasters was fine-tuned, I used Model Builder in ArcMap to help automate the process. The basic model for processing each 500 m^2 block can be seen in Figure 3.2.

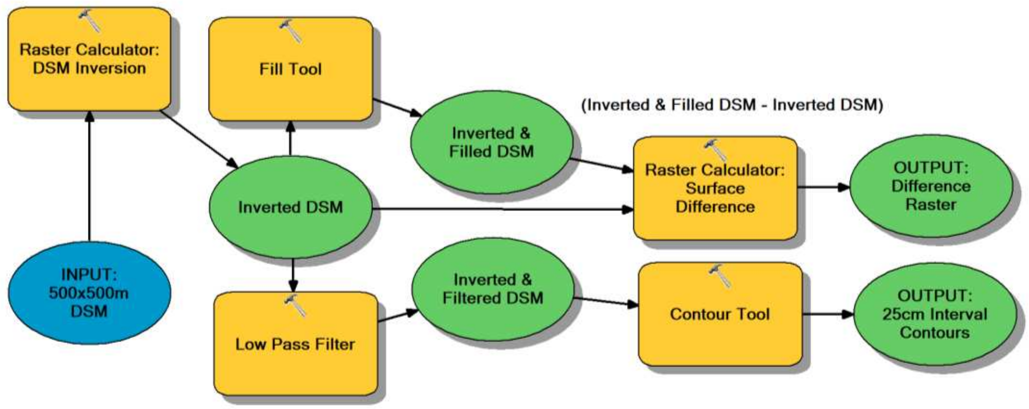

Figure 3.2: Model created in Model Builder (ArcMap 10.6) for the mathematical inversion of the DSM for each block and application of the Fill and Contour tools. See the block DSM input on the left, and the multiple output products on the right.

In the final output (see example in Figure 3.3) the portions of the DSM highlighted by the Fill tool rarely represent individual structures and should be considered more like high probability areas for monumental architecture. In many cases, the final output displays elevated areas of the site that could fit into a category of features called "modified hilltops." I borrow this terminology from Prufer and Thompson (2016), who used it to describe landscape alteration in the ancient Mayan polity of Uxbenká, in southern Belize. In this region, pre-Columbian inhabitants employed a series of cut-and-fill strategies to flatten and expand the footprint of natural topography for construction purposes (Prufer and Thompson 2016: 393). While building strategies between the ancient Maya and Purépecha were not exactly alike, residents at Angamuco seem to have altered their physical environment with similar objectives in mind. Many of the visible peaks on the processed dataset represent natural hills on the landscape that have either been cut-off or built up to be made artificially level for construction. It is essentially impossible to tell which strategy for leveling was employed at Angamuco based on the spatial data alone, but the near ubiquity of modified hilltops across the site is undeniable (see examples

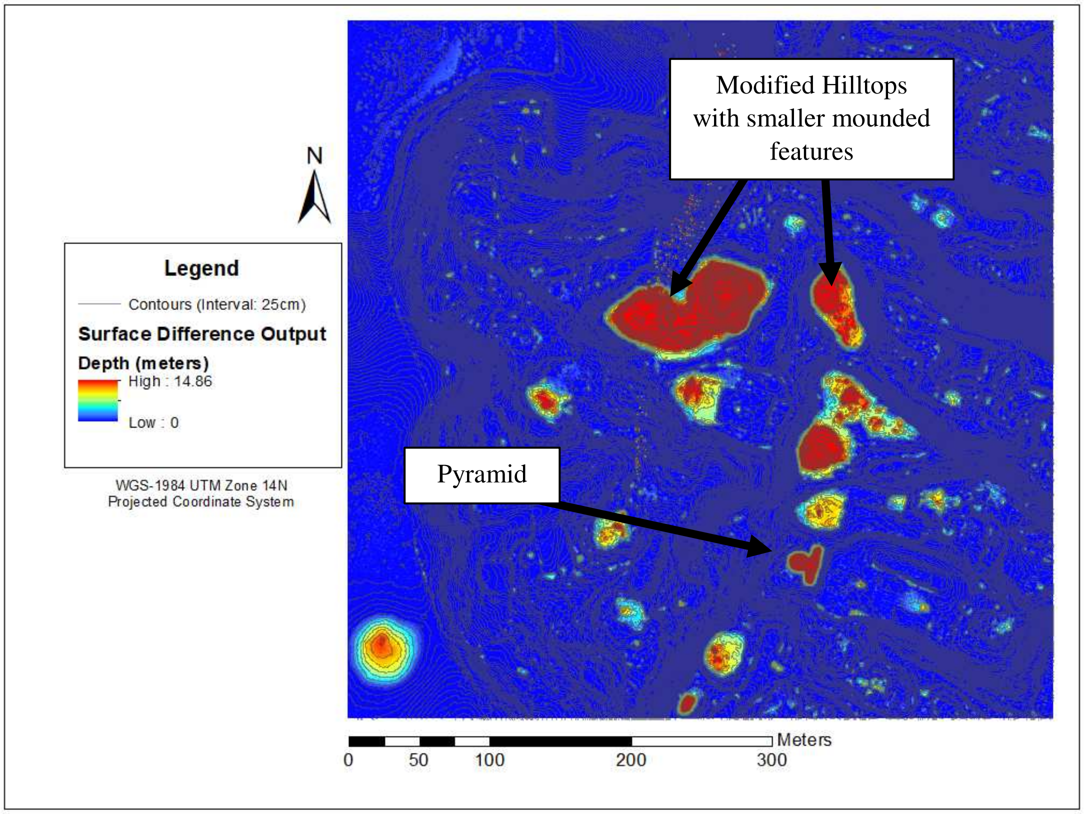

Figure 3.3: Map showing the inverted, filled, and subtracted DSM for Block AN73, toward the south end of the site. Examples of modified hilltops can be seen to the north, and pyramid structure AN73-1 (MO 5037) can be seen to the south.

in Figure 3). In addition to evidence for hilltop leveling, intensive landscape terracing is apparent on many sloped surfaces, further confounding the distinction between built features and natural topography during digital analysis. While the modified hilltops certainly include important cultural features, my focus was on architecture of monumental proportion, and more specifically pyramid and temple structures. In addition to pyramid structures, a sample of well-defined mounded features were identified across the site as well. In some cases these structures may represent smaller civic and ceremonial contexts, or possibly altars, but exact designation of smaller mounded features is difficult from the geospatial data alone.

In order to differentiate between monumental constructions and modified or terraced hilltops, I used a raster visualization method known as a Red Relief Image Map (RRIM). This approach to 3D data visualization was first described by Chiba et al. (2008) and it involves the overlay of three different layers representing various elements of the landscape. These layers include raster datasets expressing topographic slope, positive openness, and negative openness, which are briefly summarized in the table below (Table 3.1). In order to produce these layers, I used an open-source program called the Relief Visualization Toolbox (RVT) that was developed by researchers in Slovenia for the identification of small-scale features on raster datasets (see Kokalj et al. 2011 and Zaksek et al. 2011 for full description). The advantage of using this toolbox is that many different visualizations can be created simultaneously, at a high speed, while using a single input surface file.

Table 3.1: Table including brief descriptions of raster layers needed for production of the Red Relief Image Map (RRIM).

Visualization Method	Description
Topographic Slope	Model expressing slope gradient in either percent or degrees
Positive Openness	Model expressing the convexity of the given surface (see Yokoyama et al. 2002)
Negative Openness	Model expressing the concavity of the given surface (see Yokoyama et al. 2002)

Once these layers are created using the RVT, the RRIM can then be constructed by merging the layers for positive and negative openness and overlaying the layer modeling topographic slope. The result is a multi-layered image that models the convexity and concavity of the earth's surface without relying on incidental lighting, such as that found in traditional shaded relief models (e.g. hillshades) (Figure 3.4). The RRIM for the entire Angamuco site was created by my colleague Edwin Harris, who was gracious enough to share it with the rest of the Angamuco research team. Essentially, the RRIM presents a better visualization method for fine topographic structure and it was particularly useful for illuminating the built environment at Angamuco. For a full description on how to create the RRIM and more information on its advantages for 3D data visualization, please see Chiba et al. (2008).

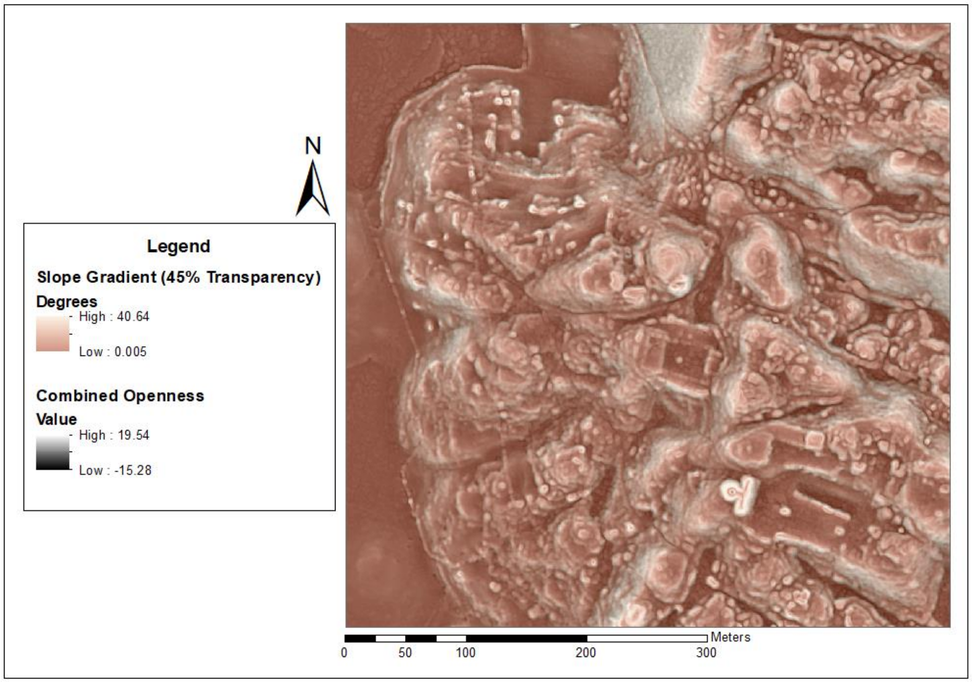

Figure 3.4: Map showing the Red Relief Image Map (RRIM) for Block AN73. The RRIM for the entire site was created by Edwin Harris, after Chiba et al. (2008).

Quantification through Consideration of Scale, Form, and Orientation

As previously established, monumental structures are characterized by their large scale, and at Angamuco they appear in two recognizable forms (rectilinear and *yacatá*), that can be identified with relative certainty from the geospatial dataset. Once the locations of all recognizable pyramid and temple structures were determined across the site, my focus shifted to calculating a volumetric measure, as well as measuring basic dimensions and a directional orientation (azimuth) for each pyramid and temple structure. Since I was working with primarily raster datasets, I decided to use the Surface Volume tool in the Spatial Analyst extension for volume calculations. On a basic level, this tool calculates the area and volume of a region between a surface and a selected reference plane. In my analysis, the inverted DSM raster is the input surface and the selected 10 cm contour representing the base of each pyramid structure constitutes the reference plane. In addition to the 25 cm contours created for the site during the first phase of data processing, I also made 10 cm contours for pyramid complexes and their surrounding areas. These contours with a smaller interval helped me to better define the base of each pyramid and therefore define the reference planes necessary to run the Surface Volume tool. For each pyramid and temple, I attempted to select a contour that defines the base of the singular structure alone. I also used profile views generated using the 3D Analyst tool bar in ArcMap to help distinguish between natural topography and built environment. Again, this differentiation is not always perfectly clear due to terracing on many of the sloped surfaces across the site, but I have been as careful as I can to include only built surfaces in my analysis. Each basal contour selection was converted into a polygon shapefile representing the pyramid or mound construction. Using the surface volume tool, three metrics were calculated for each structure, including 2D surface area, 3D surface area, and volume in cubic meters. Model Builder was used to simplify this process as well (Figure 3.5).

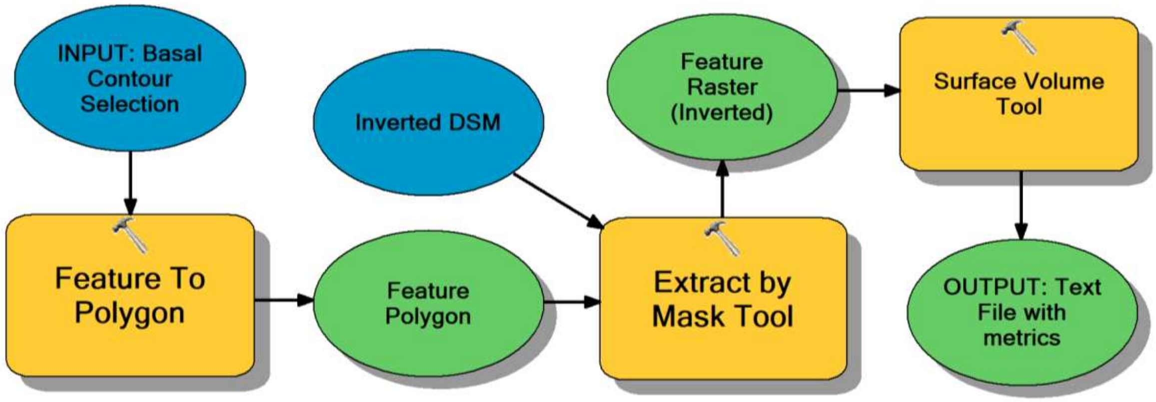

Figure 3.5: Model created in Model Builder (ArcMap 10.6) for the creation of polygons representing monumental structures and for the calculation of surface area and volume metrics using the Surface Volume tool.

In addition to metrics calculated by the Surface Volume tool, heights for each structure were determined by calculating low and high points within each polygon and subtracting the results within ArcMap. Using the Measure tool, basic dimensions along the primary and secondary axes of each pyramid and temple were also recorded.

Finally, azimuth determinations were made for each pyramid following methods outlined by Šprajc (2018). This method involves taking multiple azimuth measurements for any given structure and averaging together the measurements to get composite North-South and East-West azimuths. As Šprajc (2018: 202-3) points out, the walls of ancient structures are rarely parallel and perpendicular to each other, either because of intentional design or because of shifting through time. This means that building orientations cannot be expressed as a single azimuth because there is high potential for variation in the angle of different construction elements. Similar to Šprajc (2018), this analysis takes into account multiple azimuth measurements for each analyzed structure. Based on 10 cm contours created across the site, between 9 and 14 different azimuths were measured for each pyramid and temple utilizing the COGO editing function in ArcMap. These measurements were recorded as degrees clockwise from polar north and included multiple North-South and East-West lines that were determined to be most representative of the structure. In an effort to account for orientational variation that may be intentionally present in the same structure, measurements were taken at different points, including the base, the middle and the top of every pyramid. In some cases, where there was obvious damage or disturbance to a structure, the damaged area was avoided and fewer overall measurements were taken. Following the collection of azimuth data, all the North-South and East-West angles for each structure were averaged and the standard deviation was calculated for each average. This method creates two representative azimuths for each structure that are considered in the Results Chapter. All of the averages, standard deviations, and individual measurements taken in this analysis can be seen at the end of this thesis in Appendix A.

The benefit of this method for calculating azimuths is that it can be applied broadly at different archaeological sites and it produces quantitative data that can be used for intra-site and regional scale comparisons. It is important to note that the averages calculated in this study and any similar research have varying standard deviations that can make their average azimuth determinations slightly less certain. For the purposes of this analysis, the average azimuth calculations for each structure at Angamuco will be considered as is, with the known caveat that some of the proposed orientational groupings become less distinct when the margin of error is considered. This study is aimed at understanding the general distribution of azimuth orientations at the site, however, in the future it is my hope to incorporate standard deviations of the averaged azimuths and additional data that will add greater weight to the directional determinations. A full discussion on this form of analysis can be found in (Šprajc (2018).

In this chapter, I have described my own methods for identifying and quantifying pyramid and temples at the Sacapu Angamuco site. I have reviewed my own process for highlighting "peaks" on the landscape and explained how pyramids are distinguished and defined for the purposes of this study. After establishing the volume, basic axial dimensions, and directional orientation for all 26 pyramid and temple structures, a basic investigation of intra-site variation in building scale and planning is possible. I hope this chapter highlights the importance of using multiple visualizations for 3D data sets, especially when faced with interpreting archaeological features among highly complex topography. In the next chapter, I will go on to discuss my results and their potential for elucidating monumental construction trends at the site during the Postclassic period (AD 900-1350).

CHAPTER 4 : THE PYRAMIDS TEMPLES OF ANGAMUCO

The analysis of monumental architecture, especially when associated with complex societies, is an important way that archaeologists can attempt to understand the distribution of power across ancient landscapes, as well as access cultural meaning expressed through the built environment. As discussed in Chapter 1, monumental architecture can communicate many different sociocultural messages, often related to status, power and identity, but also including cosmological or sacred concerns (Rapoport 1990). In many different ancient urban contexts around the world, significant monumental buildings have been found to be oriented in relation to celestial observances and their orientations can sometimes influence entire city layouts. This phenomenon is particularly prevalent in the ancient urban centers of Mesoamerica, such that comparisons in building alignment can be made on both intra-site and regional scales (Šprajc 2000, 2005). As a result, these buildings are regularly considered in terms of their scale, dimension, and axial orientations. When the basic morphology and arrangement of these features in urban contexts are examined in conjunction with their multi-scalar variation, preliminary insights on architectural patterning of monumental features can be gained.

In this chapter, the monumental architecture at Angamuco is analyzed in relation to basic form, directional orientation, and scale. This discussion is focused primarily on major pyramid and temple structures at the site but will also include limited discussion of related plazas and other above-ground features as classified by the architectural typology for the site (Fisher et al., forthcoming publication). In the final chapter that follows, these results will be synthesized and considered in connection with the evolution of pyramid and temple structures at the site and how this could relate to the broader Mesoamerican tradition of important building orientations in the 17 degree family (discussed in Chapter 1).

Pyramid and Temple Types at Angamuco

Over the course of this analysis, 26 pyramid and temple structures were identified across the Angamuco *malpaís* of varying size and configuration (Figure 4.1). Additionally, the average azimuths of two likely ballcourt features were calculated. While several of these features on the southern end of the site were previously recorded during ground survey efforts, most of the complexes discussed in this chapter fall outside the 2009-2011 pedestrian survey areas.

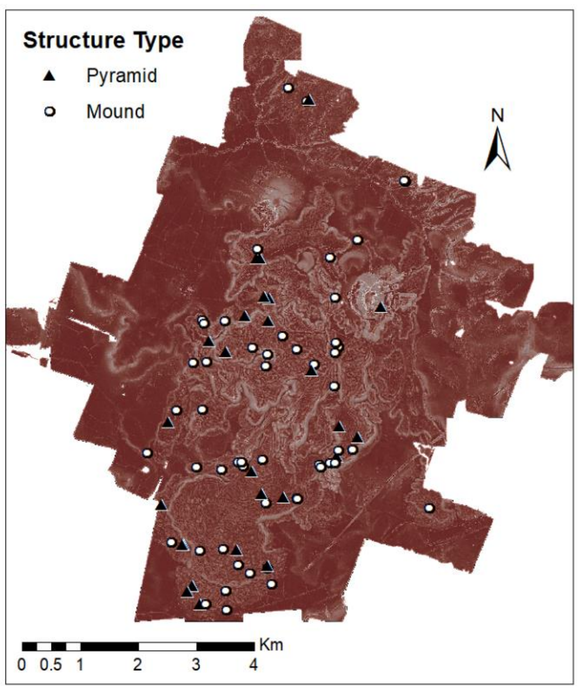

Figure 4.1: Map displaying pyramid and prominent mound features identified across the entire Angamuco landform. These features are displayed on top of the RRIM for the site.

The Keyhole or Yácata Pyramid

The keyhole-shaped or *yácata* pyramid generally consists of both a round and rectilinear element and it is widely considered the characteristic pyramid form of the Postclassic period Purépecha empire in western Mexico (Acosta 1939; Rubín de Borbolla 1941, 1944). During ground survey at Angamuco, at least five clear *yácata* examples were recorded, including a formalized complex and several morphological variants (Fisher et al., forthcoming publication). In this GIS analysis of the site, only one additional formal *yácata* pyramid was discovered, bringing the total to six *yácata* structures on the site, with the potential for more (more on this topic later). Structure AN73-1 (or MO 5037), was recorded during the course of ground survey and the complex has been a major focus of excavation efforts by the LORE-LPB research team. The newly located *yácata* (AC75-1) is on the far northwestern edge of the site and it has not yet been recorded by the LORE-LPB on the ground. Looking at this northern *yácata* (AC75-1), it is clear there has been some level of disturbance, likely from modern agriculture and looting. This damage becomes highly visible in the form of large holes when the building is viewed in profile (Figure 4.2). While many cultural features at Angamuco are relatively undisturbed due to the undesirability of the malpaís for modern agriculture, this structure is located on the northwestern edge of the landform, not far (about 1.2 km) from the modern town of Coenembo. The structure is one of few at the site that is visible on aerial imagery because the immediate surrounding area has been cleared, likely for modern farming activities.

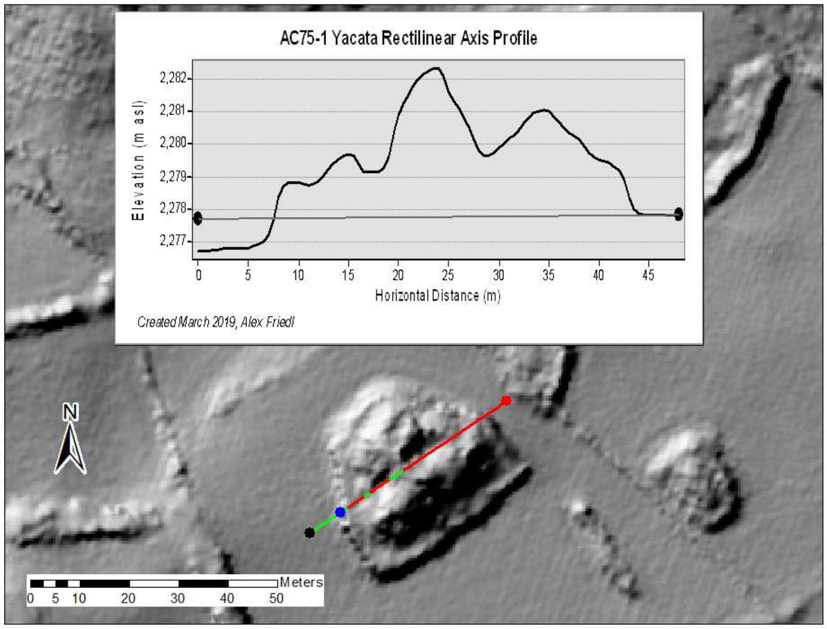

Figure 4.2: AC75-1 Yácata rectilinear axis profile demonstrating extensive looter damage. Below, the line of sight is shown across the yácata structure, which is displayed using a multi-directional hillshade derived from the 50 cm resolution DEM.

Despite obvious damage, this structure is by far the largest pyramid on the site, based on the volume measurement (1788.80 m^3) and a keyhole shaped structure on a platform is evident. Based on measurements taken from the DSM, the rectilinear portion of this pyramid is about 32 m long and about 12 m wide. The circular element of the structure is pretty severely disturbed, but its current dimensions are about 20 m by 15 m. It appears there may have been a plaza associated with the northern *yácata* toward the southeast, however, the limits of this space are no longer clear since the area has been cleared and probably plowed repeatedly. The average North-South (NS) azimuth for this structure is 223.8° and the average East-West (EW) azimuth is 320°. In this case, the primary (short) axis is represented by the EW azimuth, running from the southeast to the northwest. To the east of the northern *yácata*, there is some sort of rectilinear structure (AC75-2) that is also likely damaged (visible toward bottom right-hand corner of Figure 4.2). Even in its disturbed state, this feature is quite large in scale (Volume = 271.9 m^3), and it ranks as the fifth largest rectilinear building identified over the course of this analysis. This structure could represent another pyramid that once bounded an edge of the AC75-1 *yácata* plaza, but more investigation is needed to confirm this idea. The AC75-2 rectilinear structure is oriented toward the southwest with an average NS azimuth of 144.71° and average EW azimuth of 226.62°. The primary building axis runs EW, and was measured from the northeast to southwest. Since this northern *yácata* complex and the surrounding area are so affected by modern activity, it is hard to draw strong inferences from scale alone, however the clear keyhole morphology marks this as a significant place on the Postclassic period landscape related to Purépecha imperial influence.

The southern *yácata* (AN73-1 or MO 5037) is the second largest pyramid at Angamuco based on volumetric measure and it is mostly intact compared to its northern counterpart. In addition to being the second largest pyramid at the site, this structure is accompanied by a large plaza area on the southeastern side of the rectilinear portion of the building. At an estimated 5101.74 m^2 in surface area, this plaza represents an immense planned open area at the site. Like *yácata* AC75-1, the southern *yácata* (AN73-1 or MO 5037) has a rectilinear element that faces is a southeastern direction, but at a slightly different angle. The NS average orientation for this building is 199.71°, while the EW azimuth average is 282.40°. Based on these measurements, it appears that structure AN73-1 could fit within broader Mesoamerican patterns for civic and ceremonial features aligned for solar cycles. While official declinations need to be calculated in order to confirm this idea, both average azimuths are skewed from cardinal directions between 12-20°, which makes it a strong candidate based on directional orientation.

During the 2014 LORE-LPB field season, the southern *yácata* was associated with Area C excavations. These data recovery efforts were focused on the plaza area and altar located directly below the south eastern pyramid face, making this perhaps the best contextualized pyramid and temple complex at the site thus far (Figure 4.3). These excavations are detailed in a LORE-LPB technical report from 2014 and described by Cohen (2016: 193-215). The rectilinear section of *yácata* AN73-1 (MO 5037) measures 34 by 13 m and the circular part is 17.5 by 19 m (Cohen 2016: 137), making the dimensions similar to those measured from the DSM for the northern *yácata* (AC75-1). Intensive mapping of *yácata* AN73-1 (MO 5037) revealed probable staircases allowing access to the top of the structure from both the rectilinear and round portions, along with the remnants of a large (4 x 6 m) stone-floored room on top of the circular element (Cohen 2016: 137). Pollard (1993: 159) suggests that according to images in the RM, there may have also been a perishable structure on the rectilinear element with a thatched roof. Plaza features to the east and northeast of *yácata* AN73-1 (MO 5037) appear to have highly restricted access that is limited to only a few specific points. Materials from the Area C excavations date the plaza and altar contexts to the Middle and Late Postclassic periods (AD 1200-1530) and the pyramid structure was likely used at the same time (Fisher et al. 2014; Fisher et al., forthcoming publication).

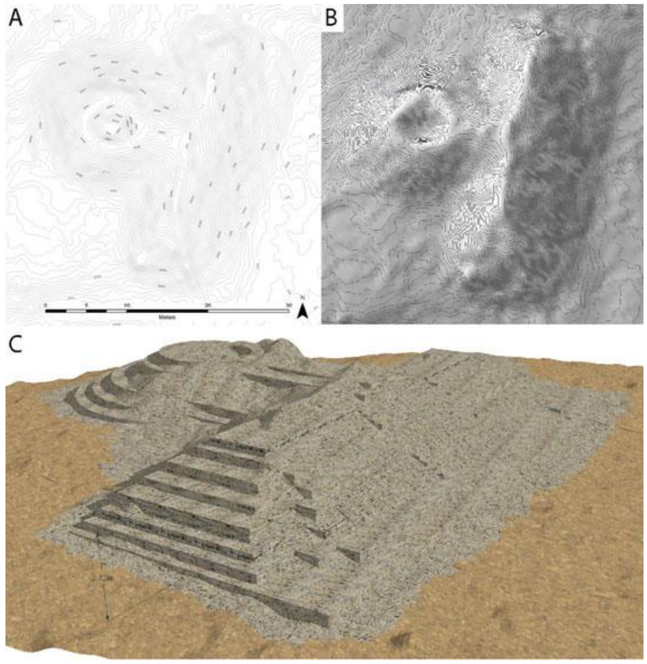

Figure 4.3: Traditional-style Purépecha ‘*yácata*’ pyramid from Angamuco. A. Shows a plan view of this feature as a 5 cm contour map, B. shows a perspective view of this same feature using the same contour map overlain on a hillshade. Both are derived from LiDAR data with a 25 cm resolution; C. Artists reconstruction based on intensive mapping. (from Fisher et al., forthcoming publication).

In addition to these two major *yácata* structures, there are variations of the traditional building form present at the site. These structures are discussed by Cohen (2016: 138-9) and have been termed pseudo- or proto-*yácata* structures. Several examples with slightly different morphologies have been documented through the course of previous ground survey work, but these features are admittedly harder to identify from the geospatial data alone.

One example of a proto-*yácata* documented during survey and discussed by Cohen (2016: 138-9) includes a structure with a much smaller rectilinear portion in relation to the round element. In this morphological variation, the two elements are directly joined together, resulting in a functional space on top of the rounded part. Structure MO 2784 (not quantified in this study) is one example of this form recorded on the southern portion of the *malpaís.* Similar to the formal *yácata* AN73-1 (MO 5037), access to the top of this pyramid appears restricted and the remains of a stone floor and possible perishable structure are evident (Cohen 2016: 138). The larger circular element in this pyramid layout makes it resemble rounded pyramid forms found in multiple other Mesoamerican cultures dating as far back as the Preclassic period (Cohen 2016: 139; Castro Leal Espino 1986: 48-63; Smith 2008: 103-105).

The primary proto-*yácata* quantified in this analysis is AM73-2 (MO 2740), which borders the western side of a sunken patio, also bordered by a rectilinear pyramid (AM73-1 or MO 2768). The volume of this proto-*yácata* (34.80 m^3) is considerably less than the formal *yácata* structures, but this makes sense when placed into context with survey data. Based on intensive mapping of this feature, it seems that the circular portion could have been a later addition to the rectilinear element and that the structure did not initially have a keyhole layout (Cohen 2016: 140). In this case, the rectilinear and circular portions are joined by another linear mound, resulting in three visible facades for the rectilinear element (Figure 4.4). Through the course of survey, it was observed that the top of this feature was only accessible from stairs on the rectilinear portion. The average NS azimuth of this structure is 203.36° and the average EW azimuth is 291.84°, with the primary axis running EW. These azimuths are like those from the large formal *yácata* further to the south, but the EW measurement for AM73-2 has a relatively high standard deviation (StDev = 12.06) that could indicate less overall consistency in the angles of the building.

Although this is one of the most evident proto-*yácata* structures when looking at the Lidar derived DSM, this analysis includes few other examples because these features do not seem to follow an exact pattern and are therefore exceedingly difficult to identify consistently from the remotely sensed data. There appear to be multiple different proto-*yácata* variations present at Angamuco and more traditional survey and mapping is needed to understand how these structures were constructed and utilized. With a total of at least six *yácata* style pyramids at Angamuco, and the potential for more proto-yácata structures, the Purepecha imperial influence on architecture at the site is clear. More formal structures similar to *yácata* AN73-1 (MO 5037) have been documented at sites surrounding Lake Patzcuaro, including at Tzintzuntzan, Ihuatzio, Patzcuaro, Lagunillas, and San Juan Parangaricutiro (Fisher et al., forthcoming publication; Acosta 1939; Castro-Leal Espino 1986; Lumholtz 1987; Cruz Robles et al. 2014; Rubin de Borbolla 1941). While rounded pyramid and temple forms are not exclusive to the Purépecha in Mesoamerica, this particular form is consistently associated with the authority of their Postclassic empire in western Mexico.

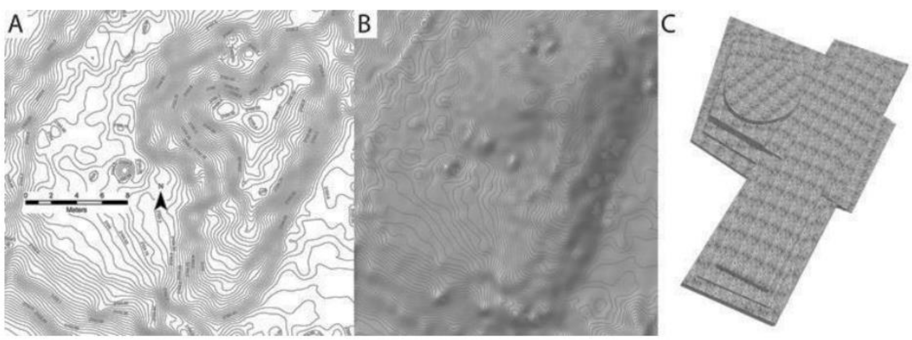

Figure 4.4: Variation of a traditional-style Purépecha pyramid from Angamuco. A. Plan view of this feature using a 5 cm contour map, B. Perspective view using the contour map overlain on a hillshade, C. Reconstruction of the pyramid based on mapping. All features derived from a 25 cm resolution DEM created from Lidar data (modified from Fisher et al. 2012; Fisher et al., forthcoming publication).

Rectilinear Pyramids

The other more common form of pyramid present at Angamuco is the rectilinear pyramid and these structures vary in terms of scale, configuration, and primary axis orientation (Fisher et al., forthcoming publication; Cohen 2016: 136). One of the most prevalent forms of this structure type on the site includes a primary axis that is much smaller in proportion to the secondary axis, creating a building with two long open sides. Over the course of this analysis, 23 rectilinear pyramids were identified across the site. Prior to this spatial analysis, there were a couple of known examples of large rectilinear pyramids toward the southern end of the site. These include structures AN73-2 and AM73-1 (MO 2768). Over the course of survey, structure AM73-1 (MO 2768) was the largest recorded rectilinear pyramid on the site, but this changes when the entire area of remotely sensed data is taken into consideration. When the size, orientation, and location of these buildings are examined together, several patterns begin to emerge.

Rectilinear Pyramid Group 1

According to this research, the largest rectilinear pyramid on the site appears to be structure AE76-1, with a volume of 412.19 m^3 and axial dimensions of about 30 m by 20 m. This pyramid is in the northern central portion of the dataset, at a point where the upper *malpaís* narrows significantly. Similar to many of the monumental features identified in this study, pyramid AE76-1 is close to the edge of the upper part of the landform, located just over 100 m from a significant drop in elevation to a lower area. Additionally, there is a modern access road that cuts through the immediate area about 80 m to the east and a cleared area related to modern activities to the immediate west. Based on available aerial imagery for the region, it appears that the pyramid and what looks like a small associated sunken plaza to the south east are still under tree cover and there is no clear evidence of disturbance as seen in profiles of other structures like the AC75-1 *yácata.* While there is no obvious disturbance based on the visualizations produced for this study, the proximity of the structure to multiple modern features makes it hard to believe this area has not been affected in some way.

Despite this fact, the AE76-1 structure seems oriented toward the south east (EW average azimuth = 309.12°), and the NS average azimuth (223.92°) is very close to that of the northern *yácata* (structure AC75-1). When looking at the EW average azimuth frequency distribution, there are 8 rectilinear pyramid structures that fall in a relatively narrow range between around 308-321°. Additionally, these 8 pyramids have NS average azimuths between 217-235° (Figures 4.6 and 4.7). This group of pyramids has a southeastern orientation and many of the buildings appear to have an associated plaza to the southeast.

In this group of similarly oriented rectilinear structures, there are three different size groupings that can be loosely formed based on volume and the length of primary and secondary axis measurements from this study. Structures AE76-1 and AG77-2 have large volumes that stand out from other southeastern oriented pyramids. Both structures have secondary axis measures well over 20 m long and primary axes between 18-20 m long (Table 4.1).

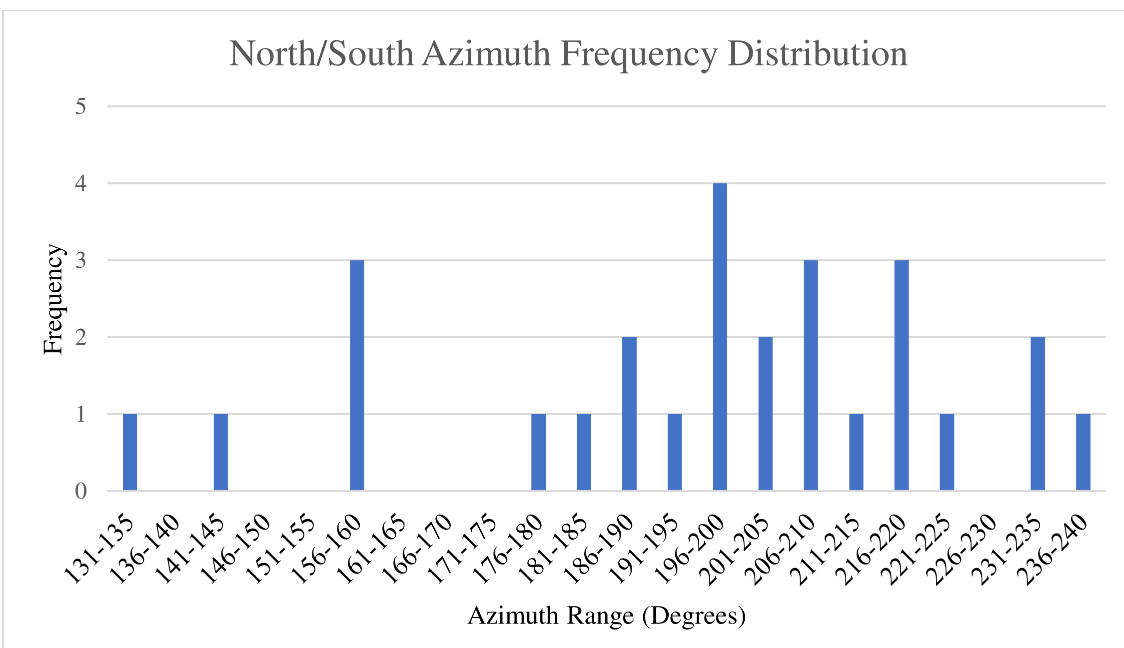

Figure 4.5: Frequency distribution of NS average azimuths measured in this analysis for pyramids and ballcourts at Angamuco (n=28).

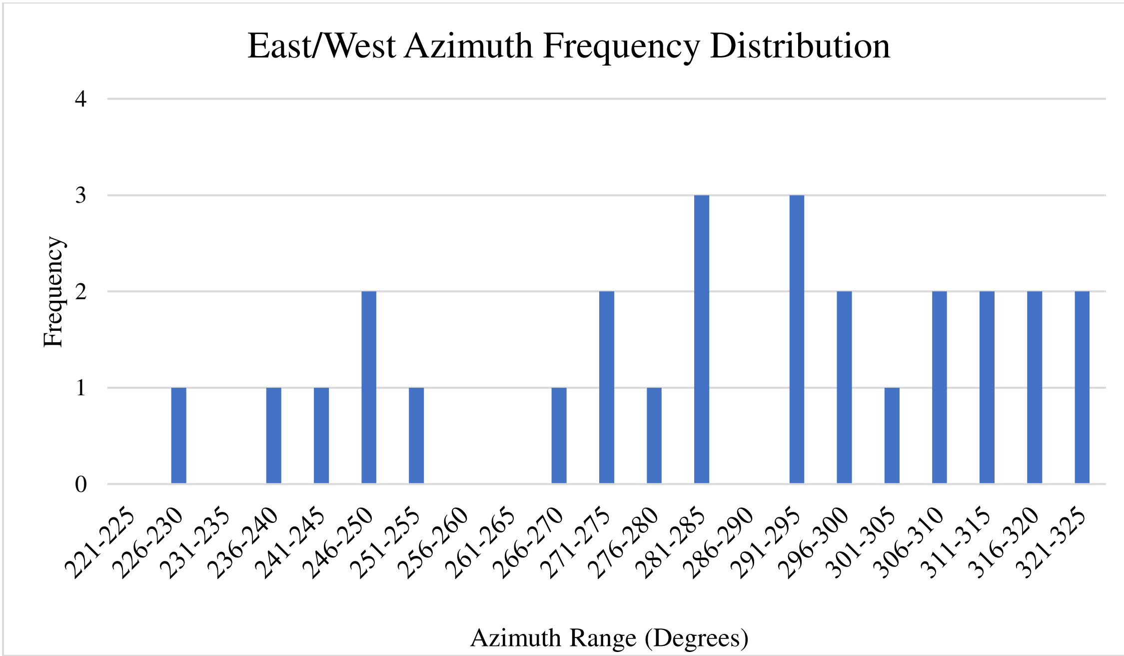

Figure 4.6: Frequency distribution of EW average azimuths measured in this analysis for pyramids and ballcourts at Angamuco (n=28).

Table 4.1: Table expressing various metrics for rectilinear pyramids with a similar southeastern orientation. This group of structures represents Rectilinear Group 1 as proposed by this study.

Rectilinear Pyramid Group 1						
Class	Structure Number	Volume (m^3)	NS Average Azimuth	EW Average Azimuth	Primary Axis Measure (m)	Secondary Axis Measure (m)
1	AE76-1	412.19	223.92°	309.12°	19.94	29.28
	AG77-2	359.56	217.13°	315.12°	17.98	22.55
2	AM75-2	250.99	232.45°	317.93°	17.30	20.34
	AK76-5	180.18	231.64°	321.55°	16.20	20.69
	AN73-2	176.98	206.58°	312.66°	12.63	20.22
	AN76-3	138.47	222.75°	308.96°	12.87	20.50
	AG76-2	118.40	235.27°	321.57°	13.80	20.15
3	AK72-1	134.89	220.30°	315.10°	10.61	15.68

The next class of smaller southeastern oriented rectilinear pyramids (including AM75-2, AK76-5, AN73-2, AN76-3, and AG76-2) all have secondary axis measurements that are almost exactly 20 m long, and short axes between about 13-17 m in length. The third and final size class in this orientation category includes structure AK72-1, which has secondary axis measurements just below 16 m and a primary axis a little over 10 m long.

Rectilinear Pyramid Group 2

In a slightly different plan for rectilinear pyramid construction, there are several rectilinear pyramids oriented toward the southeast that have EW average azimuths between 291-301°, and NS average azimuths between 197-213°.

Table 4.2: Table expressing various metrics for rectilinear pyramids with a primarily southeastern orientation slightly different from the first group. These structures constitute Rectilinear Group 2 as proposed by this study.

Rectilinear Pyramid Group 2					
Structure Number	Volume (m^3)	NS Average Azimuth	EW Average Azimuth	Primary Axis Measure (m)	Secondary Axis Measure (m)
AJ75-2	370.85	199.79°	301.87°	18.68	23.69
AI79-1	284.92	197.83°	292.55°	15.58	25.12
AJ78-4	143.74	206.30°	299.37°	11.44	15.67
AO73-1	126.18	213.41°	296.27°	12.43	15.64

Since there are fewer examples within this orientation category, scale as expressed by volume and basic axial dimensions will be discussed more generally. Looking at the size metrics for this group, one immediate trend is that these are relatively large buildings. Structure AJ75-2 is the second largest rectilinear pyramid quantified in this study and its primary axis measurements are similar to pyramid AG77-2 from the first group of southeastern oriented pyramids (Table 4.2). Looking at pyramid AI79-1, its dimensions are not particularly similar to any of the structures discussed thus far. It is a relatively large structure (Volume = 284.92) that seems to be oriented toward a narrow plaza to the southeast, also bordered by a heavily terraced area to the slight northeast.

Rectilinear Pyramid Group 3

There are multiple other rectilinear pyramids at Angamuco that seem to have a primarily southwestern directional orientation. This orientational group includes five rectilinear pyramids of varying scale and dimension (Table 4.3). Two of these structures are located in block AD76, about 700 m south of AC75-1 *yácata* complex (Figure 4.8). Rectilinear pyramid AC75-2, which is adjacent to the northern *yácata,* also falls within this group and its proximity to AD76-1 and AD76-2 could mean that similar planning principles were at work for pyramids in this area of the *malpaís.* Looking at Google Imagery for the area, there is considerable modern disturbance including fields, water retention features, and a couple of buildings in close proximity to the identified pyramid structures. Even though there is modern development in this area, it looks like both pyramids are still covered in vegetation. Additionally, these structures are located within what looks like a larger walled area with an irregular modified-diamond shape. In this scenario, it is difficult to distinguish exactly what is modern versus pre-hispanic, but the identified pyramid structures seem to have an orientation and scale like other rectilinear pyramids visible in more clear contexts on the DSM and other data visualizations used for this analysis (see Chpt. 3).

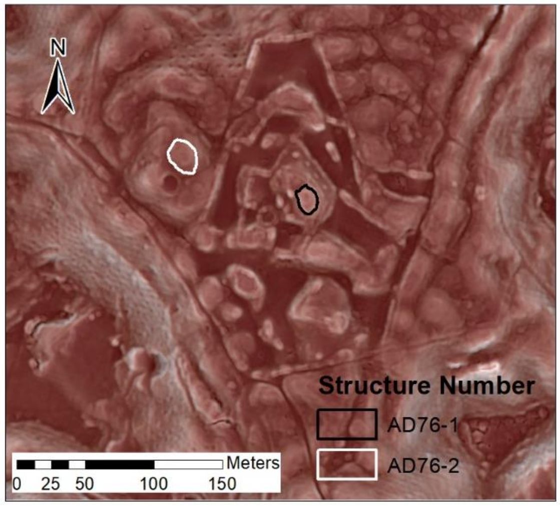

Figure 4.7: Image showing the locations of rectilinear pyramids AD76-1 and AD76-2, outlined in black and white respectively. Image displayed using the RRIM for the site.

Structure AI78-1 is another instance where aspects of building morphology and orientation are less obvious. While the structure does seem rectilinear in form, it is less clear which face of the building to consider the front. This issue is complicated by the fact that the structure is surrounded by sunken areas on multiple sides. Pyramid AI78-1 is definitely a structure, but whether it represents a pyramid, or some other form is less clear. As with nearly all features discussed in this chapter that are outside the LORE-LPB ground survey area, more investigation in the field is needed to confirm these preliminary insights.

Table 4.3: Table expressing various metrics for rectilinear pyramids with a primarily southwestern orientation pattern. These structures constitute Rectilinear Group 3 as proposed by this study

Rectilinear Pyramid Group 3					
Structure Number	Volume (m^3)	NS Average Azimuth	EW Average Azimuth	Primary Axis Measure (m)	Secondary Axis Measure (m)
AD76-2	357.20	134.12°	237.34°	18.12	25.25
AC75-2	271.90	144.71°	226.62°	14.78	20.66
AD76-1	217.81	160.49°	242.65°	14.40	18.86
AE80-1	121.22	159.61°	249.12°	11.13	16.72
AI78-1	110.13	157.39°	250.43°	11.05	16.80

Pyramid AE80-1 represents another context where modern disturbance and activity make it more difficult to confirm that this feature is related to pre-hispanic occupation at Angamuco. This feature is at the base of the southern volcano on the site, on the western side. Again, when the area is viewed using aerial imagery, modern mining activity is obvious adjacent to the pyramid structure. However, the structure itself appears to be in the shadow of the volcano in the image and is therefore not directly visible, making interpretation even more difficult. The reason that this feature is included in this analysis is because it is anomalous for that part of the site and appears to maybe have a plaza or patio area to the southwest. The basic dimensions of this structure (11.13 x 16.72 m) are most like pyramid AJ78-4, discussed as part of Rectilinear Pyramid Group 3 in this analysis, but they have likely been affected by modern activity surrounding the volcano. The EW average azimuth is 249.12°, which is very close to that of AI78-1 also in this group. While southwestern oriented pyramids and temples seem overall less common that those facing toward the southeast at Angamuco, there are several clear examples that seem to be concentrated toward the upper western and central portion of the landform. It is unclear as of now whether this southwestern orientation pattern represents structures built during a similar time period or for similar purposes at different times because all of these structures are located beyond the LORE-LPB ground survey area and we lack enough context for dating.

Rectilinear Pyramid Group 4

In yet another distinctive orientational pattern for rectilinear pyramids, there are four examples that have either primarily southern or northern primary axis orientations toward a clear sunken plaza area. One such structure (AK76-1) is oriented almost due south (NS Average Azimuth = 176.60°), making up the northern border of a deep sunken plaza. Pyramid AK76-1 is a large rectilinear pyramid located in the western central region of the *malpaís*, a little over 250 m north of the landform's edge. This structure has a large sunken plaza directly to the south and another similarly sunken area to the east (Figure 4.9). The calculated volume for the AK76-1 pyramid is 153.89 m^3, however this metric is likely low because of extensive looter damage to southern face of the structure. Despite this disturbance, the dimensions of the pyramid structure (14.31 by 12.76 m) are noticeably smaller than the previously discussed rectilinear buildings with more southeastern orientations. Since the plazas at this complex are so well defined, volumetric calculations were also possible for these features. The plaza directly to the south of pyramid AK76-1 has a volume of 438.71 m^3 and the slightly smaller plaza to the east has a volume of 116.39 m^3. Although the pyramid itself does not seem to be the largest on the site, the immense work that went into the AK76-1 complex is clear when the complex is considered more wholly.

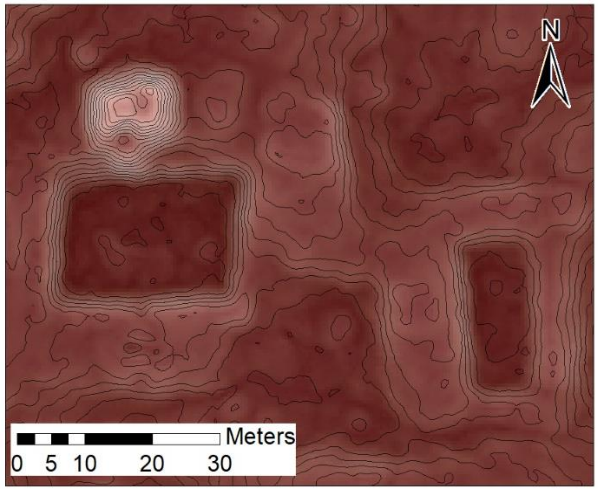

Figure 4.8: Image showing the AK76-1 rectilinear pyramid and associated sunken plazas/patios to the immediate south and east. Image displayed using 10 cm contours overlain on the RRIM for the site.

Pyramid AI72-2 represents a pyramid in this category where the azimuth determination is slightly less certain. This structure is located on the far eastern side of the landform, about 100 m from an edge that drops into modern farm fields. Unlike most of the structures discussed in this chapter, AI72-2 has dimensions that make the building nearly square (11.34 by 11.59 m) and there are sunken plaza or patio-like areas to the immediate east and south. Based on the 10 cm contours for this block produced from the DSM, a square-ish platform is also present underneath the pyramid. With a volume of 119.76 m^3, this structure is smaller than others considered in this group and its morphology is slightly different. It may be that this structure (AI72-2) represents a modified pyramid form, or that its dimensions have been affected by post-depositional processes. As of now, the morphology and directional orientation of this structure should be considered tentative pending more investigation (Table 4.4).

Table 4.4: Table expressing various metrics for rectilinear pyramids that appear to be primarily oriented along north and south cardinal directions. These structures constitute Rectilinear Group 4 as proposed by this study.

Rectilinear Pyramid Group 4					
Structure Number	Volume (m^3)	NS Average Azimuth	EW Average Azimuth	Primary Axis Measure (m)	Secondary Axis Measure (m)
AM73-1	195.20	204.17°	293.49°	13.39	15.21
X77-1	185.40	186.79°	269.14°	11.69	21.32
AK76-1	153.89	176.60°	254.40°	12.76	14.31
AI72-2	119.76	184.61°	272.29°	11.34	11.59

AM73-1 (MO 2768) is an additional example of this format that has already been documented through the course of LORE-LPB ground survey (Figure 4.10). Prior to this analysis, this was the largest rectilinear pyramid documented at the site and it has as least four courses, standing about 15 m high. According to Fisher et al (forthcoming publication), the remains of a perishable structure are visible on top of the pyramid and a stairway that ran along the primary axis of the western face would have provided access to this space. The primary (NS) average axis azimuth measured in this study for AM73-1 (MO 2768) is 204.17°, which is not as close to due south as the previous structure mentioned in this group (AK76-1). This angle is more like the NS average azimuth of pyramids mentioned as part of Rectilinear Pyramid Group 2 (e.g. AJ78-4), however, in that group the NS axis represents the secondary (long) axis of the structure. The primary axis of the structure measures 13.39 m and the secondary axis is 15.21 m. These dimensions are slightly larger than pyramid AK76-1, but not dissimilar and the volume reflects this pattern as well (182.36 m^3). Structures AK76-1 and AM73-1 are similar to Middle Postclassic rectilinear pyramid contexts excavated at Prieto in the Zacapu Basin. Like these examples to the north, the southward facing pyramid and sunken plaza complexes at Angamuco

likely served ritual purposes related to religious and funerary activity (Fisher et al., forthcoming publication; Forest 2014; Pereira et al. 2012).

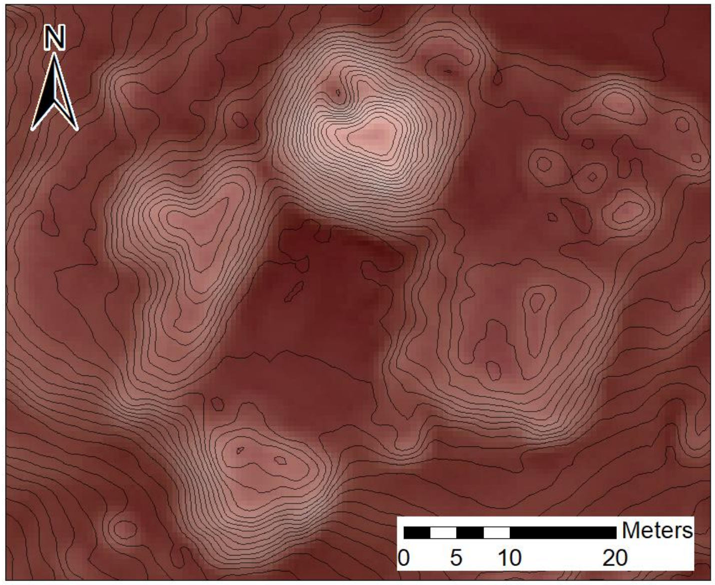

Figure 4.9: The AM73-1 rectilinear pyramid complex showing sunken plaza to the south, proto-yacatá (AM73-2) to the west, and leveled area to east. Image displayed using 25 cm contours over the RRIM for the site.

Structure X77-1 is at the extreme north of the data set, about 1 km west of the modern town of Atzimbo. This structure may not be a structure or may even be related to modern activity, but features in this area are less clear due to what looks like extensive erosion. This feature has a secondary axis measuring 21.32 m and a primary axis measuring 11.69 m. With a volume of 185.40 m^3, the general scale and dimensions of this feature do not necessarily rule it out as a pyramid structure, but the orientation appears to be almost due north toward a possible rectilinear plaza, making this feature different than all other pyramids analyzed in this study. Additionally, the location of this pyramid at the far north end of the dataset makes it even more anomalous.

Rectilinear Pyramid Outliers

Based on this analysis, there are two pyramids at Angamuco whose spatial characteristics set them apart from other rectilinear pyramids that have thus far been discussed. The first of these is pyramid AF74-1, which is located in the northwestern portion of the landform. The scale and axial dimensions of this feature are not particularly exceptional, however, when looking at the EW average azimuth (283.06°), it falls directly in a narrow range with the southern keyhole pyramid (AN73-1) and both ballcourt features (AN73-5 and AO73-5) that were measured in this analysis (Table 4.5). Given that the average azimuths for structure AF74-1 have relatively high standard deviations, this similarity in angles could be less pronounced, but it is clear looking at the DSM that AF74-1 has a slightly different orientation than other southeastern facing rectilinear pyramids at the site. Furthermore, the fact that AF74-1 is located on the western side of the landform like *yácata* AN73-1 strengthens the argument for their overall similar orientation.

Table 4.5: Table expressing rectilinear pyramid 'outliers' from Angamuco.

Rectilinear Pyramid Group 4					
Structure Number	Volume (m^3)	NS Average Azimuth	EW Average Azimuth	Primary Axis Measure (m)	Secondary Axis Measure (m)
AE75-1	328.44	198.72°	271.53°	14.04	16.95
AF74-1	113.63	210.12°	283.06°	10.45	13.28

The next pyramid included in this outlier section is a rectilinear pyramid (AE75-1) on a platform that appears to have a different morphology and/or configuration than other pyramids identified. It seems based on this spatial analysis that structure AE75-1 has also suffered significant disturbance due to likely looting and agricultural activity like several other pyramids on the site (Figure 4.11). The volume calculated for this structure represents what appears to be a pyramid on top of a broader platform. Due to the damage to this structure, which appears focused on the southeastern side, its form is somewhat unclear, and its dimensions have likely been affected as well. The azimuth distinctions for this structure (see Table 4.5) do seem representative of the pyramid overall, but they are admittedly more tentative because of the obvious damage.

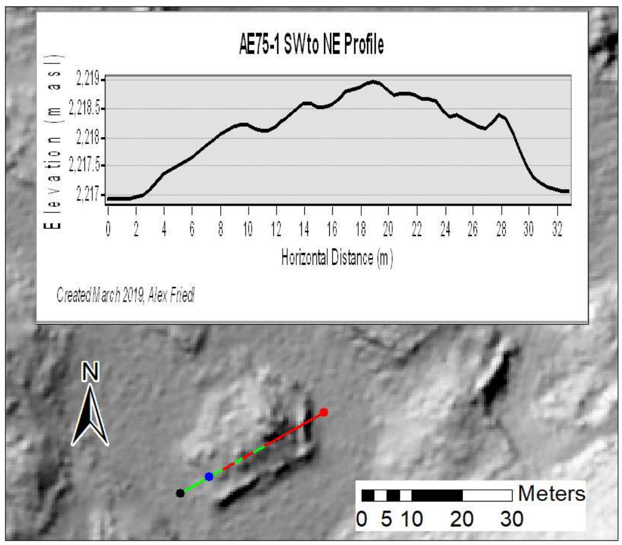

Figure 4.10: AE75-1 Platform and structure rectilinear axis profile demonstrating extensive looter damage. Below, the line of sight is shown across the structure, which is displayed using a multi-directional hillshade derived from the 50 cm resolution DEM.

Ballcourts

In addition to identifying and quantifying 26 different pyramids for this analysis, the average NS and EW azimuths were calculated for two features at the site that had already been identified as potential ballcourts. Prior to the identification of these features at Angamuco, no ballcourts had been documented in the Lake Pátzcuaro Basin, but these spaces are common throughout other parts of Mexico, including in the Zacapu Basin (Michelet et al. 1995; Taladoire 1989) and at Tingambato (Piña Chan and Oi 1982) (Fisher et al., forthcoming publication). Both of these features are located toward the southern end of the landform. Ballcourt AO73-5 is an I-shaped feature that is the first of its kind to be recorded in the lake basin and it is located just over 250 m to the southeast of the AN73-1 *yácata* complex and about 100 m northwest of rectilinear pyramid AO73-1.

Ballcourt AN73-5 is located about 120 m northwest of the AN73-1 *yácata* and its morphology is slightly different than that of AO73-5. The shape is vaguely I-like, but it is more clearly divided into three parts, with elevated areas on either side of what would presumably be the playing court. This area has thus far not been surveyed on the ground, but because of its general configuration and proximity to other important civic and ceremonial features, it has been included in this analysis. Even if this space does not represent a ballcourt, it likely functioned as an important landscape feature linked to civic and ceremonial purposes as it is unique among other plaza-like constructions at the site.

Interestingly, the average NS and EW average azimuths for both ballcourt features are very similar, and the EW average azimuths in particular are like those of the major southern keyhole pyramid (AN73-1). Ballcourts AN73-5 and AO73-5 have average EW azimuths between 282-285° and average NS azimuths around 195-200°. Additionally, these angles are similar to rectilinear pyramid AF74-1, which is also located on the western side of the landform. Compared to many of the average azimuths calculated for this study, the ballcourts have relatively low standard deviations, adding weight to their directional determinations. More archaeological investigation is needed to understand the temporal context of these features, but their construction at similar angles to other civic and ceremonial features on the site was likely not accidental.

General Trends in Monumental Architecture at Angamuco

A GIS-based analysis of Lidar derived products from Angamuco confirm that there are numerous pyramid and temple complexes present across the entire site. When the axial orientation of these buildings is compared in conjunction with their scale, and other spatial characteristics, several patterns begin to emerge.

As previously suggested, understanding the scale and distribution of monumental architecture at a site can provide insights into shifting power relationships (Trigger 1990). Also, when buildings share orientations and/ or arrangements in reference to common features, this can provide evidence for architectural and urban planning (Smith 2007). Patterns in the scale and arrangement of pyramid and temple complexes revealed through the course of this analysis provide further evidence for the coordinated arrangement of buildings and space at Angamuco (see Bush 2011). The majority of pyramids, temples, and ballcourts at the site fit into five major categories for directional orientation, and their volumetric scale as well as basic axial dimensions help to further comparative abilities (Figure 4.12).

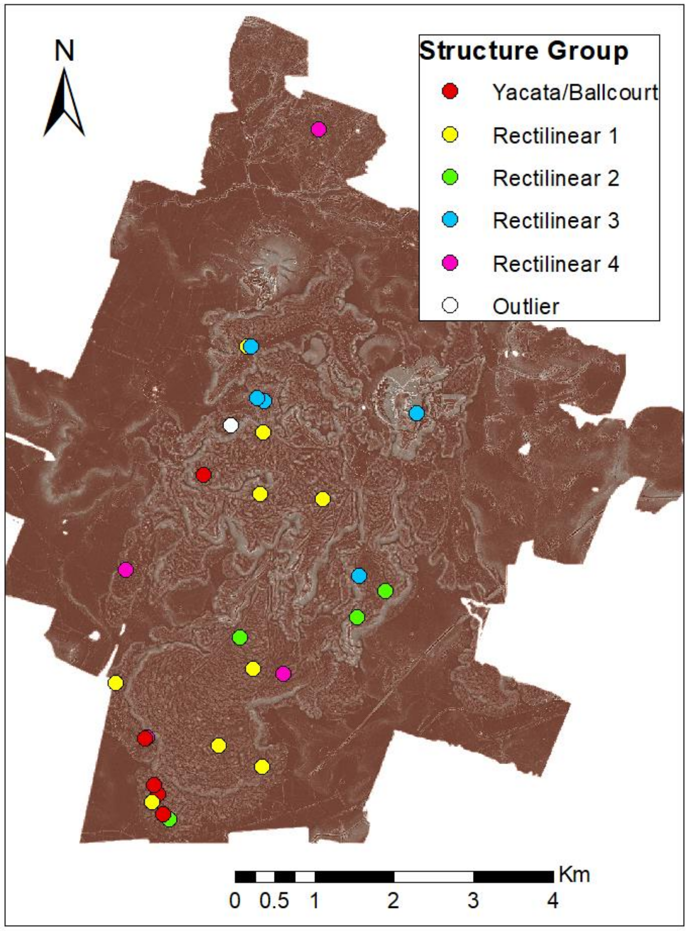

Figure 4.11: Map showing the pyramids of Angamuco, categorized into orientation groups as proposed by this study. Displayed over the RRIM for the site.

Generally speaking, most pyramid structures at Angamuco have a southeastern orientation toward some type of sunken plaza or patio (including Rectilinear Groups 1 and 2 in Figure 4.11). Additionally, nearly all the pyramids are located relatively close to the edge of the volcanic landform, where they would have been both visible and accessible from various points on the landscape. The construction of pyramids and temples on the sides of hills and mountains is common throughout the Purépecha world since it put people physically closer to the sky, which was considered the realm of the gods. Placement on hills had the additional practical benefit of not occupying valuable agricultural land and increasing the monumentality of structures without excessive increases in construction costs (Pollard 1993: 152). The largest pyramids on the site fall into the keyhole or *yácata* category and this makes sense as they are typically associated with the Postclassic Purépecha empire and increasingly consolidated hierarchical political organization in the region. It is clear based on this analysis that many of the pyramids and temples at Angamuco can be grouped together, at least tentatively, based on directional orientation. Although the averaging of azimuths can create results with fairly high standard deviations (see discussion Chapter 3), understanding even the general distribution of azimuths in an area can be a useful way to identify building patterns. The five building groups discussed above are intended to be an initial framework for intra-site comparison of pyramid and temple complexes at Angamuco.

Although more work is needed to refine these categories based on directional orientation and scale, there are several insights we can draw from these results related to their meaning within the broader built environment. In the next chapter, possible implications of these patterns will be discussed with attention to how they could inform our understanding of the evolution of monumental architecture at the site.

CHAPTER 5 : CONCLUSION

Unlike many cultures in Mesoamerica, the Purépecha have received relatively little consideration from archaeologists. Although extensive investigations have occurred at sites around the shores of Lake Pátzcuaro, there is little explanation in the dominant regional narrative and ethnographic sources for significant urban centers located outside the traditionally defined geopolitical core. In an effort to demonstrate that Angamuco is indeed a significant ancient Mesoamerican urban center located in western LPB, I have identified pyramid and temple features across the landscape and quantified them using various metrics, creating the opportunity for basic intra-site and regional comparison.

In order to complete this research, I used digital models of the earth's surface derived from Lidar data, which provide a highly accurate representation of architectural features on the ground. I also used ESRI ArcMap 10.6 software toolkits to measure various spatial traits of each pyramid and temple feature, including their volume, basic dimensions, and axial orientations. When this data is compared on an intra-site level, general patterns for building orientation begin to emerge, with the potential for subgroups based on variation in scale. These orientational categories, as well as similarities between dimensions of these features suggest that there were multiple seemingly standardized forms for pyramid and temple construction at the site. In several examples from the site, building orientations also clearly correspond to a broader Mesoamerican tradition for urban planning, with primary and/or secondary axial angles between 15-17° askew of cardinal directions.

Looking at the general spatial distribution of pyramid and temple structures at the site, they tend to be located on the edges of the volcanic landform, or at points where the landform narrows and is accessible from the east and west. This distribution could be explained by the increased ruggedness of the interior of the *malpaís,* which would make coordination of monumental building projects more difficult. At this time, there are no obvious patterns in the distribution of structures as it relates to the orientational groups delineated in the previous chapter. It appears that most of the pyramids and temples were built on already naturally elevated areas like the civic ceremonial mound excavated in the mid-eastern portion of the site in 2014. This should be considered a general observation though, because the natural and built environment are not always easy to separate from the digital surface model. However, the fact that there are 26 total pyramid and temples at the site represents a significant finding in and of itself. At the imperial capital of Tzintzuntzan both *yácata* and rectilinear pyramids have been identified, but not in numbers like Angamuco. Tzintzuntzan is the Purépecha site with the most known *yácata* pyramids (five), but Ihuatzio is the next most significant *yácata* context, featuring only two. Angamuco has what appears to be two formal *yácata* structures, putting it on par with sites like Ihuatzio.

Monumental architectural features communicate important social messages, that can be conceptualized in terms of their high-level and middle-level meaning as defined by Amos Rapoport (1990). In an effort to access some of the socio-cultural meaning of these structures, archaeologists can examine form, dimension, scale, and directional orientation. Smith (2007: 34-5) contends that this type of data can allow for insights on the power of the state or ruling body, as well as its control of labor forces, and the degree to which hierarchical political control is consolidated within a society. At Angamuco, pyramid and temple structures seem to fall into four major orientational groups, which indicates some level of building standardization and the utilization of urban planning principles for monumental architecture at the site. These categories contain pyramids of varying scale and form, possibly representing differentiation related to status and power at the site.

While it is not possible to know putative astronomical targets for individual building alignments without calculating distance to horizon and declination angles to specific stars, we can begin to interpret the directional orientations at Angamuco through the lens of more broadly established orientation patterns for civic and ceremonial architecture in Mesoamerica. As summarized by Šprajc (2018), there are several pervasive orientation patterns for these constructions that have been reliably linked to the observance of solar cycles, as well as the movements of Venus and the moon. Generally speaking, solar building alignments tend to have EW azimuths between 65-115° (or 235-305°). When looking at all of the average EW azimuths calculated for this study (Figure 5.1), most of the structures appear to fit within that range, with the exception of the eight southeastern oriented pyramids that comprise Rectilinear Group 1 and the northern *yácata* pyramid (AC75-1), which faces in a similar southeastern direction. Aside from Rectilinear Group 1, all other pyramid groups discussed in the previous chapter include buildings that could be aligned along their EW axes to solar cycles based on the aforementioned basic azimuth criteria.

At this point in time it is not possible to know how many of these structures have alignments that make them observationally functional in terms of celestial calendars, but there are several constructions at Angamuco that seem to closely align with known orientation patterns in Mesoamerica that have been linked to the observance of sunrises and sunsets on particular dates. In the widespread analysis of Mesoamerican building orientations conducted by Šprajc (2018), several different observational calendars were reconstructed for popular solar alignments that involved a skew from cardinal directions between 11-17°. A full discussion on

Mesoamerican calendrics is beyond the scope of this thesis, but it is important to note that each solar aligned building marks 4 separate dates (2 sunrises and 2 sunsets) that likely broke up the year into significant intervals related to the scheduling of agricultural activities. Based on this analysis, there are four civic and ceremonial structures at Angamuco that have EW axes around 11-17° north of west. These structures include the major southern *yácata* (AN73-1), both ballcourts (AN73-5 and AO73-5), and rectilinear pyramid AF74-1. Although the orientation of these features cannot yet be definitively linked to the observance of sunrises and sunsets, it is intriguing that three of the most prominent civic and ceremonial constructions (AN73-1, AN73-5, and AO73-5) on the site have EW average azimuths that fall within such a tight range. This orientation pattern is also one of few revealed during the course of this analysis that seems to have a clear locational association on the landscape, with all four structures in this category confined to the western side of the Angamuco *malpaís.* Since *yácata* or keyhole style pyramids are associated with the Postclassic Purépecha empire, it is reasonable to speculate that the large southern *yácata* (AN73-1) could have been built to honor the sun god Curicaueri. We know from ethnographic sources that each Tarascan temple seems to have been devoted to worship of a particular deity, and this includes the five *yácatas* at the state capital of Tzintzuntzan, which were committed to the glorification of Curicaueri and his five brothers (Pollard 1993: 152).

Mesoamerican building orientations have also been associated with significant peaks on the local horizon and orientations may mark solar cycles over those features as well. This attention to sunrises and sunsets over local significant natural peaks seems to have influenced building construction throughout Western Mexico and the Maya regions, and prominent examples of this phenomenon have been documented at sites like Xochicalco (Morelos, Mexico) where the Late Classic period Pyramid of the Feathered serpents and the eastern section of the acropolis are aligned to a hilltop marking sunrises on calendrically important dates (Šprajc 2018: 214-215). It was suggested to me by Chris Fisher (personal communication, 2019), that the alignment of the formal southern *yacatá* and associated features could be intended to face westward, toward Lake Pátzcuaro and the Cerro Tariacuri peak on its western shore. The visibility of this topographic feature from Angamuco was not analyzed as a part of this study, but it could represent an interesting avenue for future research. The orientations of other buildings at the site should also be analyzed for their potential alignment with the two volcanoes at the north end of the site that formed the landform. It may be that multiple structures at Angamuco are angled in relation to significant local topographic features, but no other specific connections between the natural and built environment can be proposed at this time.

When it comes to interpreting meaning from the rest of the pyramid orientations at Angamuco, associations between directionality in the built environment and cosmological observances becomes less clear. There are certainly clusters that are visible in the distribution of EW average azimuths (Figure 5.1) that suggest that certain structures have similar directional orientations, but more archaeoastronomical research is needed to make any concrete conclusions about how Purépecha worldview may have influenced the planning of civic and ceremonial features. As mentioned in Chapter 1, Ihuatzio, located on the eastern shore of Lake Pátzcuaro, is the only site in the Purépecha world that is brought up in the literature in reference to ritual orientation (see Pollard 1993: 151-152). It is believed that the two rectilinear pyramids on the platform overlooking a plaza to the east are dedicated to the Purépecha moon goddess, Xarátanga, and that their orientation is related to observance of equinox points in the lunar cycle. Despite this conclusion, there is no azimuth data reported for the site. In Šprajc's (2018) analysis of civic and ceremonial architecture orientations across Mesoamerica, he concluded that the observance of lunar and Venus cycles were likely reasons for many of the azimuth orientations around 120° (or 300°). At Angamuco, this generalized azimuth is most similar to EW average azimuths for pyramids in Rectilinear Group 2, however, it is not that far off from the same directional azimuths for Rectilinear Group 1. Given that there can be considerable variation in building orientations intended to capture different points in the same celestial cycles, it is impossible to say at this time which pyramids at Angamuco were angled for lunar, Venus, or other more minor star cycles. From a cosmological perspective, it would make sense for most Purépecha sites to have pyramids or temples devoted to the moon and Venus because we know from the RM (Alcalá 2011) that two of the major religious cults were linked to these celestial bodies. Cuerauáperi, the Tarascan creator goddess associated with rain from the east (Pollard 1993), encompasses similar themes to many fertility goddesses across cultures in Mesoamerica that were associated with the northern and southern extremes of Venus. Based on ethnohistoric identifications, we know there are temples devoted to Cuerauáperi at the site of Zinapécuaro in the Lake Cuitzeo Basin, but the orientation of these structures has not been analyzed thus far. It is also quite possible that some of the pyramids at Angamuco are oriented for observance of lunar cycles, likely linked to the worship of Xarátanga, goddess of the sea, the west, and the moon. The two rectilinear pyramids at Ihuatzio are devoted to Xarátanga and have an alignment related to the lunar cycle, but it is unclear whether the y*ácatas* at the same site are also related to the goddess, or if they were linked to the sun god Curicaueri, like the five *yácatas* at Tzintzuntzan (Pollard 1993: 152). The only way to tell apart building alignments related to the movements of Venus and the moon are to calculate distance to the horizon and exact declinations for each structure. According to Šprajc's (2018) study of building alignments across Mesoamerica, potential Venus orientations occur with the greatest frequency in the Yucatán peninsula (e.g. El Caracol, an Early Postclassic circular temple at Chichén Itzá) and the construction of these features seems to be confined to the Classic and Postclassic periods.

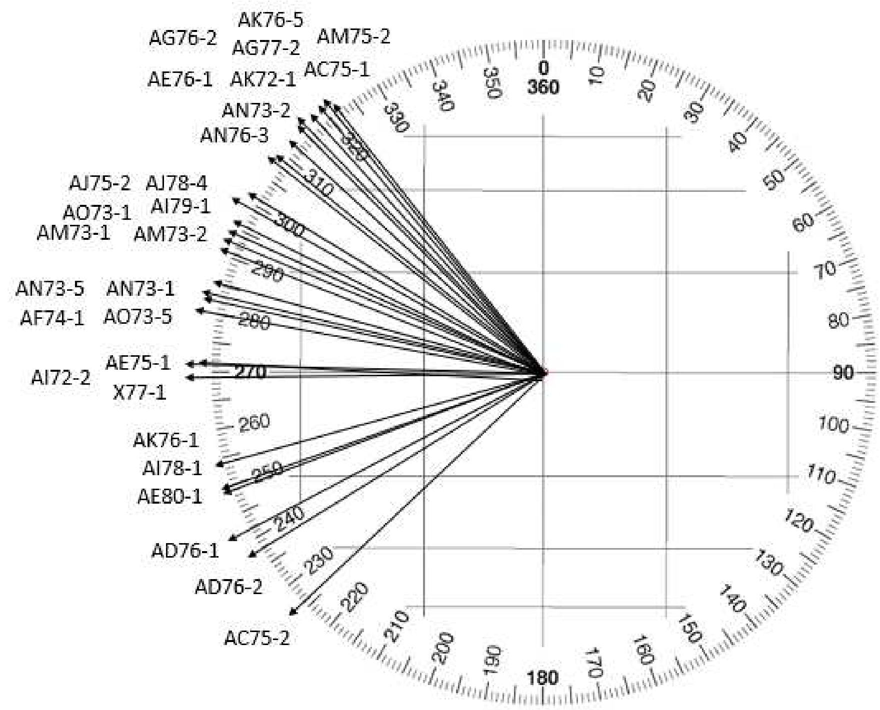

Figure 5.1: Figure showing all EW average azimuths calculated for structures during the course of this study. Note multiple visible clusters, which helped inform orientation groupings proposed in the previous chapter.

As of now, more data collection for specific declinations is needed at Angamuco before individual celestial targets for building alignments can be proposed. In addition to alignments to the major cycles of the sun, the moon, and Venus, alignments to other more minor stars have been proposed for buildings throughout Mesoamerica (e.g. Aveni 2001: 262-271; Dow 1967; Milbrath 1999: 271–273; Popenoe de Hatch 2002). These hypotheses are often based on information from ethnographic sources and they can be difficult to examine because they refer to unique cases with little support from independent data (Šprajc 2018: 217). The next step in continuing this research on directional orientation at Angamuco should include the calculation of distance to horizon and declinations for each feature. Only after the azimuth data is combined with declination data can we begin to make clear associations between orientation patterns and particular celestial observances.

As previously suggested, the patterned orientation and multi-scalar variation of monumental urban structures can provide insights on the sociocultural evolution of a society. One particular finding in this research that could be related to this process is the similarity in orientation between the major northern *yacatá* (AC75-1) and structures in Rectilinear Pyramid Group 1. Since the northern keyhole pyramid (AC75-1) does not match the orientation of the formal *yacatá* pyramid at the southern end of the site, it could suggest they were built at different times or planned according to different spatial principles. We know from LORE-LPB survey that the proto-*yacatá* (AM73-2 or MO 2740) was an accretionary structure, with the rounded element likely constructed after the rectilinear element. Based on the similarity in orientational patterns between the northern *yacatá* and other major rectilinear pyramids at the site, it is possible that AC75-1 could have also been modified through time. In ancient societies, increasing levels of social complexity are often linked with the increased scale and elaborateness of monumental architecture. As Purépecha imperial influence became consolidated at Angamuco, it is possible that the circular element of *yacatá* AC75-1 was added to an already significant rectilinear pyramid as an effort to co-opt the space on the landscape and assert a new political order. This is only speculation, but the difference in orientation between the two major *yacatá* structures is likely not accidental.

Excavation data from the 2013-2014 LORE-LPB field seasons provides additional context for the meaning of monumental architecture at Angamuco. In the Area C excavations, the plaza area and altar located immediately in front of the southeastern pyramid face were clearly associated with ritual activities, including funerary ceremonies and construction episodes. The presence of certain architectural elements related to the altar context, as well as burials with polychrome vessels and tripod bowls link the area to the Purépecha elite and suggest that the altar was a significant feature in Area C. Although we do not have excavation data directly from a pyramid context, many of these buildings would likely have served ritual purposes and excavation of pyramid and temple complexes at other sites in the ancient Purépecha territory have supported this notion.

At the current research stage, specific meanings for monumental architecture at Angamuco cannot be proposed. While it seems that several buildings could conform to larger Mesoamerican patterns for directional orientations, further research is needed at the site to understand the reasons for these orientational patterns, especially in relation to significant dates in the agricultural cycle and visibility of significant local topographic peaks. The orientational categorization of pyramids in this thesis is intended to create a foundation for the further analysis of variation within these structures across the site, and the region as a whole. Through the continued examination of spatial patterning between pyramid and temple buildings and other significant features of the built environment at Angamuco, we will be able to draw stronger conclusions related to the social meaning of architecture at the site and establish it as a part of a greater Mesoamerican urban tradition.

REFERENCES

Abrams, Elliot M.

1989 Architecture and energy: An evolutionary perspective. *Archaeological method and theory* 1:47–87.

1994 *How the Maya built their world: energetics and ancient architecture*. University of Texas Press. Austin.

Acosta, Jorge

1939 Exploraciones arqueológicas realizadas en el estado de Michoacán durante los años de 1937 y 1938. *Revista mexicana de estudios antropológicos* 3(2):85–99.

Alcalá, Jerónimo de

2011 *Relación de Michoacán*. Linkgua digital.

Arnauld, Marie Charlotte, and Brigitte Faugère-Kalfon

1998 Evolución de la ocupación humana en el Centro-Norte de Michoacán (Proyecto Michoacán, CEMCA) y la emergencia del Estado Tarasco. In *Génesis, culturas y espacios en Michoacán*, edited by Véronique Darras, pp. 13–34. Centre d'Etudes Mexicaines et Centre-Américaines, Mexico City.

Arnauld, Marie-Charlotte, Patricia Carot, and Marie-France Fauvet-Berthelot

1993 Arqueología de las Lomas en la cuenca lacustre de Zacapu. *Cuadernos de Estudios Michoacanos* 5.

Aveni, Anthony F.

2001 *Skywatchers: a revised and updated version of Skywatchers of ancient Mexico*. University of Texas Press. Austin.

Aveni, Anthony F., Edward E. Calnek, and Horst Hartung

1988 Myth, environment, and the orientation of the Templo Mayor of Tenochtitlan. *American Antiquity* 53(2):287–309.

Aveni, Anthony F., and Sharon L. Gibbs

1976 On the orientation of precolumbian buildings in central Mexico. *American Antiquity* 41(4):510–517.

Aveni, Anthony, and Horst Hartung

1986 Maya city planning and the calendar. *Transactions of the American Philosophical Society* 76(7):1–87.

Baker, Geoffrey H.

2003 *Design strategies in architecture: an approach to the analysis of form*. Taylor & Francis. Oxfordshire.

Beaumont, Pablo de la Purísima Concepción

1932 *Crónica de Michoacán*. No. 19. Talleres gráficos de la nación.

Bradbury, J. Platt

2000 Limnologic history of Lago de Patzcuaro, Michoacan, Mexico for the past 48,000 years: impacts of climate and man. *Palaeogeography, Palaeoclimatology, Palaeoecology* 163(1–2):69–95.

Broda, Johanna

1991 Cosmovisión y observación de la naturaleza: el ejemplo del culto de los cerros en Mesoamérica. *Arqueoastronomía y etnoastronomía en Mesoamérica*: 461–500.

1993 Astronomical knowledge, calendrics, and sacred geography in ancient Mesoamerica. *Astronomies and Cultures*, University Press of Colorado, Niwot: 253–295.

Burger, Richard L., and Robert M. Rosenswig

2012 *Early new world monumentality*. University Press of Florida. Gainesville.

Bush, Jason W.

2012 Architectural patterning in the Purepecha heartland: An intrasite settlement study at the urban center of Sacapu Angamuco, Michoacán, México. Unpublished MA Thesis, Colorado State University. Fort Collins.

Cárdenas García, Efraín

1999 *El Bajío en el clásico: análisis regional y organización política*. El Colegio de Michoacán AC. Zamora.

Carlson, John B.

1981 A geomantic model for the interpretation of Mesoamerican sites: an essay in cross-cultural comparison. in *Mesoamerican Sites and World-views*, ed. Elizabeth P. Benson. Dumbarton Oaks. Washington, D.C: 143-216.

Carrasco, David

2000 *City of sacrifice: The Aztec empire and the role of violence in civilization*. Beacon Press. Boston.

Castro-Leal Espino, Marcia

1986 *Tzintzuntzan, capital de Los Tarascos*. Gobierno del Estado de Michoacán, Morelia, Michoacán.

Chacón-Torres, Arturo

1993 Lake Patzcuaro, Mexico: watershed and water quality deterioration in a tropical high-altitude Latin American lake. *Lake and Reservoir Management* 8(1):37–47.

Chacón-Torres, Arturo, and Elizabeth Múzquiz-Iribe

1997 Climatic trends, water balance and Lake Pátzcuaro, a tropical high altitude lake. *Quaternary International* 43:43–51.

Chan, Román Piña, and Kuniakí Oi

1982a *Exploraciones arqueológicas en Tingambato, Michoacán*. Instituto Nacional de Antropología e Historia. Mexico.

1982b *Exploraciones arqueológicas en Tingambato, Michoacán*. Instituto Nacional de Antropología e Historia. Mexico.

Chase, Arlen F., Diane Z. Chase, Christopher T. Fisher, Stephen J. Leisz, and John F. Weishampel

2012 Geospatial revolution and remote sensing LiDAR in Mesoamerican archaeology. *Proceedings of the National Academy of Sciences* 109(32):12916–12921.

Chiba, Tatsuro, Shin-ichi Kaneta, and Yusuke Suzuki

2008 Red relief image map: new visualization method for three dimensional data. *The international archives of the photogrammetry, remote sensing and spatial information sciences* 37(B2):1071–1076.

Clark, John E.

2004 Mesoamerica goes public: Early ceremonial centers, leaders, and communities. in *Mesoamerican Archaeology: Theory and Practice*, ed. Julia A. Hendon and Rosemary Joyce, Blackwell, Oxford: 43-72, 61.

Coe, Michael D.

2003 *Angkor and the Khmer Civilization (Ancient Peoples and Places)*. New York: Thames and Hudson. Oxford.

Cohen, Anna Stephanie

2016 Creating an Empire: Local Political Change at Angamuco, Michoacan, Mexico. Unpublished PhD Dissertation. University of Washington, Seattle.

Cowgill, George L.

2003 Teotihuacan: Cosmic glories and mundane needs. *The Social Construction of Ancient Cities,* Smithsonian Institution Press, Washington, DC:37–55.

Cruz Robles, Concepción, José Rodolfo Cid Beziez, and Salvador Pulido Méndez

2014 Lagunillas, un sitio uacúsecha en la perifiera de la Meseta Tarasca. *Arqueología* 47:67–89.

Darras, Véronique

2006 Las relaciones entre Chupícuaro y el Centro de México durante el Preclásico reciente. Una crítica de las interpretaciones arqueológicas. *Journal de la Société des Américanistes* 92(92–1 et 2):69–110.

Darras, Véronique, and Brigitte Faugére

2005 *Cronología de la cultura Chupícuaro: estudio del sitio La Tronera, Puruaguita, Guanajuato*. Colegio de Michoacán. Zamora.

Darras, Véronique, and Brigitte Faugère

2010 Chupicuaro and the Preclassic shaft tomb tradition. *Mexicon*:22–30.

Darras, Véronique, Brigitte Faugére, Christophe Durlet, Catherine Liot, Javier Reveles, Rosalba Bérumen, Omar Cervantes, Cédric Caillaud, and Cybèle David

1999 Nouvelles recherches sur la culture Chupicuaro (Guanajuato, Mexique). *Journal de la Société des Américanistes* 85:343–351.

Dow, James W.

1967 Astronomical orientations at Teotihuacan, a case study in astro-archaeology. *American antiquity* 32(3):326–334.

Eliade, Mircea

1959 *The sacred and the profane: The nature of religion*. Vol. 144. Houghton Mifflin Harcourt. Boston.

Fernández Villanueva, E.

2004 Evidencias de una tradición mesoamericana en Zaragoza. *Tradiciones arqueologicas, Colegio de Michoacán, Zamora*: 291–306.

Fisher, Christopher T.

2005 Demographic and landscape change in the Lake Pátzcuaro basin, Mexico: abandoning the garden. *American Anthropologist* 107(1):87–95.

Fisher, Christopher T., Jason W. Bush, Florencia Pezzutti, and Anna S. Cohen

2011 *Legados de la Resiliencia: La Cuenca del Lago de Pátzcuaro Proyecto Arqueológico (proyecto LORE-LPB). Proyecto Informe Técnico Parcial, Temporada 2010.* Instituto Nacional de Antropología e Historia, Mexico.

Fisher, Christopher T., Anna S. Cohen, Juan Carlos Fernández-Diaz, and Stephen J. Leisz

2017 The application of airborne mapping LiDAR for the documentation of ancient cities and regions in tropical regions. *Quaternary International* 448:129–138.

Fisher, Christopher T., Anna S. Cohen, Karine Lefebvre, Rodrigo Solinis-Casparius, Florencia Pezzutti, and Kyle Urquhart

2014 *Legados de la Resiliencia: La Cuenca del Lago de Pátzcuaro Proyecto Arqueológico (proyecto LORE-LPB). Proyecto Informe Técnico Parcial, Temporada 2013.* Instituto Nacional de Antropología e Historia, Mexico City.

Fisher, Christopher T., Anna S. Cohen, Rodrigo Solinis-Casparius, Florencia Pezzutti, Jason W. Bush, Marion Forest, and Andrea Torvinen

2019 A Typology of Ancient Purépecha (Tarascan) Architecture From Angamuco, Michoacán, Mexico. forthcoming publication.

Fisher, Christopher T., Anna S. Cohen, Rodrigo Solinis-Casparius, Kyle Urquhart, Cynthia Cárdenas, Sandra Damas, and Florencia Pezzutti

2016 *Legados de la Resiliencia: La Cuenca del Lago de Pátzcuaro Proyecto Arqueológico (proyecto LORE-LPB).Proyecto Informe Técnico Parcial, Temporadas 2013-2014.* Instituto Nacional de Antropología e Historia, Mexico City.

Fisher, Christopher T., and Stephen J. Leisz

2013 New perspectives on Purépecha urbanism through the use of lidar at the site of Angamuco, Mexico. In *Mapping archaeological landscapes from space*, pp. 199–210. Springer.

Fisher, Christopher T., Florencia Pezzutti, Anna S. Cohen, and Rodrigo Solinis-Casparius

2012 *Legados de la Resiliencia: La Cuenca del Lago de Pátzcuaro Proyecto Arqueológico (proyecto LORE-LPB). Proyecto Informe Técnico Parcial, Temporada 2011.* Instituto Nacional de Antropología e Historia, Mexico City.

Fisher, Christopher T., Helen P. Pollard, and Charles Frederick

1999 Intensive agriculture and socio-political development in the Lake Pátzcuaro Basin, Michoacán, Mexico. *Antiquity* 73(281):642–649.

Fisher, Christopher T., Helen P. Pollard, Isabel Israde-Alcántara, Victor H. Garduño-Monroy, and Subir K. Banerjee

2003 A reexamination of human-induced environmental change within the Lake Patzcuaro Basin, Michoacan, Mexico. *Proceedings of the National Academy of Sciences* 100(8):4957–4962.

Forest, Marion

2014 L'organisation sociospatiale des sites urbains du Malpais de Zacapu [1250-1450 aprés J.-C.]. Unpublished Ph.D. dissertation, Université Paris 1 - Panthéon-Sorbonne, Paris.

Freidel, David A., and Jeremy A. Sabloff

1984 *Cozumel: Late Maya Settlement Patterns (Studies in Archaeology)*. Academic Press, New York.

Galindo Trejo, Jesús

1994 Arqueoastronomía en la América antigua. *Coleccion La Ciencia y la Tecnologia en la Historia,* Equipo Sirius, Madrid.

González-García, A. César

2015 Lunar Alignments-Identification and Analysis. *Handbook of Archaeoastronomy and Ethnoastronomy*: 493–506.

Gorenstein, Shirley, and Helen Perlstein Pollard

1983 *The Tarascan civilization: a late Prehispanic cultural system*. 28. Vanderbilt University, Nashville.

Gutschow, Niels

1993 Bhaktapur: sacred patterns of a living urban tradition. *Studies in the History of Art* 31:163–183.

Hartung, Horst

1977 Relaciones urbanísticas lineales-visuales en Teotihuacan y su zona de influencia. *Los Procesos de Cambio*:267–275.

1979 El ordenamiento espacial en los conjuntos arquitectónicos mesoamericanos: el ejemplo de Teotihuacan. *Comunicaciones, Proyecto Puebla-Tlaxcala* 16:89–103.

Hartung, Horst, and Anthony F. Aveni

1978 Los Observatorios astronómicos en Chichen Itza, Mayapan y Pallmul. *Boletín de la Escuela de Ciencias Antropológicas de la Universidad de Yucatán*(33):2–13.

Hillier, Bill, and Julienne Hanson

1989 *The social logic of space*. Cambridge University Press. Cambridge.

Hosler, Dorothy, and Andrew Macfarlane

1996 Copper sources, metal production, and metals trade in Late Postclassic Mesoamerica. *Science*:1819–1824.

Hurtado Mendoza, Francisco

1986 La religión prehispánica de los purhépechas: Un testimonio del pueblo tarasco. *Linotipográfica" Omega", Morelia, Mexico*.

Israde-Alcántara, I., V. H. Garduño-Monroy, C. T. Fisher, H. P. Pollard, and M. A. Rodríguez-Pascua

2005 Lake level change, climate, and the impact of natural events: the role of seismic and volcanic events in the formation of the Lake Patzcuaro Basin, Michoacan, Mexico. *Quaternary International* 135(1):35–46.

Israde-Alcántara, Isabel, Otoniel Buenrostro-Delgado, Víctor Hugo Garduño-Monroy, Víctor Manuel Hernández-Madrigal, and Erna López Granados

2008 Problemática geológico-ambiental de los tiraderos de la Cuenca de Cuitzeo, norte del estado de Michoacán. *Boletín de la Sociedad Geológica Mexicana* 60(2):203–211.

Iwaniszewski, Stanislaw

1994 Archaeology and archaeoastronomy of Mount Tlaloc, Mexico: A reconsideration. *Latin American Antiquity* 5(2):158–176.

José, Corona Núñez

1957 *Mitología tarasca*. Fondo de Cultura Económica, Mexico.

Kokalj, Žiga, Klemen Zakšek, and Krištof Oštir

2011 Application of sky-view factor for the visualisation of historic landscape features in lidar-derived relief models. *Antiquity* 85(327):263–273.

Lehner, Mark, and Richard H. Wilkinson

1997 *The complete pyramids: solving the ancient mysteries*. Thames and Hudson. Oxford.

León, Nicolás

1979 *Los tarascos: notas históricas, étnicas y antropológicas, colegidas de escritores antiguos y modernos, documentos inéditos y observaciones personales: historia primitiva, descubrimiento y conquista*. Editorial Innovación.

Lumholtz, Carl

1903 *Unknown Mexico: A Record of Five Years'exploration Among the Tribes of the Western Sierra Madre; in the Tierra Caliente of Tepic and Jalisco; and Among the Tarascos of Michoacan*. Vol. 2. Macmillan, London.

Lynch, Kevin

1981 *A theory of good urban form*. Cambridge: MIT Press. Cambridge.

Metcalfe, Sarah E., Sarah J. Davies, John D. Braisby, Melanie J. Leng, Anthony J. Newton, Nicola L. Terrett, and Sarah L. O'Hara

2007 Long and short-term change in the Pátzcuaro Basin, central Mexico. *Palaeogeography, Palaeoclimatology, Palaeoecology* 247(3–4):272–295.

Michelet, Dominique

1995 La zona occidental en el posclásico. In *Historia antigua de México, Tomo III: El horizonte posclásico y algunos aspectos intelectuales de las culturas mesoamericanas*, edited by Linda Manzanilla and Leonardo López Luján, pp. 153–188. Instituto Nacional de Antropología e Historia, Universidad Nacional Autónoma de México, and Grupo Editorial Miguel Angel Porruá, Mexico City.

2008 Vivir en forma diferente. Los sitios de la fase Milpillas (1250-1450 dC) en el Malpaís de Zacapu (Michoacán). In *El urbanismo en Mesoamérica*, edited by William Sanders, Alba Guadalupe, Mastache de Escobar, and Robert H. Cobean, pp. 593–620. Instituto Nacional de Antropología e Historia; Pennsylvania State University, México D.F.; University Park.

Michelet, Dominique, Grégory Pereira, and Gérald Migeon

2005 La llegada de los uacúsechas a la región de Zacapu, Michoacán: datos arqueológicos y discusión. *Reacomodos demográficos del Clásico al Posclásico en el centro de México*:137–154.

Migeon, Gérald

1998 El poblamiento del malpaís de Zacapu y de sus alrededores, del Clásico al Posclásico. *Génesis, culturas y espacios en Michoacán*:35–46.

Milbrath, Susan

1999 *Star gods of the Maya: Astronomy in art, folklore, and calendars*. University of Texas Press, Austin.

Millon, René, Robert Bruce Drewitt, and George L. Cowgill

1973 *The Teotihuacan Map.*pp. 1-154.

Moedano, Hugo

1941 Estudio preliminar de la cerámica de Tzintzuntzan, Temporada III. *Revista Mexicana de Estudios Antropológicos* 5(1):21–42.

Morante López, Rubén B.

1993 Evidencias del conocimiento astronómico en Xochicalco, Morelos. *Unpublished Master's thesis, Escuela Nacional de Antropología e Historia,* México, DF.

1996 Evidencias del conocimiento astronómico en Teotihuacan. Unpublished PhD Thesis, Ph. D. thesis, Facultad de Filosofía y Letras, UNAM, Mexico City.

Morrison, L. V.

1980 On the analysis of megalithic lunar sightlines in Scotland. *Journal for the History of Astronomy Supplement* 11:S65.

Neuendorf, K. K. E., J. P. Mehl Jr, and J. A. Jackson

2005 *Glossary of geology*. 5th ed. American Geological Institute, Alexandria.

O'Hara, Sarah L.

1993 Historical evidence of fluctuations in the level of Lake Pátzcuaro, Michoacán, Mexico over the last 600 years. *Geographical Journal*:51–62.

Ortega, Beatriz, Cecilia Caballero, Socorro Lozano, Isabel Israde, and Gloria Vilaclara

2002 52,000 years of environmental history in Zacapú basin, Michoacán, Mexico: the magnetic record. *Earth and Planetary Science Letters* 202(3–4):663–675.

Pauketat, Timothy R.

2000 The tragedy of the commoners. *Agency in archaeology*:113–129.

Pereira, Gregory

1996 *Nuevos hallazgos funerarios en Loma Alta, Zacapu, Michoacán*. Colegio de Michoacán, CEMCA, ORSTOM, Zamora.

Pereira, Grégory

1999 Potrero de Guadalupe: anthropologie funéraire d'une communauté pré-tarasque du nord du Michoacán, Mexique. In *BAR International Series 816*. British Archaeological Reports, Oxford.

Pereira, Grégory, Marion Forest, Dominique Michelet, Elsa Jadot, Luis Barba, Brigitte Faugère, Michelle Elliott, and Aurélie Manin

2012 *Proyecto Uacúsecha. Informe técnico sobre los trabajos de campo llevados a cabo en Malpaís Prieto y otros asentamientos de la region de Zacapu, Michoacán. Temporada 4 (2011-2012).* Instituto Nacional de Antropología e Historia, Mexico City.

Pereira, Gregory, Dominique Michelet, and Gérald Migeon

2007 Cerro Barajas, Guanajuato. *Arqueología mexicana* 15(87):77–82.

Pollard, Helen P.

2008 A model of the emergence of the Tarascan State. *Ancient Mesoamerica* 19(2):217–230.

2003 Central places and cities in the core of the Tarascan state. *Urbanism in Mesoamerica* 1:345–390.

2016 Ceramics, social status, and the Tarascan state economy. *Cultural Dynamics and Production Activities in Ancient Western Mexico,* Archaeopress, Oxford:163–178.

2000 Proyecto Desarollo del Estado Tarasco: Los Senorios Urichu, Xaracuaro, y Pareo. *Informe Final al Consejo de Arqueologia, Instituto Nacional de Antropologia e Historia*.

2006 Proyecto Erongaricuaro. *Informe técnico parcial al Consejo de Arqueología, Instituto Nacional de Antropología e Historia. Temporada II. May*.

1993 *Tariacuri's Legacy: The Prehispanic Tarascan State*. University of Oklahoma Press.

1997 Recent research in west Mexican archaeology. *Journal of Archaeological Research* 5(4):345–384.

Pollard, Helen P., and Laura Cahue

1999 Mortuary patterns of regional elites in the Lake Patzcuaro Basin of western Mexico. *Latin American Antiquity* 10(3):259–280.

Pollard, Helen P., Amy Hirshman, Hector Neff, and Michael D. Glascock

2001 Las élites, el intercambio de bienes y el surgimiento del area nuclear Tarasca: análisis de la cerámica de la cuenca de Pátzcuaro. *Estudios ceramicos en el occidente y norte de Mexico, Colegio de Michoacán, Zamora*:289–309.

Pomédio, Chloé

2013 *Tradiciones cerámicas del epiclásico en el Bajío y regiones aledañas: cronología e interacción*. Edited by Grégory Pereira and Eugenia Fernández-Villanueva. British Archaeological Reports.

Ponce De León, H.

1982 Fechamiento arqueoastronömico en el Altiplano de Mexico. *Direcciön General de Planificaciön,* Mexico DF.

Popenoe de Hatch, Marion

2002 Evidencia de un observatorio astronómico en Tak'alik Ab'aj (antes Abaj Takalik). In *XV Simposio de Investigaciones Arqueológicas en Guatemala, Museo Nacional de Arqueología y Etnología, Guatemala*, edited by J.P. Laporte, H. Escobedo, and B. Arroyo, pp. 378–398. Museo Nacional de Arqueología y Etnología, Guatemala.

Porter Weaver, Muriel

1969 A reappraisal of Chupícuaro. *The Natalie Wood Collection of Pre-Columbian Ceramics at UCLA Los Angeles: University of California*:5–18.

Prufer, Keith, and Amy E. Thompson

2016 Lidar-Based Analyses of Anthropogenic Landscape Alterations as a Component of the Built Environment. *Advances in Archaeological Practice* 4(3):393–409.

Ramírez Uribe, Israel

2017 Geología y aspectos arqueológicos del volcán monogenético Rancho Seco y estructuras volcánicas vecinas (Michoacán, México). Unpublished Thesis. Facultad de Ingeniería. Universidad Nacional Autónoma de México. México DF.

Rapoport, Amos

1990 *The meaning of the built environment: A nonverbal communication approach*. University of Arizona Press. Tucson.

1993 On the nature of capitals and their physical expression. *J. Taylor et al.(ed. s), Capital Cities: International Perspectives/Les Capitales: Perspectives Internationales, Carleton University Press, Ottawa, Ontario, Canada*:31–67.

Rosenswig, Robert M., and Richard L. Burger

2012 Considering early new world monumentality. *Early New World Monumentality*:3–22.

Rubín de la Borbolla, Daniel

1939 Antropología Tzintzuntzan-Ihuatzio: Temporadas I y II. *Revista mexicana de estudios antropológicos* 3(2):99–121.

Rubin de la Borbolla, Daniel

1941 Exploraciones arqueológicas en Michoacán: Tzintzuntzan Temporada III. *Revista Mexicana de Estudios Antropológicos* 5(1):5–20.

Rubín de la Borbolla, Daniel F.

1944 Orfebrería tarasca. *Cuadernos americanos* 3(3):127–138.

Ruggles, Clive LN

1997 Whose equinox? *Journal for the History of Astronomy* 28(22):S44–S50.

Seler, Eduard

1914 *Gesammelte abhandlungen zur amerikanischen sprach-und alterthumskunde*. Vol. 1. Behrend & Co., Berlin.

Smith, Adam T.

2000 Rendering the political aesthetic: Political legitimacy in Urartian representations of the built environment. *Journal of Anthropological Archaeology* 19(2):131–163.

2003 *The political landscape: Constellations of authority in early complex polities*. Univ of California Press.

Smith, Michael E.

2005 City size in late postclassic Mesoamerica. *Journal of Urban History* 31(4):403–434.

2007 Form and meaning in the earliest cities: a new approach to ancient urban planning. *Journal of planning history* 6(1):3–47.

Spodek, Howard, and Doris Srinivasan

1993 *Urban Form and Meaning in South Asia: the shaping of cities from prehistoric to precolonial times*.

Šprajc, Ivan

1997 La astronomía en Mesoamerica. In *Historía antigua de México*, edited by L. Manzanilla and L. López-Luján, 4:. 2nd ed. Instituto Nacional de Antropología e Historia, México D.F.

2000 Astronomical alignments at Teotihuacan, Mexico. *Latin American Antiquity* 11(4):403–415.

2001 *Orientaciones astronómicas en la arquitectura prehispánica del centro de México*. Vol. 427. Instituto Nacional de Antropología e Historia. Mexico.

2005 More on Mesoamerican cosmology and city plans. *Latin American Antiquity* 16(2):209–216.

Šprajc, Ivan, and Pedro Francisco Sánchez Nava

2015 *Orientaciones astronómicas en la arquitectura de Mesoamérica: Oaxaca y el Golfo de México*. Vol. 8. Založba ZRC.

Šprajc, Ivan, Pedro Francisco Sánchez Nava, and Alejandro Cañas Ortiz

2016 *Orientaciones astronómicas en la arquitectura de Mesoamérica: Occidente y Norte*. Vol. 12. Založba ZRC.

Taladoire, Eric

1989 Las canchas de juego de pelota de Michoacán (CEMCA: Proyecto Michoacán). *Trace*(16):88–99.

Thompson, John Eric Sidney

1939 *The moon goddess in Middle America: With notes on related deities*. Carnegie Institution of Washington Washington DC.

Tichy, Franz

1991 *Die geordnete Welt indianischer Völker: ein Beispiel von Raumordnung und Zeitordnung im vorkolumbischen Mexiko*. Vol. 21. F. Steiner.

Trigger, Bruce G.

1990 Monumental architecture: a thermodynamic explanation of symbolic behaviour. *World Archaeology* 22(2):119–132.

2003 *Understanding early civilizations: a comparative study*. Cambridge University Press.

2004 Cross-cultural comparison and archaeological theory. *A companion to social archaeology*:43–65.

Urquhart, Kyle Ryan

2015 The Ireta: A model of political and spatial organization of P'urépecha cities. Unpublished MA Thesis, Colorado State University. Fort Collins.

Warren, J. Benedict

1968 Minas de cobre de Michoacán, 1533. In *Anales del Museo Michoacano*, 6:pp. 35–52.

Watts, William A., and J. Platt Bradbury

1982 Paleoecological Studies at Lake Patzcuaro on the West-Central Mexican Plateau and at Chalco in the Basin of Mexico 1. *Quaternary Research* 17(1):56–70.

Webster, David, and Jennifer Kirker

1995 Too many Maya, too few buildings: Investigating construction potential at Copan, Honduras. *Journal of Anthropological Research* 51(4):363–387.

Wheatley, Paul

1971 *The pivot of the four quarters: a preliminary enquiry into the origins and character of the ancient Chinese city*.

Williams, Eduardo

2005 *El antiguo occidente de México: nuevas perspectivas sobre el pasado prehispánico*. El Colegio de Michoacán.

Yoëli, Pinhas

1965 Analytical hill shading. *Surveying and Mapping* 25(4):573–579.

Yokoyama, Ryuzo, Michio Shirasawa, and Richard J. Pike

2002 Visualizing topography by openness: a new application of image processing to digital elevation models. *Photogrammetric engineering and remote sensing* 68(3):257–266.

Zakšek, Klemen, Kristof Oštir, and Žiga Kokalj

2011 Sky-view factor as a relief visualization technique. *Remote sensing* 3(2):398–415.

APPENDIX A

This Appendix includes all of the data used to calculate the average axis azimuths for civic and ceremonial features at Angamuco that was produced for this analysis. The first table includes the NS and EW average azimuths for each structure, in addition to their calculated standard deviations. The second table includes all of the individual azimuth measurements taken on each structure that allowed for the calculation of the averages within the first table. Each individual measurement was given an Azimuth ID based on what order they were measured on each feature. Additionally, there is a column including brief descriptions of where each measurement was taken on the structure being analyzed.

Appendix Table 1: Table expressing the NS and EW averages for each structure in this analysis, along with their calculated standard deviations.

Structure Number	NS Average Azimuth	NS Standard Dev.	EW Average Azimuth	EW Standard Dev.
AC75-2	144.712	8.879559	226.6174	10.83462
AD76-2	134.1157	5.091055	237.3425	14.65032
AD76-1	160.4903	8.169901	242.6478	15.30694
AE80-1	159.6095	22.81604	249.1357	19.64209
AI78-1	157.3942	11.55173	250.4346	23.07192
AK76-1	176.5965	6.384676	254.3955	11.45038
X-77	186.7887	13.927	269.1422	1.064648
AE75-1	187.7626	20.72336	271.5207	25.06655
AI72-2	184.608	19.65883	272.2929	18.85166
AO73-5	199.4407	0.947014	280.9936	6.826591
AN73-1	199.7108	6.819371	282.3993	5.68075
AF74-1	210.1153	18.42909	283.0588	17.57504
AN73-5	194.9746	7.795846	285.2729	8.503244
AM73-2	203.3595	2.006532	291.8444	12.0638
AI79-1	197.826	12.15447	292.553	27.19193
AM73-1	204.172	3.178491	293.4938	6.787961
AO73-1	213.4113	18.09217	296.265	11.9717

AJ78-4	206.3031	21.76343	299.3662	14.23004
AJ75-2	199.7933	19.34088	301.867	14.13511
AN76-3	222.745	12.33003	308.9648	20.80865
AE76-1	223.916	12.37178	309.1168	9.811207
AN73-2	206.5827	2.632179	312.659	18.07738
AK72-1	220.3027	6.920911	315.0978	8.676734
AG77-2	217.1272	12.60522	315.1233	14.20502
AM75-2	232.4458	31.001	317.9327	18.08316
AC75-1	223.8008	8.472032	320.994	7.465708
AK76-5	231.6422	12.23763	321.5486	24.46734
AG76-2	235.2737	16.27138	321.574	19.34212

Appendix Table 2: Table expressing all of the individual azimuth measurements taken on each structure. These measurements were used to calculate the averages and standard deviations in Appendix Table 1.

Azimuth ID	Structure Number	Direction	Azimuth Measure	Basic Locational Description
1	AC75-1	EW	332.17099	Base of platform, E side
2	AC75-1	EW	325.2569885	Base of platform, W side
3	AC75-1	EW	316.1600037	Rectilinear element edge, E side
4	AC75-1	EW	315.3460083	Rectilinear element edge, W side
5	AC75-1	EW	316.0360107	Top of yacata, center
6	AC75-1	NS	232.1940002	Base of platform, SE side
7	AC75-1	NS	216.1970062	Base of platform, NW side
8	AC75-1	NS	229.9920044	Top of rectilinear element, center
9	AC75-1	NS	216.8200073	Near top of rounded element, N end
1	AC75-2	NS	133.8639984	Edge with plaza to SW
2	AC75-2	NS	141.0529938	Top of pyramid, SW side
3	AC75-2	NS	152.3159943	Base of pyramid, NE side
4	AC75-2	NS	151.6150055	Top of pyramid, NE side
5	AC75-2	EW	235.8730011	Base of pyramid, S end
6	AC75-2	EW	211.9499969	Base of pyramid, N end (1)
7	AC75-2	EW	232.5110016	Base of pyramid, N end (2)
8	AC75-2	EW	234.5590057	Mid-pyramid, S end
9	AC75-2	EW	218.1940002	Mid-pyramid, N end
1	AD76-1	NS	161.3070068	Mid-pyramid, E side
2	AD76-1	NS	160.3009949	Base of pyramid, E side
3	AD76-1	NS	167.5330048	Top of pyramid, E side
4	AD76-1	NS	167.6069946	Base of pyramid, W side
5	AD76-1	NS	160.9539948	Top of pyramid, W side
6	AD76-1	NS	145.2400055	Mid-pyramid, W side
7	AD76-1	EW	228.7879944	Base of pyramid, S end
8	AD76-1	EW	248.2819977	Mid-pyramid, S end

9	AD76-1	EW	235.6340027	Base of pyramid, N end
10	AD76-1	EW	261.5939941	Mid-pyramid, N end
11	AD76-1	EW	224.4750061	Top of pyramid, NW side
12	AD76-1	EW	257.1140137	Top of pyramid, S side
1	AD76-2	NS	133.7890015	Base of pyramid, SW side
2	AD76-2	NS	129.0410004	Edge with sunken area to SW
3	AD76-2	NS	130.0189972	Mid-pyramid, SW side
4	AD76-2	NS	134.5650024	Top of pyramid, SW side
5	AD76-2	NS	133.8540039	Base of pyramid, NE side
6	AD76-2	NS	143.4259949	Mid-pyramid, NE side
7	AD76-2	EW	229.026001	Base of pyramid, S end
8	AD76-2	EW	236.904007	Mid-pyramid, S end
9	AD76-2	EW	244.923996	Top of pyramid, S end
10	AD76-2	EW	213.052002	Base of pyramid, NW side
11	AD76-2	EW	254.0800018	Mid-pyramid, N end
12	AD76-2	EW	246.0690002	Top of pyramid, N side
1	AE75-1	NS	156.9880066	Edge of platform SW side
2	AE75-1	NS	163.7299957	Edge of platform, E side
3	AE75-1	NS	197.1459961	Base of pyramid, E side
4	AE75-1	NS	200.0709991	Base of pyramid, W side
5	AE75-1	NS	212.6679993	Edge with plz to NW
6	AE75-1	EW	242.6490021	Base of platform, SE side
7	AE75-1	EW	246.2559967	Edge of platform, NW side
8	AE75-1	EW	293.8240051	Edge of platform, N side
9	AE75-1	EW	269.5969849	Base of pyramid, S side
10	AE75-1	EW	313.1820068	Base of pyramid, NE side
11	AE75-1	NS	182.9629974	Top of pyramid, W side
12	AE75-1	NS	200.7720032	Top of pyramid, E side
13	AE75-1	EW	263.6910095	Mid-pyramid, S side
14	AE75-1	EW	271.4460144	Top of pyramid, N side
1	AE76-1	EW	322.9089966	Top of pyramid, SW side
2	AE76-1	EW	311.0230103	Top of pyramid, NE side
3	AE76-1	EW	304.6010132	Base of pyramid, S side
4	AE76-1	EW	293.1329956	Base of pyramid, N end
5	AE76-1	NS	228.2149963	Edge with plaza to SE
6	AE76-1	NS	235.7339935	Mid-pyramid, SE side
7	AE76-1	NS	229.8399963	Top of pyramid, SE side
8	AE76-1	NS	203.5119934	Base of pyramid, NW side
9	AE76-1	NS	222.279007	Mid-pyramid, NW side
10	AE76-1	EW	311.3770142	Mid-pyramid, S end
11	AE76-1	NS	311.6579895	Mid-pyramid, N side
1	AE80-1	NS	148.996994	Base of pyramid, E side
2	AE80-1	NS	162.7189941	Base of pyramid, W side
3	AE80-1	NS	141.3300018	Mid-pyramid, E side
4	AE80-1	NS	171.7619934	Mid-pyramid, W side
5	AE80-1	NS	135.5549927	Top of pyramid, SW side
6	AE80-1	EW	248.4029999	Base of pyramid, S end
7	AE80-1	EW	241.7250061	Mid-pyramid, N end

8	AE80-1	EW	233.1439972	Top of pyramid, N end
9	AE80-1	EW	237.5740051	Mid-pyramid, S end
10	AE80-1	EW	287.5639954	Edge with sunken area, NE side
11	AE80-1	NS	197.2940063	Edge with sunken area, SE side
12	AE80-1	EW	246.404007	Top of pyramid, center
1	AF74-1	NS	218.5350037	Platform? edge NW side
2	AF74-1	NS	224.6239929	Mid-pyramid, NW side
3	AF74-1	NS	220.5039978	Base of pyramid, plat?, SE side
4	AF74-1	NS	194.6239929	Base of pyramid, NE side
5	AF74-1	NS	179.871994	Mid-pyramid, E side
6	AF74-1	NS	222.5330048	Top of pyramid, W side
7	AF74-1	EW	290.2619934	Base of pyramid, N end
8	AF74-1	EW	273.7640076	Base of pyramid, S end
9	AF74-1	EW	264.2780151	Top of pyramid, S side
10	AF74-1	EW	303.9309998	Mid-pyramid, S side
1	AG76-2	EW	293.7299967	Base of pyramid, NE side
2	AG76-2	EW	337.1029968	Mid-pyramid, N side
3	AG76-2	EW	331.6099854	Top of pyramid, NE side
4	AG76-2	EW	323.8529968	Base of pyramid, SW side
7	AG76-2	NS	250.7310028	Base of pyramid, NW side
8	AG76-2	NS	215.6670074	Base of pyramid, W side
9	AG76-2	NS	257.8299866	Top of pyramid, N side
10	AG76-2	NS	240.0319977	Top of pyramid, S side
11	AG76-2	NS	214.5980072	Base of pyramid, SE side (1)
12	AG76-2	NS	235.2910004	Mid-pyramid, SE side
13	AG76-2	NS	232.7669983	Edge with sunken area to NW
1	AG77-2	EW	334.9890137	Base of pyramid, NE side
2	AG77-2	EW	315.5899963	Base of pyramid, SW side
3	AG77-2	EW	303.8080139	Mid-pyramid, SW side
4	AG77-2	EW	301.8059998	Top of pyramid, SW side
5	AG77-2	EW	329.5090027	Mid-pyramid, NE side
6	AG77-2	EW	305.0379944	Base of plt, NE side
7	AG77-2	NS	233.0079956	Edge with plaza to SE
8	AG77-2	NS	225.7749939	Mid-pyramid, SE side
9	AG77-2	NS	205.2380066	Top of pyramid, SE side
10	AG77-2	NS	216.9140015	Edge with sunken area to NW
11	AG77-2	NS	222.0690002	Mid-pyramid, NW side
12	AG77-2	NS	199.7590027	Top of pyramid, W side
1	AI72-2	NS	172.2550049	Mid-pyramid, NE side
2	AI72-2	NS	191.0720062	Base of pyramid (plat?), W side (1)
3	AI72-2	NS	171.526001	Base of pyramid (plat?), NE side
4	AI72-2	NS	192.7899933	Base of pyramid (plat?), W side (2)
5	AI72-2	NS	216.8509979	Mid-pyramid, SE side
6	AI72-2	NS	163.154007	Top of pyramid, center
7	AI72-2	EW	272.1820068	Base of pyramid (plat?), N side
8	AI72-2	EW	260.026001	Mid-pyramid, N side
9	AI72-2	EW	269.3299866	Base of pyramid, S side (1)
10	AI72-2	EW	253.7050018	Top of pyramid, S side

11	AI72-2	EW	251.7140045	Top of pyramid, N side
12	AI72-2	EW	296.1839905	Base of pyramid, NE side
13	AI72-2	EW	303.7250061	Base of pyramid, S side (2)
14	AI72-2	EW	271.4769897	Base of platform, N side
1	AI78-1	NS	165.4400024	Base of pyramid, E side (1)
2	AI78-1	NS	156.3760071	Base of pyramid, E side (2)
3	AI78-1	NS	137.8769989	Top of pyramid, E side
4	AI78-1	NS	165.7700043	Mid-pyramid, W side
5	AI78-1	NS	161.5079956	Top of pyramid, center
6	AI78-1	EW	222.25	Base of pyramid, SE side
7	AI78-1	EW	268.6570129	Base of pyramid, S side
8	AI78-1	EW	276.4460144	Base of pyramid, N side (1)
9	AI78-1	EW	249.4080048	Top of pyramid, S side
10	AI78-1	EW	262.5880127	Base of pyramid, N side (2)
11	AI78-1	EW	215.9559937	Base of pyramid, NW side
12	AI78-1	EW	257.7369995	Top of pyramid, center
1	AI79-1	NS	196.9389954	Base of pyramid, E side
2	AI79-1	NS	183.4839935	Base of pyramid, W side
3	AI79-1	NS	208.6380005	Top of pyramid, E side
4	AI79-1	NS	182.951004	Top of pyramid, W side (1)
5	AI79-1	NS	209.4620056	Top of pyramid, W side (2)
7	AI79-1	EW	323.4710083	Base of pyramid, N end
8	AI79-1	EW	258.4389954	Base of pyramid, S end
9	AI79-1	EW	313.6409912	Top of pyramid, N end
10	AI79-1	EW	272.8099976	Top of pyramid, S end
6	AI79-1	NS	205.4819946	Top of pyramid, center
11	AI79-1	EW	294.4039917	Top of pyramid, center
1	AJ75-2	NS	224.5740051	Base of pyramid, SE side
2	AJ75-2	NS	171.8910065	Base of pyramid, NE side
4	AJ75-2	NS	184.8849945	Base of pyramid, W side
3	AJ75-2	NS	212.201004	Mid-pyramid, SE side
5	AJ75-2	NS	209.151001	Top of pyramid, W side
6	AJ75-2	NS	196.0579987	Top of pyramid, center
7	AJ75-2	EW	294.07901	Base of pyramid, N end
8	AJ75-2	EW	303.1220093	Base of pyramid, S side
9	AJ75-2	EW	301.401001	Top of pyramid, N end
10	AJ75-2	EW	324.2380066	Top of pyramid, S end
11	AJ75-2	EW	286.4949951	Top of pyramid, center
1	AJ78-4	NS	206.8119965	Base of pyramid, W side (1)
2	AJ78-4	NS	220.2350006	Base of pyramid, W side (2)
3	AJ78-4	NS	177.8930054	Base of pyramid (plat?), W side
4	AJ78-4	NS	205.7140045	Top of pyramid, W side
5	AJ78-4	NS	219.8800049	Base of pyramid, E side
6	AJ78-4	NS	242.9440002	Base of pyramid, SE side
7	AJ78-4	NS	179.7839966	Base of pyramid, NE side
8	AJ78-4	NS	197.1629944	Top of pyramid, E side
9	AJ78-4	EW	299.0400085	Base of pyramid, N end
10	AJ78-4	EW	299.5549927	Base of pyramid, S end

11	AJ78-4	EW	290.0230103	Mid-pyramid, N end
12	AJ78-4	EW	285.7000122	Top of pyramid, center
13	AJ78-4	EW	322.5130005	Top of pyramid, N end
1	AK72-1	NS	220.7799988	Base of pyramid, SE side (1)
2	AK72-1	NS	232.4140015	Base of pyramid, SE side (2)
3	AK72-1	NS	216.897995	Top of pyramid, SE side
4	AK72-1	NS	219.9589996	Base of pyramid, NW side (1)
5	AK72-1	NS	211.3110046	Top of pyramid, NW side
6	AK72-1	NS	220.4539948	Top of pyramid, center
7	AK72-1	EW	310.1359863	Base of pyramid, S end
8	AK72-1	EW	309.42099	Mid-pyramid, S end
9	AK72-1	EW	319.0100098	Base of pyramid, N end
10	AK72-1	EW	328.618988	Top of pyramid, N side
11	AK72-1	EW	308.303009	Top of pyramid, center
1	AK76-1	NS	173.1230011	Base of pyramid, E side
2	AK76-1	NS	177.1060028	Top of pyramid, E side
3	AK76-1	NS	185.3439941	Base of pyramid, W side
4	AK76-1	NS	170.8130035	Top of pyramid, W side
5	AK76-1	EW	243.8760071	Base of pyramid, S side
6	AK76-1	EW	240.2890015	Base of Pyramid, N side (1)
7	AK76-1	EW	271.7969971	Base of pyramid, N side (2)
8	AK76-1	EW	257.9440002	Top of pyramid, S side
9	AK76-1	EW	252.7879944	Top of pyramid, N side
10	AK76-1	EW	259.6789856	Top of pyramid, center
1	AK76-5	NS	230.647995	Base of pyramid, SE side
2	AK76-5	NS	238.2689972	Top of pyramid, SE side
3	AK76-5	NS	210.871994	Base of pyramid, NW side
4	AK76-5	NS	237.1909943	Top of pyramid, NW side
5	AK76-5	NS	241.2310028	Top of pyramid, center
6	AK76-5	EW	330.9179993	Base of pyramid, S side
7	AK76-5	EW	320.3009949	Mid-pyramid, S side
8	AK76-5	EW	289.2460022	Base of pyramid, N side (1)
9	AK76-5	EW	288.8599854	Edge of platform, N side (1)
10	AK76-5	EW	350.2399902	Edge of platform, N side (2)
11	AK76-5	EW	344.8670044	Base of pyramid, N side (2)
12	AK76-5	EW	326.4079895	Top of pyramid, center
1	AM73-1	NS	205.1269989	Base of pyramid, E side
2	AM73-1	NS	200.2129974	Top of pyramid, E side
3	AM73-1	NS	207.8200073	Base of pyramid/plat?, W side
4	AM73-1	NS	203.5279999	Mid-pyramid, W side
5	AM73-1	EW	287.5320129	Base of pyramid, N side (1)
6	AM73-1	EW	301.3320007	Base of pyramid, N side (2)
7	AM73-1	EW	289.0559998	Base of pyramid, S edge with plaza
8	AM73-1	EW	290.4710083	Top of pyramid, S side
9	AM73-1	EW	302.9559937	Top of pyramid, N side
10	AM73-1	EW	289.6159973	Mid-pyramid, S side
1	AM73-2	NS	206.0330048	Base of pyramid, SE edge with plaza
2	AM73-2	NS	203.5399933	Top of pyramid, E side

3	AM73-2	NS	201.2899933	Mid-pyramid, E side
4	AM73-2	NS	202.5749969	Rectilinear element, center
5	AM73-2	EW	304.0910034	Rectilinear element, S end (1)
6	AM73-2	EW	291.303009	Rectilinear element, S end (2)
7	AM73-2	EW	291.6059875	Top of pyramid, center
8	AM73-2	EW	272.5820007	Base of pyramid, N end (1)
9	AM73-2	EW	299.6400146	Base of pyramid, N end (2)
1	AM75-2	NS	221.5249939	Base of pyramid, SE side
2	AM75-2	NS	185.1820068	Base of pyramid, W side
3	AM75-2	NS	261.17099	Base of pyramid, NW side
4	AM75-2	NS	235.8470001	Top of pyramid, SE side
5	AM75-2	NS	258.5039978	Top of pyramid, NW side
6	AM75-2	EW	302.7950134	Base of pyramid, S end
7	AM75-2	EW	313.4129944	Base of pyramid, N end
8	AM75-2	EW	311.3569946	Top of pyramid, N end
9	AM75-2	EW	344.1659851	Top of pyramid, S end
1	AN73-1	NS	197.4019928	SE edge with plaza
2	AN73-1	NS	195.4869995	Top of rectilinear element
3	AN73-1	NS	195.6159973	Rectilinear and round element junction
4	AN73-1	EW	283.8299866	Top of rounded element, center
5	AN73-1	EW	287.2279968	Rectilinear element, north end
6	AN73-1	EW	276.1400146	Rectilinear element, south end
7	AN73-1	NS	198.3309937	Mid-pyramid, E side
8	AN73-1	NS	211.7180023	Outer edge of patio to SW (W edge)
1	AN73-2	NS	209.1000061	Top, center
2	AN73-2	NS	203.848999	Pyramid SE side
3	AN73-2	NS	206.798996	NW side
4	AN73-2	EW	287.67099	Pyramid S end
5	AN73-2	EW	309.1730042	Platform/patio edge to S
6	AN73-2	EW	306.0029907	Top of pyramid, N end
7	AN73-2	EW	328.072998	Bottom of pyramid, N end
8	AN73-2	EW	332.375	Edge of platform/patio, N end
1	AN73-5	NS	195.0850067	Ballcourt interior, E side
2	AN73-5	NS	205.5330048	Outer edge of upper platform (E side)
3	AN73-5	NS	190.2059937	Ballcourt interior, W side
4	AN73-5	NS	198.7870026	Outer edge of upper platform (W side) (1)
5	AN73-5	NS	185.2619934	Outer edge of upper platform (W side) (2)
6	AN73-5	EW	282.8359985	Ballcourt interior, N side
7	AN73-5	EW	287.5509949	Ballcourt interior, S side
8	AN73-5	EW	299.1010132	Outer edge of upper platform (S side) (1)
9	AN73-5	EW	292.1319885	Outer edge of upper platform (S side) (2)
10	AN73-5	EW	275.6459961	Outer edge of upper platform (N side) (1)
11	AN73-5	EW	275.8009949	Outer edge of upper platform (N side) (2)
12	AN73-5	EW	283.8429871	Interior ballcourt, mid-line (thru altar?)
1	AN76-3	NS	226.9759979	Base of pyramid, SE side
2	AN76-3	NS	225.9219971	Base of pyramid, NW side
3	AN76-3	NS	209.125	Top of pyramid, SE side
4	AN76-3	NS	239.5500031	Top of pyramid, NW side (1)

5	AN76-3	NS	212.1519928	Top of pyramid, NW side (2)
5	AN76-3	EW	274.473999	Base of pyramid, S side (1)
6	AN76-3	EW	324.6119995	Base of pyramid, N side (1)
7	AN76-3	EW	301.8890076	Base of pyramid, N side (2)
8	AN76-3	EW	331.9819946	Base of pyramid, S side (2)
9	AN76-3	EW	301.8580017	Top of pyramid, S side
10	AN76-3	EW	318.973999	Top of pyramid, N side
1	AO73-1	NS	224.8300018	SE edge with plaza
2	AO73-1	NS	216.1289978	NW side
3	AO73-1	NS	225.6340027	Pyramid top, SE side
4	AO73-1	NS	187.052002	Mid-pyramid, W side
5	AO73-1	EW	292.4429932	Pyramid edge, S side
6	AO73-1	EW	284.321991	Pyramid edge, N end
7	AO73-1	EW	295.5320129	Mid-pyramid, N side
8	AO73-1	EW	312.7630005	Top of pyramid, center
1	AO73-5	NS	200.2310028	W edge of ballcourt
2	AO73-5	NS	199.6999969	Edge with plaza, W side
3	AO73-5	NS	198.3910065	E edge of ballcourt
4	AO73-5	EW	275.3129883	Ballcourt interior, N wall
5	AO73-5	EW	276.631012	Ballcourt interior, S wall (W end)
6	AO73-5	EW	291.7619934	Ballcourt interior, S wall (E end)
7	AO73-5	EW	277.5580139	Ballcourt mid-line
8	AO73-5	EW	283.70401	Outer edge of upper platform (S side)
1	X-77	NS	215.0339966	Base of pyramid, E side
2	X-77	NS	178.6999969	Base of pyramid, W side
3	X-77	NS	183.4880066	Mid-pyramid, E side
4	X-77	NS	181.2689972	Mid-pyramid, W side
5	X-77	NS	180.4259949	Top of pyramid, W side
6	X-77	NS	181.8150024	Top of pyramid, E side
7	X-77	EW	269.6789856	Edge with plaza to N
8	X-77	EW	268.0570068	Top of pyramid, N side
9	X-77	EW	268.4719849	Mid-pyramid, S side
10	X-77	EW	270.3609924	Base of pyramid, S side